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

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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.

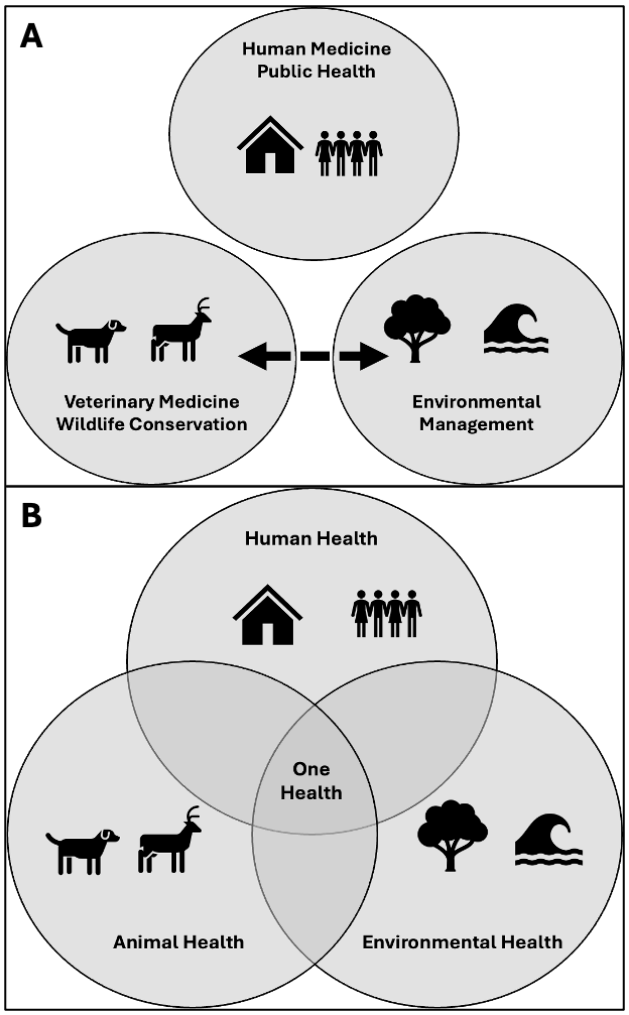

Figure 1. Classic Model of Siloed Environmental and Health Stewardship

(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

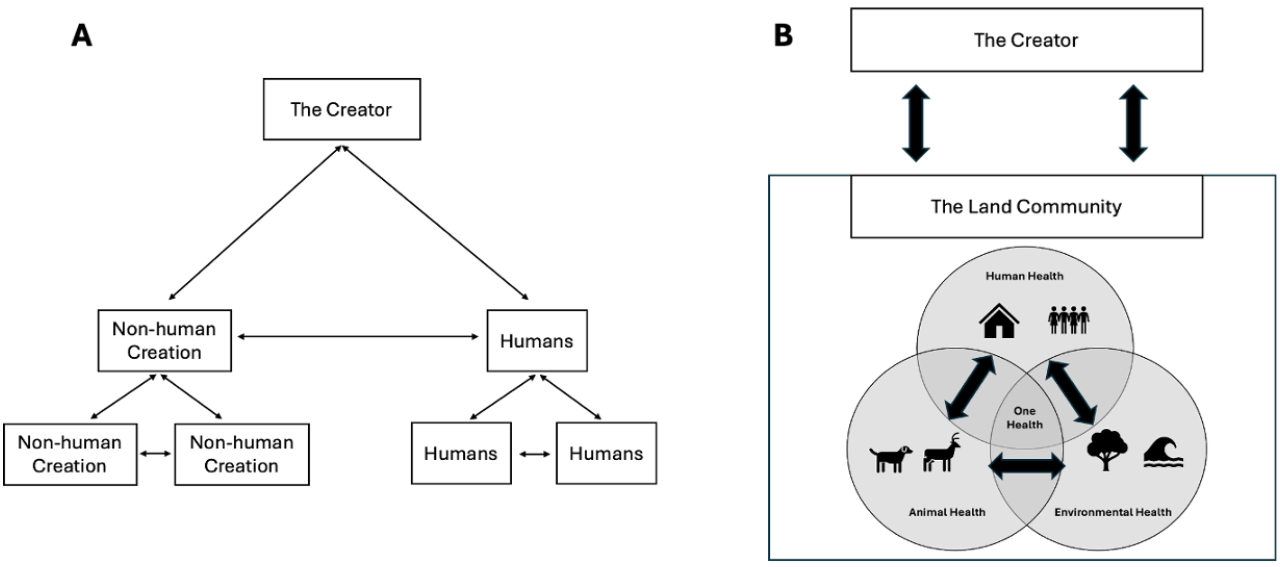

Figure 2 A. The original reconciliation ecology paradigm focused on the restoration of shalomic relationships between the Creator, the human creation, and the nonhuman creation (adapted from David Warners, Michael Ryskamp, and Randall Van Dragt, "Reconciliation Ecology: A New Paradigm for Advancing Creation 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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