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In This Reconciliation Ecology Theme Issue …

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

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David R. Clements

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Hope for Reconciliation Ecology in the Anthropocene

In this thematic issue of *Perspectives on Science and Christian Faith*, the authors take on what has been a central challenge to humanity from the beginning. Although God created all things to be good, due to our fallen nature, we have damaged the creation so much that it is groaning for redemption and reconciliation (Rom. 8:22). As the human population has grown exponentially commensurately with our ability to damage creation, we have reached a time which seems aptly named "the Anthropocene" because of the overwhelming influence of humans on planetary function.

As I reported in my call for papers for this special issue,[1] the Anthropocene Working Group announced on July 11, 2023, that Crawford Lake in Ontario was chosen as the golden spike of the Anthropocene.[2] This led to a flurry of excitement in Ontario and beyond; the enthusiasm extended to the American Scientific Affiliation meeting in Toronto, Ontario, later that same month when the field trip I was on made a detour to stop at the suddenly famous Crawford Lake. Alas, it was not long before the International Commission on Stratigraphy poured cold water on the Anthropocene concept in February 2024, voting against the proposed geological epoch, arguing that the geological indicators were insufficient to establish the Anthropocene as distinct from the Cenozoic.[3] The decades-long debate over the Anthropocene label is itself one of many signs that reconciliation ecology is needed.

Arguments are heating up over what to do about a damaged creation, even as record heat waves and ever-increasing global temperatures continue to sound the alarm about climate change. These long-running arguments as seen from faith perspectives have frequently found their way into the pages of this journal, portraying both the angst associated with the groaning of creation and the hope faith promises to bring to the table. In 2014, a theme issue was published on the implications of new findings in environmental science.[4] Topics included climate change, stewardship of marine resources, geoengineering, and reconciliation ecology as a new paradigm for advancing creation care. Evidently, eleven years later these issues are still top of mind, in that many similar topics are covered in this current theme issue, with all four articles highlighting the value of the reconciliation ecology paradigm that was delineated by David Warners, Michael Ryskamp, and Randall Van Dragt in the 2014 issue.[5]

The first essay in this current issue on reconciliation in the Anthropocene, by Abigail Tamkin and David Wituszynski, purports to build a bridge to reconciliation ecology through the concept that, as we humans are creatures made in the image of God, it is in our very nature to practice reconciliation ecology. They point out that whereas many Christian believers are skeptical about caring for the environment, the doctrine of the *imago Dei* is universally upheld by the Christian faithful. If, in truth, all people of all cultures and religions are made in God's image, then all are called to participate in the mending of broken relationships among each other *and* between humans and nonhuman creations. To make their case, Tamkin and Wituszynski discuss how the expectation of imaging God from Genesis can be seen as a vocational

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calling for all to pursue good relationships with the non-human creation. They also emphasize how Jesus entered into the creation he himself crafted as a loving sojourner and ruler, modeling the same kind of role we are created to take on as God's image bearers.

The second essay is written by William Miller, who researches tick-borne diseases and how they are on the rise in North America. Zoonotic diseases inextricably link environmental health and human health. As Miller points out, when it comes to tick-borne diseases, a changing North American landscape, increasing wildlife and wildlife-human proximity, together with climate change are a recipe for disaster. How should we respond? Reconciliation ecology is the answer. Like Tamkin and Wituszynski, Miller finds another extension to make reconciliation ecology more relevant to a wider audience—the One Health concept. One Health is increasingly being adopted in many circles as a model which recognizes the closely entangled relationships among human, animal, and ecosystem health.

In the third article, "Restoration Aquaculture: Reconciling Aquatic Creatures and Ecosystems to Enhance Fruitfulness for All" by Steven Hall and his colleagues, we are introduced to several cases in which human ingenuity is brought to bear on the reconciliation of a groaning creation. Alligators brought back from the brink of extinction now support a $77 million sustainable industry in the United States. The authors envision a similar pathway for pairing the conservation and culture of sturgeon. The use of marine aquaponics is already supplying a rapidly increasing proportion of the world's food supply: at 6% annual growth, aquaculture is outpacing all other protein sources. Like Tamkin and Wituszynski, Hall et al. refer with hope to the *imago Dei*. They are convinced that human wisdom through imaging God can result in sustainable aquaculture systems. Success in sustainable aquaculture would reduce overexploitation of terrestrial and aquatic systems.

The final article by Sam Pimentel is both inspiring and daunting, as Pimentel expounds on the beauty of the world's glaciers while warning that many of them are in rapid decline. The fact of the matter is that 50% of the world's glaciers will disappear by 2100 due to rising global temperatures, with stark consequences for both land and sea, and by extension, us. These beautiful glaciers act as markers for what we might call the Anthropocene, and as inspiration to do the right thing and attempt to reduce greenhouse gas emissions to slow glacier melting via reconciliation ecology.

The five stages of reconciliation ecology as articulated by Warners et al. in the 2014 issue on environment are worth repeating here to underline how reconciliation ecology works.

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)[6]

Whether we are looking at zoonotic diseases, alligators, or glaciers, it is about making relationships right. Indigenous cultures have a long-standing recognition of the power of relationship healing. As Indigenous ecologist Robin Wall Kimmerer advocates in *Braiding Sweetgrass*:

> We need acts of restoration, not only for polluted waters and degraded lands, but also for our relationship to the world. We need to restore honor to the way we live, so that when we walk through the world we don't have to avert our eyes with shame, so that we can hold our heads up high and receive the respectful acknowledgment of the rest of the earth's beings.[7]

This is the hope for reconciliation ecology in the Anthropocene if we each work to better reflect God's image. May you be inspired by this hope as you read the contributions to this special issue.

Notes

[1]David R. Clements, "Reconciliation Ecology in the Anthropocene," *Perspectives on Science and Christian Faith* 76, no. 2 (2024): 125–38, https://www.asa3.org/ASA/PSCF/2024/PSCF9-24Clements.pdf.
[2]Alexandra Witze, "This Quiet Lake Could Mark the Start of a New Anthropocene Epoch," *Nature* 619 (2023): 441–42, https://doi.org/10.1038/d41586-023-02234-z.
[3]Ritwick Ghosh, "A Fond Farewell to the Anthropocene," *Issues in Science and Technology* 40, no. 3 (2024): 20–22, https://doi.org/10.58875/OUAY7538.
[4]Dorothy Boorse, "New Findings in Environmental Science and Their Implications for Christians," *Perspectives on Science and Christian Faith* 66, no. 4 (2014): 194–202, https://www.asa3.org/ASA/PSCF/2014/PSCF12-14Boorse.pdf.
[5]David Warners, Michael Ryskamp, and Randall Van Dragt, "Reconciliation Ecology: A New Paradigm for Advancing Creation Care," *Perspectives on Science and Christian Faith* 66, no. 4 (2014): 221–35, https://www.asa3.org/ASA/PSCF/2014/PSCF12-14Warners.pdf.
[6]Warners et al., "Reconciliation Ecology," 226.
[7]Robin Wall Kimmerer, *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants* (Milkweed Editions, 2013), 195.

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Guest Editor

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The *Imago Dei:* A Bridge to Faith-Infused Reconciliation Ecology

Abigail Tamkin and David Wituszynski

David Wituszynski

Other authors have made a compelling case for the Christian practice of Faith-Infused Reconciliation Ecology (FIRE) as an important aspect of Christian faithfulness. However, the ecological reasoning that has birthed this idea may not be convincing (or particularly cogent) to the average North American churchgoer. We suggest that the doctrine of the image of God (imago Dei) *can be used to bring people to understand faith-infused reconciliation ecology as part of their Christian vocation. In particular, we argue that the* imago Dei *includes the vocation to a specific (loving and responsible) relationship with nonhuman creation, which leads naturally to the requirement for reconciliation with that creation when we fail in our vocation. While this interpretation of the* imago Dei *is not widespread in North American churches, it uses concepts and language that are readily accessible to most churchgoers, making it an approachable way to engage the subject. Our goal is to show how the* imago Dei *doctrine can lead to a faith-infused reconciliation ecology paradigm.*

Keywords: *imago Dei*, image of God, vocation, creation care, reconciliation ecology, earthkeeping, environmental stewardship, incarnation, resurrection, embodiment, church

Emerging awareness of the environmental crisis has caused a growing number of Christians to engage the Bible and the Christian tradition in a search for theological grounding for environmental action.[1] Several names have been attached to this effort, including "earthkeeping,"[2] "stewardship," and "creation care."[3] Ten years ago, David Warners, Michael Ryskamp, and Randall Van Dragt argued in this journal that the idea of "reconciliation ecology" offers a more accurate description of what is required of Christians as they seek to live in proper relationship with God's creation.[4]

Reconciliation ecology is a term from the ecological literature which describes the intentional creation of habitat for nonhuman organisms in human-dominated spaces, adapting our homes and lives to allow mutual flourishing of both humans and other members of creation.[5] By adapting this idea into a creation-care paradigm, Warners, Ryskamp, and Van Dragt suggest that "Faith-Infused Reconciliation Ecology" (FIRE) differs from contemporary ideas of "stewardship" by emphasizing the relationships between humans and nonhumans, which need to be restored.

They prescribe five steps in the process of reconciliation, taken from the literature on reconciliation between people:

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David Wituszynski *(PhD, The Ohio State University) works in research and development for Engineering Ministries International, which provides design services to Christian ministries around the world. He studied ecological engineering (stormwater, urban wildlife) and theology (through Au Sable Institute) together with Abby. Writing this paper justified shipping his library to Uganda.*

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).[6]

To distinguish between reconciliation ecology as a Christian calling and the strictly ecological use of the term, we will refer to the creation-care paradigm using Warners, Ryskamp, and Van Dragt's term of faith-infused reconciliation ecology, or FIRE.

Whatever one calls it, there is a good case to be made for Christians living wisely in the world God has made and where God has placed us to live. This case is an easy one to accept as a Christian working in an environmental field—by inhabiting both theological and ecological spheres, we can see the imperatives of conservation, restoration, and stewardship, as well as the wounds and harm we often cause.[7] As we (the authors) have synthesized Christian and environmental worldviews (largely through the Au Sable Institute's Graduate Fellows program while we were both in graduate school at Ohio State University), we have come to not only care more deeply about the fate of creation and our fellow creatures but have also found our faith and wonder at God deepened as we gain a greater understanding of God's world, his creatures, and how we fit in. Taking this physical world seriously has also reflected back to our theological understanding of reality, particularly the incarnation and resurrection. We will discuss the importance of these doctrines, how they relate to the image, and the vision they provide for life in the new creation.

However, as we have worked to integrate these two spheres of faith and science in our vocations, we have realized that these concepts are not intuitive for many of our fellow churchgoers. They see our interest in creation care as merely idiosyncratic: a passion that we are permitted to pursue but that does not hold relevance for them. Some express skepticism of our efforts, believing that environmental concerns are not relevant to Christian faith beyond some limited and generalized application of kindness or responsibility. This perspective is reinforced by the culture within their churches, which teaches them to focus on more "spiritual" concerns, and the broader culture beyond the church, which does little to confront us with the reality of environmental degradation, the nonhuman suffering it causes, and our complicity in this brokenness. We are concerned that the paradigm of FIRE, moving as it does from seeing the world as a resource to be managed to seeing the world as a web of relationships to be reconciled, can be difficult to incorporate into the average churchgoer's internal understanding of the nonhuman creation.

However, we strongly believe that caring for creation is not a calling only for those with years of training, but for all of humanity, and that FIRE presents an important way to approach this concept. How do we bridge this divide and exhort both laity and pastors to care for creation, especially those without environmental interest or education? We have made some attempts at translating creation care and reconciliation ecology concepts for our fellow believers, and we propose the doctrine of the image of God, or the *imago Dei*, as a bridge to the concept of FIRE. The *imago Dei* is the doctrine that humans are created in the image of God. In this article, we will briefly review the main views of the *imago Dei*. We then organize aspects of the image through the lens of the *munus triplex*, or three-fold office, of Christ:[8] the royal, priestly, and prophetic aspects of our vocation. Our key text will be Genesis 1–3, but we will also look at how the Israelites, as God's people, were called to display God's image. In addition, we consider how Christ came as the second Adam, reinterpreting the image for us, since Christ himself is the image of God.[9] Looking forward, to the new heavens and new earth, the image can inform the eschatological vision of what humans were made for versus what we struggle with now in our fallen world. Our goal is to make this concept clear to a predominantly Christian audience, so we often assume a Christian worldview on behalf of our reader. However, we strongly believe that we are speaking of a vocation applicable to all humans, and we hope that any reader may benefit from the attention we give it here.

The Image

The Bible is God's revelation to humans, and since it is written for us, we can fall into the trap of thinking we are the main characters. The true protagonist of the story is the Creator and Sustainer, the God of the Universe, our Savior and Redeemer. The doctrine of the *imago Dei* can help us remember our place in the story: *We are royal representatives called to work toward and proclaim the shalom (peace, wholeness, and flourishing) of God's creation*.[10] God is the one who orders the cosmos and

fills it with creatures; the creation of humans comprises only part of day six. While the creation of humans gets special treatment,[11] once humans are created, they are immediately integrated into the rest of what God has made. They are given a place (the garden), a task (to fill the earth and subdue it), and relationships with their surroundings and their fellow creatures (as they tend and keep the garden and name the animals[12]). The creation is not simply a backdrop for the story of humans. God made this good (eco)system and entwined humans within this web to tend and keep it.

We are by no means the first to connect the *imago Dei* and creation care. Douglas Hall connects them explicitly in *Imaging God: Dominion as Stewardship*,[13] and the specific interpretation of the image of God we will be describing is adapted from Richard Middleton's *The Liberating Image*[14] and the more recent *Being God's Image* by Carmen Imes.[15] Both of these authors connect the *imago Dei* to care for creation, and the *imago Dei* is included in many discussions of creation care and reconciliation ecology.[16] Our contribution is to connect the *imago Dei* specifically with the paradigm of FIRE in a way that can reach the average North American churchgoer.

The image has been understood in several ways throughout history, and one can still find a variety of views in the church today. The main three interpretations are

1. the structural or substantialist view, focused on physical and mental particularities;
2. the relational view, focused on the relationship humans have with God; and
3. the functional or royal representative view, focused on the vocation or office given to humans.

While each of the views can be helpful, we will present a hybridized concept that focuses on the functional view.

The structural (also called substantive or substantialistic) view understands the image as attributes possessed by humans that distinguish them from other animals: human abilities to think, reason, and work, and the possession of an immortal soul, are often given in this description of the image. The structural view was held by Augustine and Aquinas,[17] and has been expressed by more-contemporary theologians such as Charles Hodge[18] and Louis Berkhof.[19] However, this view can be problematic when we think about humans who have undeveloped or diminished cognitive[20] or physical abilities—are they less of God's image? What about humans who are not yet born? There is certainly merit to considering the characteristics that make humans unique among God's creatures, but we do not view such abilities as the primary meaning of being God's image.[21]

The relational view, developed by John Calvin[22] and furthered by Karl Barth,[23] focuses on humans as fundamentally relational beings, both to God and among fellow humans, analogous to the relationships in the Trinity. Barth sees the creation of two genders as an "analogy of relation," with the relationship among the persons in the Trinity demonstrated in some way by the relationships between male and female humans.[24] Douglas Hall and Colin Gunton refine this view, emphasizing that God is fundamentally a relational being and that humans are defined by their ability to reflect his image in relating properly (that is to say, in a loving way) to God, to others, and to creation.[25] Usefully, Hall does not reject the structural notion of the *imago Dei* wholesale but instead argues that

> if [humanity] is "endowed" with any qualities that are different from the qualities with which other creatures of God are endowed, these human qualities should not be considered ends in themselves but only a means for the fulfilling of its relational ends.[26]

The structural view has tended to focus on the human distinction from the rest of creation. Neither the structural view nor the relational view requires much from the body, as they focus on intangible aspects, such as relationships (in the case of the relational view) and abstract qualities, especially rationality (in the case of the structural view). This has the effect of "exclud[ing] the body from the image (whether explicitly or by omission), thus entrenching a dualistic reading of the human condition."[27]

The royal representative, or functional, view is rooted in the function and actions of humanity, especially related to the cultural mandate in Genesis 1.[28] This interpretation draws on contemporary ancient near east (ANE) usage of the term "image" (Hebrew *tselem*).[29] Kings in the ANE were said to be sons of the gods, their *tselem* to the common people. Temples of the gods would contain physical representations of the god—these were also *tselem*. It was understood that these images were not actually the god, but rather an embodiment or manifestation—a vital representation of the god on Earth.[30] The king, then, has a responsibility to carry out the will of the god when ordering his kingdom. However, the use of *tselem* in Genesis differs significantly from that in the contemporary ANE: rather than just kings and cultic

statues, the Genesis account uses *tselem* to refer to all of humanity![31] Thus each human, individually and corporately, is given the vocation of pursuing God's will for creation.[32] We see this corporate image, for example, in how the nation of Israel is called to be a light to the nations,[33] but we also see that the individual has great value[34] due to their identity as the image of God. An additional layer to the royal representative view is kinship, whereby we have the royal role and name due to our kinship with our creator—just as a queen inherits a throne from her father, we inherit the royal responsibilities by our kinship in being God's image.[35]

While all of these descriptions of the *imago Dei* have an element of truth to them, we believe that the functional view is required to fully "flesh out" an authentic vision of humanity in the image of God. Just as Hall incorporates the substantive view as "means not ends" to imaging God faithfully in relationship, the functional view (and Hall arrives at a similar conclusion) gives form and direction to the quality of our image-bearing relations. Thus, we may say these things of the *imago Dei*: Humans are endowed with certain unique qualities and capabilities that enable us to engage relationally with God, each other, and creation; and they are given a unique responsibility and role in these relationships.

To discuss aspects of the image of God and how they relate to FIRE, we will organize our vocation into three categories: king, priest, and prophet—the *munus triplex*. These three roles, all of which were historically bestowed by anointing, were first identified by Eusebius[36] and further developed by John Calvin.[37] Recent commentators have observed that Adam also occupies these roles,[38] tying them to the image of God which is given to Adam, expressed corporately in Israel, and perfected in Christ, who is The Image (Col. 1:15). We see these three offices held by people throughout the Old Testament, but rarely does one person occupy all three. In fact, there appears to be a pattern of progressive fracturing of these offices: for example, the priestly role is removed from Moses's duties during his meeting with God at the burning bush.[39] While Moses still rules and talks to God, bringing God's words to the people of Israel (thus holding both royal and prophetic offices), Aaron's line and the tribe of Levi become the ones to officially hold the priestly duties. This division of the offices seems to continue through Joshua and the Judges, culminating in Samuel, who appears to fill all three offices due to the corruption of the priesthood. Eventually the people demand from Samuel a king. The royal office is then separated from the prophetic, leaving the three offices in the hands of different people. Once Israel has a king, the office of prophet has little formal authority in society (not a priest, not royal) but still the responsibility to bring God's word to the king, to the people of Israel, and to the nations (Nathan, Ahijah, and Huldah, to name just a few). The offices remain separate until the advent of Jesus, the Messiah, who brings them together again.

Thus the *imago Dei* runs forward from Adam in Genesis to Jesus, who is The Image (Col. 1:15), the Messiah/*Christos*, anointed one. Because Jesus brings three fractured offices into one person who perfectly images God as we should have, we can interpret the image given in Genesis to all of humanity in view of the revelation of Jesus's incarnation and life among us. We see Genesis 1–3 by a retroactive light, just as many prophetic passages were reinterpreted in light of Jesus.

Our analysis is helped considerably by a recent paper by Gijsbert van den Brink on the ecological implications of the threefold office, published in *PSCF*.[40] He helpfully points out that the idea of the *munus triplex* is ecumenical, that is, shared broadly across the Christian traditions. Van den Brink also emphasizes the importance of integrating the roles: they are not three separate people but a single person fulfilling three responsibilities. Thus, while he ties the royal role to concepts of stewardship and justice, the priestly role to identification and love, and the prophetic role to truth-telling, all three of these aspects are required for faithful Christian living. We here repeat and elaborate on some of his work by discussing each office in turn, showing how it is present in Genesis 1–3 and how the life of Jesus guides our application of it to our human vocation today. We also tie each office to the FIRE paradigm, showing how each one points us to fractured relationships with the nonhuman creation and offers opportunities for reconciliation.

The Royal Office

As noted above, the functional view of the image is rooted in royal language and metaphors. In Genesis 1, we see that God commands humans to "be fruitful and multiply, and fill the earth, and subdue it; and rule over the fish of the sea and over the birds of the sky and over every living thing that moves on the earth."[41] Further, in Genesis 2, Adam is placed in the Garden of Eden "to cultivate it and tend it."[42] These two verses have traditionally been interpreted as granting human authority over creation and expressing the nature of that authority.[43] The idea of human authority over creation has attracted its share of critics,[44] but it is consistently

assumed in the biblical witness.[45] In addition, the power humans hold over creation has become more and more an inescapable empirical reality during the last century: no matter what is thought of the ethics of dominion, it is clear that humans currently can dramatically order, or disorder, the nonhuman creation.[46]

Our contemporary reluctance to accept dominion over creation stems in part from our historical abuse of that authority. We believe it is important to critically examine the nature of the dominion conferred in Genesis 1–2. The job of the image (*tselem*) in the ancient Near East was to represent the gods on earth, and in the case of the king-images, to rule in their stead, "representing [their] deity … and … mediating divine blessing to the earthly realm."[47] This is the reason that the word "royal" appears in our description of the image.[48] However, "royal" does not necessarily mean despot. "The image of God in the human person is a mandate of power and responsibility. But it is power exercised as God exercises power."[49] Thus to properly exercise our dominion, we should look to God as our example.

The Old Testament has a clear vision of the ethical responsibility of rulers to care for the poor and the vulnerable, to not show favoritism, and to execute justice.[50] Kings were specifically criticized when they used their power primarily for their own benefit.[51] The human dominion over nature should be understood similarly.[52] The "task of dominion [in Genesis 1:26] does not have to do with exploitation and abuse. It has to do with securing the well-being of every other creature and bringing the promise of each to full fruition."[53] Many also point out that the Hebrew verbs *abad* and *shamar* in Genesis 2:15, translated "cultivate" and "tend" above, have meanings related to protection and service, resulting in flourishing.[54] Thus Adam's role in the garden was not merely to look after his own needs, but to preserve order and enhance the fruitfulness of the nonhuman creation, perhaps even extending the garden into the surrounding wilderness.[55]

This Old Testament evidence shows that dominion is expressly intended not only for human benefit, but for the benefit of all creation. Looking at Jesus's exercise of royal authority provides yet more definition to how we should view our own authority over creation. While first-century expectations for the Messiah seemed to include political conquest of Israel's foes, Jesus emphatically rejects this use of power.[56] Instead, he uses his power to serve, and ultimately to redeem, his subjects, at great cost to himself. He describes himself as "gentle and humble in heart."[57] From the beginning, we see him in lowly circumstances, born in a stable, not seeking to climb any power structures. He is a suffering servant, instructing us to follow in his footsteps by turning the other cheek and offering a second mile of carrying labor to the oppressor.[58] Jesus does not allow the importance of his task (the redemption of humanity and of the entire creation!) to justify the use of alienating force.

We see Jesus working for the flourishing and peace of those under him,[59] rather than for his own aggrandizement; in fact, he quite literally sacrifices his own glory for the sake of the world:[60]

> Have this attitude in yourselves which was also in Christ Jesus, who, as He already existed in the form of God, did not consider equality with God something to be grasped, but emptied Himself by taking the form of a bond-servant and being born in the likeness of men. And being found in appearance as a man, He humbled Himself by becoming obedient to the point of death: death on a cross. (Phil. 2:5–8, NASB)

Thus Christ's rule is profoundly counter-cultural and other-focused. He emphatically rejects the power and privilege that the world associates with his royal office. And as those called to be conformed to "the image of Christ," our rule should look the same. "A Lord who serves does not beget disciples who act like lordlings!"[61]

In addition, Christ's rule over us is profoundly relational. Through the incarnation he "moved into the neighborhood."[62] Although he was already intimately involved in bringing the creation into existence and in sustaining the entire cosmos,[63] he became even more intimately involved, in a way our eyes could see and our hands could touch, through the incarnation.[64] The Gospels depict Jesus's life with his disciples as filled with meals and travel, anchored in a specific time and place, and investing in specific people. He humbled himself not only to death but to friendship and family. The doctrine of the incarnation was a key entry point for us into the theology of creation care and FIRE. If Jesus became human, all this matter must truly matter.

In the same way, our calling is to serve the nonhuman creation which has been entrusted to us. We do this in part by acknowledging our shared creatureliness with creation.[65] Ours is not a disinterested rule based on decrees from a distance. It is a rule that involves incarnation: direct availability and identification with those in our charge. We "move into the neighborhood" of creation, identifying with both its joy and its pain.[66] Only then can we truly understand the consequences of our actions and make wise decisions for those in our

charge.[67] But Jesus's rule over us is also not ultimately divorced from his desire for relationship with us. He is our King, not only out of obligation, but out of love. So we too are called to rule creation not as some transcendent emperor handing down decrees, no matter how well intentioned, but as fellow creatures participating in the joy and travails of creation as we work to serve it with careful attention.

When we do not properly discharge our rule, creation is not simply disorganized and unproductive; it groans.[68] There is a break in relationship, a lack of justice. It is clear to us that humans have misused our royal authority by turning dominion into subjugation. One of the characteristic features of the Anthropocene, the new human-dominated geological epoch,[69] is a vastly increased rate of species extinction.[70] Far from protecting those under our care, we have destroyed them for our convenience. Far from helping God's creatures to flourish, we have systematically impoverished creation in pursuit of our own selfish purposes. The prophets often called Israel's rulers to task for misusing their royal authority, and the proper response was always confession and repentance.[71] So, we too must become aware of our sin against creation (step 1), confess and lament it (step 2), and start working to exercise our royal vocation rightly, as demonstrated by Christ (step 3). (We will address steps 4 and 5 later in this article).

The Priestly Office

A priestly role is one of mediation between God and the creation. Scripture is clear that Jesus fulfills a priestly office toward the people of the church,[72] mediating our relationship both by his death and resurrection, and by his ongoing intercession. Both Israel[73] and the church[74] are referred to as a nation of priests. For both communities, this involves an aspect of performing service in worship of God (in the temple for Israel, and as a gathered community of the church), and in displaying God's love to the nations. In a similar way, commentators have argued that Adam had a priestly vocation in the garden: one of tending a sacred space[75] and of "offering" creation to God in service.[76] Adam's and our role as priests with respect to creation may be understood through these two primary actions: that of worship (mediating creation's praise to God) and that of loving care (mediating God's love to creation).

Worship

One of the duties of the Levitical priests was to offer sacrifices on behalf of the people. This is associated not only with atonement but also with the act of worship.[77] In a similar way, we suggest that part of the human vocation is to worship God both with and on behalf of the nonhuman creation. As we "tend and keep" the world, we so order it into a place where God's presence is happy to dwell: a place of shalom, of flourishing, and of justice. In doing so, we necessarily utilize the nonhuman creation. This is clearly seen in the arts—for example, when creation (paints, clay, charcoal, ink) is ordered in ways to express human worship of God. It is less clear, but no less present, in other cultural activities: in the human use of creation in ways that glorify God by loving God, neighbor, and creatures in uniquely human ways—that is, as we image God in creative ways, by participating with God in the act of (sub)-creation, we draw creation into our worship of God.

We must be careful, however, to not assume that creation requires human intervention to worship God. Scripture is quite clear that it does not: whether it is in litanies calling all creatures to praise the LORD, such as Psalm 148, or in the image of all creation praising God in Revelation 5:11–14. Jesus, though likely intending to be hyperbolic, speaks in Luke 19:40 of even the inanimate creation as able to praise God.[78] Thus, even as we draw creation into our praise, we also allow creation to draw us into its own praise of God. The ability of either one of us to praise God "on our own" surely does not invalidate the ability of our joint efforts to add to that praise in unique ways. Human praise and creation's praise may rise together in harmony: each may enhance the other, with the result more than the sum of its parts.

Many are rightfully fearful that casting humans as a component of creation's praise will end in subsuming creation's inherent characteristics or unique voice beneath that of humans:[79] that humans will dominate (and not just direct) the resulting symphony of praise. This may be what we typically observe, but it is not a necessary outcome of the partnership in praise. A sculpture may draw out rather than obfuscate the character of the stone from which it is made, giving new expression to the unique characteristics of this part of creation. A human may tend a garden, providing a home to birds singing God's praise. And as creation takes new form under human guidance, it itself may praise God in new ways. Human cultivation can enhance the diversity of flora and fauna, bringing new notes into the symphony of praise: consider the varieties of flowers or apples, that have resulted from human attention and care; or the domestication of dogs from wolves. Do these creatures not uniquely praise God on their own, even though they are in part a result of human intervention?[80]

To ensure that our worship is a partnership with creation, we must again look to Jesus as our supreme example of the *imago Dei*. Jesus did not merely use humanity to enhance his own worship of God. He rather gave himself up for us that our own worship of God might be revived. In such a way, our worship with creation needs to be characterized by love for that creation. God does not merely want to hear our praises enhanced by the creation, but rather the true polyphony of our diverse voices.[81] In this sense, our worship cannot be properly separated from the other sense of our priestly vocation: to show God's love and concern for the creation.

Loving Care

As a priest expresses the community's worship to God, they also express God's loving care toward that community on God's behalf. As priests, then, humans are called to "tend and keep" creation with loving attention.[82] While there is overlap here with the royal steward's call to bring order and peace to creation, we wish to focus our discussion of this role on the preservative and protective aspect of our calling. However disordered or unpleasant creation may be, we are still called to love it and serve it. Robert Farrar Capon puts it succinctly: "Man's real work is to look at the things of the world and to love them for what they are. That is, after all, what God does, and man was not made in God's image for nothing."[83] Moses intervenes for the people of Israel even in the midst of their rebellion,[84] and through Jesus, "God demonstrates his own love toward us, in that while we were still sinners, Christ died for us."[85] For this reason, our care for creation must include some responsibility to preserve natural systems as they are: even as we domesticate wolves into dogs, we also must love the wolf for what it is, ensuring that it has the habitat it needs to flourish, and that human-wolf conflict is minimized.

This love extends beyond mere provision for the needs of creation, or attention to its flourishing, as discussed with the royal office. It includes the act of knowing and valuing the individual aspects of the creation. Jesus did not love us by merely ordering things for our flourishing from afar; he became incarnate and loved *individual people*. Indeed, it is a tenet of orthodox Christianity that each person is not loved by God in the abstract as a member of the human race, but is, in fact, loved individually, as a person precious in God's sight.[86]

Such a loving attention to the things of the world both requires and results in attachment through webs of relationship. This is a difficult thing to grasp in our day because we are not used to thinking of the nonhuman creation in relational terms. In *The Embers and the Stars*, Erazim Kohák, no less a product of modernity than we ourselves, reflects on his years of living "beyond the power line" in a cabin he built in a forest clearing in New Hampshire. He observes that our modern conception of creation as fundamentally "matter in motion" is neither historically common nor necessarily more true than older, relational concepts of creation. Based on his own experiences, he suggests that it is at least as valid to consider creation as "a society of persons"[87]—and all the more so because it is created by a personal God! This is not to say that the nonhuman creation is populated by human persons, but that the fundamental way of relating to creation is as to a subject with inherent (God-given) value and meaning, rather than an object that is only valuable in so far as it is useful.

Relations between human and nonhuman persons are, of course, different from those between human and human persons—and different yet again from those that exist between different nonhuman persons. As bearers of the *imago Dei* we express God's love toward creation in ways that uniquely affirm creation's goodness, and perhaps even add elements of purpose and direction to its praise. Kohák says, "Humans … by the power of their love … bring the world alive, [and] give things the love, care, and use they need for their fulfillment. Thus, they act out the incarnation. That is not a matter of taking possession of the world but of making it our own in a bond of mutual belonging."[88] This "bond of mutual belonging" is not a legal title to possession, but rather a bi-directional relationship characterized by interdependence and reciprocated respect.[89]

For both Kohák and Capon, these two aspects of priesthood are intrinsically related: in loving things, we offer them to God as they are, precious in his sight and in ours.[90] Far from enveloping creatures into human-centered artifice,[91] we are to first love creation for what it is, and then, through our care-filled and respect-filled interactions with creation, live out our lives in joyful, creation-affirming cooperative worship. When we consider this aspect of our vocation, it is easy to see how horribly humans have failed. Rather than truthfully mediating God's love for creation, we have instead used creation for only our own ends. We have substituted utility for intrinsic value, breaking the loving relationship we were meant to have with the creation, treating it as object instead of subject. Once we are aware of this failure (step 1), it is clear that repentance (step 2) and reconciliation (step 3) are needed.

The Prophetic Office

The biblical prophet characteristically communicates directly with God and conveys God's messages to the Israelites and to the nations. In this sense, we see that Adam and Eve's direct communion with God[92] displays the prophetic aspect of the *imago Dei*. Later, Israel receives God's revelation through both the *Torah* and the prophets; they are meant to "be a light to the nations,"[93] welcoming the nations and pointing them to worship of the true God.[94] Israel's rulers (Moses, Joshua, and the judges) occupied the role of both regent and prophet until the institution of the monarchy, when the offices appear to have split (Samuel retaining the role of prophet and Saul taking the role of king). We see Jesus as the exemplary prophet in Hebrews 1:1, revealing the truth of the character of God and his plans for the world. Jesus announced his ministry[95] by quoting from Isaiah 61, which itself speaks of proclamation of truth and good news from God.[96] Finally, the church is called to speak God's truth clearly to the people within[97] and around it,[98] and even to all creation.[99]

If the prophet speaks God's truth, how are humans called to speak truth to creation? While this may conjure images of preaching to the creation, as purportedly practiced by St. Francis of Assisi, words are only one way of speaking. In fact, there is a strong biblical tradition of prophetic acts that convey God's truth.[100] It seems clear that humans can still act out God's truth[101] with respect to creation, and we suggest that we are called to speak the truth that God made creation "very good" by extending God's loving rule and care to creation as outlined above. This behavior demonstrates the truth, that God cares for creation, to both the creation itself and to other humans who witness such behavior.[102] It also means that we should be willing to speak difficult truths, even if we ourselves are implicated and need to consider changing our behavior.[103]

However, the role of prophet has something else to offer, in that the prophet is concerned with communicating truth even if nobody listens. The history of Israel's prophets is largely one in which the prophets are ignored, resulting in ridicule of the prophet and the people's willful disobedience to the will of God. Some prophets were even informed beforehand that their message would fall on deaf ears.[104] Yet they were still called to speak and are commended for their obedience.[105] In the context of creation care, the role of prophet empowers us to speak and act even when such action seems ultimately meaningless, since our hope is ultimately not in the power of our actions but in Jesus Christ our Lord who created, sustains, and will redeem and restore all things. Steven Bouma-Prediger is worth quoting at length here:

> If God is really at the center of things and God's good future is the most certain reality, then the truly realistic course of action is to buck the dominant consequentialist ethic of our day—which says that we should act only if our action will most likely bring about good consequences—and simply, because we are people who embody the virtue of hope, do the right thing.[106]

This is an important point to make, because the scope of environmental devastation coupled with the availability of information about it can often cause despair.[107] The quasi-designation of the Anthropocene as a distinct human-dominated epoch[108] in some sense signals a quickening and gathering together of these negative perceptions into "anxiety-laden narratives."[109] We the authors have attended more than one environmental seminar which seemed to point only toward despair: in effect, "go and visit the coral reefs before they all disappear." It is in this context that prophetic action can speak, offering direct examples of a different world, one that is ruled by God's truth rather than by worldly wisdom. Even if this holy work of reconciliation is eventually lost, it is precious in God's sight. And it points toward a powerful truth: that ultimately the reconciliation of the world depends on God, and God is faithful. He will accomplish the work he has set out to do.[110] In this sense, the prophetic action of caring for creation not only offers a vision of the sure future, but it also convicts the hearts of those who destroy creation in apathy or despair, thinking "there is no other choice." We must offer not only chastisement for wrongdoing but also a vision of faithful action, powered by hope in God's faithfulness and eventual restoration of all things. Efforts such as A Rocha's work to preserve the estuary near their field station in the Portuguese Algarve[111] show that, while the odds often seem against those engaged in faithful creation care, God's care for creation can prevail.

The prophetic aspect of the image thus removes one of the most visceral objections to creation care: that, in the face of overwhelming ecological destruction, our individual actions have little value. Have we erred so much that acknowledging our sin will lead only to despair? The prophet insists not; confession and repentance will always produce a meaningful outcome, and even if much will be lost, a remnant will be saved and the kingdom will ultimately come to fruition.[112]

The Image and Eschatology

Throughout the previous discussion, we have shown how the royal, priestly, and prophetic aspects of the *imago Dei* connect with steps 1, 2, and 3 of the faith-infused reconciliation ecology paradigm proposed by Warners, Ryskamp, and Van Dragt. It remains to be shown how the doctrine of the image of God connects with the last two steps. Step 4, which requires "accepting forgiveness from the agent that was wronged" is, the authors concede, difficult to visualize. They state that "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."[113] Kohák makes a similar observation about his own existence in the New Hampshire forest.[114] In a sense, forgiveness is offered and received by experiencing the restored relationship itself (step 5). However, it is also important to remember that, as God has given us the task of caring for creation, failure to fulfill our obligations is also an offense against God. Thus, we seek forgiveness not only from creation, but from God, for our sins of environmental destruction.[115]

Step 5 is "moving forward in a new relationship marked by mutual flourishing." What does this look like? While examples can be drawn from contemporary environmental work,[116] we can also look to the eschatological vision of the Bible for how restored humans, bearing the image of God, interact with nonhuman creation. Much of the work of being a Christian comes in opposing sin and healing brokenness in the world. But the way we do this is motivated by the knowledge that Christ has fully dealt with sin, and that God will wipe away every tear.[117] Both the vision in Revelation and how the human vocation is depicted before the Fall, in Genesis 1–2, can offer strong indications of what this will look like, and we are called to foreshadow that reality in meaningful, tangible ways.[118] In our sin, we do not live out the image fully as we should, but we still *are* the image. A virtuous and regenerate life is a renewal of that image[119]—a whole human living toward shalom. Combining the renewed scenes in Revelation with the earthly calling from Genesis 1 and 2 also counters the notion that heaven sounds boring. Heaven is not our ultimate hope. We are waiting for the "life after life after death."[120] The biblical vision of eternal life is physically embodied, taking place in the physical "new heavens and new earth." Christ's resurrection was not the end of his triumph over death: He is only the "first fruits from among the dead."[121] Whatever Revelation means, it means that humanity will be resurrected as Christ was. On the cross and in the tomb, Jesus defeated not only sin and the powers but also death itself. Unfortunately, many Christians do not see the resurrection as being a future event. Heaven is as far as their sights go. Instead of a renewed creation they look forward to going "where God and glory shine … where feet nor wings could never climb"[122] and "like a bird from these prison walls I'll fly."[123] The idea of release from our bodies into heaven is present in many hymns and other church songs,[124] but this gnostic-dualism impulse of separating soul and body is from Plato rather than Christ. Gerald Hiestand puts it in clear terms: The "Platonic and Stoic narrative has steadily pulled Christian eschatology up and out of the material world into the world of the forms, gods, and spirits. The problem with the Platonic eschatological narrative, of course, is that it is wrong. Heaven is not the final resting place for the people of God. God has created us from the earth, as earth people."[125]

This ethereal existence is a diminishment of not only our embodiment (the doctrine that our bodies are part of who we are), but also of Christ's life and resurrection. The whole chapter of 1 Corinthians 15 has much to say about the resurrection (Christ's and ours), but especially starting in verse 16:

> For if the dead are not raised, then not even Christ has been raised; and if Christ has not been raised, your faith is worthless; you are still in your sins. Then also those who have fallen asleep in Christ have perished. If we have hoped in Christ only in this life, we are of all people most to be pitied. (1 Cor. 15:16–19, NASB)

An embodied existence after the events of Revelation points to an aspect of the image that we have alluded to but not explicitly named: that we are beings made to work. This work is paired with rest, as God demonstrated with the seventh day, but humans who spend their time only resting or only working are missing out on a pattern God has set for us.[126] In Genesis, we see humanity given work before the Fall,[127] so the Fall did not introduce work but it did introduce futility into our work—"thorns and thistles" and "painful toil."[128] So a restored cosmos will presumably remove the futility but not the good work that we have been called to do since the beginning. What might that work look like in the new creation? As we do now, we will work with God and in his power to further his kingdom and bring shalom (peace, wholeness, and flourishing) to creation.

The clearest picture of the renewal of creation is in Revelation 21–22, where John reports seeing "... a new

heaven and a new earth … I saw the holy city, the new Jerusalem, coming down out of heaven from God, prepared as a bride adorned for her husband."[129] In Revelation 22, we see the "river of life" flowing from the throne of God through the middle of the city, and watering "the tree of life" growing on either side of it.[130] The imagery in Revelation draws heavily from the Old Testament, and this passage is a clear reference to Ezekiel's vision of the restored temple in Ezekiel 40–48.[131] In this vision, Ezekiel sees a river flowing out of the temple. Trees crowd around its banks, and it winds through the Arabah desert and into the Dead Sea. When it enters the sea, it makes its waters fresh,

> And it will come about that every living creature which swarms in every place where the river goes, will live. And there will be very many fish, for these waters go there and the others become fresh; so everything will live where the river goes.[132]

The overall vision is one of restoration—not only of humans but of the whole creation!

This is God's work: the work of one who is "reconciling the world to himself."[133] The doctrine of the *imago Dei* is a clear call for us to be engaged in that work, to labor with God toward the vision—the vision of the reality—of the restored earth, watered from the river of life that flows from the New Jerusalem, the garden city where human culture and nonhuman creation flourish together under the loving headship of Christ.

Conclusion

We believe that some Christians are skeptical of the call to care for creation because it is perceived to be a concern imposed from outside the Christian tradition. What we have shown in this article is that care for the nonhuman creation is, in fact, an essential part of our vocation as God's image bearers. As royal representatives, we order creation to promote its fruitfulness and peace. As priests, we join creation in its praise to God, while showing loving care for each individual part of God's world. And as prophets, we speak the truth of God's love for all God's creatures by both our words and our actions.

We contend that God's intent for the human vocation is to exercise loving and self-sacrificing dominion over the nonhuman creation and to "tend and keep" God's world in ways that promote peace and fruitfulness—indeed, in ways that mirror God's own loving dominion over humanity. We believe that there is a strong relational component to this dominion, and that therefore the failure of humans to care for nonhuman creation requires repentance and reconciliation.

Our hope is that our readers will see this not as another burden to bear, but as a hopeful vision of the future—where deep, mutually self-giving relationships exist not only between humans and God, and humans and other humans, but also between humans and the nonhuman creation that sustains and delights them; that all our voices would rise together in a symphony of praise to God. This vision gives us direction as we confront the environmental challenges of today, but it rests secure in the hope that God is the one who "reconcile[s] all things to himself."[134] While its ultimate fulfillment awaits the return of Jesus, our lives are meant to proactively anticipate this future by acting it out—however imperfectly—today. In doing so, we not only care for our fellow creatures (human and nonhuman) but also show the love of God to a scared, cynical, and hurting world. The Good News that God loves the world is just as necessary today as it was 2,000 years ago, and we have a chance to speak it.

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Notes

[1]Organizations such as Christians for the Mountains, the Evangelical Climate Initiative and Evangelical Environmental Network, A Rocha, and the Au Sable Institute of Environmental Studies are but a few movements that have grown since the 1980s.

[2]Loren Wilkinson, ed., *Earthkeeping, Christian Stewardship of Natural Resources* (Eerdmans, 1980).

[3]Colin Bell and Robert S. White, eds., *Creation Care and the Gospel: Reconsidering the Mission of the Church* (Tyndale House, 2016).

[4]David Warners, Michael Ryskamp, and Randall Van Dragt, "Reconciliation Ecology: A New Paradigm for Advancing Creation Care," *Perspectives on Science and Christian Faith* 66, no. 4 (2014): 221–35, https://www.asa3.org/ASA/PSCF/2014/PSCF12-14Warners.pdf.

[5]Michael L. Rosenzweig, *Win-Win Ecology: How the Earth's Species Can Survive in the Midst of Human Enterprise* (Oxford University Press, 2003).
[6]Warners et al., "Reconciliation Ecology."
[7]This case is made eloquently by many; among them, Jonathan A. Moo and Robert S. White, *Let Creation Rejoice: Biblical Hope and Ecological Crisis* (IVP Academic, 2014); Steven Bouma-Prediger, *For the Beauty of the Earth: A Christian Vision for Creation Care*, 2nd ed. (Baker Academic, 2010); and Bell and White, eds., *Creation Care and the Gospel*.
[8]Col. 1:15–20.
[9]Col. 1:15–20.
[10]This description of the image is the one we use in teaching creation care at our church.
[11]The narrative slows down and returns in Genesis 2 for more detail; there is also a different mechanism at work: humans are formed from dust and given breath instead of simply arising from the places God has made ("Let the land produce plants … let the land produce animals …" in Gen. 1:11, 24).
[12]Gen. 2:15, 19.
[13]Douglas John Hall, *Imaging God: Dominion as Stewardship* (Wipf & Stock, 2004).
[14]J. Richard Middleton, *The Liberating Image: The* Imago Dei *in Genesis 1* (Brazos Press, 2005).
[15]Carmen Joy Imes, *Being God's Image: Why Creation Still Matters* (IVP Academic, 2023).
[16]Ellen F. Davis, *Scripture, Culture, and Agriculture: An Agrarian Reading of the Bible* (Cambridge University Press, 2008). She specifically references Middleton's *The Liberating Image* on pages 55 and 56.
[17]Middleton, *The Liberating Image*, 19.
[18]Charles Hodge, *Systematic Theology Volume 2* (Thomas Nelson and Sons, 1872), 97ff.
[19]Louis Berkhof, *Systematic Theology* (Eerdmans, 1996), 204.
[20]The noetic view, which is focused specifically on the intellectual and reasoning differences between humans and animals, is a particular emphasis within the structural view. See Lucy Peppiatt, *The* Imago Dei: *Humanity Made in the Image of God*, Cascade Companions (Cascade Books, 2022).
[21]Following Imes (*Being God's Image*, p. 6), we use the phrase "being God's image" instead of "bearing God's image" because the image is not something we pick up and put down but something we are.
[22]Middleton, *The Liberating Image*, 21.
[23]Catherine McDowell, "'In the Image of God He Created Them': How Genesis 1:26–27 Defines the Divine-Human Relationship and Why It Matters," in *The Image of God in an Image Driven Age: Explorations in Theological Anthropology*, ed. Beth Felker Jones and Jeffrey W. Barbeau (IVP Academic, 2016), 33.
[24]McDowell, "How Genesis 1:26–27 Defines."
[25]See Hall, *Imaging God*; and Colin E. Gunton, "The Human Creation: Towards a Renewal of the Doctrine of the *Imago Dei*," chap. 6 in *The Promise of Trinitarian Theology*, 2nd edition (T&T Clark Ltd., 1997).
[26]Hall, *Imaging God*, 107.
[27]Middleton, *The Liberating Image*, 24.
[28]Peppiatt, *The* Imago Dei.
[29]Imes, *Being God's Image*, 31; Middleton, *The Liberating Image*, 25, 121; and Sandra L. Richter, *The Epic of Eden: A Christian Entry into the Old Testament* (InterVarsity Press, 2010), 107.
[30]Jon D. Levenson, *Creation and the Persistence of Evil: The Jewish Drama of Divine Omnipotence* (Princeton University Press, 1994), 114.
[31]But see Levenson, *Creation and the Persistence of Evil,* 114, for an example from Egyptian mythology that also suggests that all people are made in the image of (a) god.
[32]Colin Gunton notes in *The Promise of Trinitarian Theology:*

> The image is not a static possession, but comes to be realized in the various relationships in which human life is set. The New Testament's reorientation of the concept to Jesus makes the point well. It is because Jesus is "the image of the invisible God" that God is "through him to reconcile all things, whether on earth or in heaven ..." (Col. 1:15, 20). (p. 116)

[33]Exod. 19:5–6: "Now therefore, if you will obey my voice and keep my covenant, you shall be my own possession among all peoples; for all the earth is mine, and you shall be to me a kingdom of priests and a holy nation. These are the words which you shall speak to the children of Israel"; Also Isa. 42:6–7: "I am the Lord, I have called you in righteousness, I have taken you by the hand and kept you; I have given you as a covenant to the people, a light to the nations, to open the eyes that are blind, to bring out the prisoners from the dungeon, from the prison those who sit in darkness."
[34]Gen. 9:6: "Whoever sheds human blood, by man his blood shall be shed, for in the image of God He made mankind." Also see Psalm 139.
[35]McDowell, "In the Image of God," chap. 1 in *The Image of God in an Image Driven Age*, ed. Jones and Barbeau, 29–46.
[36]Eusebius, *The History of the Church from Christ to Constantine* (Dorset Press, 1965), Section 1.3.
[37]John Calvin, *Institutes of the Christian Religion* 2.15.
[38]L. Michael Morales, *Who Shall Ascend the Mountain of the Lord? A Biblical Theology of the Book of Leviticus* (IVP Academic, 2015).
[39]Joshua Mathews, *Melchizedek's Alternative Priestly Order: A Compositional Analysis of Genesis 14:18–20 and Its Echoes Throughout the Tanak* (Penn State Press, 2013), notes:

> Aaron's first introduction into the narrative of the Pentateuch comes in conjunction with Yahweh's burning anger and as a concession for Moses' apparently faithless resistance to Yahweh's instructions … Moses was punished for his unwillingness to accept Yahweh's commission and was likewise denied the honor that would have come with it … 'The glory of fulfilling the task did not belong to Moses alone, but was shared in part by his brother Aaron.' The author seems to be portraying the scenario as gradually deviating from what Yahweh initially envisaged or what the ideal scenario might have been had Moses not responded with such resistance. (pp. 83–84)

[40]Gijsbert van den Brink, "King, Priest, Prophet, and Climate Science: Ecological Implications of the Threefold Office," *Perspectives on Science and Christian Faith* 76, no. 3 (2024): 154–64, https://doi.org/10.56315/PSCF12-24vandenBrink.
[41]Gen. 1:28, NASB.
[42]Gen. 2:15, NASB.
[43]For a description of how this interpretation has changed throughout time, see Richard Bauckham, "Dominion Interpreted: A Historical Account," in *Living with Other Creatures: Green Exegesis and Theology* (Baylor University Press, 2011), 16–62.

[44]Most famously by Lynn White, Jr., "The Historical Roots of Our Ecological Crisis," *Science* 155, 3767 (1967): 1203–07 and vigorously debated since then.

[45]The royal office is referenced throughout the Bible, often appearing along with the priestly office, as it seems clear that Israel and the church are intended to fulfill both of these roles. Psalms 2 and 8 seem to speak to the vocation of humanity in general. Exod. 18:5–6 applies specifically to Israel, and 1 Pet. 2:5–6 and Rev. 1:6 apply this to the church as well.

[46]For one well-referenced example, see Johan Rockström et al., "A Safe Operating Space for Humanity," *Nature* 461 (2009): 472–75, https://doi.org/10.1038/461472a. Additionally, our removal, or alienation, from creation in our modern lifestyles with air-conditioning, agribusiness, and Amazon online shopping, distances us from the consequences of our consumerism and resource extraction/consumption. Thanks, Ivy Tyson, for this insight! "We are less exposed to it, understand it less, feel less a part of it, and therefore feel our authority less keenly."

[47]Middleton, The Liberating Image, 27.

[48]We are royal representatives called to work toward and to proclaim the shalom (peace, wholeness, and flourishing) of God's creation.

[49]Walter Brueggemann, *Genesis, Interpretation: A Bible Commentary for Teaching and Preaching* (John Knox Press, 1982), 32.

[50]E.g., Deut. 17:14–20; Prov. 31:1–9; Eccles. 10:16–17. Many prophets condemned Israel and Judah for failing to do these things; see Heb. 4:14–5:10. Here the Old Testament participates in an Ancient Near Eastern vision of rulership as directed to social reform: see Levenson, *Creation and the Persistence of Evil*, 103.

[51]Ezekiel 34. Here God specifically promises to protect and feed His sheep (the people of Israel), in contrast to the current rulers of Israel who "have been feeding themselves! Should not shepherds feed the flock?" (Ezek. 34:2, NASB).

[52]One of the justifications for the exile into Babylon was that the land might enjoy its sabbath rest. (2 Chron. 36:21) This seems to be a fulfilment of the threat in Lev. 26:33–35.

[53]Brueggemann, *Genesis*, 32.

[54]Indeed, in most places *abad* is translated into English as "serve." See Calvin DeWitt, "Behemoth and Batrachians in the Eye of God: Responsibility to Other Kinds in Biblical Perspective," in *Christianity and Ecology,* ed. Dieter Hessel and Rosemary Ruether (Harvard University Press, 2000); Steven Bouma-Prediger, *For the Beauty of the Earth: A Christian Vision for Creation Care*, 2nd ed., Engaging Culture (Baker Academic, 2010); and J. Richard Middleton, *A New Heaven and a New Earth: Reclaiming Biblical Eschatology* (Baker Academic, 2014).

[55]William J. Dumbrell, *Covenant and Creation: An Old Testament Covenant Theology, revised and enlarged ed.* (Paternoster, 2013), 45. Dumbrell sees the outworking of this intention in Revelation 21–22.

[56]Robert Farrar Capon, inspired by Martin Luther, helpfully and memorably contrasts these as "right-handed power" and "left-handed power" in his exposition of the parables of Jesus. See Robert Farrar Capon, *Kingdom, Grace, Judgment: Paradox, Outrage, and Vindication in the Parables of Jesus* (Eerdmans, 2002), 15.

[57]Matt. 11:29, NASB.

[58]Matthew 5.

[59]Freeing the captives, restoring sight to the blind, and proclaiming good news to the poor (Luke 4:18). This is also seen as a proclamation of a Jubilee year, which Lev. 25 mandated to occur in the 50th year, but a practice we don't actually see occurring in the Old Testament.

[60]John 3:16.

[61]Hall, *Imaging God*, 193.

[62]Eugene H. Peterson, *The Message: The Bible in Contemporary Language* (NavPress, 2002).

[63]Col. 1:15; Heb. 1:1.

[64]1 John 1:1.

[65]See Kyle Meyaard-Schaap, "From Foreign to Family: Kinship as a Pathway Toward Radical Care for the Earth," in *Beyond Stewardship: New Approaches to Creation Care*, ed. David Paul Warners and Matthew Kuperus Heun (Calvin College Press, 2019) and Richard Bauckham, "The Human Place in Creation—A Biblical Overview," in *Living with Other Creatures: Green Exegesis and Theology*, 1–13.

[66]This is perhaps not so much an effort to identify with beings different from ourselves as it is a remembering of our inherent interconnectedness with the nonhuman creation. Even today, when a corner of creation groans, the people living there groan also.

[67]This does not mean that we do not make decisions that cause pain to nonhuman creatures, as that would result in inaction. It does mean that we acknowledge the potential pain caused by our choices as we endeavor to make the best one. Erazim Kohák offers a meditation on this in *The Embers and the Stars: A Philosophical Inquiry into the Moral Sense of Nature* (University of Chicago Press, 1984), 97–99.

[68]Rom. 8:20–22.

[69]David Clements, "Reconciliation Ecology in the Anthropocene," *Perspectives on Science and Christian Faith* 76, no. 2 (2024): 125–38, https://www.asa3.org/ASA/PSCF/2024/PSCF9-24Clements.pdf.

[70]E.g., Francisco Sánchez-Bayo and Kris A. G. Wyckhuys, "Worldwide Decline of the Entomofauna: A Review of Its Drivers," *Biological Conservation* 232 (2019): 8–27, https://doi.org/10.1016/j.biocon.2019.01.020; and Kenneth V. Rosenberg et al., "Decline of the North American avifauna," *Science* 366, no. 6461 (2019): 120–24, https://doi.org/10.1126/science.aaw1313.

[71]Isa. 3:13–15, Isaiah 58; Ezekiel 34; Micah 3, among many others.

[72]Heb. 4:14–5:10.

[73]Exod. 19:5–6, Isa. 61:6.

[74]1 Pet. 2:5–9, Rev. 1:6.

[75]The structure and language in Genesis 1 compares creation to a temple: the Hebrew words used to describe the priestly activities in Num. 3:8 are *abad* (attending to the furnishings) and *shamar* (doing the work of the temple). See John H. Walton, *The Lost World of Genesis One: Ancient Cosmology and the Origins Debate* (InterVarsity Press, 2010).

[76]See G. K. Beale, "Adam as the First Priest in Eden as the Garden Temple," *The Southern Baptist Journal of Theology* 22, no. 2 (2018): 9–24, https://radiantfairbanks.org/wp-content/uploads/2022/09/SBJT-22.2-Adam-as-Priest-Beale.pdf; and Dumbrell, *Covenant and Creation*, 41–44.

[77]See, for example, Heb. 13:15.

[78]This is elaborated in Bauckham in a subsection titled "Humans Are Not Priests of Creation," in *Living with Other Creatures*, 151–55.

[79]Bauckham, *Living with Other Creatures*, 151–55. We attempt to address Bauckham's fears later in this section.

[80]This must be done, however, while still acknowledging the goodness of the original creation. Domestication of wolves into dogs may add new notes to the symphony of

praise, but it is also important to safeguard wolf habitat so that wolves are able to persist in their unique wolf-ness. We discuss this in more detail below.

[81]So, both humans and each part of the rest of creation praise God on their own (rocks: Luke 19:40; mountains and trees: Isa. 55:12; the heavens: Ps. 19:1) but when we meet in creative ways, there is even more praise and glory to God. This is analogous to a statistical model that has effects (human, and rock/wolf/apple) that are independently significant in their effect on the response variable (praise for God's glory in this metaphor). But the interaction effect is also meaningful: stone sculpture, domestication of dogs, each new apple variety.

[82]These verbs (tend and keep, or *abad* and *shamar*) are present in the charge to Adam and Eve in Gen. 2:15 and are also used for the Levitical priests; for example, see Num. 3:7–8. We use the phrase "work toward" in our description of the image, in part, as a reference to the priestly office. (We are royal representatives called to work toward and proclaim the shalom [peace, wholeness, and flourishing] of God's creation.)

[83]Robert Farrar Capon, *The Supper of the Lamb: A Culinary Reflection* (Doubleday, 1969), 19.

[84]Exod. 32:31.

[85]Rom. 5:8.

[86]This is the point that Jesus is making when talking about God's love for (individual!) sparrows in Matt. 10:26–31.

[87]Kohák, *The Embers and the Stars*, 126. In this book, Kohák provides a compellingly lucid argument for the intrinsically personal character of all of creation, grounded both in the Western philosophical tradition and in his own experiences while living in a log cabin in the New Hampshire woods. As we think this is perhaps the most difficult part of FIRE for most North American churchgoers to accept, we highly recommend this book.

[88]Kohák, *The Embers and the Stars*, 48.

[89]Another angle of what is meant here can perhaps be seen in the introduction of Botany of Desire by Michael Pollan: "Seeing these plants instead as willing partners in an intimate and reciprocal relationship with us means looking at ourselves a little differently, too: as the objects of other species' designs and desires." Michael Pollan, *The Botany of Desire: A Plant's-Eye View of the World* (Random House, 2002), xiii.

[90]In "The Oblation of Things," Robert Farrar Capon gives the love of language, music, and cooking as examples. Robert Farrar Capon, "The Oblation of Things," in *An Offering of Uncles: The Priesthood of Adam and the Shape of the World* (Sheed and Ward, 1967), 77–90.

[91]As Bauckham fears in *Living with Other Creatures*, 151–55.

[92]Gen. 3:8.

[93]Isa. 49:6.

[94]See Paul Watson, "'A Light to the Nations': Israel's Mission to the World," *MDJ* 4, no. 2 (2013), https://missiodeijournal.com/issues/md-4-2/authors/md-4-2-watson.

[95]Luke 4:18.

[96]In our phrasing of the image that we use in our teaching, we use the phrase "proclaim the shalom of God's creation" to reference to the prophetic office. (We are royal representatives called to work toward and proclaim the shalom [peace, wholeness, and flourishing] of God's creation.)

[97]1 Cor. 12:28, 14:1–19.

[98]Phil. 2:14–16.

[99]Mark 16:15.

[100]For example, Isa. 20; Ezek. 4:1–17, 12:1–16; Hosea 1–3.

[101]The Hebrew word emeth can be translated "truth," as in facts, but it is also frequently translated as faithfulness (Gen. 24:26–27; Isa. 61:8). See Jared Byas, *Love Matters More: How Fighting to Be Right Keeps Us from Loving Like Jesus* (Zondervan, 2020), 81.

[102]To speak truth, prophets must first listen. Van den Brink suggests that in the context of creation care, this implies that a Christian should carefully consider the scientific evidence of the state of the nonhuman creation. See van den Brink, "King, Priest, Prophet, and Climate Science." We, of course, do not mean that Christians should blindly follow scientific consensus. But, along with van den Brink, we think that blindly rejecting that consensus, as appears to be common in some Christian circles today, shows a lack of responsibility toward our prophetic office. There are positions between blind rejection and blind acceptance, though they require substantially more effort than either of these extremes. Such effort is necessary for faithful witness.

[103]Van den Brink, "King, Priest, Prophet, and Climate Science."

[104]E.g., Isa. 6:8–13.

[105]Heb. 11:32–38.

[106]Bouma-Prediger, *For the Beauty of the Earth*, 182.

[107]Aldo Leopold famously opined that "to have an environmental education is to live alone in a world of wounds" (Aldo Leopold, *Leopold: A Sand County Almanac & Other Writings on Ecology and Conservation*, ed. Curt Meine [Library Of America, 2013], 877). For a contemporary exploration of this topic, see Panu Pihkala, "Anxiety and the Ecological Crisis: An Analysis of Eco-Anxiety and Climate Anxiety," *Sustainability* 12, no. 19 (2020): 7836, https://doi.org/10.3390/su12197836.

[108]Clements, "Reconciliation Ecology in the Anthropocene."

[109]Andrew Whitehouse, "Listening to Birds in the Anthropocene: The Anxious Semiotics of Sound in a Human-Dominated World," *Environmental Humanities* 6, no. 1 (2015): 53–71, https://doi.org/10.1215/22011919-3615898.

[110]Isa. 55:6–11. Hope is a virtue that Christianity can uniquely bring to the environmental movement, which can be a difficult place to work. Christians have hope that all shall be well, so we can act in peace and joy, knowing that our hope is not in our own strength or success but in God's consummation of his promises and plans. See Moo and White, *Let Creation Rejoice* for discussion of hope in environmental crises; and also Bouma-Prediger, *For the Beauty of the Earth* for discussion of hope and other environmental virtues.

[111]Recounted by Peter Harris, *Under the Bright Wings* (Regent College Publishing, 2000).

[112]Rom. 9:27, Isa. 9:21.

[113]Warners et al, "Reconciliation Ecology."

[114]Kohák, *The Embers and the Stars*, states,

> In the stillness of the evening, amid the sun-drenched hum of the noonday forest, in the grandeur of the lightning, there comes the overwhelming, agonizing, and reconciling recognition of being accepted, being justified. Here the dweller is alien no longer. Nature envelops and accepts him. There is no reason, no merit, only the basic reality: we are justified, we are accepted. It is not because of what we do: given the devastation we have wrought among our fellow creatures, it can only be in spite of it. It is a free gift, agonizing for being so painfully undeserved. (p. 93)

[115]Kohák insists that reconciliation with God and with nature are intrinsically linked, and Hall proposes a

mechanism: all of our relationships, he suggests, are interconnected. Just as "if anyone says 'I love God,' and yet he hates his brother or sister, he is a liar" (1 John 4:20), there is also an inherent discontinuity between love for God and disregard for our fellow creatures. See Hall, *Imaging God*, pp. 129ff.

[116]For some of these, see Bill McKibben, *Hope, Human and Wild: True Stories of Living Lightly on the Earth* (Hungry Mind Press, 1997).

[117]Rev. 21:4.

[118]Tyler Wigg-Stevenson, with reference to Hebrews 11, calls this "welcoming the kingdom from a distance." See Tyler Wigg-Stevenson, *The World Is Not Ours to Save: Finding the Freedom to Do Good* (IVP, 2013), 101–13.

[119]Col. 3:9–10.

[120]N. T. Wright, *Surprised by Hope: Rethinking Heaven, the Resurrection, and the Mission of the Church* (Zondervan, 2008).

[121]Col. 1:18.

[122]Isaac Watts, "Absent from Flesh! O Blissful Thought!," Hymnary.org, accessed February 3, 2025, https://hymnary.org/text/absent_from_flesh_o_blissful_thought.

[123]Alfred Brumley, "I'll Fly Away," Hymnary.org, accessed February 3, 2025, https://hymnary.org/text/some_glad_morning_when_this_life_is_oer.

[124]Middleton, *A New Heaven and a New Earth*, 29–30.

[125]Gerald Hiestand, "Irenaeus, the Devil, and the Goodness of Creation," in *Creation and Doxology: The Beginning and End of God's Good World*, ed. Gerald Hiestand and Todd Wilson, Center for Pastor Theologians Series (InterVarsity Press, 2018), 100–101.

[126]Eugene H. Peterson, *Christ Plays in Ten Thousand Places: A Conversation in Spiritual Theology* (Wm. B. Eerdmans, 2008), 115.

[127]Gen. 1:26, 28, 2:15.

[128]Gen. 3:17–18.

[129]Rev. 21:1–2, NASB.

[130]Rev. 22:1–2.

[131]See Richard Bauckham, *The Theology of the Book of Revelation* (Cambridge University Press, 1993), 4–5.

[132]Ezek. 47:9, NASB.

[133]2 Cor. 5:19, NASB.

[134]Col. 1:20.

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Developing New Expressions of Reconciliation Ecology in the Anthropocene: A One Health Approach to Christian Environmental Stewardship

William L. Miller

The past century was a time of significant ecological change, driven mainly by the activities of humans. Accelerating rates of biodiversity decline, loss of important ecosystem services, and climate change are symptoms of anthropogenic stress on proximate and global environments. Both conservation paradigms and Christian perspectives on environmental stewardship of the early 20th century tended to view humans as separate from ecological systems and not affected by environmental degradation. In recent decades, environmental concerns, including the emergence of zoonotic diseases, have increased focus on mutual dependencies between humans and the environment. While models of creation care have lagged behind secular conservation approaches, recent approaches emphasizing reciprocity, such as the reconciliation ecology paradigm, provide opportunities to develop a holistic framework of mutual flourishing. Here, I introduce the One Health concept, which highlights the interdependencies of human, animal, and environmental health systems, as a logical extension of the reconciliation ecology paradigm.

Keywords: reconciliation ecology, One Health, Christian environmental stewardship, creation care, disease ecology, conservation history

Environmental Stewardship and the Health of the Land Community

> *One of the penalties of an ecological education is that one lives alone in a world of wounds. Much of the damage inflicted on land is quite invisible to laymen. An ecologist must either harden [their] shell and make believe that the consequences of science are none of [their] business, or [they] must be the doctor who sees the marks of death in a community that believes itself well and does not want to be told otherwise.*
>
> —Aldo Leopold[1]

When Aldo Leopold, one of the forefathers of the modern American conservation movement, wrote his now-popular series of essays in the first half of the 20th century, he had experienced an American landscape in rapid transition. The Industrial Revolution brought with it new promises of human prosperity thanks to a period of prolific technological innovation, supported in part by the continent's vast natural resource stocks. Lumber, fisheries and wildlife, water, and fossil fuels all

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paved the way for one of the greatest periods of growth in human history. Leopold, a Yale-trained forester, became acutely aware of the strain such growth placed on ecological systems.

The implicit assumption of early North American conservation models was that human well-being was separate from the well-being of ecological systems. While utilitarians would understand a reliance on natural resource stocks, hence the emergence of sustainable utilization principles,[2] landscapes were widely converted to land uses with high capital yield (e.g., agriculture, commercial/residential). Ecosystems that could not be converted were often left neglected and degraded,[3] despite the fact that many such ecosystems render important ecosystem services (e.g., wetlands).[4] Paradoxically, staunch preservationists would also contribute to the divide between human and ecological systems. Preservationists advocated for the conservation of ecosystems set apart from human habitation, thus perpetuating a dichotomy that is still manifest in North American conservation practices, such as the fortress or Yellowstone conservation model that birthed the National Park System.[5]

Leopold would become one of the first conservation writers in North America to identify an important dissonance in the conservation approaches of the time. In his essay, "Good Oak," Leopold tells the story of a changing American landscape through the harvest of an old, lightning-damaged oak tree.[6] Decades of environmental change were documented in the concentric growth rings of the old oak, which stood sentinel to the depletion of waterfowl and game populations, conversion of large swaths of the Northwoods to agriculturally dominated landscapes, and the extinction of the passenger pigeon, a nomadic, mast specialist of northern hardwood forests that likely played an important role in nut dispersal and forest disturbance.[7] Leopold would go on to pen one of his most famous essays, "The Land Ethic," which would see him advocate for conservation and stewardship as an important moral responsibility of human society.[8] In his essay, Leopold challenges the human–nature dichotomy by evoking an Abrahamic allegory:

> Abraham knew exactly what the land was for: it was to drip milk and honey into Abraham's mouth. At the present moment, the assurance with which we regard this assumption is inverse to the degree of our education … That man is, in fact, only a member of a biotic team is shown by an ecological interpretation of history.[9]

Seeing humans as a member of the biotic team, what Leopold would call the "land community," was a statement that challenged the utilitarian and preservationist conservation philosophies of the time. While maybe not motivated directly by Leopold's writings, ecotheologians have also grappled with the human–nature relationship when considering how best to care for God's world. Environmental changes over the last century have continued to push both conservation science and Christian environmental praxis to explore the links between the flourishing of human communities and nature. Concepts of reciprocity and mutual dependencies have become an increasing feature of both secular and faith-based models of environmental stewardship. For example, the reconciliation ecology paradigm, which advocates for the importance of preserving biodiversity in human-dominated landscapes,[10] has been adopted by both communities as a conceptual model and practical expression of environmental stewardship.

The development of the reconciliation ecology concept, both in conservation science and ecotheological circles, highlighted important dependencies between humans and nature by drawing attention to the importance of biodiversity and ecosystem services. While important, one overlooked aspect of the human-nature interdependency, and its implication for environmental stewardship, consists of the interconnections between human and ecological health systems. Models of Christian environmental stewardship have often been influenced by novel insights and emerging trends in secular conservation, as was the case with the reconciliation ecology concept.[11]

One emerging trend that has the potential to benefit Christian environmental praxis is the One Health concept. One Health is an approach to ecological and health stewardship that recognizes the important interconnections between humans, animals, and environmental health systems,[12] and seeks mutual benefits for all; it contrasts the siloed, but more widespread, approaches to human and environmental health (fig. 1). Leopold's "The Land Ethic" introduces the concept of land health, which sees conservation as a system for preserving the capacity of the land community, humans included, for self-renewal.[13] Thus, the concept highlights the importance of reciprocity and mutual flourishing, as does the reconciliation ecology paradigm, but expands the idea of mutual dependencies to include linkages between health systems.

The overarching goal of this article is to present the One Health concept as an extension of the reconciliation

ecology paradigm of Christian environmental stewardship. The One Health concept, with its focus on patterns of mutual connectivity between human, wildlife, and environmental health systems, provides an important framework for addressing the rapid ecological challenges of the Anthropocene. Specific objectives of this article are to (1) review the development of the reconciliation paradigm in conservation science, (2) discuss how the reconciliation ecology paradigm was incorporated into Christian stewardship models, and (3) present the One Health concept as an extension of the reconciliation ecology model through conceptual and practical examples.

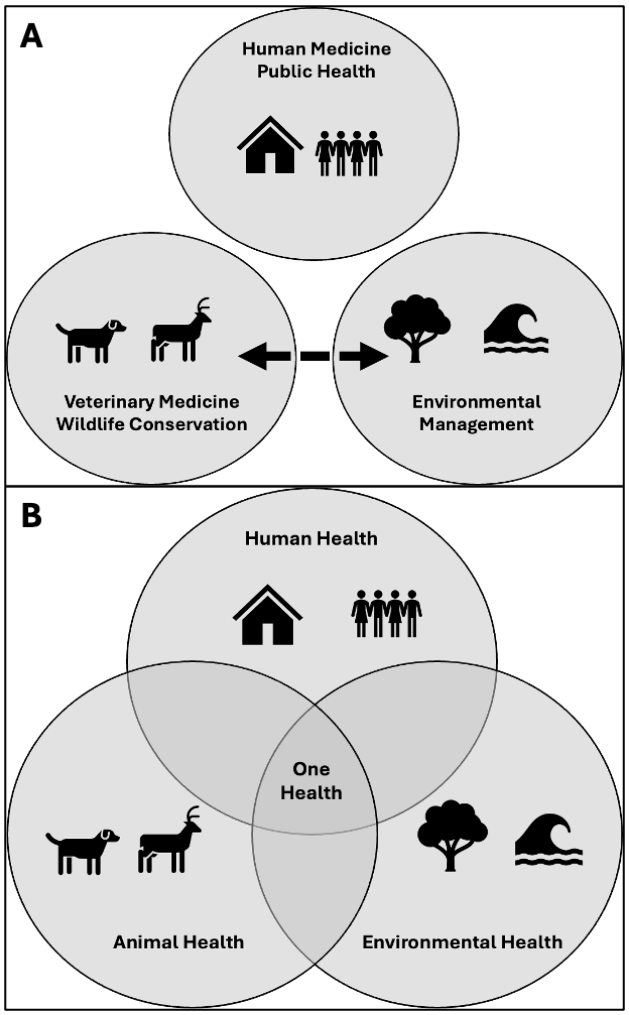

Figure 1. Classic Model of Siloed Environmental and Health Stewardship

(A). While links between wildlife conservation and environmental management were made (dashed line), conservation, veterinary, and human health systems were mostly treated as separate entities.

(B). In contrast, the One Health model emphasizes intersections of human, animal (both wildlife and veterinary), and environmental health system.

Reconciliation Ecology in the Anthropocene

The 20th and 21st centuries have been times marked by unprecedented environmental change. The Industrial Revolution heralded a loss of biological diversity on the scale of previous mass extinction events.[14] Scientists suggest that current extinction rates are at least 1000 times higher than the natural background extinction rate.[15] Human activity is the predominant driver of current biodiversity loss, with factors such as overexploitation, land conversion and habitat degradation, the emergence of invasive species due to globalization, and climate change, along with other modifications to ecological cycles, playing important roles.[16] Some have suggested referring to this current period of biodiversity loss as the Anthropocene, in part to emphasize the significant effects that humans have on Earth's systems.[17] Although the use of this term is debated,[18] it is clear that the planet's current catastrophic loss of biodiversity is tied to human activity.

While evidence for the profound influence that humans have on environmental systems has mounted, narratives of human exceptionalism and anthropocentrism have persisted in American environmental thought. Human exceptionalism is defined by sociologists as a conceptual framework in which humans exist separately from proximate ecological systems, both individually and societally.[19] A related, but distinct, social construct is the concept of anthropocentrism. Here, anthropocentrism is defined as a conceptual framework that disproportionately weights human experience and priorities above the nonhuman environment.[20] Jointly, human exceptionalism and anthropocentrism imply a strong dichotomy between human well-being and the well-being of the environment. Both frameworks recognize the negative effects of human activity on ecological systems but neglect reciprocal effects of ecological degradation on human health. While not often articulated as such, concepts of human exceptionalism and anthropocentrism are predominant viewpoints in American Christianity, and have shaped both general posture and practice around environmental issues.[21] Such posturing exists in stark contrast to the environmental conscience of many Indigenous cultures, including that of Indigenous Christians,[22] which acknowledge reciprocal relationships between human and environmental health,[23] and do not view a strong ontological dichotomy between humans and the surrounding environment.[24]

Leopold was acutely aware of the reciprocal relationship between human and environmental health and would challenge the concepts of exceptionalism and

anthropocentrism. Leopold lived through and was influenced by the Dust Bowl of the 1930s,[25] in which drought and severe erosion of the top soil of agriculturally dominated North American plains led to signficant socioeconomic pressure on rural communities, respiratory illness and malnutrition in human populations, and an intensifiction of the negative effects of the Great Depression.[26] The reciprocal relationship between humans and soil was a key theme of Leopold's land ethic. Leopold urged his readers to view humans as plain members, rather than conquerors, of the land-community, with moral-ethical obligations to the soils, waters, plants, and animals with which we share space. His essay culminates in the development of a new conservation approach, termed "land health."

> A land ethic, then reflects the existence of an ecological conscience, and this in turn reflects a conviction of individual responsibility for the health of the land. Health is the capacity of the land for self-renewal. Conservation is our effort to understand and preserve this capacity.[27]

Numerous examples of reciprocal relationships between environmental and human health systems have emerged in the decades since Leopold penned "The Land Ethic." In the 1960s, another prominent environmental writer, Rachel Carson, published *Silent Spring*, which kickstarted the American environmentalism movement by drawing attention to the toxicological effects of the insecticide DDT on predatory birds.[28] While the role of DDT as a human toxicant was a subject of continued discussion at the time, links between human health effects have been identified in subsequent decades. For example, DDT has been associated epidemiologically with certain cancers in humans.[29] Several years later, another environmental catastrophe would draw attention to the health of America's waterways. In 1969, industrial pollution in the area of Cleveland, Ohio, would result in the ignition of the Cuyahoga River. These chemical-fueled fires emphasized important linkages between human communities and associated waterways, and would play a prominent role in the passage of the Clean Water Act of 1972.[30]

Linkages between water and human health are still prominent in contemporary environmental discourse, such as with the ongoing Flint water crisis, in which the residents of Flint, Michigan, were exposed to toxic levels of lead in the city's drinking water.[31] The Flint water crisis is also an example that emphasizes that marginalized communities, such as communities of color and low-income communities, are disproportionately affected by public and environmental health crises. While initial human exposures originally occurred through pipe infrastructure (i.e., the built environment), lead-tainted water also infiltrated soils (i.e., the natural environment), leading to a new reservoir of exposure for both people and wildlife.[32] This further emphasizes that human-environmental health linkages are bi-directional. Practices such as unconventional oil and gas extraction (e.g., fracking) have also been linked to human health and animal health concerns, providing a rural example of how environmental degradation can affect both human and animal populations.[33]

Prior to the emergence of conservation biology as a distinct biological discipline in the 1980s, ecological management tended to focus on the utilitarian value of species and ecosystems. The interdisciplinary field of conservation biology was introduced to advocate for a more biocentric approach that recognized the value of preserving biodiversity outside of a strict economic sense.[34] While various approaches to conservation have been conceived over time, the recent reconciliation ecology framework is one that places a great emphasis on the reciprocal human-environment relationship. Reconciliation ecology is a form of ecological management that broadly focuses on biodiversity conservation in human-dominated ecosystems.[35] Thus, it places a greater emphasis on the reciprocal human-environment relationship than do alternative models. First proposed in the book *Win-Win Ecology* by ecologist Michael Rosenzweig,[36] reconciliation ecology frames itself as "the science of inventing, establishing, and maintaining new habitats to conserve species diversity in places where people live, work, and play."[37] By doing so, reconciliation ecology seeks to both promote human enterprise and maintain critical ecosystem services provided by biodiverse ecological communities. Reconciliation ecology challenges the ideas of human exceptionalism and anthropocentrism by viewing humans as integral members of the ecological communities in which they live, and thus representing an extension of Leopold's land ethic.

Reconciliation ecology has been an important framework for shaping discussion and practice in human-dominated ecosystems. In urban ecosystems, examples of reconciliation ecology in practice can be seen in efforts to incorporate green infrastructure practices into urban architecture and design.[38] Availability and proximity of green spaces promotes persistence and connectivity of native pollinator populations.[39] Considering green infrastructure and architectural designs that support urban wildlife populations may also provide opportunities to support conservation

efforts for wildlife, such as in the case of peregrine falcons (*Falco peregrinus*).[40] Citizen science movements, such as Homegrown National Park®[41] and the National Wildlife Federation's Sacred Grounds programs,[42] provide important examples of how the reconciliation ecology model has integrated with public practice, with the goal of increasing available habitat for wildlife near human domiciles and improving ecosystem services in human-dominated landscapes. Given that many examples of reconciliation ecology focus on creating habitat space for urban wildlife, it is worth noting that an important limitation of the reconciliation ecology framework is that it disproportionately benefits species with positive relationships with humans. For example, species with aesthetic (e.g., birds, butterflies) and/or ecosystem service (e.g., pollinators) value are prioritized, as in the examples listed above, whereas "nuisance" wildlife and mammalian predators are often ostracized and persecuted (e.g., mountain lions *[Puma concolor]*).[43]

While examples from urban ecology are numerous and intuitive, the reconciliation ecology paradigm has also been applied in other human-influenced ecosystems. In agroecosystems, practices that incorporate sustainable agricultural practices and ecological principles of design and management (diverse crop rotation, intercropping, mulching, no-till practices, hedgerows, etc.) increase biodiversity and resilience of ecosystem services (e.g., pest management, pollination).[44] The reconciliation ecology framework is also applied to watershed management where green infrastructure features, such as rain gardens, stormwater retention basins, and riparian floodplain restoration, are installed to provide habitat for wildlife and reestablish and maintain important regulating ecosystem services, such as sediment management, flood abatement, and water infiltration through soils.[45] Finally, reconciliation ecology has the potential to provide insights and opportunities into the management of marine ecosystems that are either utilized by humans or in proximity to human activity (e.g., nearshore environments).[46]

Evolving Perspectives on Creation Care

In the Christian tradition, environmental stewardship is broadly referred to as "creation care." While creation care can be defined in many ways, a broad operational definition can be drawn from Fred Van Dyke et al.[47] Because God is the creator of the world, and because humans are made in the image of God, humans have been gifted the "privilege and responsbility of carefully managing [the world]."[48] But what does it mean to "carefully manage"? The evolution of models of creation care in the Christian tradition followed a trajectory parallel to the evolution of conservation systems. This is perhaps unsurprising given the links between early conservationists and religion in the North American context. Many early-American conservationists identified with Christian faith communities. For example, the prototypic utilitarian, Gifford Pinchot, provides an example of ties between American Christian and environmental histories. Pinchot was immersed in the currents of American evangelical Protestantism of his time, grew up attending Presbyterian services, and was affiliated with the Episcopal Church in adulthood.[49] Pinchot's faith was a factor in his argument for sustainable use of natural resources as a moral imperative, which contrasted the "prodigal squandering" of natural resources that came before him.[50] Even conservationists without explicit Christian motivations for their environmental ethic, like Leopold, were likely influenced by aspects of Christian popular culture and their own upbringing. Leopold's family was of German-Lutheran heritage, and there are parallels in how Leopold frames conservation as a moral-ethical imperative and how American Baptists and Catholics of the time framed discussions on creation care.[51]

In the North American church, the most influential framework on creation care has been (and still is) the "stewardship" concept. Stewardship is defined here as the practice of "managing" Earth's environment and resources.[52] Appropriate stewardship of the environment is often discussed as a moral imperative of the "creation (=cultural) mandate." In Genesis 1:28, God delegates the task of management to humans:

> And God blessed them. And God said to them, "Be fruitful and multiply and fill the earth *and subdue it, and have dominion over* the fish of the sea and over the birds of the heavens and over every living thing that moves on the earth."

Stewardship, in this sense, is a model of delegated dominion. It is a model of management in the absence of the property owner—God. And, it is humans, as the creatures that were created in the image of God, that are tasked with its management. Perhaps it is not surprising that some of the landmark commentaries on the task of creation care have focused on a model of stewardship akin to the utilitarian ethic of Gifford Pinchot. Take, for example, *Earthkeeping: Christian Stewardship of Natural Resources*,[53] which heavily emphasized a practical approach to sustainable use of Earth's natural resources in the authors' definition of stewardship. Although

utilitarian, a Christian parallel to Pinchot's ethical critique of "prodigal squandering" can be observed in the text.

While commonly associated with the creation mandate of Genesis 1:28, and later with the similar charge of Genesis 2:15 to keep and care for the Garden of Eden, rarely, if ever, does the biblical text use the term "steward" in direct reference to care for creation. Direct references to "steward" or "stewardship" occur 26 times in the biblical text, almost all in reference to economic management of something that belongs to someone else.[54] Take, for example, Isaiah 22:15, "Thus says the LORD GOD of hosts, 'Come, go to this *steward*, to Shebna, who is over the household …'": in this passage, the author of Isaiah was describing the replacement of Shebna as steward to King Hezekiah, due to pride and mismanagement. The term "steward" in this passage is referring to a political position—a manager of the royal house. The theme of a "steward" as an ethical and faithful manager of another's assets is repeated in several of Jesus's parables, including the Parable of the Faithful Steward (Luke 12:42–48), the Parable of the Talents/Minas (Matt. 25:14–30; Luke 19:11–27), and the Parable of the Shrewd Manager (Luke 16:1–14).

The term "steward" began to see use in the American Christian context at the turn of the 19th century.[55] An outcome of the American Revolution was the constitutional separation of church and state. Churches found the need to adapt economically to the lack of state support. An increased focus on faithful tithing was emphasized as a form of financial stewardship. Sponsorship of evangelical mission was also supported through tithing, which placed a new form of ethical obligation on the practice of tithing. This financial model of stewardship would continue into the 1900s, but would be expanded to include personal commitment to church activites following World War II.

The term "stewardship" would be adopted by the secular environmentalist movement of the early 20th century, which would see it used more directly to discuss use of natural resources and handling of the growing problem of environmental degradation.[56] At the same time, the term "stewardship" would begin to fall out of favor in church communities, though this subtle back-and-forth between church and environmental communities would propagate the contemporary use of the term. In 1967, Lynn Townsend White Jr., a professor of medieval history and technology, published his now-infamous article in *Science*, titled "The Historical Roots of Our Ecologic Crisis."[57] In this article, White placed blame for the unfolding ecologic crisis with the Judeo-Christian conceptulization of the creation mandate. As the argument goes, Genesis 1:26–28 has been interpreted to give humans free reign for exploitative use of the creation for human gain, a perspective that has come to be known colloquially as dominionism.[58] Thus, White criticized the Western Christian environmental ethic as being "the most anthropocentric … that the world has seen."[59] White's short publication in *Science* would inspire a broad response from the Christian community, with many rediscovering and modernizing the stewardship principle with its contemporary posture toward creation care.

While stewardship models have been important in shaping contemporary dialogue on creation care in the American Christian context, they are ultimately economically oriented models that still hold to the idea of human exceptionalism to varying degrees. For example, in the book *The Steward: A Biblical Symbol Come of Age*, author Douglas John Hall evaluated the human-nature relationship using three contrasting frameworks: (1) humanity-above-nature, (2) humanity-with-nature, and (3) humanity-in-nature.[60] Hall described the "humanity-above-nature" framework similarly to White's anthopocentric framing of dominionism, and thus rejected it as an appropriate model for creation care. However, he was also uncomfortable with the "humanity-in-nature" viewpoint, which, he argued, presented humans as "just another creature," thus opting to define stewardship within the "humanity-with-nature" framing. In Hall's definition, the humans are distinct from the rest of creation (human exceptionalism) but are beings with a moral-ethical obligation for creation's care.

While I understand Hall's skepticism of the "humanity-in-nature" framing, the "humanity-with-nature" perspective, in my opinion, does not fully capture the ecological dependence of humans on the environment that we have become acutely aware of in the Anthropocene. The development of an ecocentric definition of the human–nature relationship is necessary. Ecocentrism can be broadly defined as an ethical system that recognizes the intrinsic, rather than solely economic, value of nature, including living things and abiotic components of the environment.[61] From a Christian perspective, I would define an ecocentric vision of the human-nature relationship as one that recognizes the interconnectedness and interdependence of humans and their natural environment, while at the same time paying homage to the special place, or niche, of humans within the created order.

The creation story of Genesis 2 creates an ecocentric image of the human-nature relationship. God "forms man of the dust" and imbues Adam with the breath of life, making man "a living creature" (v.8). The implications of the second creation story are clear. While humans are specially created in the image of God, they are also created, physical beings. Humanity was also created to be in communion with the nonhuman creation (v.19), and is given the charge of stewarding, working, and keeping the garden (v.15).[62] Ecological theory offers what I feel is a compatible example of a biblically appropriate framing of the ecocentric model. Community ecologists use the term "ecosystem engineer" to refer to a species with the capacity to modify and organize entire ecosystems through their actions; such species often have net positive effects on the biodiversity of the local environments that they are embedded in.[63]

Humans are embedded in the land community, but much like the Creator whom we mirror, humans have a special vocation as ecosystem engineers. And what exactly are humans working toward? Maintenance of shalom is a central concept of the Old Testament. Of shalom, Old Testament scholar Walter Brueggemann states,

> The central vision of world history in the Bible is that all of creation is one, every creature in community with every other, living in harmony and security toward the joy and well-being of every other creature.[64]

While engaging Brueggemann's conceptualization of shalom through the lens of ecological theory may raise questions regarding how certain organisms, such as predators and consumers, relate to other creatures,[65] the overarching implication is clear. Shalom encapsulates the God-given roles that organisms were given in the community of creation, similar to how the Eltonian niche concept evaluates the "place" of organisms in the context of their relationships with resources and other species in ecological theory.[66] This view of shalomic kinship is well established in the worldview of Indigenous Christians. For example, in *Shalom and the Community of Creation: An Indigenous Vision*, Randy Woodley (Keetoowah Cherokee Nation) writes, "the ancient Semitic shalom construct … is the Creator's original instruction for the way in which all societies should be ordered, and for how all life on this planet should be lived."[67]

Sin has distorted shalomic relationships between human and nonhuman creatures, and this leads to conflict and loss of mutual flourishing. In Romans 8:20–22, Paul evoked reference to the curse of Genesis 3, which focused primarily on negative outcomes for humanity, and established that all creation groans in response to the weight of sin. Examples of the negative effects of ecological degradation on human societal structures, including health, have motivated Christian scholars to consider more-ecocentric models of creation care. One such approach has been the ecotheological application of the reconciliation ecology paradigm.

Reconciliation ecology was introduced as a reimagination of the stewardship concept in 2014 by David Warners, Michael Ryskamp, and Randall Van Dragt.[68] In their article, "Reconciliation Ecology: A New Paradigm for Advancing Creation Care," they argue that humans were created as embedded creatures in the broader context of the whole creation and that we have a moral-ethical imperative as creatures made in the image of God to "reconfigure our own existence so that it is more a blessing than a curse to the broader landscape within which we reside."[69] What is distinct about this framing is the idea of ecological embeddedness: reciprocity, more broadly. This framing challenges the conceptualization of humans as benevolent overseers of property, and instead sees us as caretakers of the neighboring land community. Reconciliation, then, is the act of restoring and renewing shalomic relationships between the human and nonhuman components of the creation that were distorted through sin.

Developing a One Health Approach to Christian Environmental Stewardship

It is important to continue to consider how new insights from conservation science may improve the framing of our creation care paradigms. One of the most convincing critiques of the stewardship model is the question of how environmental degradation affects human communities. The "humanity-with-nature" framing of the stewardship model continues to be rooted in human exceptionalism, and thus downplays the important consequences of biodiversity loss, climate change, and ecosystem modifications. Models of creation care must be updated to reflect the evergrowing understanding of a pattern of mutual dependence between humans and the environment. The reconciliation ecology paradigm, with a growing emphasis on the principle of reciprocity, provides the groundwork for such a model. However, faith-based framings of reconciliation ecology still largely focus on creation care in human-dominated landscapes. Thus, the reconciliation ecology model of creation care, much like the secular framing of the concept, often emphasizes ways

in which biodiversity can fit around human society, rather than describing a model of mutual dependence. Broadening the reconciliation ecology paradigm to include approaches that emphasize patterns of mutual dependency between humans and the nonhuman creation may serve to expand the horizons of creation care in the Anthropocene by highlighting the ways in which the health and well-being of humans and the environment are intricately linked.

One such approach that has gained popularity in secular conservation practice is the One Health concept. The One Health concept has emerged over the past 20 years as a powerful transdisciplinary approach to health engagement and conservation that emphasizes the important connections between human, wildlife, and ecosystem health systems. The One Health approach in conservation science has been primarily focused on traditional environmental health topics, including environmental toxicology, transmission of communicable diseases, and causal factors of non-communicable diseases.[70] A One Health emphasis, however, incorporates knowledge from disciplines outside of traditional public health spheres, including conservation ecology and veterinary medicine, to highlight how effective stewardship can benefit both humans and the ecosystems that they are imbedded in.[71] Thus, the One Health approach is holistic in scope and prospective in approach; this is in contrast to the often reactive management common in siloed health and conservation systems (fig. 1).

The term "One Health" did not see wide use in the conservation lexicon until the early 2000s, but the concept is rooted in a longer history, both in conservation and medicine. For example, Leopold's land health idea is credited by some as being one of the first instances of a conceptualization of reciprocal relationships between human and environmental health emerging in modern conservation circles.[72] Similar realizations occurred in medicine. For example, Rudolf Virchow, a German pathologist, recognized that certain parasites could infect both humans and animals, and would term diseases that could be passed between humans and animals "zoonoses" in 1880. Virchow, an instrumental figure in comparative medicine, once stated: "Between animal and human medicine there are no dividing lines, nor should there be. The object is different, but the experience obtained constitutes the basis of all medicine."[73]

Parallel movements would see this early concept develop different names depending on the emphasis, such as One Medicine (emphasis on similarities between human and veterinary medicine), conservation medicine (emphasis on wildlife health systems), and EcoHealth (emphasis on human-environment linkages).[74] At the turn of the 21st century, the Wildlife Conservation Society would expand the definition to its current "One Health" moniker by bringing these concurrent streams together to draw greater attention to the importance of considering linkages between human, veterinary, and wildlife health systems in an increasingly globalized world.[75] Since its modern branding, the One Health concept has gained popularity in both national and international organizations focused on human, animal, and/or environmental health, and it is increasingly emphasized as a guiding principle in response to global effects of the Anthropocene, such as pandemics, emergence of antibiotic resistant bacteria, and climate change.[76]

While examples of the application of the One Health framework have increased since its conceptualization in the early 2000s,[77] perhaps one of the most comprehensive examples of the One Health concept in practice in North America is the response to the Lyme disease epidemic. Lyme disease is a zoonotic disease caused by the bacterium *Borrelia burgdorferi*.[78] Lyme disease is also the most common vector-borne disease in the United States, meaning that it is transmitted through the bite of an arthropod vector, in this case, the blacklegged tick (*Ixodes scapularis*).[79] Symptoms of Lyme disease develop about two- to three-weeks post-exposure, and include fever, muscle and joint pain, lethargy, and in many cases, a characteristic erythema migrans ("bulls-eye") rash.[80] If left untreated, Lyme disease can progress to cause a variety of significant health-related concerns, including facial paralysis, neuropathy, and heart arrhythmias months after the initial exposure.[81] Approximately 63,000 cases reported to the Centers for Disease Control in 2022, primarily from fifteen states in the Northeast and Upper Midwest.[82]

Borrelia burgdorferi is maintained in a natural enzootic cycle that includes interactions between blacklegged ticks and wildlife hosts. White-footed mice (*Peromyscus leucopus*) are the amplifying host for *Borrelia burgdorferi*,[83] meaning that the bacterium is capable of propagating in the tissues of mice. Blacklegged ticks have three distinct life stages, and they will take a blood meal once at each life stage.[84] Adult ticks do not transmit the pathogen directly to their offspring. Instead, overlap in feeding habits between the first (larvae) and intermediate (nymphs) life stages is sufficient to maintain the bacterium in natural settings. Both life stages preferentially feed on white-footed mice, so nymphal ticks will infect mice, which will then subsequently

infect larvae that also feed on it.[85] While blacklegged ticks will preferentially feed on small mammals in their juvenile life stages and on white-tailed deer (*Odocoileus virginianus*) in their adult life stage, they are generalist parasites, meaning that they will periodically feed on non-target hosts in all life stages.[86] Thus, blacklegged ticks can serve to bridge the pathogen from wildlife to humans and companion animals.

Lyme disease first emerged as a major public health concern in the late 1970s and early 1980s,[87] although phylogenetic evidence suggests that *Borrelia burgdorferi* has been present on the American landscape for at least 60,000 years.[88] Blacklegged ticks and white-footed mice are both forest-associated species, so it is likely that forest management practices have played a large role in its recent, explosive emergence. The years following European settlement of the Northeast and Upper-Midwest were characterized by intense logging of eastern and Great Lakes forests, followed then by landscape conversion from forest to agriculture. Concurrent with land-use change were reductions of white-tailed deer populations (which serve as the reproductive host for adult blacklegged ticks) through overharvest and habitat destruction. These ecological changes likely limited the potential transmission of *Borrelia burgdorferi* from wildlife hosts to humans by reducing densities of ticks and supportive wildlife and also by limiting interactions between humans and natural ecosystems due to land conversion.[89]

Several important changes in the 20th century likely influenced the emergence and subsequent expansion of blacklegged ticks and Lyme disease.[90] First, wildlife management practices shifted, and white-tailed deer populations, which support blacklegged tick populations, rebounded. At the same time, forests began to regenerate in North America, offering new opportunities for wildlife habitat. Agricultural landscapes became interspersed with other land-use types, including regenerative forests. These regenerative forest patches were dispersed across a human-dominated landscape, providing new ecological opportunities for wildlife. At the same time, suburban sprawl brought humans in greater contact with wooded areas. Concurrently, these factors led to increased contact between humans and wildlife. While increased human engagement with nature is associated with many benefits,[91] one of the consequences is increased human-wildlife conflict, which can include increased transmission of zoonotic pathogens.[92] Several human-associated ecological changes, including continued overabundance of white-tailed deer,[93] the presence of invasive plants that support increased contact between small mammals and ticks, such as Japanese barberry (*Berberis thunbergii*),[94] and suppression of natural fire regimes[95] have been implicated in higher tick densities and prevalence of *Borrelia burgdorferi*. Climate change may also lead to a northerly range expansion of blacklegged ticks and changes in tick activity patterns that may increase risk of Lyme disease transmission to humans.[96]

Understanding the ecology and distribution of zoonotic diseases is an important and clear example of the One Health concept in practice. By some estimates, zoonotic diseases comprise approximately 60% of all infectious diseases that affect humans and 60 to 75% of all emerging diseases.[97] Other prominent examples include rabies, ebola, malaria, and most recently, the transmission of avian influenza from wildlife and domestic animal reservoirs into humans. Disruption to ecosystem services can exacerbate the potential risk of exposure to zoonotic diseases. The dilution effect hypothesis, which suggests an inverse relationship between biodiversity and zoonotic pathogen transmission, provides a widely cited example of a regulating ecosystem service applied in the context of disease ecology.[98] One of the first descriptions of the dilution effect came from the Lyme disease system, in which higher vertebrate species diversity can disrupt the transmission cycle of Lyme disease by providing alternatives to the reservoir host (white-footed mice) for blacklegged ticks to feed on.[99] While widely cited, some questions have been raised regarding the overall relevance of the dilution effect. For example, the presence of specific diluting hosts, like lizards, has been suggested to have a stronger relationship in human transmission risk than simple vertebrate species richness.[100] Whether it be the presence of specific hosts or overall species richness, the implication is still clear—healthy ecosystem functioning can modulate the risk of zoonotic disease spillover.

While zoonotic diseases represent one of the clearest links between humans, environmental, and animal health, they are not the only link. For example, toxicologists also recognize parallels between humans and animals in shared environments. Research in the Great Lakes region on colonial waterbirds exposed to industrial chemicals in the environment, such as dioxins and polychlorinated biphenyls (PCBs), showed poor growth, malformities, and reproductive harm.[101] These environmental contaminants may also have negative effects on the health of proximate human communities, so changes in the health of bird populations may inform potential risk to human populations. Disruptions to ecosystem integrity can also modulate the risk of

toxicant exposure. For example, white-nose syndrome, a devastating fungal disease in bats, has driven large-scale population declines in multiple species across the Eastern United States.[102] Bat die-offs can lead to reductions in natural pest control in agricultural systems and an increased use of chemical pesticides.[103] Thus, a loss of biological pest control by bats may have the indirect consequence of increased exposure of human communities to harmful pesticides.

One Health as an Extension of the Reconciliation Ecology Paradigm of Creation Care

Much like previous approaches to creation care, parallel movements within secular and religious spheres have an influence on each other. In their book, *Introduction to One Health: An Interdisciplinary Approach to Planetary Health*, Sharon Deem, Kelly Lane-deGraaf, and Elizabeth Rayhel explore the potential contributions of multiple sectors to One Health. In one chapter, they evaluate the potential contributions of culture (anthropology) and theology to the One Health approach.[104] Specifically related to religious contributions, they identify four major areas that world religions can contribute to and thus expand the One Health approach, based on core tenets and praxis of the major world religions, including Christianity: (1) food and water security, (2) care for the sick, (3) providing for the homeless, and (4) stewardship of creation. In their last point (stewardship of creation), the authors urged the development of a One Health theology as an extension of ecotheology. Clearly secular communities see value in partnering with faith-based communities to grow the One Health approach. Christian scholars have also argued for a One Health approach to creation care, using zoonoses as a justification for considering the reciprocal links between human, wildlife, and environmental health systems, and for motivating concern for Christian environmental stewardship.[105]

We can expand the One Health Christian framework by looking for concurrent themes in the biblical text. Throughout the Old Testament, many examples exist of the interrelatedness of human sin and the degradation of creation. Hosea 4, for example, opens with an indictment of Israel, specifically stating that sinful behavior causes anguish to all occupants of the land:

> There is no faithfulness or loyalty, and no knowledge of God in the land. Swearing, lying, and murder, and stealing and adultery break out; bloodshed follows bloodshed. Therefore, the land mourns, and all who live in it languish; together with the wild animals and the birds of the air, even the fish of the sea are perishing. (Hosea 4:1–3)

As a recurrent theme, the mutual depreciation of human and environmental health as an effect of sinful behavior begins in Genesis 3, where the land is cursed as a consequence of Adam's failure to heed God's command. References to the curse of the land are tied to negative human health outcomes (difficult and painful childbirth, hardship in working the fields, death and return to the soil).

One of the most compelling biblical cases for a One Health theology comes from Leviticus 25 and 26. In Leviticus 25, God extends the sabbatical year to the land itself, providing a period of rest and renewal for the land. It also established the Year of Jubilee, a period representing liberation of both land and its inhabitants. Chapter 26 then articulates the rewards for faithfulness and obedience in keeping with the sabbath commandment:

> If you follow my statutes and keep my commandments and observe them faithfully, I will give you your rains in their season, and the land shall yield its produce, and the trees of the field shall yield their fruit. Your threshing shall overtake the vintage, and the vintage shall overtake the sowing; you shall eat your bread to the full, and live securely in your land. (Lev. 26:3–5)

Chapter 26 also establishes the penalities for disobedience in keeping the sabbath law:

> But if you will not obey me, and do not observe all these commandments, if you spurn my statutes, and abhor my ordinances, so that you will not observe all my commandments, and you break my covenant, I in turn will do this to you: I will bring terror on you; consumption and fever that waste the eyes and cause life to pine away. You shall sow your seed in vain, for your enemies shall eat it. (Lev. 26:14–16)

This system of rewards or penalties for keeping or breaking the sabbath commandments clearly emphasizes an early Hebrew understanding of mutual flourishing or anguish of the creation, which explicitly includes humans. The penalties, in particular, emphasize a One Health link between spiritual faithfulness (or the lack thereof), ecological integrity, and human health outcomes. The recurring cycle, of disobedience to God, desolation of land, exile of the Israelites, and reconciliation, becomes an important Old Testament motif in the lead-up to the birth of Christ.

Opportunities to Develop a One Health Approach to Creation Care

Much like the reconciliation ecology framework, the One Health approach provides a challenge to those models of creation care predicated on the ideas of human exceptionalism and anthropocentrism. Due to its guiding framework, the One Health approach is more ecocentric in practice, recognizing the importance of mutual flourishing for humans, the physical environment, and wildlife. Warners, Ryskamp, and Van Dragt identified mutual flourishing for humans and nonhuman creation as the end goal of the process of reconciliation ecology.[106] One Health provides a concrete example of what mutual flourishing can look like—a system in which positive health outcomes exist for both human society and the environment. A One Health approach invites us not only to assess the moral-ethical obligations of humans to the nonhuman creation, but also to imagine ourselves, as Leopold puts it, as full members of the land community (fig. 2).

There are several important implications of One Health extensions of the reconciliation ecology framework as a model of creation care. The first is an expansion of the scale of work. The reconciliation ecology framework, by its relation to the secular discipline that inspired the idea, often focuses on the relationship of humans and nonhuman creatures within the context of human-dominated landscapes. Thus, reconciliation ecology in practice can often be confined to local scales. For example, the works of Warners, Ryskamp, and Van Dragt; and Gail Heffner and David Warners both focus on the Plaster Creek watershed, a 58-square mile watershed that runs across an exurban-urban gradient in Grand Rapids, Michigan.[107] One Health, in contrast, addresses key conservation and human health concerns over multiple scales. For example, individual homeowners or communities can be concerned with minimizing exposure to blacklegged ticks through local landscape management, while broad-scale patterns like climate change, can affect both the geographic range and activity patterns of ticks,[108] thus influencing wider patterns of exposure to tick-borne diseases.

The second implication is that the One Health approach, compared to previous models of creation care, provides an opportunity to diversify the base of Christian scholars engaged in creation care. Current perspectives on creation care are often led by Christian scientists (particularly ecologists) and ecotheologians. Recent scholarship in the areas of creation care has begun to recognize this limitation and invite a more diverse base of scholars and practitioners to the conversation. For example, *Beyond Stewardship*, a recent discussion on new approaches to creation care, has chapters written by authors with different expertise: engineers; economists; philosophers; and professors of education, English, and urban studies; in addition to the traditional voices of

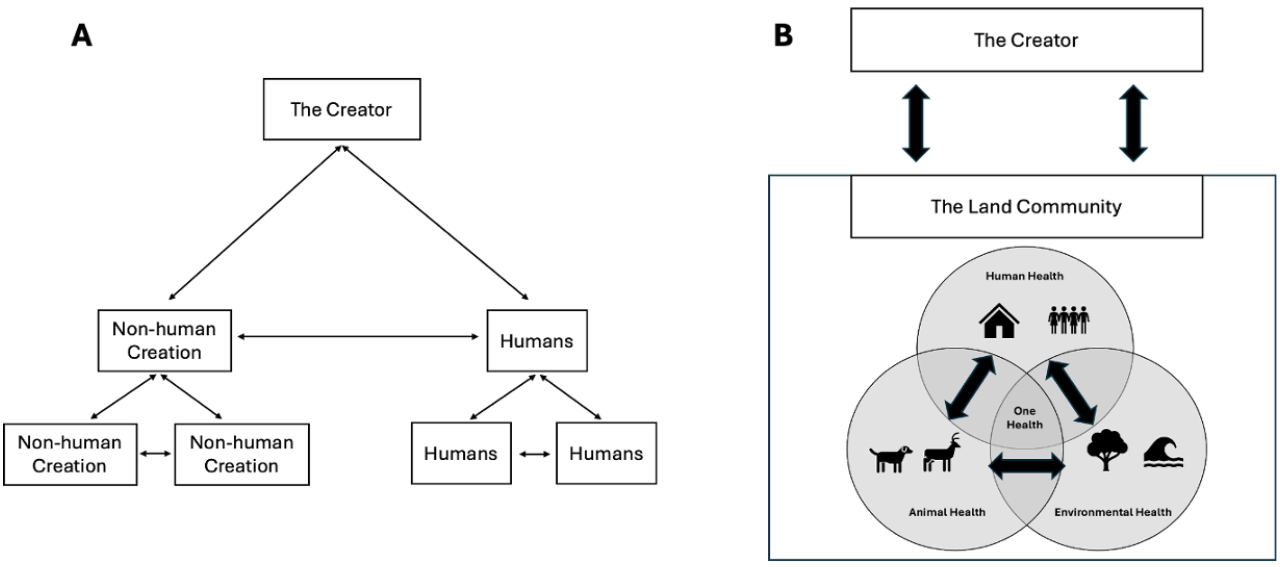

Figure 2 A. The original reconciliation ecology paradigm focused on the restoration of shalomic relationships between the Creator, the human creation, and the nonhuman creation (adapted from David Warners, Michael Ryskamp, and Randall Van Dragt, "Reconciliation Ecology: A New Paradigm for Advancing Creation Care," *Perspectives on Science and Christian Faith* 66, no. 4 [2014]: 221–35).

Figure 2 B. The One Health concept can be viewed as an extension of the reconciliation ecology paradigm, where One Health is represented as the mutual flourishing of humans, animals, and the environment. One Health is maintained through shalomic relationships between members of the land community and between the land community and the Creator.

ecologists, biologists, ecotheologians, and environmental scientists.[109] As Kathi Groenendyk points out in her chapter, both communication style and audience matter when expanding awareness of environmental issues in Christian circles, so having a diversity of approaches and perspectives is important.[110]

The One Health perspective is a transdisciplinary approach to health that includes experts from a variety of different sectors, notably public health, medicine, ecology, and animal science, but also Christian farmers, foresters, fishers, and hunters, enabling an engagement of a more diverse audience that may recognize and resonate with health-oriented languaging outside of the more specific linguistic toolbox of ecology and environmental science. While it is important to open dialogue on creation care to different stakeholders, it is also important to be aware of a limitation of broad approaches, mainly that it is possible for a conceptual framework to be so broad that it is difficult to track and balance the diverse voices. Being intentional to balance input from different, diverse stakeholders is critical to the development of an effective One Health approach to Christian environmental stewardship.

In addition to broader opportunities to engage a Christian audience on matters of creation care, a One Health approach to Christian environmental stewardship also opens up important outward-facing opportunities. Secular definitions of the One Health paradigm emphasize "the collaborative effort of multiple disciplines … to attain optimal health for people, animals, and the environment."[111] A common critique of the One Health concept is that it is still predominantly anthropocentric in practice, despite being a transdisciplinary approach to global health.[112] Optimal outcomes for human health are often the disproportionate end goal for One Health, while animals and the environment are primarily conceptualized as potential sources for human ailments. This is for good reason—many of the biggest proponents of the One Health concept are national and international public health agencies, whose core mission is to maximize positive health outcomes for their constituents and minimize harmful exposures to human communities.

Environmental ethicists and ecotheologians have the opportunity to engage the other axes of the One Health triad and highlight the positive contributions of conservation, restoration, and reconciliation ecologies in ways that public health agencies are not equipped to do. With a strong emphasis on stewarding God's creation, Christians have an opportunity to draw attention to the health of the entire land community. To do so, Christians must also be cognizant *not* to adopt an anthropocentric variant of the One Health approach, which emphasizes the value of animal and environmental health based solely on what benefits humans draw from it. Such an approach can devalue animals and environmental systems stigmatized as sources of human ailment, creating an anthropocentric system rather than one focused on mutual flourishing.

Conclusion

In the opening quote of this article, Leopold invites his ecologically minded readership to become more aware of the ailments afflicting nature and to embrace the mantle of a doctor in a world of wounds.[113] The One Health perspective provides us with a framework to pursue his call. The Anthropocene is marked by accelerated losses of biodiversity and ecosystem function. The emergence of zoonotic pathogens, such as Lyme disease, indicates that environmental change has very real consequences for human society. In conservation science, the One Health perspective and parallel concepts have pushed scientists to reconsider previous connotations of human exceptionalism and anthropocentrism. The reconciliation ecology paradigm has spurred similar discussions in Christian environmental stewardship. One Health is a logical extension of this paradigm, and a necessary one in a world of accelerating ecological change.

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Article

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Restoration Aquaculture: Reconciling Aquatic Creatures and Ecosystems to Enhance Fruitfulness for All

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In the beginning when God created the heavens and the earth and the Spirit of God hovered over the waters, everything was aquaculture. God was creating out of a watery chaos an ordered and good world. For six days God created before saying, "Let us create A'dam *in our image, male and female let us create them." Over the course of history, humans have been fruitful, but other creatures' fruitfulness has been reduced by the deeds of nearly 10 billion humans on the planet. Among problems are energy use, reduction of habitat, loss of species, and the harmful results of producing food. In* God's Good World—Reclaiming the Doctrine of Creation*, Jonathan Wilson articulates a "doctrine of creation" that invites Christians to consider what justice for all God's creation might entail, including all humans and other species. At this juncture, how can we approach restoration of order and goodness? Genesis 2:15 tells us to* shmar *and* abad *– protect and serve – creation. Jesus the great restorer charges us to care for "the least of these" (Matt. 25:40): people with limited food, water, and housing. Wilson would want us to add caring for the least of the newts, nutrients, and neutrons. In this article, we explore aquaculture for food, including species such as alligators and sturgeon; ecosystem restoration, including aquaponics coupling fish and plants; and reef systems that host many species. We contend that wisely managed restoration can provide for humans while also caring for creation, enhancing justice for this interconnected and intricate creation that isn't just good but is very good.*

Keywords: aquaculture, conservation, creation care, ecology, ecofriendly, fruitful, hydroponics, restoration, seafood, sustainability

Aquaculture is the culture of fish, crustaceans, aquatic plants, and other aquatic organisms, typically for direct or indirect use by humans, most commonly as a component of food. Aquaculture is the fastest-growing protein sector in the world, growing at 6% annually over the last 50 years.[1] It has the potential to sustainably produce healthy, high-quality protein, efficiently providing food needed for growing human populations. In this article, we examine its potential to help individuals and cultures remain faithful to provide for the most vulnerable among us while also protecting and serving all of God's good creation (Gen. 2:15).

Agriculture and aquaculture have both greatly benefited humanity by providing food; but both have also significantly damaged the environment by destroying habitats, depleting resources, and polluting air and water. We believe that acting justly with God's help we can wisely practice aquaculture and judiciously use technology to bring about flourishing within all of creation. We will explore this theme as applied to aquaculture, aquatic species, and habitat conservation.[2]

Fish have been a significant part of many human cultures over millennia. Examples include the Aztec "floating gardens" or *chinampas* which produced plants and fish for a vibrant culture.[3] Hawai'ian *ioko i'a* were historically used to enhance fish availability.[4] These fish enclosures held and grew fish, and likely also enhanced nursery habitat for young fish. Chinese systems often fertilized ponds with waste from land animals (e.g., chickens, pigs) and produced fish that grazed on the resulting algae.[5] Europeans and other cultures around the world have produced fish in ponds that also served as water reservoirs to enhance sustainability.[6] However, aquaculture on the current scale is a recent phenomenon, with a dramatic increase in production since 1960. As of 2022, aquaculture now produces more seafood than all the wild-caught fish from oceans, rivers, and lakes in the world.[7]

Aquaculture exists, is growing quickly worldwide, and has advantages of efficient conversion of feed into protein, but it is becoming a massive enterprise that poses environmental threats, including waste nutrients, use of water, fish feed costs, and energy.[8] Worldwide we now consume more aquaculture products than beef.[9] The data suggest that this may be a good thing as fish are approximately ten times more efficient than cows at converting feed to protein; in addition, aquaculture products may have better health benefits. However, while many researchers are improving efficiency and sustainability of aquaculture, more work is needed; a strong ethical approach must be made to maintain both production and sustainability. This is particularly imperative in light of damage from aquaculture in some locations. Specific long-held opposition to aquaculture has been lessened recently in some areas due to the positive benefits of filter-feeding shellfish (e.g., oysters) and aquatic plants/macroalgae.[10]

Other problems have not been well addressed, leading to greater opposition when the scale of operations has increased. One concern is that fish diseases and parasites from aquaculture may affect wild fish that come close to culture areas where aquaculture occurs. For example, parasitic sea lice may be passed from cultured fish to wild fish causing a reduction in wild fish.[11] Work on aquacultural diseases and parasites has been active in the last decade. Another point of dispute is aquaculture that does not consider the ecosystem (often driven largely by "perverse" economic incentives). In Asia, South America, and elsewhere, coastal mangrove forests were destroyed over large areas to make room for shrimp aquaculture.[12] The shrimp were largely exported to wealthy countries, but the mangrove losses proved painful not only from the loss to an ecosystem but also from the loss of coastal protection. Studies have shown that healthy mangrove forests can protect communities from tsunamis and coastal storms, saving lives while providing habitat for fish.[13] In addition, the shrimp are generally not used locally, so this cannot be argued to be "providing protein to the poor."

However, one strong driver of the growth of aquaculture as well as agriculture is that the human population is larger than it has ever been, and it would be inhumane to allow people to starve.[14] As our population approaches 10 billion, we must care for all people. On the other hand, if we affect our wild species too much, we are damaging creation. Can we grow aquaculture in a responsible way while feeding our growing world? In order to address this question, we must look beyond science to God's design for restoration of a fallen creation.

Athanasius, in the classic *On the Incarnation*, writes:[15]

> We will begin, then, with the creation of the world and with God its Maker, for the first fact you must grasp is this: the renewal of creation has been wrought by the Self-same Word who made it in the beginning. There is thus no inconsistency between creation and salvation … for the One Father has employed the same Agent for both works, effecting the salvation of the world through the same Word Who made it at the first.

This observation from historic Christianity reminds us that Christians have acknowledged restoration of the world as a consistent part of Christian faith for centuries.

In his book *Systematic Theology,* Robert Jenson suggests that "the most obtrusive feature of the priestly creation narrative is the drumbeat rhythm … And God said, 'Let there be …, and there was …'"[16] Just as the story's form has order, so too has the world the Lord creates. In other words, space and time are ordered as God speaks within the narrative and without. And what God speaks into space-time is also good.

This goodness plays out over the days of the creation narrative. God separates the light and the dark, the space above and below, the waters and land, and then fills the spaces with creatures that are good. At the end of each day, the Lord declares that what has been made and ordered is good. Most significant for our purpose here is the word of blessing in Genesis 1.

> And God said, "Let the waters swarm with swarms of living creatures, and let birds fly above the earth across the expanse of the heavens." So God created

> the great sea creatures and every living creature that moves, with which the waters swarm, according to their kinds, and every winged bird according to its kind. And God saw that it was good. And God blessed them, saying, "Be fruitful and multiply and fill the waters in the seas, and let birds multiply on the earth." (Gen. 1:21–22, ESV)

God makes, orders, and blesses the world with a future of abundance. The creatures of the sea are indicated here no less than three times.

Having made, filled, and blessed, the Lord continues to make and order and bless. On the sixth day, humans are made in God's image and are also blessed. Here the speaking turns to conversation as the man and woman are given authority and are commanded to protect and to serve.

How do we understand the right and just use of the authority given to us in a world that is blessed and at the same time broken by sin and filled with sinners? Douglas John Hall in *Imaging God: Dominion as Stewardship* suggests first that "image" is a verb: we are to actively "image" God in all that we do in God's world. He goes on to make a Christological clarification:

> Taking the Lordship of Jesus as an authentic model for understanding our human relation to the natural order means that dominion is expressed not as mastery but as service—sacrificial service of the others with and for whom one is responsible. Thus, the concept of dominion as stewardship eschews any idea of ownership or superiority in relation to nature, yet assumes a special accountability for its welfare.[17]

This definition of dominion as stewardship makes sense as we read the whole of the biblical story backwards from Jesus to Genesis. It helps us see that we are made and remade to use our capacity and communities for the good of all creation through caregiving and service. Stewardship that is faithful is not about getting and grabbing, using and abusing, but it is humble service within a world that God makes and orders and blesses.

This Christological clarification also allows us to continue to read the narrative and explore the theme of stewardship and blessing through various biblical covenants. For example, the Abrahamic covenant, in Genesis 12:2–3, clarifies that God will bless Abraham, make him a nation, and through him bless all the nations. The primary point is obvious: God blesses his creation and blesses his people not for special rights but for a special service of blessing others.

As we read the whole Bible in light of Jesus, how do we think about this kind of service in relationship to the complex systems of aquaculture? Jonathan Wilson in *God's Good World: Reclaiming the Doctrine of Creation* makes the argument that the original creation was "good," even before the creation of humans "in God's image," and that Jesus reflects this "earthy" kind of goodness, coming to care for and restore humans and creation.[18]

From this starting point Wilson considers a range of "earthy" topics including sexuality, technology, food, water, and creation care. Throughout the book, Wilson tries to clarify a driving "why." As noted earlier, Wilson puts forward a robust notion of justice or right relationship that could drive a humble servant-like attempt to steward God's good world for the good of others. The main point is that we have been created and blessed and given the authority for this kind of good work that cares for the least and the lost as well as the lichen and the lionfish.

If we hear all of this and pause, we might find a way forward as we listen to one of Jesus's most famous parables. In Luke 10, Jesus tells the story of the unlikely enemy who turns into a hero. He images Jesus by stopping, caring, mending, and restoring the body of his neighbor. In and through this good work, the Samaritan restores the one who has been used and abused by the power of those who came before!

When we stop, care, mend, and restore, we are using our God-imaged capacity in the way of Jesus, moving a broken creation toward "shalom," a kind of Godly peace, marked by harmony that overflows with blessing. In musical harmony, more than one note is sung at the same time. Each singer must listen to the other, but sing their own part in a way that complements, adds to, and makes more beautiful the notes of others. In what follows, we want to sing a few scientific songs because we believe that they carry the melody and harmony of restoration, stewardship, and creation care. They are hopeful stories, which we can tell with humility: they sound a lot like God's original aquaculture story.

Practical Aquaculture Applications: Culture and Restoration

Alligator Culture and Restoration: A Success Story

The first is the story of the alligator, a native North American reptile that was once a dominant predator in swamps and coastal areas of the southeastern US and

Mexico. Over several centuries, these populations were decimated by hunting, habitat loss, and human activities such as shipping and industrial pollution. In 1967, alligators were declared an endangered species under a law that preceded the Endangered Species Act (ESA).

In this period, a group of visionary researchers conceived the concept of trying to restore this species while also growing them as an aquacultured species. Several decades of scientific studies and discussion of conservation and aquaculture rules led to a decision in the 1970s that allowed the collection of eggs and culture of the resulting juveniles in aquaculture facilities. The agreement was that this would be supervised by representatives of both conservation and agriculture agencies overseeing harvest, culture, and eventual release of a percentage of resulting animals to the wild. During the early part of this period, for every 100 eggs collected, fifteen animals would be released at 1-meter length; at this size, survival is very high.[19]

Over the following decades, populations of wild animals rebounded, and the commercial alligator culture industry, now valued at over $77 million annually, was developed.[20] Both the ecosystem and the regulations have changed as restoration has proceeded. In short, these animals are no longer endangered.[21] The culture industry has been an economic success, and the secondary effects of the wild alligators have been felt in the ecosystem. As in other areas where predators have been re-introduced, vegetation has flourished as excess herbivores have been reduced. In Louisiana, alligators prey upon the invasive nutria, *Myocastor coypus*, introduced 100 years ago from South America. This invasive species has been reduced, and marsh plant health has improved, providing better stability for the marshes and some additional protection to humans as these marshes can reduce wave and storm energy better, even enhancing carbon sequestration, as the plants recover.[22] Shalom, harmony, and balance have been restored, with unexpected blessings as a part of the results.

Sturgeon Conservation, Culture, and Restoration

Another candidate species for culture and conservation is the Atlantic sturgeon *Acipenser oxyrinchus*. Sturgeon are ancient and unique creatures with diamond-shaped scales or scutes that armor and protect the fish. This species was once widespread but now almost all sturgeon species are either endangered or effectively extinct.[23] Perhaps a set of well-designed experiments could provide improved insights to allow one or more native sturgeon species to be restored while valuable aquaculture products are produced. Could we protect and serve—*shmar* and *abad*—the species while restoring a spirit of *shalom* in the Atlantic coastal ecosystems?

To explore what might be required for this we consider culture of two sturgeon species that are currently heavily cultured for caviar, *Acipenser baerii* (31%) and *A. gueldenstaedtii* (20.4%).[24] Author Hall has worked with *A. gueldenstaedtii* in North Carolina (it is native to Eurasia). This is a fish highly valued for caviar. Could a native North American species (e.g., Atlantic sturgeon *A. oxyrinchus* or shortnose sturgeon *A. brevirostrum*) be cultured for caviar? Could the financial incentives be coupled with an agreed-upon release scheme? Ideally, this would take place in concert with habitat restoration. Multiple agencies as well as research personnel would be needed. Agricultural, aquacultural, environmental, and water management agencies; universities; and research institutes as well as industry participants,

Figure 1. *Alligator mississippiensis* thrives in wetland ecosystems and, as an apex predator, contributes to overall wetland health. They are also cultured for their valuable hides and meat. (Photo: Steven Hall, 2025)

farmers, and community members could be involved. A similar set of partnerships helped move alligators from endangered to thriving over previous decades, and such partnerships could help restore sturgeon while enhancing related aquaculture production.

The effort would necessarily be multi-decade. It would require a longer-term source of funding (possibly a long-term public–private partnership), but with the hope that eventually most costs would be borne by the industry which could also grow with a "local, sustainable caviar" option. To do this, we need both habitat and fish, and we must address a range of challenges. There are also concerns about the survival of small sturgeon when released.[25] This suggests that we should grow fish to a somewhat larger size in "safe" captivity, and then transition them to the wild when their survival is higher—following methods similar to the current rules on alligators (e.g., release a known percentage at 1-meter length).

A series of studies is needed to address these factors:

1. habitat restoration—ideally in areas optimal for sturgeon thriving so that when released, fish have an acceptable chance of survival and fruitfulness;
2. improved understanding of breeding and early life stage—to enhance health and genetics for release;
3. legal aspects—local and global laws (e.g., US Endangered Species Act, International CITES agreement) may properly constrain transport of fish but may also limit current restoration efforts;[26] and
4. time—since sturgeon are slow growing, these efforts must be planned over decades to allow time for both culture and development of wild populations.

Each of these aspects encompasses potential theological and ethical considerations; each requires effort and resource input.

With all these challenges, it is tempting to ask, "Is this really the calling of Christians?" We suggest that this very much is a Christian calling. We are called to love and care for "the least of these." This includes people and creatures, especially those with no ability to speak for themselves. We see this as an example of servant leadership as the body of Christ carries out this work. There might also be unexpected blessings that the sturgeon provide that we do not yet realize, but our calling is to care for them; to protect and serve them; to conserve, preserve, and ultimately restore them and their habitat while also providing for humans.

Jesus, in his teaching and life, "raised the bar," calling us to serve sacrificially. Over many centuries, the body of Christ, the church, despite many imperfections, has influenced the world. Jürgen Habermas, who described himself as a "methodological atheist," acknowledged in his book with Pope Benedict: "The direct legacy of the Judaic ethic of justice and the Christian ethic of love is universalistic egalitarianism, from which sprang the … ideals of freedom, human rights and democracy."[27] Even those who are not Christians themselves may be favorably affected by the service and protection of the body of Christ.

Restoring single species can enhance overall ecology as seen in the case of alligator culture and restoration. Ecosystem restoration is important to enhance efforts to restore sturgeon populations. Ecosystems must be reasonably healthy to allow for fruitfulness of the species we seek to restore. Two areas in which an aquatic restoration approach may help restore entire ecosystems include aquaponics and reef restoration. We will explore these next.

Marine Aquaponics as a Path for Restoration and Abundance

Aquaponics focuses on culture of aquatic species (fish, shellfish) with plants and good bacteria, using nutrients from the fish to fertilize the plants and letting the plants and other species filter the water for the fish. Marine aquaponics may use brackish or salty water—both plentiful at coasts around the world—and may be a partial solution to environmental and food security challenges. Rooted in principles of ecosystem sustainability and balance, marine aquaponics aligns with the biblical concepts of stewardship and restoration. Ezekiel 47:9 and Deuteronomy 28:12, 23–24 provide a theological and ethical framework for understanding the role of aquaponics in restoring aquatic ecosystems and ensuring fruitfulness for all. By integrating advanced technologies with divine principles of care for creation, marine aquaponics emerge as one pathway to sustainable development and ecological balance.

Restoring aquatic ecosystems has become a critical global challenge in the face of overfishing, pollution, and climate change. Aquaponics offers an innovative approach to addressing these challenges by integrating aquaculture with hydroponics (growing plants in watery nutrient solutions) in order to create closed-loop systems that simulate natural ecosystems. As Ezekiel 47:9 (NIV) says, "Swarms of living creatures will live wherever the river flows. There will be large numbers of fish because this water flows there and makes the salt

water fresh; so where the river flows everything will live." This text highlights the role of water, where life thrives in the presence of flowing water. The picture echoes the sentiment that the goal of marine aquaponics is to rejuvenate the aquatic ecosystem and enhance biodiversity by ensuring that the water flowing out of the production system is clean and functional. Biblical stewardship focuses on key scriptural passages highlighting humanity's responsibility to care for creation and the consequences of neglect. The healing of ecosystems is like the river in Ezekiel's vision, which transforms salt water into fresh water, literally and figuratively. Marine aquaponics systems promote rehabilitation of aquatic environments by cycling nutrients and maintaining water quality, and by emulating natural processes that sustain life and create fruitfulness.[28]

Marine aquaponics brings Ezekiel's vision to life: "swarms of living creatures will live wherever the river flows" when fish waste nourishes the plants, and plants filter water, ensuring sustainability and productivity while nitrifying bacteria convert the toxic wastes (ammonia, NH_3) into a usable form (nitrate, NO_3–) for plants as nutrients.[29] Abundance is the original design of God for humans to manage and enjoy alongside stewardship and obedience. Deuteronomy 28:12 says, "The Lord will open the heavens, the storehouse of his bounty, to send rain on your land in season and to bless all the work of your hands. You will lend to many nations but will borrow from none."

In contrast, negligence and disobedience result in scarcity and destruction. Deuteronomy 28:23–24 states, "The sky over your head will be bronze, the ground beneath you iron. The Lord will turn the rain of your country into dust and powder; it will come down from the skies until you are destroyed." This covenant framework was first heard in ancient times but also relates to environmental degradation in modern times. We were made not to destroy creation but to protect and serve. Ezekiel reflects God's intention for creation to be fruitful and grow in abundance. Aquaponics creates a micro-ecosystem that can allow us to understand interactions between creatures; it may also be a tool for restoring larger ecosystems. Aquaponics embodies a divine purpose, similar to the vision of Ezekiel, by fostering life and addressing food security challenges. While the "bronze sky" and "iron ground" reflect

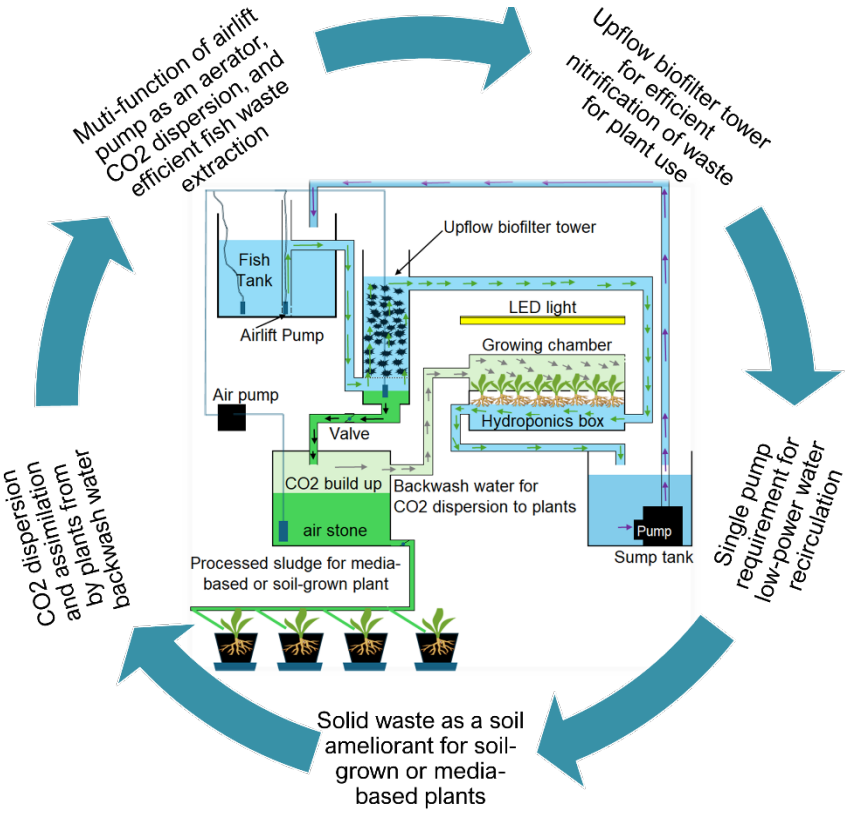

Figure 2. Schematic diagram of a marine aquaponics system, integrating fish farming (aquaculture) and hydroponic plant cultivation within a recirculating setup. The water circulation in the aquaponics system signifies circular blessings and ecosystem reciprocity as modeled in Deuteronomy (giving, receiving, and sharing). Nutrients cycle efficiently, benefiting both fish and plants, while humans reap the rewards and the environment gains through reduced pollution, improved water quality, and enhanced ecosystem balance.

the environmental consequences of exploitation and neglect, aquaponics offers a pathway to restoration by mitigating the effects of overfishing, nutrient runoff, and habitat destruction.[30]

Figure 2 is a schematic diagram for a sustainable ecosystem in marine aquaponics. By integrating aquaculture with salt-tolerant plant cultivation, this system seeks to emulate natural ecosystem processes to achieve efficient nutrient recycling, reduced environmental impact, and enhanced productivity.[31] Just as Deuteronomy speaks of rain as a blessing that ensures productivity, a marine aquaponics system relies on thoughtful design to emulate natural ecosystems. Obedience to principles of God's design ensures the system's productivity, turning limited resources into abundant outputs (fish, plants, and clean water).[32] The system reflects a harmonious balance, parallel to how obedience to God brings blessings. The principle of blessings for diligent labor aligns with the care and innovation required to maintain marine aquaponics systems. Proper management of nutrients, salinity, and biodiversity mirrors the faithfulness expected in the stewardship of God's creation. This concept ensures that all elements traditionally considered "waste" within the system are valorized and repurposed, serving as fertilizers for plant growth or as CO_2 to support plant assimilation, maximizing resource efficiency and sustainability.[33]

Figure 3. A laboratory scale marine aquaponics with hybrid striped bass and salicornia which can be utilized in urban areas. The hybrid striped bass (*Morone saxatilis*) is a key species along the Atlantic coast experiencing significant population fluctuations due to overfishing, habitat loss, and environmental changes. Breeding being done at North Carolina State University by Dr. Benjamin Reading and colleagues uses techniques such as "mixed garden" breeding to maintain healthy genetic diversity.[35]

Easing Pressure on the Ocean Through Urban Aquaponics

While aquaponics may produce plants or fish that can be used to restore aquatic and coastal ecosystems directly, numerous small-scale urban aquaponics systems can significantly reprieve ocean ecosystems by reducing the demand for wild-caught fish and mitigating nutrient runoff that damages marine environments. These systems alleviate pressure on aquatic resources and create opportunities for species restoration. Marine aquaponics systems, in particular, offer a promising avenue for conserving species nearing extinction. These systems may be capable of producing larvae and fingerlings or coastal plants for use in restoration efforts. This innovative integration of conservation and sustainable aquaculture holds immense potential for protecting marine life while addressing global food security challenges. Figure 3 shows a closed-loop recirculating marine aquaponics prototype with hybrid striped bass and salicornia (*Salicornia bigelovii*) grown in a controlled environment. Salicornia is a halophytic plant that can contribute to sustainable agriculture in saline environments. It has many uses, including food, biomass fuel, pharmaceuticals, cosmetics, and ecological restoration, making it a valuable resource for addressing global challenges.[34] Salicornia is an effective root nitrifier and nutrient absorbent (fig. 4), preventing excess nutrients from being released into the environment.

Figure 4. The root nitrification of salicornia plays a critical role in marine aquaponics by absorbing excess nutrients from fish waste, effectively preventing water pollution and mitigating environmental damage.

By integrating fish cultivation with hydroponic plant production in urban settings, recycling resources are optimized while minimizing environmental damage.[36] This approach supports local food production and lessens reliance on overfished marine species, contributing to the recovery of wild fish populations. Furthermore, urban aquaponics eliminates the need for artificial fertilizers, reducing the risk of nutrient runoff that can lead to eutrophication and harmful algal blooms in coastal waters.[37] By fostering sustainable food systems within cities, urban aquaponics represents a practical and scalable method for protecting marine biodiversity while addressing the growing demand for food in urbanized areas. Restoration via aquaponics can produce both food and other products, and it can also help people see the ecosystem restored to fruitfulness. Another set of technologies that directly affects ecosystems is ecologically friendly artificial reefs.

Habitat and Species Restoration via Ecofriendly Reef Systems

As mentioned in previous sections, both species *and* habitats must be restored together. If we release young fish into a compromised ecosystem they are likely to die. So, finding ways to restore ecosystems is critical. Ironically, many of our efforts to "protect" ourselves and other species at the coast result in "hard" infrastructure such as seawalls and jetties. These are not biofriendly and also tend to destroy or limit natural coastal habitat that is critical for young fish. One approach is to provide various forms of artificial habitat or biofriendly coastal reefs. One specific example is produced via a unique biofriendly 3-D printing technique by a company called Natrx.[38] These artificial habitats, along with others made by similar technologies, are then embedded in coastal areas to grow natural organisms, providing protection for breeding and early life stages.

Over time, these reefs transition from artificial ecofriendly concrete or rock structures to growing various encrusting organisms (oysters, barnacles, algae, plants) which allow them to eventually become natural parts of the coastal environment (fig. 5). They provide refuge for young fish; food for crustaceans, algae, and shellfish to clean the water; and protection to adjacent coastal plants. They are semipervious to water, with various openings provided for small creatures to grow on or move through, providing protective habitat, broodstock grounds, and hunting grounds for a variety of species.

Figure 6 shows what can happen in a single year. The original structures (left) have been colonized by oysters, algae, plants, and other creatures (center), providing additional habitat for fish and other aquatic creatures, as well as protecting vulnerable coastal habitat (right), allowing native species to recover and further enhance the ecosystem. This is a different form of aquaculture—we are culturing aquatic organisms and, while some

Figure 5. East River Project Photos. (Left) installation on tidal mudflats 2022 and (Right) growth and protection of shoreline 2024. (Courtesy of Natrx Inc.)

of these might be harvested for food (e.g., oysters), depending on the situation, they might be left to provide additional services, including biological and ecological benefits for other parts of the coastal system.

It should be noted that these specific techniques are most appropriate in certain habitat—for example, where encrusting organisms such as oysters are likely to grow at appropriate salinity, temperature, and other relevant conditions. As a result, sites must be considered carefully and relevant techniques applied based on local environmental conditions. Nevertheless, these appear to hold promise of protecting coastal habitat that may be threatened by larger coastal storms, while minimizing cost and providing additional benefits for local species. Many of these types of emplacements have been made in the US and around the world and more are planned. These are one more way that a form of aquaculture can assist in restoring God's creation.

We have explored ways that aquaculture, done well and creatively, can encourage restoration of various species and ecosystems. This is a somewhat idealistic view, but it is critical to consider that "we are God's handiwork, created in Christ Jesus to do good works God has prepared for us to do …" (Eph. 2:10). We have covered a number of specific practical areas in which this is already happening or could happen in the near future. These may allow us to consider other areas of aquaculture, agriculture, and human culture more broadly in which Christians, in particular, can consider restoration and reconciliation as part of our callings, fulfilling our roles to protect and serve God's creation, providing food and materials for people while restoring God's creation.

Conclusions and Future Work

In conclusion, we are called to join the Lord in restoring his good creation, blessing other humans and other species, and carrying out his calling to *shmar* and *abad* (Gen. 2:15) creation. As we do this with these and other aquaculture approaches, we find food production may be linked to habitat and much else, and even to our Creator and Restorer. Revelation 21 speaks of a "renewed heaven and earth …" Theologically, there are a variety of interpretations, but the context of "renewal" is clear. In the next chapter (Rev. 22), an angel shows the author "the river of the water of life, as clear as crystal, flowing from the throne of God and of the Lamb down the middle of the great street of the city. On each side of the river stood the tree of life, bearing twelve crops of fruit, yielding its fruit every month. And the leaves of the tree are for the healing of the nations" (Rev. 22:1–2). Here we have a depiction of renewal, fruitfulness, and healing including humans, God, water, and living creatures.

Future work should also address challenges unique to our time and culture. The "how" of this work is important. Yes, we should produce aquatic food for all. Yes, we should care for and restore God's creation to allow for fruitfulness for all. Yet the way we do this work matters too. Science and technology can be excellent tools to carry out our callings, or can be ways to distance ourselves from caring for the least of these. Ethical approaches to technology are critically important.[39] Previous work has explored these themes and further work is needed as technology, robotics, and artificial intelligence advance. In some areas of aquaculture, robotic boat systems have been developed using autonomous surface vehicles (ASV) designed to

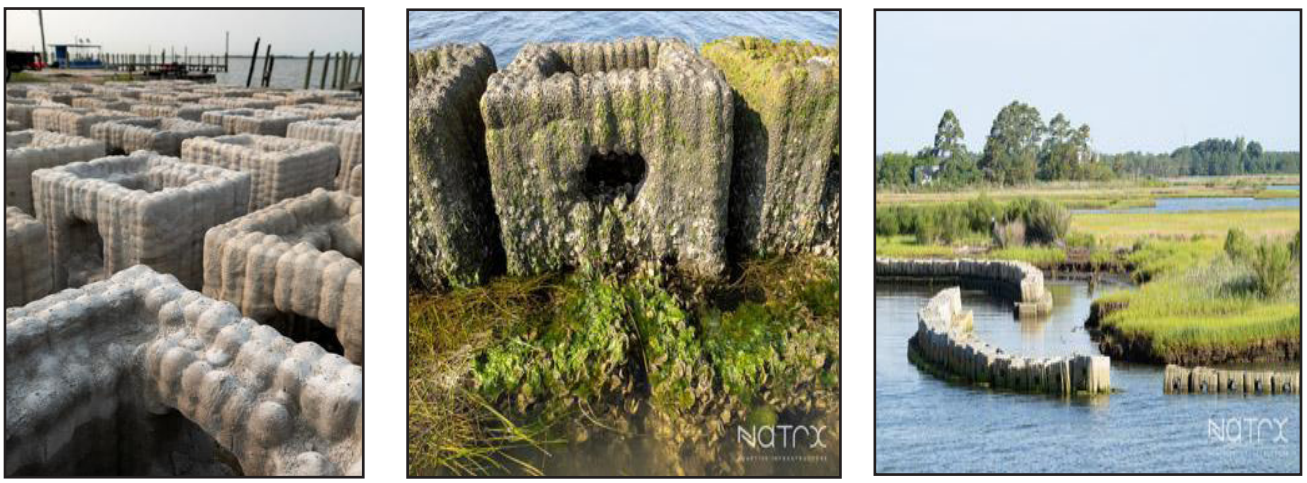

Figure 6. Hog Island Photos: Installation 2023 (left); growth of oysters, algae, spartina, and other species 2024 (center and right photos) (courtesy Natrx Inc.)

reduce bird predation on open-air aquaculture ponds; in addition, there are fleets of these aquatic robots that provide mobile sensor platforms and potentially mobile actuators.[40] Wise use of these and other forms of technology in aquaculture can help find ways to provide for humans, enhance human decision making, and provide high-protein foods while restoring healthy ecosystems. One possible approach would be to use some of these types of systems to observe and manage sturgeon and habitat conditions during restoration efforts.

Another modern reality: economics drives much; wealth may be the greatest idol of our time, but true values are real and important. Considering values (not only dollars but also environmental flourishing, human health, and other positive values) and, where possible, adding value, is important and may guide aquaculture practitioners and consumers to consider how to make wise decisions related to fish and aquatic products. Value-added seafood encompasses aquatic products that have been enhanced to improve food safety, provide convenience, increase quality, offer good taste and affordability.[41] Furthermore, value-added seafood drives sustainability by emphasizing reduced environmental damage, instituting best industrial practices, and promoting initiatives such as fisher-to-consumer marketing and product traceability.[42] Several programs and organizations (e.g., the Food and Agriculture Organization of the United Nations and the Marine Stewardship Council) encourage companies to curtail their environmental impact through implementation of industry certifications and standards such as Best Aquaculture Practices.[43] Consumers can check for these certifications, encouraging the seafood industry to improve long-term sustainability and restoration efforts worldwide. Buyers can also buy local seafood and ask how it was caught or produced.

There are many challenges that must be addressed in aquaculture as in our other endeavors. Developing culture techniques that minimize disease and pollution are critical. It is imperative that we find ways to restore aquatic ecosystems while providing food, if we are to avoid either hunger or destruction of God's creation. Ultimately, we are called to serve in our times and places by restoring and sharing shalom with humans and other creatures. Justice and mercy are both important; food for humans and care for God's creation are each necessary. We propose responding to God's calling on our lives, as Christ's body, made in the image of God, to care for God's creation, with this focus on God's aquatic creation, to restore it in our location, in our local way, in faithfulness to his grace in our lives.

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Notes

[1]Food and Agriculture Organization (FAO, hereafter), *The State of World Fisheries and Aquaculture 2024: Blue Transformation in Action* (FAO, 2024), https://openknowledge.fao.org/items/06690fd0-d133-424c-9673-1849e414543d; and World Bank, "Fish to 2030: Prospects for Fisheries and Aquaculture (English)," (World Bank Group, 2013), Agriculture and environmental services discussion paper; no. 3, http://documents.worldbank.org/curated/en/458631468152376668/Fish-to-2030-prospects-for-fisheries-and-aquaculture.

[2]FAO, *The State of World Fisheries and Aquaculture* 2024; and World Bank, "Fish to 2030."

[3]Catalina Rey-Hernández and Inge Bobbink, "Chinampas Agriculture and Settlement Patterns: The Contemporary Relevance of Aztec Floating Gardens," *Blue Papers* 1, no. 2 (2022): 90–99, https://doi.org/10.58981/bluepapers.2022.2.09. This article explores Aztec techniques to manage water, produce food, and maintain resilience in the Valley of Mexico. They cite data that these systems operated as early as 200 BC, and are being considered as examples to use when managing urban aquacultural and agricultural systems today.

[4]Anne Innes-Gold et al., "Restoration of an Indigenous Aquaculture System Can Increase Reef Fish Density and Fisheries Harvest in Hawai'i," *Ecosphere* 15, no. 3 (2024): e4797, https://doi.org/10.1002/ecs2.4797. The article suggests that historic *Ioko i'a* not only held and grew fish but also may have had positive effects on local fisheries by acting as a nursery and protective area for young fish.

[5]Ashleigh J. Rogers, "Aquaculture in the Ancient World: Ecosystem Engineering, Domesticated Landscapes, and the First Blue Revolution," *Journal of Archaeological Research* 32 (2024): 427–91, https://doi.org/10.1007/s10814-023-09191-1. This article suggests that Chinese aquaculture may have started as early as 8,000 years ago, and has been a historic and vibrant activity for many centuries. Incidentally, modern China has been the leading aquaculture producer for at least 20 years, producing some 60% of world aquaculture in 2024.

[6]Ashleigh J. Rogers also explored the history of aquaculture in Roman, medieval European, and other historic contexts. It is clear that aquaculture has been practiced for centuries. However, the scale of modern aquaculture has dramatically increased, and the scale of environmental impacts has also increased dramatically in the last 70 years.

[7]FAO, *The State of World Fisheries and Aquaculture 2024.*

[8]Rosamond Naylor et al., "Effect of Aquaculture on World Fish Supplies," *Nature* 405 (2000): 1017–24, https://doi.org/10.1038/35016500; Rosamond Naylor et al., "A 20-Year Retrospective Review of Global Aquaculture," *Nature* 591 (2021): 551–63, https://doi.org/10.1038/s41586-021-03308-6; Steven Hall, "Raising Food for Thought," *Perspectives on Science and Christian Faith* 72, no. 3 (2020): 131–43, https://www.asa3.org/ASA/PSCF/2020/PSCF9-20Hall.pdf; and Steven Hall et al., "Toward a Theology of Sustainable Aquaculture: Wisely Producing Safe Abundant Seafood While Enhancing Fruitfulness of Aquatic Creatures," *Perspectives on Science and Christian Faith* 76, no. 2 (2024): 107–24, https://www.asa3.org/ASA/PSCF/2024/PSCF9-24Hall.

[9]FAO, *The State of World Fisheries and Aquaculture 2024.*

[10]Rosamond L. Naylor, Susan L. Williams, and Donald R. Strong, "Aquaculture—A Gateway for Exotic Species, *Science* 294, no. 5547 (2001): 1655–56, https://doi.org/10.1126/science.1064875; and Rosamond Naylor et al., "A 20-Year Retrospective Review of Global Aquaculture." In this more recent article, Naylor acknowledged that macroalgae and shellfish can help enhance water quality and could be particularly sustainable forms of aquaculture, potentially contributing to restoration of some habitats.

[11]Mari Lee Larsen, Irja Vormedal, and Knut W. Vollset, "Negative Association of Sea Lice from Fish Farms on Recreational Fishing Catches of Atlantic Salmon," *Journal of Applied Ecology* 61, no. 8 (2024): 1772–83, https://doi.org/10.1111/1365-2664.14712. This article notes that challenges are posed by netpens that may allow pollutants, diseases, or parasites to harm wild populations. The authors also admit that the process is highly variable, with only 4 of 13 areas having measurable associations, as well as acknowledging these are complex systems affected by a wide variety of human and natural effects.

[12]Toiaba Taher et al., "Impacts of Shrimp Aquaculture on the Local Communities and Conservation of the World's Largest Protected Mangrove Forest," *Environmental Science & Policy* 147 (2023): 351–60, http://dx.doi.org/10.1016/j.envsci.2023.07.002. This article explores both conservation (environmental) effects and social effect on local communities in areas where shrimp aquaculture is practiced. They also note that in areas where mangrove forests are protected, there are a number of other benefits.

[13]Saudamini Das and Jeffrey R. Vincent, "Mangroves Protected Villages and Reduced Death Toll During Indian Super Cyclone," ed. Gretchen C. Daily, *PNAS* 106, no. 18 (2009): 7357–60, https://doi.org/10.1073/pnas.0810440106. These authors called the coastal protection capabilities of mangrove forests (against tsunamis and coastal storms) an "undervalued ecosystem service." These plants literally save lives! Aquaculture of shrimp that destroys these forests is not responsible aquaculture.

[14]FAO, *The State of World Fisheries and Aquaculture 2024*; and Steven Hall, "Toward a Theology of Sustainable Agriculture," *Perspectives on Science and Christian Faith* 54, no. 2

(2002): 103–7, https://www.asa3.org/ASA/PSCF/2002/PSCF6-02Hall.pdf.

[15]Athanasius, *On the Incarnation* (Gladdening Light Press, 2023), 7. This edition has a foreword by Robert Falconer; it is a translation of the original, written by St. Athanasius of Alexandria (296–373), in the 4th century. Athanasius was a bishop who helped clarify a number of Christian theological difficulties in the early church.

[16]Robert Jenson, *Systematic Theology: The Works of God*, volume 2 (Oxford University Press, 1999), 5.

[17]Douglas John Hall, *Imaging God: Dominion as Stewardship* (Eerdmans, 1986).

[18]Jonathan R. Wilson, *God's Good World: Reclaiming the Doctrine of Creation* (Baker Academic, 2013), 12.

[19]Mary J. Nickum et al., "Alligator (*Alligator mississippiensis*) Aquaculture in the United States," *Reviews in Fisheries Science and Aquaculture* 26, no. 1 (2018): 86–98, https://doi.org/10.1080/23308249.2017.1355350.

[20]FAO, *The State of World Fisheries and Aquaculture 2024.*

[21]The *Federal Register* (2021) noted that alligators are one notable success of the endangered species act as they have experienced "both drastic decline and complete recovery," https://www.federalregister.gov/documents/2021/01/19/2021-01012/endangered-and-threatened-wildlife-and-plants-regulations-pertaining-to-the-american-alligator#:~:text=The%20American%20alligator%20first%20received,the%20policy%20of%20the%20Act.

[22]Christopher M. Murray et al., "American Alligators *(Alligator mississippiensis)* as Wetland Ecosystem Carbon Stock Regulators," *Scientific Reports* 15 (2025): 3423, https://doi.org/10.1038/s41598-025-87369-x.

[23]Victor Lobanov, Joe Pate, and Alyssa Joyce, "Sturgeon and Paddlefish: Review of Research on Broodstock and Early Life Stage Management," *Aquaculture and Fisheries* 9, no. 6 (2024): 871–82, https://doi.org/10.1016/j.aaf.2023.04.001. Note that "24 of 25 extant species are classified as critically endangered … populations continue to decline, with the extinction of some species considered imminent." They also recognize "the most recent official … extinction was the Yangtze sturgeon in July 2022 …" (p. 871). This argument suggests that finding ways to restore these ancient but unique creatures is a strong calling at this time.

[24]Paolo Bronzi et al. note that five species and two hybrids account for 90% of production. Coauthor of this article, Steven Hall, has experience with *A. gueldenstaedtii*, whose caviar sells for over $100/ounce. See Paolo Bronzi et al., "Sturgeon Meat and Caviar Production: Global Update 2017," *Journal of Applied Ichthyology* 35, no. 1 (2019): 257–66, https://doi.org/10.1111/jai.13870.

[25]Saulius Stakenas and Andrej Pilinkovskij, "Migration Patterns and Survival of Stocked Atlantic Sturgeon (*Acipenser oxyrinchus* Mitchell, 1815) in Nemunas Basin, Baltic Sea," *Journal of Applied Ichthyology* 35, no. 1 (2019): 128–37, http://dx.doi.org/10.1111/jai.13871. The authors noted that young sturgeon stocked into wild habitat had very low survival level, possibly due to commercial fishing. Survival was more successful in rivers, perhaps due to limited fishing. This also should be considered when exploring optimal restoration efforts—perhaps protected rivers might be better places for sturgeon release. See also Lobanov et al., "Sturgeon and Paddlefish."

[26]Lobanov et al. note that with respect to laws (CITES and ESA) some of the laws intended to protect sturgeon actually make it very hard to restore populations to the wild: "Ironically, this stringency tends to discourage efforts to bring aquaculture and restoration together" (Lobanov et al., "Sturgeon and Paddlefish," 872).

[27]Jürgen Habermas and Pope Benedict XVI, *The Dialectics of Secularization: On Reason and Religion* (Ignatius Press, 2007).

[28]Mathilde Eck, Oliver Körner, and M. Haïssam Jijakli, "Nutrient Cycling in Aquaponics Systems," in *Aquaponics Food Production Systems: Combined Aquaculture and Hydroponic Production Technologies for the Future*, ed. S. Goddek et al. (Springer International, 2019), 231–46, available at https://doi.org/10.1007/978-3-030-15943-6_9.

[29]Christopher Pascual, "Optimizing Nutrient Conversion and Recovery in Marine Aquaponics," (PhD diss., North Carolina State University, 2025), https://www.lib.ncsu.edu/resolver/1840.20/45160. This dissertation explains in great detail how these systems operate, and analyzes the enhanced efficiency of these managed ecosystems.

[30]U. Rashid Sumaila and Travis C. Tai, "End Overfishing and Increase the Resilience of the Ocean to Climate Change," *Frontiers in Marine Science* 7 (2020), https://doi.org/10.3389/fmars.2020.00523; and Jiaxin Lan et al., "Harmful Algal Blooms in Eutrophic Marine Environments: Causes, Monitoring, and Treatment," *Water* 16, no. 17 (2024): 2525, https://doi.org/10.3390/w16172525.

[31]Pascual, "Optimizing Nutrient Conversion and Recovery in Marine Aquaponics."

[32]Christopher Pascual et al., "Intermittent Salt Application Enhances Total Soluble Solids of Strawberries (*Fragaria x ananassa*) in Hydroponics," *Discover Plants* 2 (2025): 133, https://doi.org/10.1007/s44372-025-00214-3. In this article, initially with a focus on recovering nutrients (and hence not impacting local ecosystems with excess nutrients), it was also found that slightly salty nutrient laden water made strawberries sweeter. As we seek to hear and follow God's calling to care for his creation and his people, we find, like the Psalmist: "How sweet are thy words unto my taste! yea, sweeter than honey to my mouth!" (Ps. 119:103 KJV). In this case, the result was literally sweeter!

[33]James E. Rakocy, "Aquaponics: The Integration of Fish and Vegetable Culture in Recirculating Systems," paper presented at the thirtieth annual meeting of the Caribbean Food Crops Society, Vol. 30, St. Thomas, U.S. Virgin Islands, 1994, https://doi.org/10.22004/ag.econ.258746; and Baldassare Fronte, Greta Galliano, and Carlo Bibbiani, "From Freshwater to Marine Aquaponic: New Opportunities for Marine Fish Species Production," paper presented at the conference VIVUS–On Agriculture, Environmentalism, Horticulture and Floristics, Food Production and Processing and Nutrition: With Knowledge and Experience to New Entrepreneurial Opportunities, April 21, 2016, Biotechnical Centre Naklo, Strahinj 99, Naklo, Slovenija, pp. 514–21, https://www.researchgate.net/publication/303875126_From_freshwater_to_marine_aquaponic_new_opportunities_for_marine_fish_species_production.

[34]Tanmay Chaturvedi et al., "Salicornia Species: Current Status and Future Potential," chap. 31 in *Future of Sustainable Agriculture in Saline Environments,* ed. Katarzyna Negacz et al. (CRC Press, 2022), 461–82; and A. Karimian, S. H. Pourhoseini, and A. Nozari, "*Persica Akhani* Salicornia as Novel Biodiesel Feedstock Production for Economic Prosperity in Salty and Water Scarcity Areas: Optimized Oil Extraction Process and Transesterification Reaction Using New Magnetic Heterogenous Nanocatalysts," *Renew-*

able Energy 211 (2023): 361–69, https://doi.org/10.1016/j.renene.2023.04.119.

[35]James E. Rakocy, Thomas M. Losordo, and Michael P. Masser, "Recirculating Aquaculture Tank Production Systems: Integrating Fish and Plant Culture," Southern Regional Aquaculture Center Publication 454 (November 1992), https://www.ncrac.org/files/inline-files/SRAC0454.pdf.

[36]Christopher Pascual et al., "Optimizing Light Intensity and Salinity for Sustainable Kale (*Brassica oleracea*) Production and Potential Application in Marine Aquaponics," *Sustainability* 16, no. 23 (2024): 10516, https://www.mdpi.com/2071-1050/16/23/10516. The researchers found that kale, a popular and nutritious green, can grow well up to 8 ppt salinity (a typical salt level for brackish water near the coast), producing nutritious greens, removing waste nutrients, and providing economic incentive to pursue this activity that can care for creation.

[37]L. K. Andersen et al., "Methods of Domestic Striped Bass (*Morone saxatilis*) Spawning That Do Not Require the Use of Any Hormone Induction," *Aquaculture* 533 (2021): 736025, https://doi.org/10.1016/j.aquaculture.2020.736025. This article focuses on breeding techniques that are more "natural" including the "mixed garden" technique to reduce the need for artificial hormones and to maintain good genetic diversity; and Linnea K. Andersen, Neil F. Thompson et al., "Advancing Genetic Improvement in the Omics Era: Status and Priorities for United States Aquaculture," *BMC Genomics* 26 (2025): article 155, https://doi.org/10.1186/s12864-025-11247-z. This article focuses on genetic improvement and includes a range of discussions including (1) "enhancements" such as increased growth rate that are desirable for cultured species; and (2) genetic diversity, critical for the species and longer-term success in culture (and restoration).

[38]Nartx Inc.'s president, Matthew Campbell, is coauthor of this article. Matthew D. Campbell et al., Three-dimensional printing. US Patent 9,962,855, issued May 8, 2018 (for printing customized coastal reefs). This patent produces somewhat "natural-looking" results as shown in figures, but it also allows organic inclusions that may enhance the environment or growth of desired organisms. The website, https://natrx.io, provides a great deal more information and even an approach to their philosophy. While we do not specifically advocate for these particular products over any others, they are a good example of an entire area of "living infrastructure" that is growing as people—Christians and others—recognize the need for more ecologically friendly solutions to such challenges as coastal protection. For background on this growing field, see Steven G. Hall et al., "Growing Living Shorelines and Ecological Services via Coastal Bioengineering," chap. 13 in *Living Shorelines The Science and Management of Nature-Based Coastal Protection,* ed. Donna Marie Bilkovic et al. (CRC Press, 2017), 249–70; and Steven G. Hall, "Bioengineered Reefs to Enhance Natural Fisheries and Culture Eastern Oyster *Crassostrea virginica* in the Gulf of Mexico," in D. Thangadurai, S. G. Hall, A. Manimekalan, and G. Mocz, *Fisheries, Aquaculture and Biotechnology* (Agrobios, 2009), 27–34.

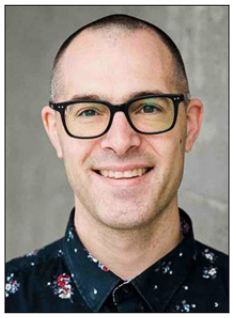
[39]Hall et al., "Toward a Theology of Sustainable Aquaculture," explored the concept of a "sustainable aquaculture" and included discussion of approaches to automation, robotics, and technology more generally.

[40]S.G. Hall and R.P. Price, "An Autonomous Scareboat to Reduce Bird Predation on Aquaculture Ponds," *Louisiana Agriculture* 46, no. 1 (2003): 4–6; Amanda Taylor et al., "Development of an Autonomous Boat for Sustainable Aquatic Plant Biomass Collection," paper 141900179 published by the American Society of Agricultural and Biological Engineers (ASABE) presented at ASABE, July 2014, Montreal, QC, https://doi.org/10.13031/aim.20141900179; and Daniel Smith et al., "Design of a Semi-autonomous Boat for Measurements of Coastal Sedimentation and Erosion," proceedings of a symposium held in New Orleans, LA, December 11–14, 2014, IAHS publication 367, 447–454, https://piahs.copernicus.org/articles/367/447/2015/piahs-367-447-2015.pdf.

[41]Michael Morrissey and Christina DeWitt, "Value-Added Seafood," chap. 13 in *Seafood Processing: Technology, Quality and Safety*, ed. Ioannis S. Boziaris (John Wiley & Sons, 2014), 343–58, https://doi.org/10.1002/9781118346174.ch13.

[42]A. K. Farmery et al., "Food for All: Designing Sustainable and Secure Future Seafood Systems," *Reviews in Fish Biology and Fisheries* 32, no. 1 (2022): 101–21, https://doi.org/10.1007/s11160-021-09663-x.

[43]Taher et al., "Impacts of Shrimp Aquaculture on the Local Communities."



Sam Pimentel

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Have You Seen the Storehouses of the Snow? Glaciers in the Anthropocene

Sam Pimentel

Within Christian theology, the beauty and grandeur of glaciated regions on Earth are seen as reflections of God's glory. These landscapes have spiritual significance in reminding us of God's power and majesty, as well as of the humility of our own humanity in relation to these awe-inspiring parts of God's creation. Yet, the current state and future prognosis of these regions also reflect humanity's desecration of God's glory in them. Projections indicate that with 1.5°C warming above preindustrial levels, 49% of the world's glaciers will disappear between 2015 and 2100. These losses have profound implications for society, particularly for the poor and vulnerable, including rising sea levels, diminished freshwater resources, and increased exposure to natural hazards. Any reduction in the ongoing temperature increase that can be achieved by humanity matters for the survival of glaciers. We must choose our future responsibly and embody God's care for these majestic parts of his creation and all who benefit from them. Christians, as witnesses to the God who creates and loves the world, have the privilege of advancing climate solutions that bring reconciliation to the world and maintain a place for glaciers within the community of creation.

Keywords: glaciers, climate change, Anthropocene, reconciliation, creation care, climate action, climate justice, water resources, sea level rise

Glaciers have shaped some of the most spectacular landscapes on Earth (fig.1).[1] In Christian theology, all of creation is viewed as a gift, loved into existence by God,[2] and glaciers are one of its most striking expressions. Everything in creation is intended by God to be a revelation, a self-disclosure; the world is full of God.[3] The sheer beauty and grandeur of glacierized regions of Earth reflect God's glory; they embody something of the divine presence.[4] They burst with joy in celebration of God's redeeming and renewing work.[5] The vast expanses of ice express the enormity and power of God. There is the unrelenting force of a glacier to level mountains and carve out valleys, to mold and make the landscape on such grand scales, and in its wake to leave the fertile places that sustain human and ecological communities.[6] Consideration of the spiritual significance of glaciers offers us an opportunity to ponder God's beauty, his power and his majesty, as well as the humility of our humanity in relation to these awe-inspiring parts of God's creation.[7] As biblical scholar Terence Fretheim writes, "the natural order provides raw materials for human praise … Human beings give voice to nonhuman praise, to a world charged with wonder and praise."[8] Glaciers are one such stunning example of this.

The Current State of Glaciers

Glacier ice represents by far the largest planetary store of freshwater. Nearly 90% of Earth's land ice is contained within Antarctica, with most of the remainder

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held in the Greenland Ice Sheet. In fact, only about 1% of the total volume of glacier ice is stored outside these ice sheets. Nonetheless, land ice masses that are separate from the continental ice sheets—hereafter referred to as "glaciers"—play an outsized role with respect to societal significance and are the focus of this article. For instance, according to one estimate, mountain glaciers account for 18.4% of the freshwater considered accessible for sustainable human use.[9] Glaciers are typically situated in steep, localized mountain environments and are of much smaller size; thus they are highly sensitive to climate change, responding to atmospheric and oceanic warming on shorter time scales, when compared to the ice sheets. As such, glaciers are one of the most visible indicators of a warming world and the ill effects of ice mass loss from glaciers are more immediately apparent. For example, ice melt from glaciers is contributing about 25% of the currently observed global sea level rise.[10]

The Randolph Glacier Inventory records 274,531 glaciers and ice caps on Earth,[11] located on mountain ranges from the tropics to the polar regions (see figs. 1 and 3) and encompassing an area of 706,744 km^2. The global glacier ice volume (apart from the ice sheets) is estimated to be 140,600 ± 40,400 km^3.[12] If all this ice were to melt completely, it would raise global sea levels by 0.311 ± 0.099 m.[13] This potential contribution is referred to as sea level equivalent (SLE).[14]

As evidenced by repeat photography, glaciers around the globe have been losing mass and retreating over recent decades (fig. 2). Changes in glacier mass have been carefully observed by multiple *in situ* monitoring programs. Although only a relatively small number of glaciers (a few hundred) are sampled with instrumentation, they form an important historical record of glacier change; in some cases, these glaciological measurements go back over 100 years.[15]

With the advent of geodetic methods that use precise geospatial techniques we can utilize spaceborne observations to monitor glaciers at the global scale, including in remote locations. Optical and radar sensors allow for the derivation of digital elevation models (DEM) of glacier surface topography. With repeat mapping and DEM differencing, we can determine multiyear trends in glacier elevation and track volume change for all glaciers in the world. Laser and radar altimetry are also used to provide higher temporal resolution along linear tracks, which can then be extrapolated to ascertain regional changes. Scientists have also utilized satellite gravimetry for determining glacier mass change by measuring changes in Earth's gravitational field which, after correcting for solid Earth and hydrological effects, reveal regional ice mass changes.

The combination of these methods—glaciological, DEM differencing, altimetry, and gravimetry—provides a robust and comprehensive picture of contemporary global glacier changes. By combining results from all major studies using these different techniques, it is estimated that the world has lost about 5% of its glacier ice since the year 2000.[16] The total amount of ice present is not uniformly distributed across regions, and there is considerable regional variability in glacier mass

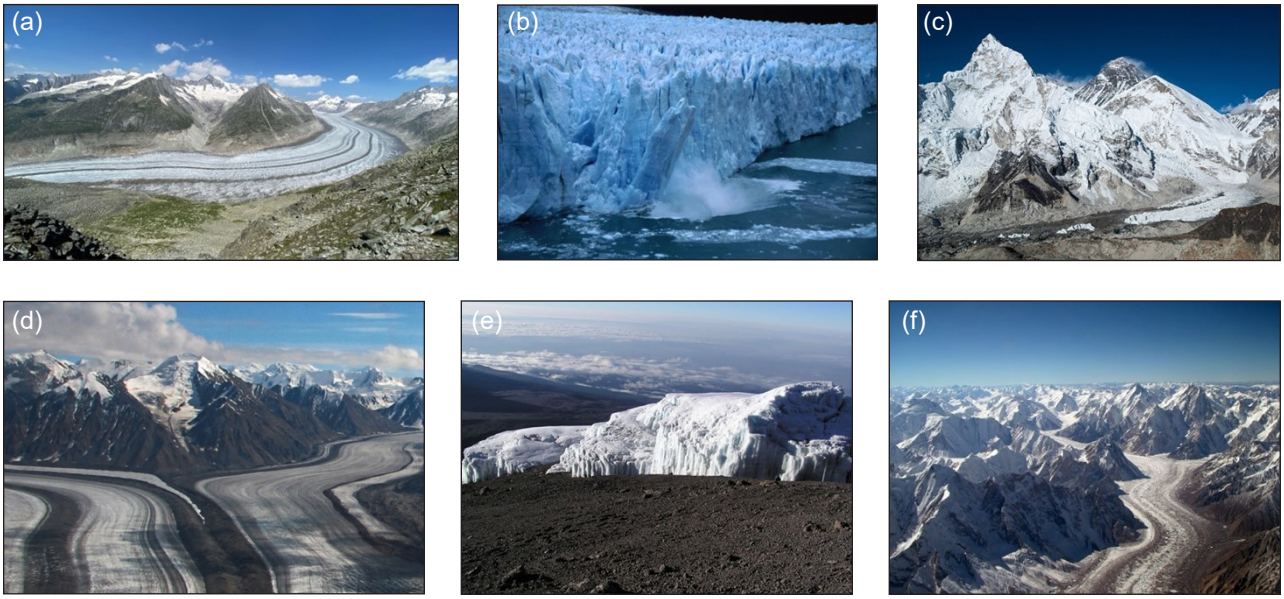

Figure 1. (a) Aletsch Glacier,[17] Switzerland; (b) Perito Moreno Glacier,[18] Argentina; (c) Khumbu Glacier,[19] Mount Everest, Tibet; (d) Kaskawulsh Glacier,[20] Yukon, Canada; (e) Rebmann Glacier,[21] Mount Kilimanjaro, Tanzania; (f) Baltoro Glacier,[22] Pakistan.

changes. For example, regions with comparatively large glacier volumes, such as the periphery of Antarctica and subantarctic, Arctic Canada North, and the Greenland periphery, experienced relatively modest losses between 2000 and 2023: approximately 2%, 3%, and 7%, respectively. In contrast, regions with smaller total ice volumes, such as Western Canada and USA, Central Europe, and New Zealand, saw much larger percentage losses over the same period: about 23%, 39%, and 29%, respectively.[23]

Hugonnet et al. provided the first globally complete and consistent estimate of 21st-century glacier mass change, using highly resolved estimates based on differencing DEM.[24] In light of this and several other studies, the Intergovernmental Panel on Climate Change Sixth Assessment Report (IPCC AR6) concludes that the global mass loss rate during the period 2000–2019 is 267 ± 16 Gt/year (Gt = gigatonne = 1,000,000,000 tonnes or 1 billion metric tons, where 1 metric ton = 1000 kg).[25] This means that each year glaciers lose roughly the same amount of mass as the total water consumed by every person on Earth over 30 years.[26] The mass loss rate has increased from 240 ± 9 Gt/year during 2000–2009 to 290 ± 10 Gt/year in 2010–2019.[27] It can be concluded, with very high confidence, that glaciers lost more mass during 2010–2019 than in any previous decade since the beginning of the observational record.[28]

The Human Influence on Glacier Change

The key variable connecting glaciers to climate is the mass balance of gain to loss over time. Throughout the year, a glacier can gain mass through snow accumulation and lose mass due to melt and other processes. The net result of these gains and losses, the balance of inputs to outputs, determines any change to the size of the glacier. A positive mass balance causes a glacier to thicken and advance, while a negative mass balance leads to thinning and retreat. As such, the mass balance is the most critical measure of a glacier's health and a direct indicator of its response to climate change.

Over geological timescales, Earth has experienced multiple glaciation events during which continental-scale ice sheets have covered much of the planet, profoundly reshaping the landscape. These glacial-interglacial cycles are a natural feature of the unfolding of God's creation and a fundamental characteristic of Earth's history over the past 2.5 million years (the Quaternary Period). Long-term climate variability is driven primarily by changes in Earth's orbit, known as the Milankovitch cycles. The past 11,700 years demarcate the latest interglacial period, that is, the current geological epoch called the Holocene. During this time, glaciers retreated to their minimum extent about 6,000 to 8,000 years ago, followed by a gradual expansion that culminated in a new maximum between the mid-15th to late 19th centuries.[29]

Over the past century or so, humanity has emerged as a planetary force, driving profound environmental changes—a shift often referred to as the Anthropocene.[30] Human activities, principally the burning of fossil fuels, have caused concentrations of atmospheric greenhouse gases to rise to levels unprecedented in at least the last 800,000 years.[31] As a result, global average surface temperatures rose to 1.1°C above the 1850–1900 baseline during the 2011–2020 period.[32] This atmospheric warming is the primary driver of contemporary global glacier recession. In some regions, precipitation changes or internal glacier dynamics have also modified the temperature-induced glacier response.

Today, the vast majority of the world's glaciers have a negative mass balance; hence, they are out of equilibrium with the current climate and are losing mass. Furthermore, because the response is lagged, even if global temperatures stabilize, glaciers will continue

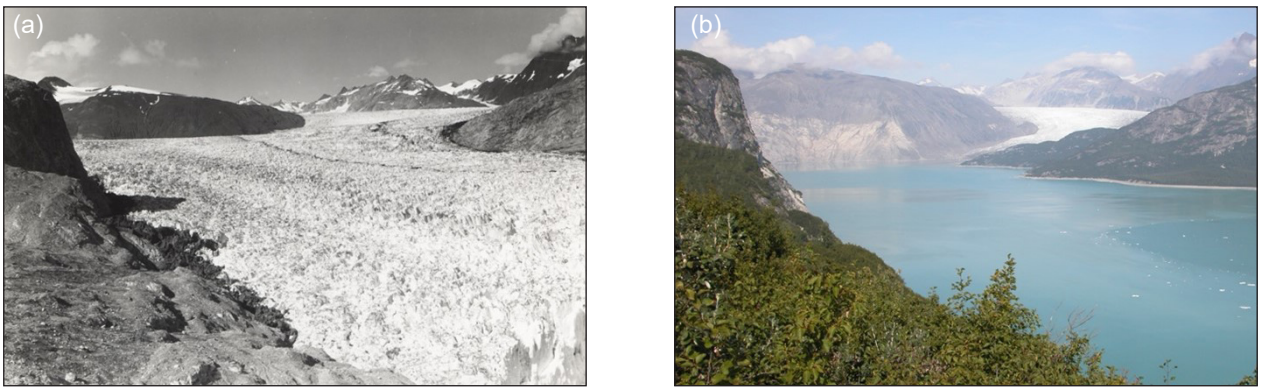

Figure 2. Muir Glacier, Alaska, USA, in (a) 1941,[33] and (b) 2004.[34]

to lose mass in the near future. The reason: although glacier mass loss is directly connected to increasing atmospheric temperatures, a glacier's response to those changes can take decades.

Attribution studies have demonstrated that the observed centennial-scale retreat of glaciers far exceeds the length fluctuations that would have occurred due to natural climate variability alone.[35] For alpine valley glaciers, it has been estimated that 85–130% of the observed cumulative mass loss since 1850 is a result of anthropogenic warming (a value over 100% indicates that, in the absence of human influence, glaciers would have gained mass).[36] Hence, contemporary glacier retreat and mass loss are entirely a consequence of human-caused climate change, which has fundamentally disrupted the patterns of natural variability.

Glaciers at the End of the Twenty-First Century

The future of glaciers is dependent on greenhouse gas emission scenarios. A recent comprehensive study by Rounce et al. have run individual model simulations of every glacier on Earth.[37] For each glacier, an ice dynamic model is "forced" with a suite of potential future climates out to 2100. This study projects that glaciers are set to lose between 26 ± 6% (+1.5°C warming) to 41 ± 11% (+4°C warming) of their mass by 2100, relative to 2015, depending on the global temperature change scenario (fig. 3).[38] This corresponds to the disappearance of 49 ± 9% (+1.5°C) to 83 ± 7% (+4°C) of the world's glaciers; note that most glaciers are small and thus inherently more vulnerable.[39]

Impacts of Glacier Loss

The ongoing decline of glaciers due to climate change will have major societal and ecological outcomes. Melting glaciers are a significant contributor to contemporary sea level rise. Sea level rise includes a steric component (thermal expansion) and a mass component (melt from glaciers and ice sheets, as well as land water storage changes). Melt specifically from glaciers contributes about a quarter of the total sea level rise.[40] The projected loss of glacier ice mass by 2100 corresponds to

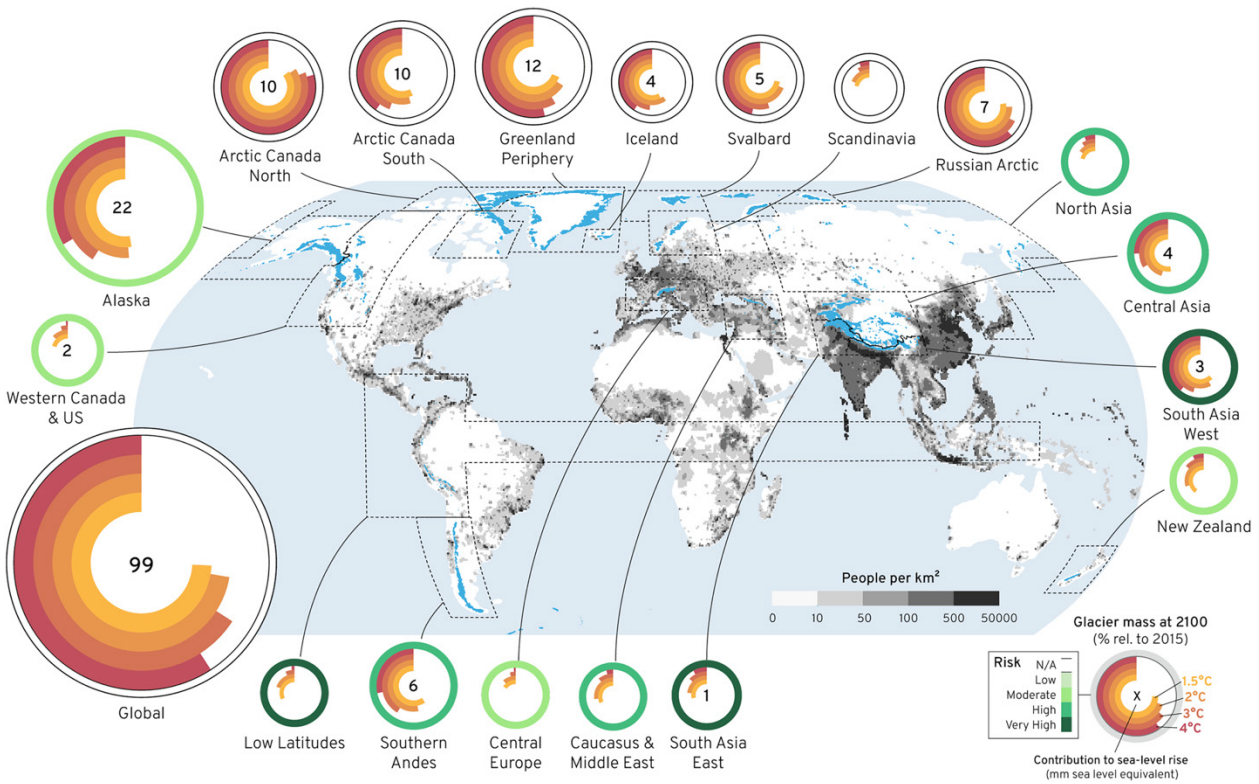

Figure 3. Regional glacier mass change and contributions to sea-level rise from 2015 to 2100. Disks show global and regional projections of glacier mass remaining by 2100, relative to 2015, for global mean temperature change scenarios. Disks are scaled based on each region's contribution to global mean sea-level rise from 2015 to 2100 for the +2°C scenario by 2100 relative to preindustrial levels. Nested rings are colored by temperature change scenarios showing normalized mass remaining in 2100. Regional sea-level rise contributions larger than 1 mm sea-level equivalent (SLE) for the +2°C scenario are printed in the center of the ring charts. The color of the rings for each region indicates the risk to livelihoods and the economy from changing mountain water resources between 1.5 and 2°C global warming. The gridded population density (people per km^2) is also shown (grey scale). Glaciers are shown in blue.[41]

an expected sea level rise of 90 ± 26 mm under a +1.5°C scenario, and 154 ± 44 mm under a +4°C scenario (see fig. 3).[42] It is estimated that 190 million people currently live on land that is projected to be below the high-tide mark in 2100 under a low emission scenario.[43] These coastal communities will become increasingly vulnerable to storm surges and flooding events, putting infrastructure and livelihoods at risk.[44]

Glaciers are effective water towers, as they play a critical role in the storage and supply of freshwater that is vital for many mountain regions (fig. 4). It is estimated that at least 1.9 billion people live in or downstream of mountain areas that receive water from glaciers.[45] This includes the high population density in the regions of High Mountain Asia, which are particularly vulnerable as they rely on glaciers for water, energy, and food security (see fig. 3). Glacier melt is seasonal and can play a buffering role as it delays the supply of melt water, compensating for water shortages during the dry season, and thus reducing drought frequency and severity. The loss of these vast storage containers of freshwater (mountain water towers) depletes regional freshwater resources as the ability of glaciers to retain and release water is diminished.

The decline and loss of glaciers affects the local mountain environment causing changes in water flow and sediment transport, and creating slope instabilities that can trigger landslides.[46] Their melting leads to increased geohazards putting local populations at risk. As glacial ice mass loss accelerates, we are witnessing an increase in glacial lakes, exposing around 15 million people to serious damage from potential glacial lake outburst floods.[48]

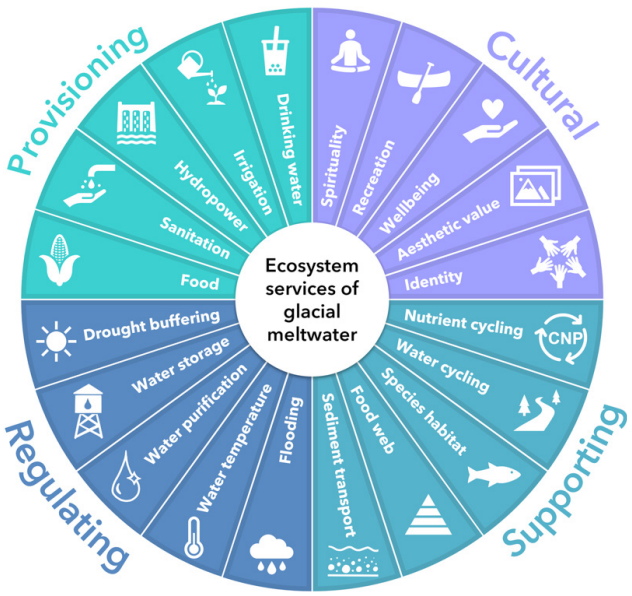

Figure 4. Examples of the cultural, provisioning, regulating, and supporting ecosystems services provided by glacial meltwater in mountain regions.[47]

Many hydroelectric power plants are principally glacier fed. As glacier runoff declines, the reduction in streamflow will reduce hydropower output, putting at risk a major source of renewable energy. Hydropower infrastructure is also vulnerable to the destabilization of the local landscape due to glacier loss that can produce slope failures and increased sediment fill.[49]

Glaciers preserve important records of past climates. Isotope content and soluble impurities trapped in the ice can be sampled through ice cores and used to reconstruct the regional environmental conditions of the past. However, the valuable "memory" stored in these natural archives is being permanently lost or contaminated due to melt caused by climate change.[50]

Glaciers hold deep cultural value.[51] For example, of the 247 natural World Heritage sites listed for their outstanding universal value,[52] 46 contain glaciers.[53] For five of those sites, glaciers are the principal reason for their status, and for 28 sites, they are a contributing factor.[54] However, for between 8 and 21 of those World Heritage sites, glaciers will become extinct through mass wastage by 2100, depending on the future emission scenario.[55] Glaciers also hold profound cultural and spiritual significance for many Indigenous cultures around the world and are an important feature in oral histories and storytelling. The disappearance of glaciers on ancestral lands represents a profound loss to cultural heritage and identity, not to mention the glaciers' life-sustaining water and ecosystem services that will disrupt the traditional ways of life for Indigenous communities.

The global retreat of glaciers is altering terrestrial and marine biodiversity. Mountain glacier ecosystems host diverse habitats, but rising temperatures and the loss of meltwater are modifying environmental conditions and putting these communities at risk.[56] As glaciers recede, proglacial and postglacial habitats emerge in the newly exposed ice-free terrain, creating opportunities for ecological succession and colonization.[57] In alpine river catchments, the diminishing glacial influence reduces cold-water inputs, affecting species adapted to stable, low-temperature environments.[58] In marine settings, tidewater glaciers function as nutrient delivery systems, enriching fjord waters with macro- and micronutrients that support plankton, fish, and seabirds. Consequently, changes in glacial meltwater delivery may undermine the productivity and viability of these communities.[59]

Climate Justice

The Anthropocene has brought about worldwide glacier retreat and decline. This is unequivocally a result of atmospheric warming driven by anthropogenic emissions. At the heart of this lies a justice issue, as those who have contributed least to this crisis are the ones who are most vulnerable to current and future changes. The poorest, the least protected, and the least resilient populations will bear the heaviest burdens.[60] Risks are not evenly distributed, and there is disproportionate exposure to harm (see fig. 3). Those living in low-lying coastal zones are in direct danger from sea-level rise driven by glacier melt. Meanwhile, communities downslope of glacierized mountain regions suffer from the loss of critical seasonal freshwater from mountain water towers. Moreover, future generations will live in a world with far fewer glaciers. They will not have contributed to this loss, yet they will nonetheless be impoverished by it. This raises the question of intergenerational justice, of what we owe to those who come after us, and of the fairness in the provision and legacy we leave behind. There is also the sense of the justice we owe to the glaciers themselves, to the ecological spaces they shape, and to the habitats they sustain. We must ask whether our interaction with the world allows glaciers to fulfill their fitting role within creation, or whether it disrupts their God-given purpose. These glaciological systems carry something of God's intention and invitation; they are an expression of God's gift to us. We should care about the glaciers because God does. It is not simply about human concerns, but justice for the whole community of creation, doing what is fair and true and fitting.

Reconciliation and Climate Action

Figure 3 illustrates that each projected increase in global mean temperature is associated with corresponding glacier mass loss.[61] Our policies and actions to curb greenhouse gas emissions are directly linked to the extent to which glaciers survive. Indeed, it has been calculated that every kilogram of CO_2 emission would eventually be responsible for about 16kg of glacial ice loss.[62] It is inevitable that we will continue to experience glacier loss and retreat; however, the differences between a 2-, 3-, and 4-degree world to global glacier coverage is stark (see fig. 3). We choose the differences now by the policies we enact today. These findings call for urgent and concrete actions to limit anthropogenic climate change.

Glacier mass loss can be halted only when glaciers are in balance with their climate and have had the necessary time to return to equilibrium. Global average temperatures must be stabilized to slow the acceleration of ice mass loss and the resulting consequences. Reaching net-zero[63] anthropogenic CO_2 emissions is a requirement to stabilize human-induced global temperature increase at any level. Transformative actions are required to achieve this, including improving energy efficiency; transitioning to renewable energy sources, particularly wind and solar; reducing deforestation and promoting reforestation; limiting the release of short-lived climate pollutants; and implementing technologies to remove and store CO_2 from the atmosphere—all whilst adapting to unavoidable changes.[64] Many of these actions have health and economic co-benefits.

Efforts to save glaciers, such as glacier blanketing—the practice of laying geotextiles across glacier surfaces to reduce ablation,[65] and building ice stupas—a form of glacier grafting to create artificial glaciers built to store winter water for spring irrigation,[66] demonstrate both human ingenuity and a commitment to environmental stewardship. These interventions reflect values such as care for creation, justice for climate-affected local populations, and community responsibility to future generations. Adaptive measures, while valuable, cannot prevent all losses or damages, which will continue to be unequally distributed and concentrated among the poorest and most vulnerable populations.[67]

Psalm 1:1[68] describes a transition from walking to standing to sitting. Where are we, as a society and as individuals, on our moral journey when it comes to climate change? Are we becoming increasingly sedentary with inaction as we sit around paying heed to the climate naysayers? Do we scoff or stand about as we wait for our scientific predictions to come true? Or should we walk the narrow path in pursuit of the kinds of choices that climate justice calls for, living with honesty and humility, and seeking Christ-like ways to relate to the world that God has entrusted to us?[69] What future climate pathway will we choose?[70] How many glaciers will we bequeath to future generations? What an awesome responsibility and challenge! Rather than fearing or denying climate change, we can embrace it as an opportunity for reconciliation.

Christian faith gives us well-grounded hope. Throughout scripture the Christian hope is directed toward what is not yet visible, a "hoping against hope." Despite human-driven degradation of glaciers and glacierized habitats, the life-giving Spirit of God remains at work. For example, receding glaciers give rise to new proglacial and postglacial landscapes, quickly pioneered by species, forming new habitat niches.[71] The recession of marine-terminating glaciers opens up new

spawning routes for salmon.[72] The loss of glacier tourism instead might result in new recreational activities such as hiking routes in the newly uncovered territory.[73] Melting glacier margins sometimes reveal remains that can shed light on past societies and ecosystems, spurring a new subdiscipline called ice patch archeology.[74]

In the words of Saint Paul in Romans, the whole of creation groans in frustration as it awaits redemption.[75] Applying his anthropomorphic characterization of nature, as glaciers recede and become remnants of their former stature, they yearn to be set free, to flourish, to be in harmony with their climate, to become a place of healing and reconciliation, and to be a visible reflection of God's glory.

God's grace is inbuilt into creation. With a favorable climate, over time glaciers can be restored and regrow. For example, in the decades following the cataclysmic eruption in 1980 of Mount St. Helens, Washington, USA, heavy winter snowfall and avalanches led to the rapid growth and formation of a new glacier within the deeply shaded niche of the crater. This newly formed glacier is now the largest on Mount St. Helens exceeding all other remaining glaciers in extent.[76]

Continuing scientific endeavors to monitor and simulate glaciers is vital for understanding the impact of climate change and accurately projecting future freshwater resources and sea-level rise. The work of glaciologists helps us live out our calling as co-creators by equipping us to make informed decisions that shape a future of flourishing for glaciers, humanity, and the whole community of creation.[77] Transformative actions, both mitigation and adaptation, to limit glacier loss and care for those most at risk are urgently needed to protect life and promote well-being, global equity, and safety.

Notes

[1]The title is a reference to Job 38:22, "*Have you entered the storehouses of the snow or seen the storehouses of the hail …?*" Although the verse isn't explicitly referring to glaciers, it seems an apt title. The writer of Job here imagines some great cache for storing these primal meteorological forces of nature from which God can dispense weather's wrath. Glaciers form from snowfall accumulated over many years. As layers of snow build up, they are compacted into firn (an intermediate stage between snow and glacial ice), and with continued compression and recrystallization, glacier ice is formed. Eventually, the mass of ice deforms and flows under the force of gravity. Although it can snow in Jerusalem and surrounding areas, there are no glaciers in the biblical geographical region. The closest would be the glaciers that are present in Turkey and extremely remote regions of Iran. As such, the biblical authors would presumably be unaware of the existence of glaciers. It is interesting to imagine how the writer of Job, who is so attuned to describing the natural world, would have described glaciers. For example, Job 6:15–18:

> My brothers betrayed like a wadi,
> like the channel of brooks that run dry.
> They are dark from the ice,
> snow heaped on them.
> When they warm, they are gone,
> in the heat they melt from their place.
> The paths that they go on are winding,
> they mount in the void and are lost.

is a beautiful and perceptive passage comparing Job's portrayal to a wadi, a desert stream that dries up. The author describes the seasonal cycle with the ice and snow heaped on top followed by warming that melts the snow and so on. Presumably the author of Job here has in mind the Lebanese mountains where there is significant seasonal snowfall.

[2]See, for example, Simon Oliver, *Creation: A Guide for the Perplexed* (Bloomsbury, 2017).

[3]See, for example, "The whole earth is full of God's glory" (Isa. 6:3); "The Lord's kindness fills the earth" (Ps. 33:5); "Do I not fill heaven and earth? says the LORD" (Jer. 23:24).

[4]The Christian tradition has held that the manifestation of the divine is through both the natural world and the biblical world. In the words of Thomas Berry, "to save Earth is an essential part of saving the pristine divine presence" (Thomas Berry, *The Christian Future and the Fate of Earth* [republished by Maryknoll, 2009], **38**). In the context of this article, it would be appropriate and relevant to replace "Earth" with "glaciers" in the above quote.

[5]See Isa. 55:12: "… the mountains … burst into song …"

[6]See, for example, Job 14:18–19:

> "… the mountain falls and crumbles away,
> and the rock is removed from its place;
> the waters [ice!?] wear away the stones;
> the torrents wash away the soil of the earth …"

[7]See, for example, the Psalmist's humility in response to God's awe-inspiring creation, "What are human beings that you are mindful of them?" (Ps. 8:4). A more in-depth exploration of this theme can be found in a chapter on wonder and humility in Steven Bouma-Prediger, *Earthkeeping and Character: Exploring a Christian Ecological Virtue Ethic* (Baker Academic, 2020), 29–50.

[8]Terence Fretheim, *God and World in the Old Testament: A Relational Theology of Creation* (Abingdon Press, 2005), 284.

[9]Matthew Mccartney et al., "Change in Global Freshwater Storage," *International Water Management Institute (IWMI)*, IWMI Working Paper 202, 2022, https://www.researchgate.net/publication/359586409_Change_in_Global_Freshwater_Storage.

[10]Romain Hugonnet et al., "Accelerated Global Glacier Mass Loss in the Early Twenty-First Century," *Nature* 592, no. 7856 (2021): 726–31, https://doi.org/10.1038/s41586-021-03436-z.

[11]RGI Consortium, "Randolph Glacier Inventory—A Dataset of Global Glacier Outlines, Version 7," NASA National Snow and Ice Data Center Distributed Active Archive Center, 2023, https://doi.org/10.5067/F6JMOVY5NAVZ.

[12]Romain Millan et al., "Ice Velocity and Thickness of the World's Glaciers," *Nature Geoscience* 15 (2022): 124–29, https://doi.org/10.1038/s41561-021-00885-z; Regine Hock et al., "What Is the Global Glacier Ice Volume Outside the

Ice Sheets?," *Journal of Glaciology* 69, no. 273 (2023): 204–10, https://doi.org/10.1017/jog.2023.1.

[13]Millan et al., "Ice Velocity and Thickness of the World's Glaciers"; and Hock et al., "What Is the Global Glacier Ice Volume?"

[14]To calculate SLE, the total ice volume above flotation is used—that is, the portion of the glacier ice that is not already displacing seawater. Approximately 15% of the global glacier volume is already submerged below sea level at grounded tidewater termini and thus would not contribute to sea level when melted. The above flotation volume is converted to the equivalent volume it would occupy in the ocean, accounting for the difference in density between ice and seawater, and this volume is then divided by the total surface area of the world's oceans to produce SLE. A commonly used approximation is that 361.8 gigatonnes (Gt) of ice correspond to 1 millimetre (mm) of global mean sea level rise.

[15]WGMS Global Glacier Change Bulletin No. 5 (2020–2021) (ISC(WDS)/IUGG(IACS)/UNEP/UNESCO/WMO, World Glacier Monitoring Service, 2023); https://doi.org/10.5904/wgms-fog-2023-09. The longest continuous mass-balance monitoring program is at Claridenfirn, Switzerland, with measurements dating from 1914.

[16]The GlaMBIE Team, "Community Estimate of Global Glacier Mass Changes from 2000 to 2023," *Nature* 639 (2025): 382–88, https://doi.org/10.1038/s41586-024-08545-z.

[17]Photo taken July 28, 2020, by Lakabo1977, shared under the Creative Commons License.

[18]Photo taken 1994 by Christof Berger, shared under the Creative Commons License.

[19]Photo taken October 19, 2009, by Vyacheslav Argenberg, shared under the Creative Commons License.

[20]Photo taken July 26, 2005, by Steffen Schreyer, shared under the Creative Commons License.

[21]Photo taken August 14, 2003, by Ansel Adams, shared under the Creative Commons License.

[22]Photo taken October 23, 2005, by Guilhem Vellut, shared under the Creative Commons License.

[23]The GlaMBIE Team, "Community Estimate."

[24]Hugonnet et al., "Accelerated Global Glacier Mass Loss."

[25]IPCC, *Climate Change 2021: The Physical Science Basis*. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, ed. V. Masson-Delmotte et al. (Cambridge University Press, 2021).

[26]Assuming a daily water intake for 1 person is 3 litres, total daily water intake of 8 billion people is 24 billion litres; total water intake of 8 billion people for thirty years is 263 trillion litres (or 263 gigatonnes). This is less than the 273 gigatonnes of glacier ice mass lost annually over the period 2000 to 2023 (see The GlaMBIE Team, "Community Estimate").

[27]IPCC, *Climate Change 2021: The Physical Science Basis*.

[28]IPCC, *Climate Change 2021: The Physical Science Basis*.

[29]Olga N. Solomina et al., "Holocene Glacier Fluctuations," *Quaternary Science Reviews* 3 (2015): 9–34, http://dx.doi.org/10.1016/j.quascirev.2014.11.018.

[30]Although not formally recognized as a geological epoch, the Anthropocene remains an important and widely used concept across many disciplines. See, for example, Jan Zalasiewicz et al., "The Meaning of the Anthropocene: Why It Matters Even Without a Formal Geological Definition," *Nature* 632 (2024): 980–84, https://doi.org/10.1038/d41586-024-02712-y.

[31]According to the IPCC (2023), atmospheric CO_2 concentrations are now higher than any time in at least 2 million years, while methane and nitrous oxide levels are at their highest in at least 800,000 years. See "Summary for Policymakers," in *Climate Change 2023: Synthesis Report*. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, ed. Core Writing Team, H. Lee, and J. Romero (IPCC, 2023), 1–34, https://doi.org/10.59327/IPCC/AR6-9789291691647.001.

[32]IPCC, "Summary for Policymakers."

[33]William Osgood Field, 1941. Muir Glacier: From the Glacier Photograph Collection. Boulder, Colorado USA: National Snow and Ice Data Center, digital media, https://nsidc.org/data/glacier_photo/search/image_info/muir1941081301.

[34]Bruce F. Molnia, 2004. Muir Glacier: From the Glacier Photograph Collection. Boulder, Colorado USA: National Snow and Ice Data Center. Image courtesy of the U.S. Geological Survey.

[35]Gerard H. Roe et al., "Centennial Glacier Retreat as Categorical Evidence of Regional Climate Change," *Nature Geoscience* 452 (2017): 95–99, https://doi.org/10.1038/ngeo2863.

[36]Gerard H. Roe et al., "On the Attribution of Industrial-Era Glacier Mass Loss to Anthropogenic Climate Change," *The Cryosphere* 15, no. 4 (2021): 1889–1905, https://doi.org/10.5194/tc-15-1889-2021.

[37]David R. Rounce et al., "Global Glacier Change in the 21st Century: Every Increase in Temperature Matters," *Science* 379, no. 6627 (2023): 78–83, https://doi.org/10.1126/science.abo1324.

[38]Rounce et al., "Global Glacier Change."

[39]Rounce et al., "Global Glacier Change."

[40]Martin Horwath et al., "Global Sea-Level Budget and Ocean-Mass Budget, with a Focus on Advanced Data Products and Uncertainty Characterisation," *Earth System Science Data* 14, no. 2 (2022): 411–47, https://doi.org/10.5194/essd-14-411-2022; and Hugonnet et al., "Accelerated Global Glacier Mass Loss."

[41]Figure taken from Mercedes Bustamante et al., "Ten New Insights in Climate Science 2023," *Global Sustainability* 7 (2023): e19, https://doi.org/10.1017/sus.2023.25, which makes use of source data from Rounce et al., "Global Glacier Change"; and IPCC, *Climate Change 2022: Impacts, Adaptation, and Vulnerability,* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, ed. H.-O. Pörtner et al. (Cambridge University Press, 2023). Reproduced under the Creative Commons License.

[42]Rounce et al., "Global Glacier Change."

[43]Scott A. Kelp and Benjamin H. Strauss, "New Elevation Data Triple Estimates of Global Vulnerability to Sea-Level Rise and Coastal Flooding," *Nature Communications* 10 (2019): 4844, https://doi.org/10.1038/s41467-019-12808-z.

[44]Kelp and Strauss, "New Elevation Data"; see also B.C. Glavovic et al., "Cross-Chapter Paper 2: Cities and Settlements by the Sea," in *Climate Change 2022*, 2163–94, https://doi.org/10.1017/9781009325844.019.

[45]W. W. Immerzeel et al., "Importance and Vulnerability of the World's Water Towers," *Nature* 577 (2020): 364–69, https://doi.org/10.1038/s41586-019-1822-y.

[46]See, for example, John J. Clague and Dan H. Shugar, "Impacts of Loss of Cryosphere in the High Mountains of

Northwest North America," *Quaternary* 6, no. 1 (2023): 1, https://doi.org/10.3390/quat6010001.

[47]Figure taken from Caroline Clason et al., "Contribution of Glaciers to Water, Energy and Food Security in Mountain Regions: Current Perspectives and Future Priorities," *Annals of Glaciology* 63, no. 87–89 (2022): 73–78, https://doi.org/10.1017/aog.2023.14. Reproduced under the Creative Commons License.

[48]Caroline Taylor et al., "Glacial Lake Outburst Floods Threaten Millions Globally," *Nature Communications* 14 (2023): 487, https://doi.org/10.1038/s41467-023-36033-x. The observed increase in the number and size of glacier lakes may result in an associated increase in glacial lake outburst flood (GLOF) hazards; however, this relationship is complex. For example, Georg Veh et al., "Progressively Smaller Glacier Lake Outburst Floods Despite Worldwide Growth in Lake Area," *Nature Water* 3 (2025): 271–83, https://doi.org/10.1038/s44221-025-00388-w. Furthermore, the risks associated with GLOFs are highly context-dependent, influenced by the size and economic vulnerability of exposed populations.

[49]Dongfeng Li et al., "High Mountain Asia Hydropower Systems Threatened by Climate-Driven Landscape Instability," *Nature Geoscience* 15 (2022): 520–30, https://doi.org/10.1038/s41561-022-00953-y.

[50]See, for example, C. J. Huber et al., "High-Altitude Glacier Archives Lost Due to Climate Change-Related Melting," *Nature Geoscience* 17 (2024): 110–13, https://doi.org/10.1038/s41561-023-01366-1.

[51]For an interesting discussion of evolving views within glacier–mining interactions, see Caroline White-Nockleby and Scott Odell, "From Obstacles to Heritage: The Shifting Status of Glaciers Across 150 Years of Mining Research," *Energy Research & Social Science* 121 (2025): 103953.

[52]That is, their natural beauty or importance for geological and biological diversity and processes.

[53]J.-B. Bosson et al., "Disappearing World Heritage Glaciers as a Keystone of Nature Conservation in a Changing Climate," *Earth's Future* 7, no. 4 (2019): 469–79, https://doi.org/10.1029/2018EF001139.

[54]Bosson et al., "Disappearing World Heritage Glaciers."

[55]Bosson et al., "Disappearing World Heritage Glaciers."

[56]Scott Hotaling et al., "Microbial Ecology of Mountain Glacier Ecosystems: Biodiversity, Ecological Connections and Implications of a Warming Climate," *Environmental Microbiology* 19, no. 8 (2017): 2935–48, https://doi.org/10.1111/1462-2920.13766.

[57]J. B. Bosson et al., "Future Emergence of New Ecosystems Caused by Glacial Retreat," *Nature* 620 (2023): 562–69, https://doi.org/10.1038/s41586-023-06302-2; and Gentile Francesco Ficetola et al., "The Development of Terrestrial Ecosystems Emerging After Glacier Retreat," *Nature* 632 (2024): 336–42, https://doi.org/10.1038/s41586-024-07778-2.

[58]M. A. Wilkes et al., "Glacier Retreat Reorganises River Habitats Leaving Refugia for Alpine Invertebrate Biodiversity Poorly Protected," *Nature Ecology and Evolution* 7 (2023): 841–51, https://doi.org/10.1038/s41559-023-02061-5.

[59]Mayumi L. Arimitsu et al., "Influence of Glacier Runoff on Ecosystem Structure in Gulf of Alaska Fjords," *Marine Ecology Progress Series* 560 (2016): 19–40, https://doi.org/10.3354/meps11888.

[60]Although glaciers are not a focus, see Christiana Zenner, *Just Water: Theology, Ethics, and Fresh Water Crises*, rev. edition (Orbis Books, 2018), for a lens on climate justice issues related to water more broadly, one that is rooted in the Catholic ecological thought of Pope Francis's *Laudato Si': On Care for Our Common Home* (Paulist Press, 2015).

[61]Rounce et al., "Global Glacier Change."

[62]Ben Marzeion et al., "Limited Influence of Climate Change Mitigation on Short-Term Glacier Mass Loss," *Nature Climate Change* 8 (2018): 305–8, https://doi.org/10.1038/s41558-018-0093-1.

[63]Net zero means the amount of CO_2 that humans emit into the atmosphere is matched by the amount removed by natural or technological means.

[64]IPCC, *Climate Change 2022: Mitigation of Climate Change,* contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, ed. P.R. Shukla et al. (Cambridge University Press, 2022).

[65]Carey Clouse, "Glacier Blanketing: Two Approaches in the European Alps," *Journal of Landscape Architecture* 17, no. 3 (2022): 70–83, https://doi.org/10.1080/18626033.2022.2195246.

[66]Carey Clouse, "The Himalayan Ice Stupa: Ladakh's Climate-Adaptive Water Cache," *Journal of Architectural Education* 71, no. 2 (2017): 247–51, https://doi.org/10.1080/10464883.2017.1340781.

[67]"'Truly I tell you, whatever you did for one of the least of these brothers and sisters of mine, you did for me'" (Matt. 25:40).

[68]"Blessed is the one
who does not walk in step with the wicked
or stand in the way that sinners take
or sit in the company of mockers" (Ps. 1:1).

[69]For a theological framing of Christ-like ways of responding to climate change, see Gijsbert van den Brink, "King, Priest, Prophet, and Climate Science: Ecological Implications of the Threefold Office," *Perspectives on Science and Christian Faith* 76, no. 3 (2024): 154–64, https://doi.org/10.56315/PSCF12-24vandenBrink. See also Katharine Hayhoe, *Saving Us: A Climate Scientist's Case for Hope and Healing in a Divided World* (Atria/One Signal Publishers, 2021), especially for the role of shared values and relational trust in motivating climate action.

[70]"All the LORD's paths are kindness and truth,
for the keepers of His pact and His precepts" (Ps. 25:10).

[71]See Bosson et al., "Future Emergence."

[72]Kara J. Pitman et al., "Glacier Retreat Creating New Pacific Salmon Habitat in Western North America," *Nature Communications* 12 (2021): 6816, https://doi.org/10.1038/s41467-021-26897-2.

[73]Examples of popular glacier tourism sites include Athabasca Glacier in Alberta, Canada, and Bashui Glacier No. 1 in Yunnan, China, which have attracted millions of visitors, as well as cruise ships visiting Glacier Bay National Park in Alaska, USA.

[74]See, for example, Lisa Baril, *The Age of Melt: What Glaciers, Ice Mummies, and Ancient Artifacts Teach Us About Climate Change* (Timber Press, 2024).

[75]Romans 8:22–23.

[76]Steve P. Schilling et al., "Posteruption Glacier Development Within the Crater of Mount St. Helens, Washington, USA," *Quaternary Research* 61 (2004): 325–29.

[77]"Human beings are God's created co-creators whose purpose is to be the agency, acting in freedom, to birth the future that is most wholesome for the nature that has birthed us" from Philip Hefner, *The Human Factor: Evolution, Culture, and Religion* (Fortress Press, 1993), 27.

Bioethics

DOI: https://doi.org/10.56315/PSCF9-25GoundreySmith

CHRISTIAN ETHICS AND BIOMEDICAL INNOVATION by Stephen Goundrey-Smith. Lexington Books, 2025. 304 pages. Hardcover; $130.00. ISBN: 9781666953602.

Stephen Goundrey-Smith is an associate tutor in Christian ethics and doctrine at Cuddesdon Gloucester & Hereford, England. His PhD research was in the Department of Theology and Religion at the University of Exeter, on transhumanism and medical/therapeutic ethics. That led to his book *Transhumanism, Ethics and the Therapeutic Revolution: Agents of Change* (Routledge, 2023). The book under review here continues the same theoretical methodology. Its most telling contribution is calling for dialogue about what helps people flourish, new medical technologies, and public policy.

Chapter 1 states three relevant topics in the Christian ethical tradition: the goodness of creation, humanity in the image of God, and human vocation in the material world. Chapter 2 argues that the currently dominant, utilitarian, and individual-driven method of health technology assessment should be augmented to consider "social justice and autonomy," "embodiment and identity," "status of the person and human dignity," and "immortality and destiny." Chapter 3 recognizes the importance of public institutions for how biomedical innovations are implemented. Chapter 4 advocates that public deliberation will be more successful if it is focused on values rather than on ethics. Chapter 5 calls for biomedical technology, ethics, and public policy to work together. The last chapter, chapter 6, lauds as a model Augustine's early fifth-century book, *The City of God*. There we see appeals to "the common good." Goundrey-Smith believes that, with concerted effort, pursuing the common good can develop an ethical consensus amidst pluralist societies then and now. While this book is centered on hope for such a consensus today, how that should be practiced is not specifically articulated.

Natural law also plays a substantial role in the author's discussion, but not as the often-cited appeal to consider our first created form as a given and set ideal. Since Goundrey-Smith is considering technology that aims to alter our nature, which would then change what fulfills it, he appeals to natural law as pursuing God's future purpose for humanity. The start of humanity was but a beginning, not a pinnacle to return to. "Humanity, as created co-creator, mediates God's creative power in the material world" (p. 258).

While highlighting its titled topic is the book's most important contribution, its greatest weakness is that it tries to encompass an already broad purpose, extending the inquiry even wider to make a plethora of distantly related observations. For example, to address the already daunting task of defining "the common good," the text begins by discussing the modern nation-state as it was first formed in the sixteenth century. To help readers follow through such disparate musings, the book often offers directions such as those found in just one paragraph on page 71:

> I will discuss this issue in greater detail in a later section of this chapter. However, in order to facilitate discussion on the ethical impact of biomedical technologies in subsequent chapters … we need to acknowledge two important issues … However, before addressing these issues, I am going to examine in more detail the concerns that different identity groups in human society might have … the views, hopes, and fears of all diverse groups must be considered.

It takes much flipping back and forth throughout the book to assemble the lines of reasoning.

Pricing the book at $130, its intended purchasers will probably be libraries that are prodded by constituents to obtain a copy. Most potential readers would find its dense bricolage impenetrable. Those who request the book might be graduate students or faculty specifically studying public policy or ethics, who are seeking bibliography, though most of the works are referenced only in passing. Augustine, Aquinas, Brian Brock, Philip Hefner, Neil Messer, Stephen Pope, and Brent Waters receive the most note. There might also be interest from those professionally addressing public policy, to search for a proposed theoretical methodology for Christian ethics and policy formation.

Where Goundrey-Smith is most salient in this book is in advocating that Christians as citizens, and as participants in a long and thoughtful tradition, should contribute to public policy. This reviewer says a hearty "yes" to that summons, especially for such a formative set of challenges as we find in the title's reference to "biomedical innovation." How biomedical innovation should be developed and implemented is not specifically addressed in this book but, whether we are ready or not, biomedical innovation is requiring a set of present decisions, with others quickly coming to the fore. Such does warrant our best attention.

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BIOENHANCEMENT TECHNOLOGIES AND THE VULNERABLE BODY: A Theological Engagement by Devan Stahl, ed. Baylor University Press, 2023. 252 pages. Paperback; $54.99. ISBN: 9781481318273.

New biomedical technologies purportedly do things such as prolong life, heal infirmities, and increase the

overall quality of life. Often, these technologies appear limited due to their use by wealthy and privileged clients. In this edited volume, Devan Stahl, associate professor of bioethics and religion at Baylor University, along with a host of other scholars, present minority perspectives on bioenhancement technologies to "develop axioms for an 'ontology of the vulnerable,'" (p. 11). Seeing in Jesus an invitation both to care for the vulnerable and to honor the image of God in each person, the contributors share their unique perspectives to consider "how Christians should understand enhancement technologies" (p. 15).

The writing occurred through a 2019 gathering of twelve scholars in Christian ethics, biotechnology, and medicine to address growing concerns around bioenhancement technologies and their impact on minority populations. The group established twenty-five working propositions addressing key problems, or conceptualizing human creatureliness, in response to bioenhancement technologies. They organized these propositions around five primary categories: problems/concerns, Christian responses to transhumanism and bioenhancement technologies, ontology/nature and grace/eschatology, ontology and techne, and, finally, embodying Christ and ecclesiology (pp. 9–10). The authors then used the propositions to organize writings into two sections that address the concerns of using bioenhancement technologies with people whose bodies seem outside the "norm" (p. 11).

Section one includes various philosophical arguments for the goodness of the vulnerable body within a Christian theological worldview. Jonathan Tran and Jeffrey P. Bishop utilize the term "ontology," that is, any philosophy of being or existence, as shorthand for specific perspectives. The authors claim ontologies come from a specific time and place and that humans create ontologies to make sense of the world around them. A Christian ontology, then, might be that suffering is good because it conforms us to the person of Christ. A Western secular ontology, on the other hand, might assert that suffering serves as a hindrance to attaining happiness, and people should use medicine and technology to overcome and/or alleviate suffering. Persons living in a Western context often use technology and science to enhance the well-being of human bodies, assuming that such an approach is a good thing. People with privilege primarily adopt this ontology; the authors believe that this action can quickly lead to "social segregation" (p. 39). In contrast, Tran and Bishop assert that a Christian perspective recognizes the value of suffering, as well as the value of diversity and difference. This Christian view does not completely exclude the use of medicine and technology, but neither does it completely embrace it. A Christian ontology is firmly rooted in the hope of bodily resurrection, rather than the hope provided by human technologies.

The authors of chapters five through nine demonstrate how Christ is present in and with the disabled. Christ is there to "suffer with" the disabled (p. 109), not necessarily to heal them and raise their bodies to a physical standard created by humans. Brian Brock gives real-world examples of the fundings of bioenhancement technologies that are later promoted by extremely wealthy men who use disabled people to cultivate the image of people healed and given new life by these technologies. Terri Laws discusses how medical institutions continue to treat Black female bodies differently from Anglo-European bodies. Kimbell Kornu asserts that the telos of the Christian life remains to attain deification through cruciformity. Letting Christ transfigure our bodies into something divine is the goal for all Christians, not fitting our bodies to the expectations of society. For Christian communities, the response to the presence of the disabled should create "an equitable 'being with' in a fulsome community of [the] vulnerable sharing life" (p. 145).

The authors clearly establish axioms for an ontology of the vulnerable in this volume. One axiom asserts that the body is the site of God's presence. Commentary on the prelapsarian state of humanity in Genesis 2 proves enlightening on this issue. Through this commentary, linked with eschatological interpretations, disability comes to be framed no longer as a result of sin or a bodily defect to be left behind after the resurrection, but as a marker of God's image and creative work in the human body.

The authors in this volume could elaborate on how sin prevents the recognition of God's presence in vulnerable bodies. One author suggests that sin is primarily corporate in nature, existing as a series of structures which denigrate others. Therefore, one way to counteract sin may occur through political action on behalf of the disabled. Perhaps calling on churches to participate in a form of corporate repentance for the ways the church has historically treated the disabled would be helpful.

Another well-documented axiom calls for caring for the vulnerable. The authors insightfully identify racism and eugenics as having historical ties. Perhaps this book can generate unifying discussions on two issues which tend to fall on different sides of the political spectrum: racial justice and abortion. For example, eugenics takes on a new form by way of prenatal screening technologies, through which parents can choose to eliminate unborn children with Down syndrome. Churches can work against eugenics and thus foster discussions and actions that get at the underlying degradation of racism

wherein some people believe that humans with certain traits or features are less worthy than others.

Those with an interest in technology and theology will benefit from reading this volume as the authors probe questions such as "what does it mean to enhance the body?" and "what does transcendence mean?" Pastors will also find helpful ways of thinking about how to fully incorporate the disabled into their church communities and ministries.

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THE CRITIQUE OF BIOETHICAL PRINCIPLISM IN CONTRAST TO A BLACK AFRICAN APPROACH TO BIOETHICS by Jude Thaddaeus Buyondo. Wipf & Stock Publishers, 2024. 270 pages. Paperback; $37.00. ISBN: 9798385217441.

What can African theologians and philosophers teach the world about bioethics? Jude Thaddaeus Buyondo's recent book offers an intriguing opportunity for the advancement of the global perspective and influence of the field of bioethics by putting African bioethical approaches and experiences into conversation with Western bioethical principlism. While this lengthy title with no subtitle points readily to a doctoral dissertation, the maturity of thought and depth of scholarship of this text somewhat exceeds what would be expected from a first post-doctoral published work. The text reviewed here appears to be the first of two books derived from Buyondo's doctoral dissertation. The first book, *The Critique*, sets the stage for critical conversations between African and Western bioethicists, and the second book, *Holistic Bioethics*, published the same year but offered as a sequel or companion volume, describes in more detail the specific content and contributions of African bioethics.

Principlism is a framework for making ethical decisions in healthcare. It is based on four principles—respect for autonomy, nonmaleficence, beneficence, and justice—as delineated by Tom Beauchamp and James Childress in their classic text, *Principles of Biomedical Ethics*, originally published in 1979. Buyondo's overall project entails a comprehensive critical analysis of African responses to Western bioethics, with specific and frequent attention to the thought of Cameroonian bioethicist G. B. Tangwa, author of *Elements of African Bioethics in a Western Frame*. The first chapter is an introductory overview of the problem under investigation, namely, that universalized Western bioethical principles do not find validation in the context of African local realities. From the outset, Buyondo establishes Tangwa as his key conversation partner. Throughout the book, Buyondo's analysis of bioethical principlism is largely framed, guided, and energized by his response to Tangwa's critique of Western bioethics and view of African moral thought.

The remaining five chapters of *The Critique* are divided into two parts: Part I: "Critique of Bioethical Principlism in an African Context," and Part II: "African Moral Thought: An African Interpretation of Bioethics." Chapter 2 offers a brief general critique of bioethical principlism, with attention to the influence of four underlying moral theories: rights, virtue, Kantianism, and utilitarianism (consequentialism). In chapter 3, again following Tangwa, Buyondo presents case studies and examples of the shortcomings of bioethical principlism in Sub-Saharan Africa. His descriptions of HIV/AIDS and Ebola vaccine research, male circumcision, and other biomedical interventions provide convincing illustrations of the ineptitude of consequentialist utilitarianism in Black African contexts.

In the first instance, HIV vaccine research, based on African traditional practices of medicine using local herbs, progressed in clinical trials but failed to find global reception because of western resistance to collaboration. In the second case, male circumcision was generally practiced in Africa prior to the arrival of European missionaries, who denounced these practices as barbaric and incompatible with Christianity. But the World Health Organization (WHO) and Joint United Nations Programme on HIV/AIDS (UNAIDS) sponsored a campaign to circumcise millions of poor African men, with mixed results. Local communities and leaders were not given a central decision-making role in planning these campaigns. Studies from the global South did not confirm the prophylactic effectiveness of circumcision in reducing HIV infection. Tangwa condemns circumcision as the "New Tuskegee," with reference to 20th-century experimentation upon poor Black men in Alabama to study the effects of untreated sexually transmitted diseases.

Part II is much longer than Part I, mainly because Buyondo devotes much more attention to African critiques of principlism than to any discussion of principlism on its own terms. Chapter 4, "An African Interpretation of Bioethics," is a substantive summary of the moral thought and bioethical practices of the Bantu of Sub-Saharan Africa, which further illustrates the contrast and conflict between the Global North and Global South in philosophical terms. In essence, western approaches to bioethics are highly individualistic and anthropomorphic. By contrast, African bioethical perspectives emphasize relationality in the three-dimensional community of the living, the dead (including the "living-dead" victimized ancestors of history) and those not yet born.

Chapter 5 describes an African ethical system that features non-dualistic thinking, relational social reality, and communitarian bioethics and theories of justice. The concluding chapter reiterates the centrality of Tangwa's studies as a guide to orchestrating an integral approach to enriching the bioethical principlism of Beauchamp and Childress with decolonized articulations of African moral thought. *The Critique* puts two comprehensively distinctive ways of thinking about bioethics on equal footing for dialogue in pursuit of an authentically global bioethics. This ultimate goal of a global bioethics is achieved by adding a fifth life principle of the sacred interconnectedness of all creation. Buyondo argues for a more comprehensive and holistic normative sense of solidarity extending ethically to all systems of life, institutions and nations, biodiversity, and ecology. This platform offers a firm foothold for addressing the morally challenging episodes and patterns of exploitation that historically characterized relations between Africa and the West.

There are not many books that address bioethical principlism from an African perspective, but a recently published text offers an interesting comparison and informative insights into Buyondo's work: *Womanist Bioethics: Social Justice, Spirituality, and Black Women's Health* (2025) by Wylin D. Wilson, an African American bioethicist. Her study of bioethics from the perspective of Black women in the U.S., especially in the rural South, begins with the experience and harm of slavery. The Black church is a key context for her analysis of Black women's lives and beliefs. Buyondo's study makes no reference to African American thought, culture, or religion with respect to bioethics; Wilson makes no reference to African thought, culture, or history in hers. What the two have in common is the critique of the inadequacy of the bioethical principles set forth by Beauchamp and Childress in the context of Black existence. Yet, their analytical approaches are distinctive: Buyondo grants equal footing to Western and African approaches to bioethics as a mutually enriching dialogue, whereas Wilson's project is a focused augmentation of bioethics with womanist (or Black feminist) principles. In both cases, their analyses are centered on Black communal life and concerned with Black suffering, especially experienced as a consequence of bioethical indifference to the violation of Black personhood and the vulnerabilities of Black people in the delivery of healthcare.

Buyondo provides an extensive bibliography, but there is no index. His text would have benefitted from more careful editing for grammar and syntax in order to make his rather lengthy sentences more readable. The title of the book as printed on the title and copyright pages is *The Critique of Bioethical Principlism in Contrast to a Black African Approach to Bioethics*. However, a different version of the title appears on the book's cover: *The Critique of Bioethical Principlism in Contrast to an African Approach to Bioethics*. The word "Black" is omitted; this is a serious inconsistency that needs to be corrected one way or the other.

Although Buyondo's training in Catholic moral theology is evident in an occasional footnote or sentence in the book citing Catholic theologians, Christian faith is not a major theme in his critique of bioethical principlism, nor does his comprehensive treatment of African moral thought, beliefs, and bioethical practices seem to be informed by any investment in Christian faith or tradition. However, this text would be of great interest to readers who seek deeper appreciation of the influence of culture on the relevance of bioethical principles and practices.

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Biology

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PLAYING POSSUM: How Animals Understand Death by Susana Monsó. Princeton University Press, 2024 (English Translation). 264 pages including index. Hardcover; $19.94. ISBN: 9780691260761.

Modern, and particularly Western, humanity seems to regard death and mortality with deep ambivalence. On the one hand, there is the tendency to excessively dwell on it, marked by an obsession for safety and frenetically risk-proofing life as much as possible. On the other hand, both human and nonhuman death is sanitized, with human mortality a near-taboo to even ponder. In theological scholarship, there is renewed interest, and several new titles published, in what is often termed the "Problem of Animal Suffering," as well as philosophical and psychological interest in the cognitive processes of animals. Susana Monsó, philosopher and associate professor at National Distance Education University (UNED) in Madrid, has provided new insights that bridge these issues with her recent book on the capacity of animals to understand death. Written for a general audience, it is engaging, mostly avoids excessively technical language, uses endnotes to improve readability, and is marked by humor, and clear compassion and empathy for the animal subjects she addresses. Each chapter begins with a narrative about the approach to death of specific animal species that frame her subsequent argument.

Monsó's intention, as a philosopher, is to contribute to the field of comparative thanatology—the study of animals' relation to death—by framing this book within "a relatively young branch of philosophy known as the *philosophy of animal minds*" (p. 4). She argues that prior

scholarship that largely denies the capacity of animals to understand death is based on anthropocentric biases excessively focused on grief, and she uses empirical evidence that many animals, at varying levels, *do* possess an understanding of death.

The author compares the responses to death in animals as either *stereotypical* (innate, automatic, rigid, linked to concrete sensory stimuli) or *cognitive* (learned, under cognitive control, flexible, not linked to concrete sensory stimuli); these responses can vary among individuals. The former is widespread in nature, such as in ants who carry their dead outside the colony. The latter is Monsó's principal interest. She (correctly, I think) negatively critiques the anecdotal nature of published studies that often lack experimental controls and base their conclusions on a single animal sample, because "the anecdotal method is the one that most favors anthropomorphism" (p. 44). The press accounts, in the author's narrative of a whale who was said to "grieve" the loss of her dead calf while carrying its corpse for seventeen days, also illustrate this. Monsó contends that anthropomorphism can err both in an anthropocentric view that would seek to diminish the cognitive capacity of animals, or in the opposite view, one that would deny that any human-typical characteristics can be found in animals at all.

Monsó is also critical of the intellectual error that adopts the "human experience as the gold standard against which we compare all animal behavior around death" (p. 51). That an animal does not conceive of death as a human would, does not mean that they lack a cognizance of death. Rather, many animals can intellectually understand *nonfunctionality* and *irreversibility* as the "minimal concept of death" (p. 76). And, as mentioned before, an anthropocentric focus on *grief* in animals' understanding of death, Monsó argues, diminishes the genuine role of animal emotions in how they process death, causing us to misinterpret their varied, unique responses.

A concept of death in nature, according to Monsó, is a "holy trinity" of "three fundamental causal factors: COGNITION, EXPERIENCE, and EMOTION" (p. 109). Interestingly, she finds that the more "social" animals, who tend to have higher levels of all three, are also K-strategists, species who tend to have few offspring that require investment of huge amounts of parental care to reach maturity. This seems to suggest that the "costly" impact of an offspring's death makes a cognitive understanding of it an evolutionary benefit to species survival. That said, not all social animals meet the requirements of the "holy trinity," such as insects that are highly social but cognitively simple. Nor do some non-social species, including large predators that are generally solitary, fail to meet these requirements. It serves as an interesting rubric to view how animals understand death, however.

Most readers will be fascinated by the penultimate chapter on violence in the animal kingdom as a force for how animals understand death, a topic that has previously been given scant academic attention. The discussion of predation is especially interesting. Predators understand that their killed prey are dead, and, in fact, view this death with great *joy*, not as a loss, but a gain, an emotion as powerful as that of the loss of a mother's young. Even animals who "play" with their prey, like cats, cognitively know when death occurs and what they did to accomplish it. Certainly, repeated hunts (and failures to kill prey) provide the experience to verify death. This experience, along with emotion and cognition, fulfills the three components of the "holy trinity."

Here I found it easy to think of biblical allusions to God's delight in his provision of prey for his created animals and in the power and "wildness" of behemoth and leviathan in the *Yahweh* speech to the biblical Job. Humans, of course, are a predatory species, so, at the risk of reverse-anthropomorphism, I do wonder if the enjoyment of many humans in hunting and fishing is less a reflection of a loss of prelapsarian kindness than a connection we share with many animals, and one that has led to the continuation of our own species.

Monsó's work will appeal to those interested in ethology, and philosophers will like the consistency of her philosophical arguments. Science-oriented readers will appreciate her significant use of empirical evidence to reach conclusions. Monsó is to be applauded for the breadth of animal species she uses to illustrate her points, beyond primates and familiar pet animals to include, for example, whales and the opossum referenced in the title.

Christian readers may have a mixed response to this work, based on some of the author's concluding comments. Monsó makes scant mention of theological implications, except as they relate to anthropomorphism; in fairness, this was her intent. Those interested in theological anthropology will have some misgivings about her conclusions related to human death. Monsó correctly asserts that "we are probably the only animal with a notion of the inevitability and unpredictability of death" (p. 208) and "the only animal with complex death-related rituals and symbolic representations of death" (p. 207). But then she concludes, regarding the concept of death, "We're not a unique species. We're just another animal" (p. 210). In fact, despite a recognition that humans have underestimated the capacity for animals to understand death, our uniquely human conceptions of death, including the possibility of a continued existence in eternity, are *inherently* different from animals. The Resurrection and the view of death as a "defeated enemy" (1 Cor. 15:26) are foundational to Christianity,

and the *imago Dei* is a distinctive that makes human processing of death more than that of "another animal."

That said, I suspect the author's intent is to broaden the reader's moral universe in respect and empathy for the animals who provide us food, labor, clothing, and companionship, and for all the animals who populate our natural environment. To this end, Monsó adds a valuable, entertaining, and elegant addition to the field of comparative thanatology. For a Christian, it does not threaten the uniquely human understanding of death to know that many animals also have their own understanding, often rather sophisticated. Instead, it provides the opportunity for even greater wonder and praise toward our Creator, in which the intricacy shown in "the work of His hands" (Ps. 111:7) calls us to deeper care and compassion for the fauna we are called to steward.

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THE SEXUAL EVOLUTION: How 500 Million Years of Sex, Gender, and Mating Shape Modern Relationships by Nathan H. Lents. Mariner Books, 2025. 336 pages. Hardcover; $32.00. ISBN: 9780063375444.

Biologist Nathan Lents's newest book on the sex lives of animals, *The Sexual Evolution*, is neither written from a Christian perspective nor written to a Christian audience. Nevertheless, this book offers a convicting call for Christians to join a rapidly growing boundary-crossing conversation: *What does nature reveal about morality?*

Lents is an accomplished scientist and thoughtful writer who recognizes the unsteady ground on which he treads: "Believe it or not, this book is not about values; it is about biology" (p. 11). However, I don't believe it. There are multitudes of fascinating topics in biology worth writing about, yet Lents has chosen a topic that inevitably flows from biology to ethics. Lents's primary message can be summarized in his repeated *is-ought* phrase: "Nature loves diversity. We should too" (pp. 40, 233). By placing human sexual behavior in an evolutionary context of living things, vertebrates, mammals, primates, and great apes, Lents proposes that we ought to accept a more inclusive concept of human sexual ethics, arguing for the moral equivalence of heterosexual and homosexual behavior, sex within marriage and sex without, and sex with one person and sex with many. Lents is, in his words, "forcefully pulling up a chair" (p. 4) for biology to join the discourse on human sexual ethics. In my opinion, this important interdisciplinary conversation is long overdue.

As biologists, Lents and I agree on many things in general. Sex is a biological category, not a social one. Lents helpfully uses the term "gametic sex" to refer to the sperm and egg producers of life and "biological sex" to mean the other aspects of reproductive biology beyond simply what gametes one makes (things such as internal and external anatomy, hormones, and hormone receptors). And while sex is based in biology, gender—how one chooses to present their sexual identity to the world—is a social construct. Too often Christians treat the words "sex" and "gender" as synonyms, which is neither linguistically accurate nor helpful when trying to understand the complexities of human sexuality. I also support Lents's compassion for marginalized people, specifically those with disorders of sex development, people whose anatomy does not easily fit into rigid categories of "male" and "female" and whose existence and intrinsic value ought to be affirmed more often in religious conversations about sexual ethics.

Ultimately, Lents provides a well-evidenced argument that (1) homosexual behavior is *natural* (i.e., found throughout the animal kingdom among normal populations), (2) homosexual behavior is *adaptive*, meaning it persists in animals because it provides some biological benefit, and (3) sexual behaviors are about far more than reproduction—animals have sex to strengthen social bonds, establish hierarchies, and just because it feels good. Each of these points is convincingly made and each one counters a common myth believed by many Christian thinkers. We have been caught relying on outdated and incorrect scientific facts when we argue that same-sex behavior *et cetera* is wrong *because* it is unnatural or maladaptive.

Lents is careful to describe animal behavior according to our best current understanding. However, in one case, he gets the facts wrong—and wrong in a way that reveals how dangerous his project can be if his logic and arguments are correct. In his exploration of sexual monogamy, Lents calls our attention to the many *socially* monogamous species that are *sexually* promiscuous. In doing so, he is making the implicit point that fidelity and promiscuity are morally equivalent because both are natural and adaptive. One of his examples is the jackdaw, a highly intelligent bird that forms lifelong pair bonds between mates. Lents suggests that pair-bonded females *willingly* seek out extra-pair copulations with neighboring males. However, according to the article Lents himself cites, this is not what happens.[1] Male jackdaws watch the nests of their neighbors and when the resident male leaves, they will invade and attempt to copulate with the vulnerable female. Importantly, the female *resists* the interloper. Their violent struggle can result in significant injuries to the female and sometimes the destruction of her eggs.[2] Studying animal behavior reveals the disturbing biological fact that pursuing *sex through violence* is also natural and adaptive. Nature loves diversity. *We should too?*

To Lents's credit, he seems aware of this potential critique and offers a solution: human sexual ethics should be decided first by Nature and then Society. When using nature as a guide, he finds that same-sex behavior and gender fluidity are (1) taxonomically widespread, (2) quantifiably beneficial to a species, and (3) biologically influenced. Therefore, Lents infers that these behaviors are morally acceptable. However, in nature we also find that sexual assault, incest, and sexual contact with minors are (1) taxonomically widespread, (2) quantifiably beneficial to a species, and (3) biologically influenced. If his reasoning is valid, one could advocate for the moral acceptability of these behaviors as well.

Lents avoids this unpalatable consequence by suggesting that it is then up to society to determine what natural inclinations are acceptable or not. He surveys human cultural diversity, finding that same-sex behavior and gender fluidity have been normalized and encouraged in various societies throughout human history. His logical conclusion then is that these behaviors *are* morally acceptable; they are natural *and* socially accepted. However, as he does for the darker parts of nature, Lents ignores or glosses over the fact that sexual assault (e.g., marital rape among the Gusii people of Kenya[3]), incest (e.g., brother-sister marriages in ancient Egypt[4]), and sexual contact with minors (e.g., the coming-of-age rituals of the Simbari and Mangaia peoples [Lents, p. 188]) have *also* been normalized and encouraged in various cultures throughout human history. These behaviors too are natural and at times socially accepted.

It is clear that neither nature nor society provide the robust standard of morality that Lents, indeed all of us, are searching for. Nature tells us that virtually all behaviors and inclinations are permissible, while morality according to society is subjective and ephemeral.

The worrisome evolutionary ethic undergirding *The Sexual Evolution* demands an effective response. Christians need to present an objective sexual ethic grounded in the character of God and affirming that all humans are made in God's image while also accurately describing our biology. Who we *were* and who we *are* by nature really does matter. Crafting this response will require careful, compassionate effort across academic disciplines. Will you join me?

Notes

[1]Lisa F. Gill, Jaap van Schaik, Auguste M. P. von Bayern, Manfred L. Gahr, "Genetic Monogamy Despite Frequent Extrapair Copulations in 'Strictly Monogamous' Wild Jackdaws," *Behavioral Ecology* 31, no. 1 (2020): 247–60, https://doi.org/10.1093/beheco/arz185.

[2]Rebecca Hooper, Kathryn Maher, Karen Moore, Guillam McIvor, David Hosken, and Alex Thornton, "Ultimate Drivers of Forced Extra-Pair Copulations in Birds Lacking a Penis: Jackdaws as a Case-Study," *Royal Society Open Science* 11, no. 3 (2024): 231226, https://doi.org/10.1098/rsos.231226.

[3]Peggy Reeves Sanday, "The Socio-Cultural Context of Rape: A Cross-Cultural Study," *Journal of Social Issues* 37, no. 4 (1981): 5–27, https://doi.org/10.1111/j.1540-4560.1981.tb01068.x.

[4]Russel Middleton, "Brother-Sister and Father-Daughter Marriage in Ancient Egypt," *American Sociological Review* 27, no. 5 (1962): 603–11, https://doi.org/10.2307/2089618.

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Environmental Science

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POETRY IN PLACE: Poetry and Environmental Hope in a Southern Ontario Bioregion by Deborah Bowen and Noah Van Brenk, eds. Guernica Editions, 2025. 378 pages. Paperback; $19.00. ISBN: 9781771839716.

In *Poetry in Place*, Deborah Bowen, emerita professor of English at Redeemer University, along with her assistant Noah Van Brenk, has gathered 125 poems by forty-three Canadian poets from the southeast corner of Ontario. The poems explore a bioregion between the Grand River on the west and Lake Ontario on the east, part of the so-called Golden Horseshoe that includes both fertile farmland and industrial cityscapes. In her beautifully written introduction, Bowen explains the purpose of her anthology as a listening to the land, a slowing down to acknowledge what is actually there around us in a particular place. Poetry can forge connection: in this case, between heart and home. The result of such connection is hope, and hope is essential to any effort of environmental repair.

The poems themselves are grouped under ten headings: "Land," "Water," "Trees," "Birds," "Wild Creatures," "Insects," "Flowers and Plants," "Farming and Gardening," "Food," and "Future Perfect Tense"—the latter category an umbrella for anxieties about climate change. Most of the poems are in free verse, though some employ the random rhyme of spoken-word poetry. And, of course, some are better than others. We learn in the section on flowers and plants that, etymologically, the word *anthology* refers to an arrangement of blossoms. But any bouquet will have its weeds.

First to the genuine blooms, however, of which there are many. From "Hibiscus," by Mia Anderson: "The barn-swallows / have breasts the colour of the borealis" (p. 189). These two lines are a liquid pleasure in our mouths. We notice the alliteration and consonance of *barn* and *breasts* and *borealis*, and we may not notice, but nevertheless feel, the vowels rise upon our palate. We also feel the swinging rhythm, the memory of meter, in the repeated two-stress segments—The barn-swallows / have breasts / the colour of / the borealis—a rhythm that matches the swinging turns of swallows in flight. And finally, of course, the surprise and explosion of

metaphor. In *borealis* we get not only a color, but also a color that pulses across the sky. A bird we might hold in the palm of our hand suddenly fills the entire horizon, large as the universe itself. This, in miniature (but not in miniature at all!) is what good poetry can do.

By contrast, take these lines from Marilyn Gear Pilling's otherwise promising poem "Looking Out": "What happens when you spend time / on the edge / of such power, such beauty, such / possibility?" (p. 70). Notice the flatness of this passage, the lack of image or metaphor, the crowding in of abstractions. Do I, as a reader, feel power, or beauty, or possibility in these lines? I do not.

Fortunately, the barn-swallows by far outnumber the flightless abstractions in this rich array of poems. I suspect such a collection as this will inevitably be uneven. First, by limiting the contributors to those with a connection to a relatively small geographic area, and by further limiting the contributors to those with environmental awareness, the editors have narrowed the field. Suppose, for example, that in the early nineteenth century some enterprising anthologist had gathered a volume of poems about the Lake District. William Wordsworth would loom large, as would Samuel Taylor Coleridge and Robert Southey. But who else, really?

The second danger of such an anthology as this is its very environmental intent. Because environmentalists have a message. When Honey Novick ends her poem "Mushquoteh" by telling us that "Norway maple is a new metaphor / for decolonization" (p. 95), I want to say, save this for an academic essay. And when she writes, in "Oh, Mother Earth," that "Expediency lives in our hearts" (p. 50), I want to say, keep this for a sermon. I suggest that it is not the job of poems to preach or to pontificate, but to cast a magic spell.

Such a spell is beautifully cast by John Terpstra in "Giants":

> They'd sit
> their giant hinds in a row along the top edge
> of the escarpment, and pick at the loose rock
> with their hands or their feet, then throw or skip
> the smoothest stones across the bay, to see who could
> land one
> on the sandstrip, three miles away … (p. 57)

There is true imagination at work in the creation of such giants sitting atop the Niagara Escarpment, standing in for the land itself.

Also notable are the many richly sensuous poems about keeping and tilling the land. Take this elderly gardener in Adam Dickinson's "Beetroot":

> Her fingers are asparagus stalks,
> stubbed and coiled cucumbers,
> thick from years of having carried the charge
> of her burly, grandmotherly care,
> the pots of turnip
> that need lugging to the kitchen. (p. 179)

One of the unique features of this anthology is a series of interviews with each of the contributing poets. Each writer is asked to describe their relationship to the land, their spiritual grounding, and their motivation in writing poetry. And many are eloquent in their responses. Twelve of the poets are thoughtfully Christian, and thirteen more admit to the influence (for better or worse) of a Christian upbringing. There is also a rich ethnic diversity, with sixteen of non-European descent, six of these appropriately First Nations. And there are even some scientists in the mix! Bowen and Van Brenk have assembled a worthy crew to give witness to a worthy place—as worthy a place as any that lies unobserved on our very doorsteps. Perhaps poetry can indeed offer hope for environmental repair. Readers of *PSCF* will find this anthology a delightful supplement to the usual academic discussions on creation care.

Reviewed by Paul Willis, emeritus professor of English, Westmont College, Santa Barbara, CA 93108.

Evolutionary Theory

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EVOLUTION "ON PURPOSE": Teleonomy in Living Systems by Peter A. Corning, Stuart A. Kauffman, Denis Noble, James A. Shapiro, Richard I. Vane-Wright, and Addy Pross, eds., Vienna Series in Theoretical Biology, Gerd B. Müller, Thomas Pradeu, and Katrin Schäfer, eds. The MIT Press, 2023. 390 pages including index. Paperback; $75.00. ISBN: 9780262546409.

This revolutionary and transformative book heralds a major paradigm shift in the science of biology and opens the door to an entirely new approach to understanding the science of life. Its core message is that while life follows the laws of chemistry and physics, it cannot be defined, described, or understood solely in terms of those laws. Most of the book's editors are pioneers in the demolition of the gene-centric, deterministic evolutionary concepts that have dominated the ideology of neo-Darwinism for many decades.

Recently, a new movement in evolutionary biology, sometimes called "The Third Wave," has emerged that questions some of the more basic tenets of the established theory. One of the milestones of this new movement was a meeting of the Royal Society in 2016, at which several leading biologists (including some of the editors and authors of *Evolution "On Purpose"*) discussed a series of possible alterations to the established theory of evolution by natural selection. These included concepts

of niche construction, whereby creatures modify their environments leading to altered evolutionary scenarios, non-random mutations, and natural genetic engineering by organisms—that is, evolution by choice. These and several other novel mechanisms outside of the standard model of random gene mutations, followed by natural selection, were part of the new "extended evolutionary synthesis" (EES).

Evolution "On Purpose," however, goes much further than the EES in challenging neo-Darwinian dogmas by strongly emphasizing that living organisms are not passive recipients of random genetic mutations but active participants in their own evolution. This has long been, and to some extent still is, considered scientific heresy by many biologists, but the data supporting it is convincing.

The book contains eighteen chapters, including an Introduction by the editors, and an excellent summary (chap. 2) by senior editor Peter Corning. The history of how biology became fixated on denying teleology to conform to the sciences of chemistry and physics is told expertly by Denis Noble and his brother Raymond Noble in chapter 12.

The following sample of chapter titles gives an indication of the major themes of the book: "Teleonomy in Evolution"; "Cellular Basis of Cognition in Evolution"; "Niche Construction 'On Purpose'"; "Relational Agency"; "Mentally Driven Goal-Directed Behavior"; "Morphogenesis as a Teleonomic Process"; and "Agency, Teleonomy, Purpose, and Evolutionary Change in Plant Systems."

The subject of biological agency (a term that was traditionally banned from biology) has been shown to play a crucial role in evolutionary processes. The details are covered in several chapters, which describe how living creatures can influence their own evolution through their interactions with the environment.

Each chapter provides a richly profound look into fundamental ideas of how life really works, with very little overlap between different chapters. One can feel the excitement of the authors as they journey into what was once forbidden territory marked with the signs of final causes and willful agency. I will briefly discuss a select set of chapters to give a sense of the book.

Chapter 3 by Baluška, Miller, and Reber describes how all of life, including single-celled organisms, plants, and, of course, those with primitive or advanced brains, can perform cognitive functions such as perception of their environments. Even a bacterium can remember, learn, and make decisions based on its cognition. Cognition leading to purposeful action also includes cooperative interactions between organisms of the same or even different species, such as symbiosis. The authors emphasize that "evolutionary development is creative not only through either mutations, or natural selection but also—and mainly—through the linked cognitive activities and preferences of individual organisms" (p. 34).

James A. Shapiro, in chapter 15, discusses one important and critical mechanism by which organisms engineer themselves: the activity of transposons, or jumping genes. These mobile genetic elements, first discovered by Nobel laureate Barbara McClintock, are cellular tools for natural genetic engineering. To quote Shapiro:

> … living organisms have the ability to rewrite and rewire their genomes when necessary. Rather than being the passive beneficiaries of random mutations and natural selection, all organisms play an active role in their own hereditary variation and evolution by activating transposable elements in response to ecological challenges. (p. 285)

Editor Stuart Kauffman is one of the most important pioneers in the emergent field of systems biology and the nature of complexity. Written with Andrea Roli, Kauffman's chapter 8 summarizes several of his contributions over the decades. These include the role of autocatalytic small molecule sets as possible precursors to the transition from chemistry to life, the statistical mechanics of evolution, and the uniqueness of life, which leads to a "third transition in science" beyond both the Newtonian paradigm and quantum mechanics, stemming from the impossibility of predicting and describing with equations the future evolution of a biosphere.

In chapter 10, Michael Levin, a rising star in many areas of new biological research, discusses the mounting evidence for teleonomy in the morphogenesis of many forms of life, from worms to frogs to mammals. He demonstrates that the way in which animals tend to build (or rebuild) their bodies (morphogenesis) is not based on a rigid program of stepwise, pre-set genetically based instructions requiring a fixed starting point to get to final shape. Instead, worms, frogs, newts, and other organisms build their bodies toward a known goal, and they use all kinds of innovative methods to get there. In other words, it is the final answer to what should be the shape of a frog face (for example) that drives the process, no matter the initial state of the tadpole face. Teleonomy drives morphogenesis.

How all this purpose-driven activity is controlled, monitored, and corrected is as yet unknown, but it is operative even in the development of mammalian (including human) fetuses, where large groups of cells self-organize into the correct organs and tissues.

A major feature of this book is its diversity in subject matter and approach. While several chapters do cover similar general topics (especially agency, cognition, and teleonomy), the number of specific applications of these and other aspects of biological complexity is very large. For example, chapter 7 by Eva Jablonka and Simona Ginsburg looks at the evolution of purposeful behavior from unconscious teleonomy in lower animals to conscious expression of goals and desires by human beings. It covers an enormous field of psychological and neurological research.

I am not aware that any of the editors or authors are professing Christians—to my knowledge, none of them are active in international associations devoted to science and Christian faith. Modern movements to reform the dogma of neo-Darwinism are not (as some atheists have claimed) part of a Christian plot to undermine settled science. Every participant in this project affirms the reality of Darwinian evolution. Their purpose is to bring the theory up to date.

Evolution "On Purpose" is a useful resource for Christians invested in describing the harmony of science (biology in particular) with our faith. Given the major impact that it is likely to have, I expect that more books and articles aimed at the general public will be making appearances shortly.

Reviewed by Sy Garte, editor-in-chief of God and Nature *magazine, author of* Beyond Evolution: How New Discoveries in the Science of Life Point to God*, and visiting professor at Rutgers University, New Brunswick, NJ 08901.*

History of Science

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THE REINVENTION OF SCIENCE: Slaying the Dragons of Dogma and Ignorance by Bernard J. T. Jones, Vicent Martínez, and Virginia Trimble. World Scientific Publishing Europe, 2024. 492 pages. Paperback; $48.00. ISBN: 9781800613607.

The "dragons" referred to in the title are the old ideas that are often hard to get rid of as new scientific data come along, in particular things that were invented out of ignorance but apparently thought to be real. This comes from ancient maps that occasionally showed dragons in regions where little or nothing was known. One well-known example is the old idea that everything was made of the elements Earth, Air, Fire, and Water. The dogma and ignorance referred to are scientific, not religious. The authors reveal little or nothing about their personal religious beliefs (if any) and do not push anti-Christian or more generally anti-religion views.

Bernard Jones, emeritus professor at Kapteyn Astronomical Institute of the University of Groningen, has worked in a variety of areas of astronomy, especially cosmology. Vicent Martínez, professor of astronomy and astrophysics at the University of Valencia, is a cosmologist who earned his degree under Jones at Cambridge. Virginia Trimble, professor of physics at the University of California, Irvine, has worked in various areas of astronomy and has written many reviews of astronomical research.

The book contains nineteen chapters in 361 pages, followed by extensive notes containing references and expansions of the information in the main text, as well as indexes of people and of subjects. It is probably not suitable for use as a textbook, but various sections might be used in courses on history or philosophy of science. One does not need to be an astronomer or physicist to read and benefit from the book, but some knowledge of science is useful, and more specialized knowledge is helpful (though not essential) in a few places. Readers with an interest in history or philosophy of science would probably find it interesting and informative. Those who primarily want the bigger picture may want to skim over some details, but they should take time to enjoy at least some of the many stories of interesting characters and the fun historical tidbits.

The book begins with what the authors call the "most famous failed experiment." In the 19th century, it was known that light behaved as a wave, and all waves anyone knew about required a medium to move in (e.g., water or air). Therefore, it was believed that light must travel in a medium, labeled as "ether," that filled all of space. As Earth moves through the ether, one should measure a different speed of light depending on whether one is moving with, across, or against the current. In 1887, Michelson and Morley found that the speed of light was the same regardless of the direction of motion through the supposed ether. This was a serious strike against the ether hypothesis, as well as showing light waves were somehow different from other waves. Some major rethinking was required, leading to Einstein's theory of relativity. It took some years for the ether dragon to die, and more years for relativity to become well accepted.

Another dragon that many readers of *PSCF* will likely recognize would be the "crystalline spheres" on which stars and planets supposedly rotated around Earth. These were part of the geocentric model of the Solar System that was replaced by the heliocentric model in the decades around 1600. As most readers are probably aware, Galileo's observations (ca. 1610) played a major role in slaying the geocentric dragon and Kepler's "laws" of planetary motion a bit later were based on the heliocentric model. It wasn't until several decades after Galileo and Kepler that Newton's laws of motion and of gravity were published (1687) to make more quantitative

sense of the observed motions of planets and to allow predictions, such as the existence of the planet Neptune or when Halley's Comet would return.

A few additional dragons are worth discussing. The authors actually tend to drop the direct mention of dragons in the later sections of the book, but the theme of discussing changes in scientific understanding that required significant rethinking remains strong. A geological and paleontological issue that many readers may be familiar with involves the great extinctions (times when many species died quite rapidly), especially the demise of the dinosaurs about 66 million years ago. Most have probably read articles or seen documentaries blaming an asteroid impact for killing off the dinosaurs, and there was definitely a major impact at the right time. Although that is certainly the best publicized explanation for that extinction, there is another explanation that is less commonly mentioned: very extensive volcanism. This is less dramatic than an asteroid impact and has received less publicity. There were enormous volcanic events in south Asia for an extended period including the time of the asteroid impact, and there is some controversy over how sudden the extinction was. If it was not sudden, then the volcanic explanation fits better. Furthermore, there were other periods of great volcanic activity that match up with the times of other great extinctions. The jury may still be out on this issue. Anyone wanting to know more about this is encouraged to read the book.

Although slightly off the topic of dragons, the authors also discuss people who were not honored with Nobel prizes, but should have been, as well as some who should have been co-authors on significant papers but weren't (or whose work was ignored until far too late). Unfortunately, women have too often been the ones ignored, but men have also been passed over. Among several others, the book discusses the frequently cited case of Jocelyn Bell (now Dame Jocelyn Bell Burnell) and her discovery of pulsars (astronomical objects with short period radio pulses, which she discovered as a grad student in 1967). Two more-senior men received the Nobel prize in 1974 for their contributions to radio astronomy, including specifically this discovery.

The last section of the book contains considerable discussion of modern views of cosmology, including the apparent discrepancy between the results of two different methods of measuring the expansion rate of the universe. The discrepancy between the results may be due to underestimated random errors, or systematic errors in one or both techniques, or new physics yet to be understood (another dragon?). Necessarily included as part of cosmology, the authors discuss dark matter and dark energy. Dark energy is the label given to whatever unknown mechanism is causing the observed acceleration (discovered ~30 years ago) in the expansion of the universe, and should certainly be considered a dragon, since it is a term invented out of ignorance. Dark matter is a different story. For several decades we have known of rapid motions of and within galaxies that are best explained by something that has gravity similar to that of normal matter, but has not yet been detectable otherwise, hence dark. Some think the observed data require a need for modification of the law of gravity, but no proposed modification has yet been successful in fitting all of the data. A clear discovery of dark matter particles, or a successful modification of gravity, will slay the dark matter dragon. Cosmology, including the dark side, is a very active area of current research.

Why should this book be of interest to readers of *PSCF*? Besides the fact that many of us are interested in history and philosophy of science, we should think about whether there are other dragons to deal with. For example, many of us may think of "god of the gaps" as a dragon that has (mostly?) been slain, though its head pops up occasionally. Readers may want to ponder whether there are other dragons in our own science, or our theology, or how we relate these areas.

Reviewed by Kyle Cudworth, former director, Yerkes Observatory, Williams Bay, WI, and professor emeritus of astronomy and astrophysics, The University of Chicago.

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THE HUXLEYS: An Intimate History of Evolution by Alison Bashford. University of Chicago Press, 2022. 423 pages plus 60 pages of notes, 75 figures, index. Hardcover; $30.00. ISBN: 9780226720111.

Alison Bashford is laureate professor in history and director of the Laureate Centre for History and Population at the University of New South Wales in Sydney, Australia. She has held prior positions at the University of Cambridge and Harvard, and served as a trustee of Royal Museums Greenwich. Prior publications include a coauthored biography of Thomas Malthus; in 2021, she received the Dan David Prize for her contributions to the history of health and medicine.

The Huxleys represents an ambitious project: an intergenerational history of the Huxley family, 1825–1975, with major emphases on the biologists Thomas Henry Huxley (1825–1895), hereafter, "Thomas"; and his grandson, Julian Sorell Huxley (1887–1975), hereafter, "Julian." Other Huxleys are essential to the narrative, and these include Thomas's beloved wife, Henrietta Heathorn (1825–1914), and their son Leonard Huxley (1860–1933). Leonard and his wife Julia Arnold (1862–1908) were the progenitors of Julian and his acclaimed novelist brother, Aldous Huxley (1894–1963). Many other Huxley children and cousins populate the book. Julia Arnold, as daughter of Thomas Arnold and niece

to Matthew Arnold, brought to the family a potent intellectual impetus of her own. Notable biologists who make appearances include, of course, Charles Darwin and Richard Owen; also Ernst Haeckel, J.B.S. Haldane, Hermann Muller, and Francis Galton. H.G. Wells figures prominently and, a revelation to this reviewer, also David Attenborough.

Rather than construct a single linear narrative, the author has split the history along topical themes. Each theme develops the narrative line and integrates it into the prior composite. The result is a multidimensional tapestry, brought to life by the characters themselves and by Bashford's wonderful prose.

Part I, "Genealogies," presents an overview of the genealogy, social milieu, and family tragedies of the Huxley clan from its origins in poverty to its high social status. It begins with a chapter sketching the genealogy of the Huxley lineage, beginning with the parents of Thomas and Henrietta. Thankfully, a genealogical chart is provided. Thomas and Henrietta had eight children. Son Leonard and first wife Julia Arnold (died young, of breast cancer) had four and then Leonard with second wife Rosalind Bruce (1890–1994), another two. Among the latter was Andrew Fielding Huxley (1917–2012), half-brother to Aldous and Julian; Andrew would win a Nobel prize for his research on neurophysiology.

Chapter 2 provides an overview of the biological threads that would be woven into the thought of Thomas and Julian. Charles Darwin and Ernst Haeckel are both introduced as good friends of Thomas and Henrietta. Bashford concludes that Thomas at first accepted Darwinian evolution with certain qualifications, but that it was Haeckel's work which fully convinced him, as well as the data of paleontology. "It was only from 1868 that evolutionary concepts were directly applied by Huxley to his own research, and it was less Darwin than Haeckel's applications of Darwin's idea that finally convinced him … in 1866" (p. 65). The young Julian was tutored in developmental biology and rigorous materialism by Haeckel; both themes were incorporated into his zoological and popular writings. The discoveries of genetics during the 1890s–1930s period are presented well. Notably, Julian worked in both William Bateson's and Thomas Hunt Morgan's laboratories just prior to taking up his first real position at brand-new Rice University in Houston (1912). Julian shortly thereafter recruited Hermann Muller from Morgan's lab to Rice University. They formed a strong friendship which would later yield joint anti-Nazi and pro-eugenics tracts.

The third chapter details the trials and tragedies of the Huxley lineage. The family appears to have been predisposed to depression, which was particularly manifest in Thomas and Julian. Julian exacerbated his instability with protracted episodes of marital infidelity. He underwent hypnosis and Freudian psychoanalysis. "Julian's finely honed self-absorption plus his intelligence and conceptual sensibilities were made for Freud" (p 115). Later, he elected electroshock therapy, which left him unable to concentrate for periods of time. A devout familial commitment to reductionistic materialism, bequeathed by Thomas, left the family without spiritual resources to cope; this lacuna ironically became a trigger for a fascination for Julian with spiritualism late in life.

Part II, "Animals," focuses on zoological achievements. Wonderful subject matter! One could wish for more, especially in view of the author's accessible prose. It details the insights provided by Thomas into such diverse organisms as cnidarians, crayfish, herring, and horses; by Julian into bird behavior; and by both into the biology and behavior of apes. Chapter 4, "Creatures of the Sea and Sky," begins with an overview of Thomas's early research in marine biology. His expertise would earn him deserved positions on British governmental commissions charged with surveying its coastal biota and regulating fisheries. In 1854, Thomas would assume a professorship of comparative anatomy and paleontology at the Royal School of Mines. While there, he undertook signal studies of fossil vertebrates (an aspect of his life which unfortunately receives scant coverage in this book), including one of the first proposals that birds were simply feathered theropod dinosaurs. Julian initially studied ornithology and maintained a lifelong fascination for pied-billed grebes. However, during the late 1920s, he became sidetracked. H. G. Wells (a former student of Thomas), having completed his *Outline of History* (1920), persuaded Julian to collaborate on a sequel of sorts: an introduction to current biological knowledge. Their magisterial product, *The Science of Life*, was serialized and published in three volumes, 1929–1930. The effort was enormously successful, both in distribution and royalties. This marked a profound turning point in Julian's career, to science popularization.

Chapter 5, "Animal Politics," details the involvement of the family, and particularly Julian, in conservation. *The Science of Life* catapulted Julian into the public eye, and he accepted the position of Secretary of the London Zoological Society, which ran the London Zoo. However, German bombing beginning in 1939 forced the relocation (or outright euthanasia) of the zoo's occupants. Huxley was given leave to come to America for a few months. This move resulted in his departure from the organization. Meanwhile, he became involved with many influential conservation groups. He was tapped as the first director-general of UNESCO, where, in 1948, he initiated the collaborative project that became the IUCN (International Union for Conservation of Nature).

"Of all orders of animals, primates were core Huxley business, their appreciation stretching from the wild to the captive, from the historical to the filmic" (p. 198). Chapter 6 focuses on primates, principally apes. Thomas was instrumental in applying Darwinian themes to the origin of humans, especially in his 1863 volume *Evidences as to Man's Place in Nature*. There were few fossils available for him to discuss, so his emphasis lay on the anatomy of contemporary monkeys and apes. Julian, in turn, became entranced with apes and particularly gorillas while with the London Zoo, and was in turn a tutor and promoter of the work of primate ethologists George Schaller and Jane Goodall. His collaborative work with the latter included publicity trips to East Africa to advocate for conservation of primates in the wild.

Part III, "Humans," examines Thomas's and Julian's evolving perceptions of the role of humans in the history of life. Chapter 7 carries the story of the Huxley family's contributions to paleoanthropology forward, and the following chapter reviews the involvement of Thomas and then Julian in politics. Notably, Julian was a member of a select committee of geneticists, including Hermann Muller, J.B.S. Haldane, C.H. Waddington, and Theodosius Dobzhansky, who issued a (1939) manifesto controverting the overt racism of the Nazi regime and its purported biological basis. This manifesto for racial parity would later become known as the Humanist Manifesto. When Julian took on the directorship of UNESCO, in 1946, it became the template for its foundational document, *UNESCO: Its Purpose and Philosophy*. Julian made sure that the underlying philosophy was areligious, monistically evolutionary, and Freudian.

Chapter 9 tells a sad tale, interweaving the Huxleyan family preoccupations with Malthusian biology and with mental illness. Julian pondered what likely was a genetic predisposition to his own temperament, even as he took on leadership roles in the British and international eugenics movement. Along with geneticist R.A. Fisher and others, he served on the Committee of the Eugenics Society for Legalising Eugenic Sterilisation. He praised the efforts of states like California to implement mandatory sterilization policies.

Part IV, "Spirits," is a dénouement of sorts, documenting the paradoxical return to a vague spiritualism on the part of Julian, prodded by his brother Aldous's experiments with mind-altering drugs and the research of his son, the ethnologist Francis Huxley (1923–2016).

This book comprises a magnificent narrative of a family marked by brilliance, accomplishment, and tragedy, and is highly recommended. It is symphonic in scope. Sadly, an underlying dirge is audible within the Huxleyan polyphony; perhaps it is a product of an insistent turning of the face away from the Almighty.

Reviewed by Ralph Stearley, professor of geology emeritus, Calvin University, Grand Rapids, MI 49546.

Physics

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LOST IN MATH: How Beauty Leads Physics Astray by Sabine Hossenfelder. Basic Books, 2020. 304 pages. Paperback; $19.99. ISBN: 9781541646766.

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EXISTENTIAL PHYSICS: A Scientist's Guide to Life's Biggest Questions by Sabine Hossenfelder. Atlantic Books, 2023. 248 pages. Paperback; $19.99. ISBN: 9781838950385.

"I invent new laws of nature; it's what I do for a living." This is the way German physicist Hossenfelder begins her 2020 book, *Lost in Math*. She goes on, through ten chapters, to explain why particle physics is at an impasse. Particle physicists have been unable to improve upon their "Standard Model," which goes back to the 1970s, largely because experimentation has become so expensive. The $6 billion Large Hadron Collider (LHC) is a prime example. It confirmed, as expected, the existence of the Higgs boson, but otherwise its results have been disappointing. So, Hossenfelder laments, "The LHC hasn't seen anything that would support our newly invented laws of nature" (*Lost*, p. 5).

By her account, contemporary particle physicists have little to work with besides their imaginations and mathematics. Driven to make progress, but without experimental data to guide or constrain them, physicists increasingly rely on aesthetics, on an unreasonable quest for beauty and mathematical simplicity, to theorize. The result: mathematical constructs—new and imaginary particles, string theories, and the multiverse—that pose as science, but are neither testable nor useful. In other words, anyone hoping for an overarching theory of everything is at a dead end. Disaffected with both physics and academia, Hossenfelder's attention has shifted to writing and a popular YouTube channel, "Science with Sabine."

As an engineer, I was barely able to follow Hossenfelder's story since several sections were beyond me. What drew my attention was her honesty and provocative style. She is not a religious person but, like some other scientists, she understands that studies of the fundamental properties inherently involve discussions of God. She acknowledges that religious faith can be consistent with science, while scolding scientists who are dismissive of religion since their criticisms are ill-informed and harmful.

In *Existential Physics*, Hossenfelder looks beyond how physics is (un)done to examine "big questions" about science, academia, life, consciousness, and the nature of reality itself. She prefaces her discussion with "A Warning," letting readers with religious views know she is "both an agnostic and a heathen," and the book might "negatively affect some readers' mental health" (pp. xv–xvi). Readers may be "genuinely disturbed" and ask, "What sense does life make without free will? What is the point of human existence if it is just a random fluke? How can you not freak out knowing that the universe might blink out any moment?"

After the preface, her nine chapter titles are all questions, such as "How did the universe begin? How will it end?" "Why doesn't anyone ever get younger?" and "Are you just a bag of atoms?" Several chapters examine questions of special interest to Christians: "Has physics ruled out free will?" "Was the universe made for us?" and "What's the purpose of anything anyway?" Between chapters are four short conversations with fellow scientists, each beginning with the same question: "Are you religious?" Three respond negatively, but all, to one degree or another, hold to unscientific explanations of existence, even ones that are spiritually laden.

Hossenfelder thinks "Stephen Jay Gould got it right when he argued that religion and science are two 'nonoverlapping magesteria'" (p. 219). Employing that perspective, she emphasizes that science has limits, and its findings do not conflict with many religious beliefs. She closely examines the "fine-tuning" of physical constants (pp. 152–53) that make life possible, as well as competing explanations of them, both religious (i.e., a creator God) and scientific (i.e., the multiverse). Again, she notes the limits of science, admitting that some things are beyond our ability to test them experimentally. Given those limits, she allows people to decide, without prejudice, what they will believe.

Christian readers will appreciate Hossenfelder's openness to theism and her readiness to admit that science is limited, even doubting that it could ever settle some questions. They will also like her condemnations of philosophical naturalism and scientism, such as her statement that

> It's not that I want to be nice to religious people for the sake of being nice. To begin with, I'm not exactly known for being nice. But more important, scientists who claim, as Stephen Hawking did, that "there is no possibility of a creator," or as Victor Stenger has, that God is a "falsified hypothesis," demonstrate that they don't understand the limits of their knowledge. When prominent scientists make such overconfident proclamations, they make me cringe. (p. 218)

Even more, Hossenfelder's appreciation of creation and its religious significance is worthy of praise. She well understands, "Religion matters to many people in a way that science doesn't" (p. 219). Further, she notes:

> Scientists can learn from religion that not every get-together needs to come with a teachable lesson. Sometimes we just enjoy the company of like-minded people, want to share experiences, or look forward to a traditional ceremony. Science is severely lacking in such social integration. (pp. 220–21)

Perhaps she would enjoy the fellowship of an ASA Annual Meeting?

I recommend both books to *PSCF* readers. *Existential Physics* is more accessible, and of more value to a wider audience. Although Hossenfelder would not likely specify, readers may appreciate that "all things were created through him and for him," and "in him all things hold together" (Col. 1:16, 17). Without that knowledge, science can only reach dead ends.

Reviewed by David C. Winyard Sr., Department of Engineering, Grace College & Seminary, Winona Lake, IN 46590.

Psychology/Neuroscience

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DETERMINED: A Science of Life Without Free Will by Robert M. Sapolsky. Penguin Press, 2023. 528 pages. Hardcover; $35.00. ISBN: 9780525560975.

In his latest book, Robert Sapolsky takes on the monumental task of trying to convince his readers that personal agency, free will, and moral responsibility do not exist. As a staunch determinist, he argues for the philosophical position referred to as "hard incompatibilism" (determinism and free will are incompatible positions to hold simultaneously). Sapolsky readily acknowledges how challenging this task will be, settling for a more modest goal—to get readers to intellectually move in the direction that there is less free will than they previously assumed.

Sapolsky is an author who should be read, and his arguments, whether you agree with them or not, need to be discussed. He is a neuroscientist and primatologist, and holds the position of professor in biology, neurology, and neurosurgery at Stanford University. By the age of 30, he was awarded a MacArthur Foundation "Genius" grant. His writing is intelligent, clever, lucid, and at times hilarious, infuriating, and profane. Personally, I admire Sapolsky's command of the written word. In one sentence he can make the reader laugh by employing whimsical literary devices and in the next sentence he can be punishingly argumentative and scholarly. He writes with a chip on his shoulder, knowing that most people reading the book disagree with his extreme deterministic position. His prose is never dull or boring,

even when the subject matter addresses neurological topics such as brain anatomy or chemistry.

PSCF readers will be familiar with the lack of humility sometimes found in the writings of other scientists who are extreme determinists. Here, Sapolsky mirrors the language of these writers who have often asserted that our thoughts and actions are nothing more than the aggregation of prior biological antecedents. In his words, "when you behave in a particular way, which is to say when your brain has generated a particular behavior, it is because of the determinism that came just before, which was caused by the determinism just before that, and before that, all the way down" (p. 3). Sapolsky believes so strongly that we are nothing more (or less) than the "cumulation of biological and environmental luck" that he frequently crosses the line and lapses into arrogant outbursts such as: "How can you believe in free will by ignoring history?" (p. 85). He seems to have trouble accepting the reality that the vast majority of determinists adopt a position that allows for freedom of choice.

Early in the book, Sapolsky delineates some of the common attitudes held by people writing about free will. He describes a four-fold typology that encompasses almost everyone. His category of "compatibilists"—determinists who believe in free will—comprises over ninety percent of those who are intellectually engaged with the topic. Due to the popularity of this position, Sapolsky spends much of his book attacking it. One proponent of this view is the eminent scientist, Michael Gazzaniga, who co-founded the discipline of cognitive neuroscience and authored the book, *Who's in Charge? Free Will and the Science of the Brain*. Gazzaniga's book had a profound effect in shaping my own understanding and eventual embracing of the compatibilist position.

The first half of *Determined* is devoted to the notion that free will cannot be demonstrated. Two chapters are focused on *intent* since Sapolsky says a disproportionate amount of research on the free will debate revolves around this construct. Here he meticulously dissects the empirical literature on experimentation that emanated from Benjamin Libet's classic series of electroencephalogram (EEG) experiments in 1983. These experiments, along with dozens of others performed in the intervening 40 years, demonstrated that an electrophysiological "readiness potential" originating from the supplementary motor area of the prefrontal cortex is initiated 200–300 milliseconds prior to when people reported making a decision. Comparable results have been observed using fMRI imaging, demonstrating neuronal activity up to ten seconds prior to the time when subjects reported making a conscious decision.

These results have been used to support the notion that free will is "just a post hoc illusion, a false sense of agency" (p. 22). Interestingly, Sapolsky is highly critical of this research and concludes that these studies are irrelevant to the free will debate since none of them address the question: Where did that intent come from in the first place? For this question, Sapolsky spends an entire chapter on *where* intent comes from by elucidating neurobiological processes that occur seconds prior to an action, then hours prior, then days prior, then months prior, and so on. Essentially, he attempts to demonstrate how a series of biological antecedent events *could* produce a behavior without ever being able to show what *actually* occurred to lead to an action or thought.

Next, Sapolsky addresses the question: What if some moments aren't caused by anything preceding them? This could open the door to allow free will to sneak in. This is an important question since determinacy has been challenged by the sciences of chaos theory, emergent complexity, and quantum indeterminacy. Sapolsky uses six challenging chapters to argue that none of these three major developments pose insurmountable problems to his hard incompatibilism worldview. *PSCF* readers without a physics background may have difficulty understanding his arguments. Given the assumptions and uncertainties of these challenging areas, I was not convinced that Sapolsky's interpretation of the data was supportive of this book's overriding thesis that free will does not exist.

To Sapolsky's credit, *Determined* does not abruptly end with no discussion of what moral responsibility looks like in a world lacking free will. He devotes chapters to questions such as: If free will is a myth and our actions are the byproduct of amoral biological processes leaving us without moral culpability (as Sapolsky believes), will we not "run amok" engaging in all sorts of maladaptive and even heinous behaviors? He also delves into why people enjoy seeing others punished when they commit a crime or engage in morally reprehensible behavior. Lastly, since Sapolsky believes that people cannot be held ethically responsible for their behaviors, he insists we must change how society deals with those who break our laws since there is no ethical justification for blame and punishment. As an alternative to a retributive justice system, he proposes that we adopt a quarantine model similar to what the medical field uses to deal with patients stricken with a disease in which it is in society's best interest to remove them from the general population. Regardless of what you might think about Sapolsky's ideas, at least he is trying to find a solution to major social ramifications in case he has convinced you (and others) that free will is nothing more than an illusion.

Sapolsky includes a lengthy footnote stating he will not discuss any theologically based Judeo-Christian views that relate to free will, agency, and moral responsibility. This decision omits important questions that should be part of the conversation. *PSCF* readers may ask: How can an omniscient God who knows everything about the present, as well as the future, still allow for personal agency? Also, if the theological "hard determinists" are correct, and God has predetermined how the world is going to play itself out, how does the construct of moral responsibility fit into this framework? Finally, what is the interplay between supporting, as well as opposing, arguments for natural determinism and theological determinism? Complex issues, enlightened by faith, can guide us towards alternative understandings that will bring us closer to the truth. For me, the debate between free will and determinism is no exception.

If you are interested in exploring the question of free will and determinism from perspectives drawn primarily from scientific research findings—as opposed to philosophical or theological musings—I recommend this book. Even if you find the author's position of hard incompatibilism to be too extreme, the book is instructive and entertaining.

Reviewed by Bryan C. Auday, retired professor of psychology, Gordon College, Wenham, MA 01984.

Science and Faith

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CHRISTIANITY AND SCIENCE by Herman Bavinck, trans. and ed. N. Gray Sutanto, James Eglinton, and Cory C. Brock. Crossway, 2023. 240 pages. Hardcover; $32.99. ISBN: 9781433579202.

Among the architects of the neo-Calvinist movement is the Dutch theologian Herman Bavinck (1854–1921). In 1902, Bavinck moved from his professorship of theology at Kampen Theological Seminary to the Free University of Amsterdam, succeeding its founder Abraham Kuyper as the professor of theology. He wrote *Christelijke Wetenschap* early in his professorship in Amsterdam; this English edition has been translated midst the recent reinvigoration of Bavinck studies.

Christianity and Science was written in the same year as, and serves as a complementary expansion to, his treatise *Christian Worldview*. In *Christian Worldview*, Bavinck argues that modernity had failed the modern person. Modernity fragments the person, rendering their lived experience as lacking holistic integration. Christianity unites who we are, who we are becoming, and how we relate to the world in an organic unity. In *Christianity and Science*, Bavinck applies these ideas to scholarly inquiry and academic disciplines. He argues that the Christian worldview offers the believer unity in the life of the mind and, thus, uniquely equips the Christian for the academic endeavor in all fields of science.

What does Bavinck mean by "science"? In contrast to its common meaning of empirical disciplines, he uses the word more broadly, claiming that science encompasses all scholarly activity aimed at knowing truth. "The end goal of science can be none other than the knowledge of the truth—of the full, pure truth" (p. 127). It is for this reason the book covers disciplines from the natural sciences to literature, history, and theology. Bavinck's concept of science does not separate them but sees them as a unified whole.

Throughout his book, he postures an attitude of intellectual engagement between science and faith, and not of fundamentalist retreat. Bavinck stands in the Augustinian tradition of faith as enabling science: "Faith and science thus stand next to one another in relationship like conception and birth, like tree and fruit, like work and wage; knowledge is the fruit and wages of faith" (p. 58). He takes time to trace both the historic precedent of this idea within Christianity, and its later divergence culminating in the Enlightenment.

While still relevant to today's world, Bavinck's work is a challenging read for the contemporary reader, as his turn-of-the-century Dutch context is far removed from ours. Writing against the backdrop of positivism, he spends considerable time interacting with and arguing against it. Its power within disciplines is marked by its own flavor of religious ferocity. Remarkably, Bavinck seems prescient of the wane of positivism, about half a century before its eventual decline.

Positivist science, contrary to what it claims, is not presuppositionless. Bavinck lists several assumptions inherent to the practice of science and argues that no scholarly activity can be conducted from an intellectually neutral place. One's individual personality will always come to bear on the scientific inquiry. This is not a flaw of science but of its essence, for "Science remains bound to life" (p. 115). Building on an illustration Bavinck offers, the agriculturalist might not dig their fingers into the soil with the intimate knowledge of the farmer, but both will carry presuppositions concerning the earth, land, and community that radically influence their treatment and study of the same land.

Considering the natural sciences, Bavinck claims that "... all science, including that of nature, rests upon metaphysical presuppositions …" (p. 131). After listing several assumptions inextricable from the natural sciences, he argues that the implications of a worldview can be found even in natural sciences: "… natural science stands under the influence of a worldview, of

philosophy, and thus also of faith and unbelief" (p. 135). While positivism has since fallen as the prevailing philosophy governing natural science, Bavinck's critique is still a welcome point, laying to rest the conception of science as an objective, neutral space, as opposed to theological and liberal arts disciplines.

The alternative to positivism may appear to be subjectivism. But rather than abandoning all hope in the face of apparent subjectivism, Bavinck recognizes that the extent of the influence worldview has on scholarship varies by discipline. He says, "In math, chemistry, [and] anatomy, the difference in life view may count for little; as soon as subjects like geology, paleontology, biology, [and] anthropology come into view, faith and unbelief lay their weight on the scales. This comes to the fore to a greater degree in the humanities" (p. 138–39). Such recognition is instructive to all who may be tempted to reject the natural and social sciences altogether merely because they have presuppositions.

The influence of worldview on science, according to Bavinck, is the source of much of the dispute between science and religion. One's worldview can lead scientists to hold onto hypotheses long after they are deemed untenable. "History is abundantly rich in examples in which the so-called undisputable results of science were played against religion and which, after a short period of growth, were themselves rejected after scientific advancement and fell into obscurity" (p. 137).

To his credit, Bavinck covers a vast terrain of scholarship in his book. However, certain discussions felt wanting. For instance, he says regarding a miracle, "… it is in no way in conflict with the facts and methods of natural and historical science, because it leaves them fully intact and is itself, by virtue of its nature, withdrawn from the judgment of these sciences" (p. 202). A reader seeking a fuller exploration of the relation of miracles to the natural sciences shall not find it in this book. Indeed, given Bavinck's expansive definition of science, the reader may approach the book with different questions concerning Christianity's relationship to scientific discovery from the answers the book supplies.

The relation of Christianity to science developed within this book is also a manifesto for Bavinck who ends his book by arguing for a distinctly Christian higher education. He contends for state support of Christian universities and not merely of secular ones, for no university can be truly unbiased. He also sees the Christian confession of the Christian university to be beneficial to scholarship—the confession offers guardrails to practitioners within the university and accounts for the noetic effects of sin. In addition, the confession compels Christian universities to stay up to date with science "precisely because they take up a position in the field of science" (p. 217).

Throughout his book, Bavinck helps Christians engaged in higher learning grasp a vision of the relation between Christianity and scholarship. Christianity is the greatest motivation in the pursuit of truth because it presumes the unity of all truth in a world created by God. Even in this day and age, *Christianity and Science* remains relevant for Christian scholars. For Bavinck is not merely concerned with fitting faith into the ever-changing landscape of science. Rather, he locates the place of science in a world known through faith—an endeavor that shall always remain relevant.

Reviewed by Kevin Valson Jacob (assistant professor of physics at Wheaton College, IL) and Skyler Flowers (PhD student at the University of Aberdeen and associate program director at The Keller Center for Cultural Apologetics).

TECHNOLOGY

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THE ANXIOUS GENERATION: How the Great Rewiring of Childhood Is Causing an Epidemic of Mental Illness by Jonathan Haidt. Penguin, 2024. 400 pages. Hardcover; $30.00. ISBN: 9780593655030.

"They don't make 'em like they used to." That old saying came to mind more than once as I read Haidt's masterful new book, about how significant changes to American childhood in the last decade and a half have led to a recent explosion in depression, anxiety, and other "internalizing" disorders, especially among those under the age of 30. Well-known social psychologist Haidt lays the blame for our national decline in mental health squarely at the feet of technology, in an account that Christian scholars (and parents) working in a variety of scientific fields will find compelling.

The Anxious Generation succeeds on many levels. It is well researched, well written, and persuasive. It provides specific and actionable recommendations for parents, educators, and legislators: no smartphones before high school, no social media before age 16, phone-free schools, and more unsupervised play and childhood independence. It attempts to start a thoughtful conversation at the national level about a problem that affects every American family individually, but that will require collective action to solve.

Haidt also shows, in a way scientists might appreciate, that life is never a well-controlled experiment. The sheer number of variables is mind-boggling. The rise of screens has been bad for children—yes, that much many parents and teachers have known for a while, intuitively.

But Haidt does more than just prove that their intuitions were correct. He also adeptly demonstrates that the rise of screens has been connected to many other developments in American life and culture, from mounting anxieties about "stranger danger" and the legal liability of playgrounds, to the erosion of norms and rites of passage in a society characterized by pluralism and consumerism. The rise of screens has also been the fall of play, in all of its many forms, and a precipitous drop in real-time, face-to-face encounters with other human beings. Unfortunately, those two things—play and face-to-face encounters—are precisely how children learn.

In short, *The Anxious Generation* is a book about far more than just keeping smartphones out of the hands of children and adolescents until high school. The story of how screens and social media are affecting young people today is tangled and complicated.

One consequence of this tangled, complex reality is that some causes have become very, very far removed from their effects. To give one example, Haidt cites five studies measuring the effect of high-speed internet rollout on adolescent mental health. In all five, the arrival of high-speed internet was followed by an increase in diagnoses and hospitalizations for behavioral and mental health problems, especially among teenaged girls. One can only assume that the men and women who dug trenches for fiber-optic cables in Spain had no way of knowing that their labors would go on to harm the young men and women around them—perhaps even their own children (p. 150).

CEOs, by contrast, did know. Sean Parker, the first president of Facebook, told a reporter for Axios in 2017 that the platform had been specifically designed to exploit "a vulnerability in human psychology." Executives and engineers "understood this consciously. And we did it anyway," Parker admitted. "God only knows what it's doing to our children's brains" (p. 227).

And, we might add, what it's doing to children's souls. Although Haidt was raised in a secular Jewish household and now considers himself an atheist, he includes a chapter on "Spiritual Elevation and Degradation." His diagram of "three dimensions of social space"—which plots Closeness on the x axis, Hierarchy on the y axis, and Divinity on the z axis—was not the easiest for me to follow, as a reader whose scholarly training is in American literature. But his analysis struck me as sound. To the extent that our phones pull us "downward" on this graph, Haidt writes, "spiritual harm" is occurring. And "if more people are spending more time below zero on the z axis," then "we would perceive a general society-wide degradation that would be hard to put into words" (p. 201). As, indeed, many of us are.

Ultimately, *The Anxious Generation* is an eloquent delineation of the cultural, societal, and technological conditions that are most conducive to shaping a moral human person from birth to adulthood. Children need to take on responsibility and risk incrementally, in age-appropriate ways. They need real-life experiences from which to learn, practice, and refine their abilities. They need ample time with parents (who can nurture them and model appropriate behaviors) and with friends (who can, through improvised games and hours of talking and playing, become sparring partners who help them discern what is appropriate and safe, and what is not, in conversations in school, on the playground, and every other place that children and adults go).

What children too often get now, instead, is time alone on the Internet. Although virtual worlds might seem safer than physical spaces, Haidt makes it clear that they are not. He compares the online environment to Mars. Like astronauts in protective gear in the airless vacuum of outer space, children today lack opportunities for developing their natural "anti-fragile" properties, which are designed to strengthen living creatures by exposing them to moderate challenges (as with wind-tried "stress wood" or our immune systems). Like astronauts, children may find that under such hostile conditions even a single small mistake can be fatal.

Most unsettling to me was the way in which this shift to online childhood has proceeded in a manner at once systematic and haphazard. Tech companies have methodically sought ways to "hack" our human need for connection and belonging to improve their bottom line. The development of "advertising-driven apps" between 2008 and 2013 set companies off on an arms race "to see who could hold onto eyeballs the longest" (p. 115). The invention of the "like" button by Facebook and the "retweet" button by Twitter, both in 2009, "quantified the success of every post and incentivized users to craft each post for maximum spread," which led to increasingly "extreme" content designed to produce strong (and usually negative) emotional responses (p. 117). Next came push notifications, front-facing cameras, autoplay, infinite scroll; all with the same effect of keeping eyes glued to screens. The road to hell is paved with shareholder profits and minor software tweaks. The veneer of good intentions is gone.

Meanwhile, on the user end, it's a different story. Parents and young people alike speak of feeling "trapped and powerless," as if they'd lost all human agency without knowing how (p. 23). Now, thanks to Haidt, we know how. All of this reveals that the conditions forming children today are far removed from the wisdom of Proverbs 22:6: "Train up a child in the way he should go, and when he is old he will not depart from it." The

question posted by *The Anxious Generation* is: what, if anything, are we willing to do about it?

Reviewed by Cassandra Nelson, visiting fellow in literature at the Lumen Center, Madison, Wisconsin, and associate fellow of the University of Virginia's Institute for Advanced Studies in Culture.

Letter

Comments on Wood's Unification Paradigm

I just completed reading the article by W. Robert Wood, entitled "The Unification Paradigm in Theoretical Physics and the Beauty of God" (*PSCF* 77, no. 2 [June 2025]: 82–96). My professional background in physics makes the topic of special interest to me. Unification theories are at the heart of physical sciences.

Robert Wood has done a comprehensive study in preparing the article and has done it well. I have two comments.

The first involves the story behind the quote from Eugene Wigner, "the miracle of the appropriateness of the language of mathematics for the formulation of the laws of physics is a wonderful gift which we neither understand nor deserve" (p. 88). As a graduate student at Princeton, I was taking a course in quantum mechanics from Wigner. He made that well-documented quote first in the classroom, shocking all of us. It was later published in 1960.[1]

Second, Sy Garte published a brief version of one such unification principle I had made ("Four Forces in Nature," *God & Nature* [Fall 2022], https://godandnature.asa3.org/touryan-four-forces.html), regarding the four fundamental forces of nature: the electromagnetic force, the strong force, the weak force, and the gravitational force. The weak forces and strong forces are united, but the gravitational forces could not be captured. The point I raised was from Hebrews 1:3 NIV: "Jesus … sustaining [unifying] all things by his *powerful word*"; hence, the unification of *all* four forces becomes evident for the scientist who also takes scripture seriously.

Note

[1]Eugene Wigner, "The Unreasonable Effectiveness of Mathematics in the Natural Sciences," *Communications on Pure and Applied Mathematics* 13, no. 1 (February 1960), 1–14, https://onlinelibrary.wiley.com/doi/10.1002/cpa.3160130102.

Cheers,
Ken Touryan (PhD, Princeton)
ASA Fellow

American Scientific Affiliation

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