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Abstract

The diminishing of the Earth's biological diversity due to human activity, and in particular the accelerated rate of species extinctions, are among the critical environmental trends that mark this as an unprecedented era in human history. The human influence on genetic, species, and ecosystem diversity and on the Earth system as a whole has intensified since the mid-1900s. Definitions of, and approaches to, conservation have evolved in response. This process now includes critical re-examination of the ethical foundations of conservation and unresolved visions for its future trajectory.

Conserving Biodiversity in a Time of Rapid Environmental Change

Like other natural processes and phenomena, the expansion and contraction of the Earth's biological diversity at the genetic, population, species, and ecosystem levels has occurred throughout evolutionary time. Our current era, however, is distinguished by the rapid loss of diversity on a global and geologically significant scale, driven by anthropogenic forces of environmental change (Barnosky et al. 2011). The major trends that now negatively influence biological diversity include global climate change and its associated effects; extensive disruption and conversion of terrestrial, freshwater, and marine ecosystems; widespread modification of hydrological systems and regimes; pollution and other forms of environmental degradation; overharvesting of biological resources; and the global dispersal of invasive species.

Driving these trends in biodiversity loss are social and economic forces that shape the relationship between people and the landscapes and ecosystems they inhabit. These forces are not new. Throughout history human communities and economies have influenced the composition, function, and character of ecosystems. Some societies evolved behavioral norms that contributed to relatively sustainable and resilient environmental conditions—others not. As the human population has grown and spread geographically, and as human economic activity has expanded and intensified, sustainability has become a global concern. In recent decades it has become evident that the long-term vitality and security of human socioeconomic systems depends on the health and resilience of ecosystems, and the Earth system in which they are embedded. The resilience of ecosystems, in turn, is associated in complex ways with their coevolved diversity. The conservation of biological diversity is essential to the broader movement to foster resilient ecosystems and a sustainable future in a world increasingly influenced by human activity. Conservation ethics, it follows, must now address issues beyond just the need for local or regional adaptation and coexistence.

Antecedents to contemporary biodiversity conservation efforts can be found in “proto-conservation” cultural practices, land stewardship methods, and ethical systems that have evolved throughout history and in landscapes around the world. As a modern professional and political movement, conservation emerged most prominently in the early twentieth century as part of Progressive Era's campaign for political reform in the United States. Policy-makers, scientists, business leaders, and citizens responded to decades of rampant resource exploitation in North America by adopting measures to stem losses and encourage the protection and rational use of natural assets. Over its history conservation has evolved continually as scientific

knowledge has increased and social values have shifted. The preservationist and utilitarian approaches that marked (and divided) early conservation efforts would come over time to reflect a broader and more integrated set of values. A critical aspect of that process has involved the growing appreciation of biodiversity's role in maintaining ecosystem resilience. Now biodiversity conservation faces the challenge of evolving to respond effectively to the realities of accelerated social and environmental change at the global scale. For conservation to be effective, its ethical foundations must evolve as well.

Understanding the Human Impact on Biological Diversity

The needs and challenges of biodiversity conservation in the Anthropocene cannot be fully appreciated outside of their historical context. Contemporary approaches to conservation build upon the historic advances in scientific understanding of life's diversity and the evolution of conservation philosophy, policy, and practice in response to that knowledge. Developments in conservation ethics over the last century reflect this continuing and dynamic interplay. Although anthropogenic biodiversity loss can be traced back millennia, scientific understanding of that loss, and the role that humans have played in it, has come together relatively recently. Only in the last two centuries has science critically studied the origins, development, and diversification of life (Mayr 1982). Only in the last several generations have scientists identified Earth's ancient extinction events and speculated on their cause and effect (Ward 2000). And only in recent decades have we come to assess more fully the fate of life's diversity and extinction under the increasing influence of humanity (Barrow 2009). Religious, philosophical, and ethical traditions that predate these advances in scientific knowledge continue to adapt in response. Conservation scientists, conversely, have had to consider the social and ethical implications of their research and knowledge.

It is essential to recognize how, over the last two centuries, we have come to understand diversity and extinction as an evolutionary process increasingly influenced by human activity. Geology, paleontology, taxonomy, systematics, biogeography, and evolutionary biology have shown how life forms have originated, diversified, adapted, and gone extinct. Archaeology, cultural anthropology, and environmental and economic history have illuminated the role of *Homo sapiens* in altering the trajectory of life over the last hundred millennia. And ecology, genetics, population biology, and conservation biology have revealed changing patterns in life's diversity, vulnerability, and resilience. The story of extinction has continually changed through the ongoing synthesis of knowledge from this wide range of scientific disciplines.

Ancient mass extinctions. A general account of the interaction of humans and nature's diversity has come into focus since the mid-twentieth century (although new research and analysis of course require constant revision of this narrative). Prior to the advent of the human species, the four-billion-year odyssey of life on Earth followed a pattern of increasing complexity and diversification, punctuated by regular and occasionally catastrophic episodes of extinction. Although there is no clear threshold at which an extinction episode comes to be regarded as a "mass extinction," paleontologists now generally concur that multicellular animal life on Earth has experienced five such events: the Ordovician-Silurian (440-450 million years ago); Late Devonian (360-375 million years ago); Permian-Triassic (252 million years ago); Triassic-Jurassic (201 million years ago); and Cretaceous-Tertiary (66 million years ago; also known as the Cretaceous-Paleogene event).

These events had different (and still debated) causes, with varied impacts on different families and genera of marine and terrestrial organisms. They also differed in terms of the rate at which life subsequently recovered. In general, life re-diversified over a period of 5-10 million years following mass extinctions, 15-30 million years in the case of the more severe Ordovician-Silurian and Permian-Triassic events. Knowledge of this pattern of diversification, extinction, and recovery has yielded efforts to define a background (or normal) extinction rate. The Earth is now thought to be experiencing, due to human activity, a species extinction rate about 1,000 times higher than the background rate (De Vos et al. 2014). Such estimates and analyses also predict continual increases in relative rates of extinction into the future—findings with obvious ethical implications.

Broad patterns of anthropogenic extinction. The accelerated rate of extinction reflects the complex record of the growth and diffusion of the human population around the world over the last 70-100,000 years. It also reflects the changes in social and economic arrangements, technological capacities, and belief systems that occurred as we adapted to and altered new environments.

Genetic, archeological, and anthropological research has revealed with increasing precision the pathways by which *Homo sapiens* spread from Africa to populate Asia, Europe, Australia, Polynesia, and North and South America through the late Pleistocene and Holocene epochs. A broad but clear pattern of human impacts on species diversity emerges from these studies. Having coevolved with and within African ecosystems (and especially their large fauna) over several million years, *Homo sapiens* had relatively limited effects on the species diversity of its home continent. As humans moved out of Africa and encountered abundant populations of naïve fauna, these populations fell victim to increasingly sophisticated hunting and trapping techniques and technologies. As our ancestors migrated across the previously uninhabited continental land masses, species losses mounted, especially of the larger-bodied mammals. These megafaunal extinctions in turn had cascading effects on the composition and function of the ecosystems where they occurred (Malhi et al. 2016). When humans arrived on islands and migrated across island chains, endemic species found themselves vulnerable as well (this was especially the case with flightless birds that had previously lacked mammalian predators).

Perhaps the best known and most dramatic episode in this process was the arrival of humans into the Americas, perhaps in several waves, between 13,000 and 17,000 years ago. (Some researchers have proposed even earlier arrival dates.) A closely correlated wave of extinctions involving dozens of Pleistocene fauna, many of them large carnivores and herbivores, swept over North America. Although debate over the timing and causes of these extinctions remains vigorous, researchers generally agree that extensive human predation was a key causal agent (the “overkill hypothesis”), in combination perhaps with climate change, ecosystem disruption, and disease. This wave of continental extinctions extended to affect insular species in the Caribbean basin and elsewhere.

Biodiversity and the rise of human civilizations. Extinction was not the only expression of the evolving relationship between prehistoric humans and biological diversity. Other species experienced local and regional extirpations (the disappearance of a species from a portion but not the totality of its range). Still other species benefitted from their affinity with humans, and vice versa. The domestication of animals (beginning in the Late Pleistocene with the dog) and plants (beginning in the Neolithic with cereal grains in southwest Asia) initiated the

process by which *Homo sapiens*, through artificial selection, redirected the pathways of genetic and species diversity. Domestication was one expression of human “niche construction” that, by altering ecological relationships and processes for human benefit, contributed to the loss and redirection of diversity at the genetic, species, and ecosystem levels (Boivin et al. 2016).

These broad trends played out differently, and to varying degrees, within landscapes around the globe. In contrast to the dominant record of prehistoric anthropogenic extinction, there are counter-examples of cultures having achieved relatively sustainable ways of life that effectively conserved biological diversity (Berkes 2012). Indigenous peoples in landscapes throughout the world developed sophisticated belief systems and resource-use practices that recognized their connections to and dependence on nonhuman nature. In the past, these traditions allowed people to adapt to and sustain themselves in even extreme environments throughout the world. Some of these cultural traditions have survived into the modern era. Now, however, they contend with altered land tenure systems, economic development pressures, and rapid technological change, as well as increasing stress due to climate change.

Over the last ten millennia the rise and spread of agriculture across the globe has had broad environmental and social impacts with far-reaching consequences for biodiversity. Agriculture has resulted in widespread conversion of forests, savannas, grasslands, and wetlands. This in turn has led to changes in hydrologic function and watersheds through soil erosion, irrigation, and drainage. With the establishment of permanent settlements and eventually cities, lifeways became more sedentary. These trends in human interactions with landscapes were tied to changes in human social relations. The agricultural revolution led to increased social stratification, reinforced by more rigidly prescribed political structures and gender roles. Diverse indigenous nature-centered and animist belief systems gave way to religious movements that reflected the changing relationships to natural systems within the emergent agrarian societies. Traditions that emphasized kinship and respect for non-domesticated creatures, natural processes, and specific landscapes and landscape features were transformed by incipient religions based on spiritual hierarchies and generalized concepts of the divine (Oelschlaeger 1991).

Contemporary environmental dilemmas have prompted modern scholars to reclaim proto-conservation insights found in texts and stories from animist, Native American, Hindu, Buddhist, Judeo-Christian, Islamic, and other faith traditions (Grim and Tucker 2014). In Native American experience, for example, we may find echoes of the loss of the Pleistocene megafauna. Kiowa poet and writer N. Scott Momaday (1997, 32) has voiced this view, describing the appearance of Clovis culture and the effect of Paleoindian hunting on the evolution of Native American land ethics.

...[T]his latter-day [Native American], unlike his ancient predecessor, is only incidentally a hunter; he is also a fisherman, a husbandman, even a physician. He fells trees and builds canoes; he grows corn, squash, and beans, and he gathers fruits and nuts; he uses hundreds of species of wild plants for food, medicine, teas, and dyes. Instead of one animal, or two or three, he hunts many, none to extinction as the Paleo-Indian may have done. He has fitted himself far more precisely into the patterns of the wilderness than did his ancient predecessor. He lives on the land; he takes his living from it; but he does not destroy it. This distinction supports the fundamental ethic that we call conservation today. In principle, if not yet in name, this man is a conservationist.

In the Judeo-Christian tradition, to draw upon another example, the biblical injunction to “fill the earth and subdue it, and have dominion over every living thing that moves upon the earth” (Genesis 1:28) has often been cited as providing the justification and rationale for centuries of environmental exploitation in the Western experience. In his 2015 encyclical letter *Laudato Si’* (49), Pope Francis addressed this passage specifically, stating that “nowadays we must forcefully reject the notion that our being created in God’s image and given dominion over the earth justifies absolute domination over other creatures.” He offers an alternative interpretation that emphasizes “a relationship of mutual responsibility between human beings and nature. Each community can take from the bounty of the earth whatever it needs for subsistence, but it also has the duty to protect the earth and to ensure its fruitfulness for coming generations.”

Early Western approaches to conservation. Since classical times, observers have recorded instances of environmental deterioration due to human action. Plato, for example, compared the deforested mountains of Attica to the “bones of a wasted body... the richer and softer parts of the soil having fallen away, and the mere skeleton being left” (Jewett 1892, 532). However, evidence of early resource stewardship practices can also be found in the history of both Western and non-Western cultures. These include efforts to protect particular species and special lands, to maintain populations of wild plants and animals, and to sustain the productivity of agroecosystems.

European traditions of forestry and game-keeping date back to the Middle Ages and beyond. The establishment of royal game preserves and forests on the land estates of feudal Europe led to the development of customs and formalized laws regulating hunting and use of the forests—while also generating local resentment over centralized resource management. On the continent, Germany and France in particular developed silvicultural systems and techniques that prevented wholesale destruction of the forest estate.

Europeans carried these proto-conservation traditions to their expanding colonial empires. The change in jurisdiction over natural resources, from indigenous peoples to colonial and state governments, had profound implications for social systems and ecosystems alike. Colonial domination, coupled with rising populations and industrialization, disrupted traditional patterns of land tenure and resource use. In many regions, native peoples became increasingly alienated from their landscapes, while Western conservation ideas and practices were slow to adapt to the new environments. At the same time the meeting of the Old and New Worlds was having profound impacts on biodiversity in general. Through the 15th and 16th centuries the “Columbian Exchange” saw the transfer of plants and animals, diseases, crops, livestock, and cultural influences and technologies, with permanent consequences for ecosystems and human populations on both sides of the exchange.

Early conservation efforts in North America. In the New World, European colonists encountered a landscape of abundance as disease and displacement decimated Native American/First Nation populations. Unchecked resource exploitation was the norm as European settlement of North America proceeded. Despite this record, seeds of the later conservation movement were apparent in early efforts to protect wild game populations, forests, soils, water, and special natural features. Through the 1800s, for example, the new American states intermittently passed laws establishing closed hunting seasons and prohibiting hunting of

nongame birds. Other measures, reflecting the pre-ecological state of knowledge of natural systems, included the establishment of bounties on predators and other “vermin.”

Despite such early resource conservation measures, exploitation of North America’s extensive native forests—for conversion to agriculture, for construction and shipbuilding materials, for charcoal and domestic fuel supplies—drove economic development through much of the colonial and early American era. With the exhaustion of the eastern forests and the continuing settlement of interior North America, the focus of forest exploitation shifted to the Great Lakes region. A parallel pattern of resource degradation and early conservation response affected wetlands, wildlife, and fisheries, and marked the process of agricultural development in North America. By 1776 the problem of soil erosion was evident to the new nation’s leading statesmen. Over the next century, destructive agricultural techniques and the onset of the industrial revolution continued to take their toll on native plant and animal communities across North America (and in other parts of the world as well).

At the same time, the preservation impulse found special expression in the North American setting, as European settlers encountered scenic landscapes and natural features unlike any in their prior experience. Thomas Jefferson, for example, celebrated Virginia’s Natural Bridge in his *Notes on the State of Virginia*. The artist George Catlin suggested after his first excursions in the West that portions of the continent’s undeveloped lands were “worthy of our preservation and protection” (Nash 2001, 101). These expressions of concern were not aimed at conserving biological diversity in the modern sense, but sought primarily to protect economically and aesthetically important components of the landscape or ecosystem. Although limited in intent, such measures provided the foundation on which a more coherent conservation movement began to take shape in the latter half of the nineteenth century.

Emergence and Evolution of Biodiversity Conservation

These early cultural practices, statutes, and artistic expressions in support of restrained use of natural resources developed with limited empirical knowledge of the state of biological diversity. This would begin to change with the Enlightenment and the founding of the natural sciences. Exploration of the world’s diverse ecosystems—from the earliest voyages of discovery through the New World scientific expeditions of Alexander von Humboldt, John and William Bartram, Meriwether Lewis and George Rogers Clark, and others—initiated a golden age of natural history studies in the eighteenth and nineteenth centuries. Adoption of the Linnaean system of binomial nomenclature in the 1700s allowed for the flourishing of taxonomic research. This, along with developments in geology, provided essential foundations for the formulation of evolutionary theory in the work of Alfred Russel Wallace and Charles Darwin. Although the biological sciences had not yet developed field methods for comprehending the full diversity of life, they had begun to reveal the processes through which life diversifies and maintains itself. At the same time, geologists and other earth scientists were assembling the foundations of modern climate science.

These gains in scientific understanding of biodiversity occurred even as the industrialization and the expansion of market economies altered the scale, pace, and character of human environmental impacts. Through the 1800s the advent of a broad array of more efficient technologies—from saws and firearms to the railroad and telegraph—resulted in increasingly intensive exploitation of all natural resources. Traditional resource management practices and established land tenure systems were abandoned or changed to fit the emerging economies of

scale. For the first time, industrial pollution and the spread of invasive species became global in scope. As the Industrial Revolution took hold, the concentration of carbon dioxide and other heat-retaining gases in the atmosphere began to increase with the shift to, and increasing reliance on, fossil fuel energy sources.

Foundations of conservation philosophy and policy. Coincident with these developments, the Enlightenment and Romantic movements were revolutionizing Western conceptions of value, order, and beauty in the natural world. The natural philosophers of the Enlightenment stressed the smooth workings and stability of a mechanistic natural order. The romantic philosophers and poets emphasized the organic unity and wholeness to be found in a spontaneously creative nature. Although offering fundamentally different conceptions of nature, both worldviews encouraged human comprehension of natural objects and processes, and so laid the foundation for greater appreciation of human impacts upon the natural world. The treatises of Thomas Malthus and other early economic philosophers provided the basic framework for considering the interwoven fate of the human population, human economies, and natural resources.

In Europe the Romantic Movement drew heavily upon the experiences of New World explorers and immigrants. Old World artists, writers and philosophers found new value in nature through exposure to wild landscapes and interactions with indigenous cultures. In turn, adaptation of the romantic impulse in the North American setting provided important literary and philosophical foundations for conservation. The strong American identification with wild nature found early expression in, for example, the essays of the transcendentalists Ralph Waldo Emerson and Henry David Thoreau, the poetry of William Cullen Bryant and Walt Whitman, and the novels of James Fenimore Cooper. Artists such as George Catlin, Thomas Cole, Frederic Edwin Church, and Albert Bierstadt depicted native peoples and landscapes in ways that highlighted sublime natural beauty and the agency of indigenous Americans.

George Perkins Marsh's *Man and Nature; or, Physical Geography as Modified by Human Action* (1864) is widely acknowledged as the first work to document the extensive and long-term environmental effects of human actions. A native Vermonter, Marsh saw the destruction of New England's forests as the latest expression of an ancient human tendency to "[derange] the original proportions between different orders of organic life" (103). Drawing on his extensive scholarship and personal observations of environmental change in New England and the Mediterranean, Marsh argued that human actions had caused widespread disruption of the "harmonies" of the natural world. Marsh's reasoning followed lines that would sound familiar to later generations of ecologists and biodiversity conservationists. "All nature," he wrote, "is linked together by invisible bonds, and every organic creature, however low, however feeble, however dependent, is necessary to the well-being of some other among the myriad forms of life with which the Creator has peopled the earth" (109). Marsh drew particular attention to the influence of humans on plants, mammals, birds, fish, reptiles, fish and other aquatic species, and even microbial life.

Marsh's book provided direction and definition to the nascent conservation movement through the remainder of the 1800s and the first decades of the 1900s. In North America, the dispossession of Native American tribes, enactment of liberal land distribution policies, and flow of settlers and capital into "virgin" landscapes resulted in an unprecedented wave of exploitation of natural resources. The swift destruction of the pine forests of the upper Great Lakes in the latter 1800s marked a turning point in forest conservation and the conservation movement

generally. It also brought to the surface the philosophical tensions between nature preservationists and utilitarian resource conservationists. Those tensions would emerge fully as conservation grew into a national movement.

The Progressive conservation movement. Conservation was only one component in the broad platform of policy reforms that advanced under the banner of the Progressive movement in the United States. Across its array of initiatives, the Progressives were united by a commitment to more open and inclusive democratic processes. This entailed an active role for government in safeguarding the public interest against the power of concentrated wealth and unrestrained private interests, and a strong policy role for science in informing legislation and administration.

These came together when conservation emerged as a new arena of public policy, informed by shifting values and attitudes toward the natural world. The campaign for nature preservation gained its preeminent voice in John Muir, the literary celebrant and political champion of California's Sierra Nevada and other threatened wild and scenic landscapes of western North America. Muir's book *Our National Parks* (1901) appeared fifteen years before the U.S. National Park Service was established—before even the term *conservation* was being widely used. Muir's lament—that “the continent's outer beauty is fast passing away, especially the plant part of it, the most destructible and most universally charming of all” (7)—contributed to the gathering political movement that gave conservation its modern meaning.

The movement came into sudden focus in 1901 when an assassin's bullet took the life of William McKinley and made Theodore Roosevelt the 26th president of the United States. Roosevelt, already nationally recognized as a naturalist, sportsman, and advocate for the protection of wild game populations, brought forester Gifford Pinchot into prominence as his “Chief Forester” and head of the newly created (in 1905) U. S. Forest Service. Pinchot carried into that role a utilitarian view of conservation as the “wise use” and efficient management of natural resources—“for the greatest good, for the greatest number, over the long run” (as Pinchot's reformulation of the utilitarian credo had it). He thus provided a counterpoint to John Muir's impassioned crusade for the preservation of wilderness, although both held more nuanced views than later critiques would recognize.

In practice the Progressive conservation crusade aimed to develop a trained, professional workforce to manage the nation's forests. The newly trained foresters were to apply scientific principles to achieve sustained yields of timber resources through efficient planning, exploitation, and processing. And the wealth derived from the forests was to be equitably distributed to serve the common good. As applied not only to forests, but to natural resources in general, this resource conservation ethic provided the dominant paradigm of the early movement. Absent from many of the Progressive political initiatives were the voices of the increasingly influential preservationists and nature protectors. In contrast to the utilitarian view that Pinchot espoused, adherents of the romantic-transcendental preservation ethic emphasized wild nature's aesthetic and spiritual values and the need to secure those values for future generations through strict prohibitions on development and manipulation (Callicott 1990).

Roosevelt, friend and admirer of both Muir and Pinchot, held the uneasy middle ground between them. To Muir's veneration of wild landscapes and Pinchot's commitment to the greater public good, Roosevelt added a third element—a scientist and sportsman's appreciation of wild animals. Under his presidency, the nation not only expanded its domain of protected parks and conserved forestlands, but initiated its continental system of national wildlife refuges.

These moves, however, were not informed by concerns over biodiversity loss in its contemporary sense, or by a sufficient understanding of ecological processes and requirements. These would come only as evolutionary biology and ecology began to inform conservation values and policy.

Ecology and conservation. As conservation became institutionalized in the United States, it tended to follow the tenets of utilitarian conservation. By the 1930s, those principles of utilitarian had been applied not only to forests, but to other “useful” components of the biota and the landscape, i.e. agricultural soils, rangelands, game and wildlife populations, sport and commercial fisheries, scenic lands and recreational areas, river systems. New academic disciplines and professional societies arose to promote sustained yields of and from these various “resources.”

By the late 1930s developments in ecology and evolutionary biology over the previous decades had begun to inform conservation issues, even as contemporary problems forced conservationists to reexamine their scientific assumptions. Ecology was revolutionizing scientific understanding of the functioning of biological communities, landscapes, and systems. Evolutionary biology provided new perspectives on, for example, the adaptations and interactions of all forest species—in contrast to the basic descriptive botany, dendrology, timber physics, and forest mensuration upon which silviculture and forestry had previously rested.

These scientific advances suggested the need to introduce ecological perspectives into all the resource management fields in the effort to sustain, not just the yields of particular commodities, but the long-term health and functional integrity of entire ecological systems. A key voice for this perspective was the American forester and wildlife ecologist Aldo Leopold. In the course of his career Leopold would apply ecological principles first to the conservation of forests, then to soils, watersheds, and wildlife, and ultimately to the land “as a whole” (including its human inhabitants and economies). In so doing, Leopold sought to reconcile the old tension in conservation between utilitarianism and preservation. Writing in 1939, he noted that ecology provided “a new fusion point for all the natural sciences” and that its emergence “placed the economic biologist in a peculiar dilemma: with one hand he points out the accumulated findings of his search for utility, or lack of utility, in this or that species; with the other he lifts the veil from a biota so complex, so conditioned by interwoven cooperations and competitions, that no man can say where utility begins or ends The only sure conclusion is that the biota as a whole is useful, and [the] biota includes not only plants and animals, but soils and waters as well” (Meine 2013, 438).

Leopold’s expanded conservation philosophy, as finally expressed in his landmark essay “The Land Ethic” in *A Sand County Almanac* (1949), emphasized the diversity, functional integrity, and beauty of what he termed “the biotic community” and rejected the view of nature as a mere collection of disaggregated natural resources. It shifted the role of human beings “from conqueror of the land community to plain member and citizen of it” (Meine 2013, 173). Leopold’s evolutionary-ecological land ethic provided an alternative to the simple economic and utilitarian paradigm on the one hand, and the strict preservationist approach on the other.

This provisional reconciliation would confront continuing challenges in the dramatically altered circumstances of World War II and the immediate postwar period. Internationally, these years saw increasing recognition of the global scope of conservation challenges and initial efforts to institutionalize a response to those challenges. With the outbreak of the war conservation issues fell into the background of concerns, proving the difficulty of maintaining attention to

human-nature relationships when social crises erupt. Yet, as in no time since the Progressive Era, these years demonstrated the interwoven nature of social, economic, and environmental problems. The advent of nuclear weaponry posed a new environmental threat of unprecedented scope, and provided an ultimate example of the dilemmas posed by scientific and technological advances untethered to ethics.

Biodiversity conservation and the modern environmental movement. In the postwar period, revolutionary developments in fields from genetics and evolutionary biology to atmospheric chemistry and geology began rapidly to reshape our understanding of the global biosphere and the human place within it. New tools provided greater scientific understanding of the interrelations within and among the Earth's terrestrial, aquatic, and atmospheric systems. The publication of Rachel Carson's landmark book *Silent Spring* (1962), examining the biological impacts of DDT and other synthetic chemical pesticides, gave rise to the modern environmental movement. Although focused on the specific issue of indiscriminate use of synthetic pesticides, Carson framed her case against a background of nature's diverse systems. She wrote, "Nature has introduced great variety into the landscape, but man has displayed a passion for simplifying it" (10). Moreover, Carson echoed Leopold in calling for a new ethical stance for humanity within the larger community of life. "The 'control of nature,'" she wrote, "is a phrase conceived in arrogance, born of the Neanderthal age of biology and the convenience of man" (297).

One expression of the new environmentalism was the rise of interdisciplinary approaches to environmental problems, at all scales from the local to the global. As part of this broad trend, the scientific foundations of biodiversity conservation continued to shift through the 1970s and 1980s. Taxonomy, systematics, and biogeography provided more robust estimates of the extent of species diversity and of its historic and potential loss. The sub-field of island biogeography revealed principles governing the spatial distribution, persistence, and extinction of species. This carried important implications for land use and the establishment and management of protected areas. Genetics became an increasingly important component of conservation science as attention focused on the reproductive success of rare and endangered species and the viability of their populations, in captivity and in the wild. Ecology moved away from a paradigm that emphasized stable, deterministic equilibria, and toward a view of ecosystems that underscored their constant flux, uncertainty, and contingency. The new field of restoration ecology sought to apply ecological principles to the remediation of species loss and ecosystem degradation. Increasingly, conservation strategies required the integration of knowledge from these many branches of basic and applied biological science, involving various levels of biological organization.

Conservation biology and environmental ethics. The need to rethink conservation across disciplinary lines was driven not only by changes in the foundational sciences, but by changes in the environment itself. By the late 1970s, scientists and conservationists were raising alarm over the escalating loss of genetic, species, and ecosystem diversity at the global scale. Of special concern was the accelerated destruction of the species-rich forests of the humid tropics. The principles derived from island biogeography revealed that ecosystems of all types were being fragmented by human activity. Even the most effective protected areas were at risk due to their inadequate size and isolation. Conservation biologists increasingly understood that preservation alone was an inadequate management strategy, and that the loss of diversity and the

disruption of ecological functions were intimately associated. Natural resource managers were likewise increasingly concerned about the breakdown of ecosystem processes and the loss of diversity in more humanized landscapes.

These concerns prompted the emergence in the mid-1980s of conservation biology. The new field was devoted specifically to the integration of scientific disciplines, social sciences, and humanities in the effort to conserve biological diversity. It sought to address conservation problems within an evolutionary and ecology context, and to stimulate the traditional resource management professions to reassess their methods and goals accordingly. The truncated term *biodiversity* itself was coined in 1986 and has since been widely adopted by conservationists. Concurrently, the concepts of *sustainability* and *sustainable development* came into general usage, reflecting the complex challenge of integrating long-term social, economic, and environmental factors in assessing human demands and impacts on ecosystems.

These concepts, addressing the biological and socioeconomic dimensions of conservation, soon became closely entwined, gaining broad international footing in 1992 at the United Nations' "Earth Summit" in Rio de Janeiro. Among the products of the summit was the Convention on Biological Diversity, which recognized the conservation of biodiversity as "a common concern of humankind." The Convention bound its signatories to address biodiversity conservation needs at the genetic, species, and ecosystem levels. To do so, it encouraged its signatories to integrate traditional conservation approaches with the sustainable use of biological resources, and to undertake conservation efforts in concert with development.

Complementing and informing these developments in conservation science and policy, environmental ethics gained definition as a new sub-field of philosophy in these years. The new field explored the ethical dimensions of human-nature relationships, building on foundations in indigenous belief systems and world religions, Eastern and Western philosophical and literary traditions, and the science-based precepts of Leopold, Carson, and others. Environmental ethics both drew upon and influenced biodiversity conservation efforts. Conservation biology was conceived explicitly as a "value-laden" and "mission-driven" enterprise, dedicated to the protection and maintenance of the world's biological diversity (Meine et al. 2006). The Earth Charter movement, coming out of the "Earth Summit," sought to create through a global participatory process a consensus document that could express this merging of science and ethics on behalf of biodiversity conservation and sustainable societies (Tucker 2008).

Philosophical tensions, reminiscent of those that divided preservationist and utilitarian conservationists a century before, remained central to conservation discourse. A basic fault-line divided those who found intrinsic value in biodiversity and those who emphasized the instrumental value of biodiversity as essential to human well-being. This contrast often played out in a continuing tension between "deep ecologists" and others advocating for protection of biodiversity against human impacts (especially through the establishment of protected areas), and pragmatists seeking to promote sustainable use in more humanized landscapes. Although that fault-line was deep, and still persists, the commitment to biodiversity conservation in general provided at least the potential for finding greater common ground.

Biodiversity Conservation in the Anthropocene

Although debate continues over the acceptability of the term *Anthropocene*, biodiversity conservation efforts are inevitably evolving in response to the reality of unprecedented rates of anthropogenic environmental change. Science continues to enhance our understanding of such

change, of the extent of historic and contemporary human impacts on biodiversity, and of the potential biodiversity loss we face. In response the foundations of conservation are shifting. Tensions over conservation's aims remain, even as new needs and opportunities for conservation action are rising.

Although the friction between inherent and instrumental value in conservation ethics endures, the context in which that tension plays out is changing. As science reveals the fully interwoven reality of Earth systems and social systems, and of natural background rates of change and human-exacerbated rates, it becomes more and more difficult to distinguish between conservation efforts that aim to enhance long-term human well-being and those intended primarily to sustain the rest of nature. In coming fully to terms with the rates, scales, and types of anthropogenic change, conservationists are redefining basic concepts and approaches to conservation, and responding to critical trends affecting the status and fate of biodiversity. All of these entail reconsideration of conservation ethics in the Anthropocene and, in particular, the complex reasoning over what constitutes appropriate human interventions in natural systems and processes.

Climate change and biodiversity. The most obvious and significant trend affecting biodiversity conservation in the Anthropocene involves global climate change. Conservation actions must now be conceived and undertaken within the context of larger Earth systems whose future is increasingly uncertain. For some species and ecosystems, especially those at high elevations and latitudes, climate change is an immediate, direct, and overriding threat to biodiversity. For this reason, the “assisted migration” of species in anticipation of climate change has been proposed and, for at least a few species, already undertaken. However, climate change will affect all species and ecosystems everywhere in complex ways, especially through changes in interspecific relationships, altered migration patterns, and environmental thresholds of tolerance. Through its effects, too, on human communities and social systems, climate change will affect the capacity of conservation biologists, resource managers, private businesses, and citizens to respond to other key threats to biodiversity.

Conserving dynamic systems. The shift away from a “balance of nature” paradigm in ecology, and toward an appreciation of the “flux of nature” and the dynamic nature of ecosystems, has reframed strategies for biodiversity protection and sustainable use. Conservation's long-standing focus on sustaining biological diversity within presumably stable landscapes is increasingly complemented by an emphasis on larger-scale ecosystem function and resilience. This recasts, for example, the role of protected areas as a conservation tool, as protection *per se* cannot be assured if the matrix in which such areas are embedded is not sustainable. Conversely, sustaining ecosystem goods and services for human benefit requires full consideration of the diversity of those ecosystems.

Ecological restoration. Ecological restoration—the intentional renewal and rehabilitation of degraded, damaged, or destroyed ecosystems—has in the last several decades become an important new dimension of conservation practice. It has provided an active and positive alternative to both biodiversity protection and sustainable use, aiming to recover lost diversity and function in ecosystems. (Related proposals have also been made to “rewild” landscapes by allowing managed lands to revert to a “natural” state and reintroducing extirpated wildlife species or their proxies.) Under Anthropocene conditions, however, fundamental

premises of restoration are being reexamined. Restorationists must now wrestle with complex challenges involved in trying to restore systems under unprecedented and rapidly changing climatic circumstances, within landscapes increasingly shaped and constrained by human economic activity (Woodworth 2013).

Historic baselines and range of variability. Land stewards, natural resource managers, and restoration ecologists have relied on historical conditions as a helpful guide in biodiversity conservation and planning. Historic baselines provide a measure with which to gauge conservation progress and setbacks. The historic range of variability (HRV) is an index of past ecosystem flux that foresters, hydrologists, and others have used to understand what constitutes “normal” functioning of those ecosystems. These measures must now be reconsidered within the context of rapid anthropogenic change, where the past is no longer a simple or straightforward guide to future conservation aims and actions. Instead, ecologists have recognized the reality of “shifting baselines” in understanding the past trajectory and present condition of ecosystems.

“Novel” ecosystems. Given the rapid acceleration and global scale of environmental change, the relative nature of historic ecological baselines, and the proven capacity of humans to thoroughly reshape landscapes, some ecologists have argued the need to recognize “novel” ecosystems as an evident reality. *Novelty* in such ecosystems refers to the degree of that system’s dissimilarity relative to historic conditions (Radeloff et al. 2016). At the extreme end of the spectrum of novelty, “no-analog” ecosystems are those that lack equivalents in the historic record. Although these terms and concepts remain subject to debate, the notion of “no-analog” and “novel” ecosystems serve as indicators. Ecologists are seeking to comprehend the complexity that rapid anthropogenic environmental change entails, while their applied colleague in biodiversity conservation are trying to understand what such change means for restoration and conservation efforts.

Ecosystem services. The economic constraints on biodiversity conservation have long presented a challenge to effective conservation action. The dominant economic structures, market forces, incentives, and externalities have generally served to exacerbate biodiversity loss, and driven the post-World War II “great acceleration” that underlies proposals to designate the Anthropocene. In parallel with the emergence of conservation biology, efforts to define an alternative paradigm of ecological economics have taken hold in recent decades. This has yielded, among other results, focused attention on the services that biodiversity and ecosystems provide to the human economy. This in turn has raised question of how such instrumental values can be reconciled with ethical commitments based on intrinsic value and human responsibilities to, and within, the larger community of life.

Community-based conservation. Over the last generation, rapid socioeconomic change has also resulted in extensive criticism and reform involving the social dimensions of biodiversity conservation. In particular, community-based conservation has emerged as an alternative to the traditional model of top-down planning and management, emphasizing the importance of participatory decision-making and governance. These community-based approaches—including, land trusts, collaborative watershed groups, and landscape-scale coalitions—invariably involve ethical questions involving the management of common-pool

resources, equitable access, individual and institutional responsibility, economic relations, and commitments to future generations.

Biodiversity conservation on urban and “working” lands. The criticism has often been lodged that biodiversity conservation efforts have focused too heavily, if not exclusively, on the protection of wildlands. In fact, conservation has a long history of sustaining and restoring the economic landscapes of farms, forests, and ranches—so called “working” lands—and in integrating natural landscape with and within urban environments. In a world where the human population continues to grow, and where a greater percentage of that population is living in or migrating into cities, biodiversity conservation must devote an even greater amount of its efforts to these more humanized portions of the landscape. Coordination of conservation efforts across this continuum of land use intensity likewise becomes an even higher priority.

Environmental justice. Since the early 1990s the environmental justice movement has worked to broaden the political purview and demographics of conservation and the environmental movement. Motivated especially at first by the inequitable exposure of minority populations to pollution, environmental contaminants, and other environmental risks, the environmental justice movement has evolved to embrace a broad range of conservation and environmental issues. Reflecting these needs and the international scale of biodiversity conservation needs, the field has become increasingly diverse. As these trends continue, they seek to create not just an enhanced conservation movement, but enduring cultures of conservation. Of particular significance in this context has been the emergence of Traditional Ecological Knowledge (TEK) as an avenue for documenting, preserving, imparting, and applying the empirical knowledge of ecosystems developed within indigenous cultures worldwide.

Synthetic biology and biodiversity conservation. Biodiversity conservation has always availed itself of new technologies, from satellite imagery and global positioning systems to gene sequencing and artificial reproduction techniques. Now an array of emerging technologies in synthetic biology with conservation applications are presenting new risks and opportunities—and unprecedented ethical conundrums. Projects involving the “de-extinction” of lost species through the reconstruction of their genomes are being undertaken. The application of “gene-editing” (CRISPR) and gene drive techniques is being proposed to eliminate populations of disease vectors, control invasive species, and reduce agricultural pests and weeds. For the first time in human history, these new technologies of genetic manipulation can conceivably be used intentionally to drive species to extinction.

Biodiversity, Conservation, and Ethics for a Sustainable Future

All of these trends involve shifting social and scientific foundations in biodiversity conservation. All also involve new ethical challenges and choices. Since the origins of the human species, and especially since the dawn of modern civilization, humans have influenced the status of life’s diversity. The spatial and temporal scale of that human influence has expanded over the millennia. When the human population and presence on the planet was limited, our environmental impacts were local and short-term effects. As the human footprint has become pervasive, our influence has become global and permanent.

What this requires in terms of ethical evolution remains unresolved. Some see in the Anthropocene a mandate, and even the necessity, for even more extensive human manipulation of the environment. According to this view, humans ought to engineer the Earth's climatic conditions and ecological systems to ensure long-term human well-being. In such a domesticated world, it follows, biodiversity can and ought to be conserved, but primarily to promote the well-being of humans and the sustainability of the human economy.

Others see in the Anthropocene a call for humility in human relations with non-human nature. In some ways this represents a reclaiming of traditions of reciprocity and respect found in many indigenous cultures worldwide. In this understanding, the conservation movement can be characterized as modern society's conscious effort to develop and exercise analogous social practices and restraints to guide its relations with the nonhuman world. This view of an appropriate ethic stresses that, however humanized our species may have rendered the living world, biodiversity is not and ever can be fully a product of human creation (or re-creation). In a world that will always be to some degree beyond human influence and control, biological diversity holds a claim on our attention and affections not only as it serves our own species' interest, but for its own sake as the expression of life's creative evolutionary past and potential. Human influence need not, and should not, imply wholesale human domination.

Now, in a world ever more affected by the impacts of human activity, biological diversity and the effort to conserve it both face intensifying challenges. As in the past, biological evolution will increasingly be shaped by human values, economies, and institutions. If the trends of recent decades and centuries continue unabated, the loss of biological diversity, and especially of species, is expected to accelerate even further. Future rates of species loss are predicted to be 10,000 times higher than the background rate of extinction (De Vos et al. 2014). Social evolution has allowed human communities, cultures, and economies to adopt ethical guidelines and practices that encourage conservation of other lifeforms and landscapes. Although these moral frameworks have proven vulnerable and limited in their effectiveness, they do demonstrate, at minimum, that such ethical innovation is possible. The power of the human species to influence the conditions of life on Earth has never been greater. The ethical challenge for life in the Anthropocene is whether that species has the capacity to exercise responsibility and reciprocity in its relations with the full community of life, and with the Earth.

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