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INVITED ARTICLE

Must we lose our biological connection to nature to endure changing times?

Joel Berger[1,2] | Vernon C. Bleich[3] | R. Terry Bowyer[4]

[1]Global Programs, Wildlife Conservation Society, Bronx, NY 10460, USA

[2]Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins, CO 80521,

[3]Department of Natural Resources and Environmental Science, University of Nevada Reno, Reno, NV 89557, USA

[4]Institute of Arctic Biology, University of Alaska Fairbanks, Fairbanks, AK 99775, USA

Correspondence

Joel Berger, Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins, CO 89523, USA.
Email: Joel.Berger@colostate.edu

Abstract

Earth has >8 billion people. Scholarly publications number nearly 7 million annually with >1 million in the life and biomedical sciences, and ≥52 professional journals specializing in conservation, ecology, or related disciplines. The challenges of applying ecological data to conservation and wildlife management can easily become overwhelming. Herein we offer reflective perspectives about the changing face of applied knowledge and engagement from our personal employment histories as ecologists working in agency, university, and non-governmental organization (NGO) biologist positions. We suggest natural history will always be nature's glue, but knowledge steeped mostly in muddy boots and field biology are no longer the soup *du jour* of our profession. In many ways, new technologies have changed data collection and the scientific questions asked. Arguably, such change is not welcomed by all, but a change in overlap across decades is needed to sustain and improve upon how the planet's biological diversity can coexist with increasingly difficult human conditions. Given that 80% of the people in the United States live in urban areas, with similar numbers internationally, a future possibility may be an even greater divide between wild nature, ecological services, and enjoyment in the field. This is disturbing. Despite fundamental scientific insights that help understand critical components of the natural world, once society loses touch with nature, what will remain?

KEYWORDS
academia, agency, biodiversity, conservation biology, curricula, Earth, natural history, non-governmental organization, opinion, perspective, wildlife management

Businessmen, they drink my wine
Plowmen dig my earth
None of them along the line
Know what any of it is worth

Bob Dylan, 1967
All Along the Watchtower

Nobel Laureate Bob Dylan's dark sonnet of despair and lacking in exoneration is for a future we appear to be confronting now. If written today the words climate catastrophe, biodiversity disaster, and apathy might be included. Big money, pollution, and societal issues might be there too. Regardless, Earth harbors some 8 billion people competing with wildlife and their habitats. Future wildlife management and conservation will be strikingly different and more dynamic than in the past. Indeed, technological change is near instantaneous and shapes how we approach science. With some 7 million academic articles published annually (Fire and Guestrin 2019) and >1 million centered on life and biomedical sciences each year (Landhuis 2016), it is easy to become buried in minutia and lose sight of the importance of questions being asked. Beyond our immediate scholarly readership, how many people truly realize that the world's fauna, flora, and associated biotic and abiotic factors (i.e., our natural history) are what govern our lives through ecological processes, agro-ecosystems, and the hydrosphere? If we as ecologists, and other scientists also, lose connections to the natural world, our chances of slowing its attrition dim.

In this essay, we address a complex question. What are the central issues for wildlife management and conservation as we look into the future? Our take on this is reflectively biased and derived from our 3 perspectives, which combine our histories as ecologists working for a state wildlife agency, an international non-governmental organization (NGO), or as university faculty. Although the missions of each entity differ in nuanced and important ways, we share the vision that the world is better served with robust wildlife populations than without. Our assessments in this essay address attitudinal and mission-influenced shifts across time (Figure 1) and, collectively, how society might benefit by prioritizing what we call the wildlife-biodiversity interface (WBI); these encompass our overlapping perspectives.

NATURAL HISTORY WILL ALWAYS BE NATURE'S GLUE

Arabian tahr (*Arabitragtus jayakari*) quench their thirst by drinking salt water from the Indian Ocean (Alsaid et al. 2024). Greenland sharks (*Somniosus microcephalus*) may live 400–500 years. North American porcupines (*Erethizon dorsatum*) have a gestation of 7 months, which is remarkable for a rodent. Each of these factoids stem from scientists interested in learning about animals by methods involving field biology. It is natural history at its finest, but why should natural history be a focus at all? The answer is surprisingly simple. Natural history is the metaphorical glue that connects all.

In his explorations of South America in the 1830s, Charles Darwin dug deep to understand plants, people, and animals (Darwin 1889). Three decades earlier and also in South America, Alexander von Humboldt (1858) noted that plants and animals were not merely isolated species but that they formed a link to other forms of life. Clearly, these synthetic field naturalists along with Alfred Russell Wallace (1871) were the progenitors for today's more formal fascination with food webs and biodiversity.

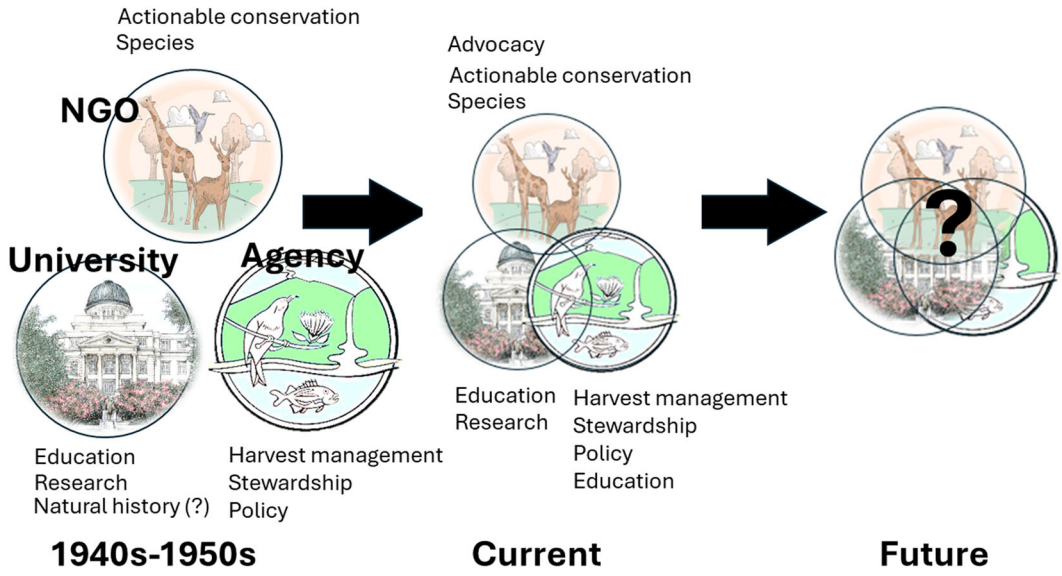

FIGURE 1 Convergence of academic, agency, and non-governmental organization (NGO) missions in wildlife management and conservation over time in the United States, but with much future uncertainty in overlap. Topics by organizational focus are obviously far more complex than depicted, and missions, including inspiration, may be large. There is no reason to expect stronger overlap in future scenarios, although we suspect if there were efforts, a more potent wildlife-biodiversity interface would result.

Although the term biodiversity was first used in the 1980s (Sarkar 2021) and in contexts appealing for conservation (Soulé 1986), challenges to a healthy living planet had been chronicled far earlier, regularly noting the seminal role for knowledge about natural history to repair, restore, or manage ecosystems (Grinnell 1939; Leopold 1933, 1949). Universities, agencies, museums, and NGOs were on board at the outset of the twentieth century some 125 years ago in the effort to understand the value of species, their diversity, and ecological roles (i.e., their natural history) and were already serving as real or intellectual repositories for specimens, education, and research.

Calls to maintain natural history as the bedrock for conservation have not diminished (Table 1), although natural history is less frequently the focus of university curricula in part because it is no longer prioritized at administrative levels (Greene and Losos 1988, Fleischner 2011, Tewksbury et al. 2014, Bowyer 2022). As a respectable discipline, natural history seems to have lost its luster despite widespread recognition by ecological and conservation luminaries like Michael Soulé, E. O. Wilson, and George Schaller who often refer to themselves as naturalists or field biologists (Wilson 2006, Schaller 2012, Sanjayan et al. 2020).

Many definitions of natural history exist, but one published in this journal is as apt today as it would have been even centuries ago. In his poignant essay, Herman (2002:934) defined natural history as, "… the scientific study of plants and animals in their natural environments. It is concerned with levels of organization from the individual organism to the ecosystem, and stresses identification, life history, distribution, abundance, and inter-relationships. It often and appropriately includes an esthetic component." Terminology is of obvious relevance, but it is clear from this definition that natural history is the metaphorical glue we referenced above. Despite its relevance, laments about the failure of natural history as a respected academic field of study sadly continue at the WBI, regardless of the listed supporters (Table 1).

Stepping back and then forward, the transition from natural history to sophisticated tools and integrated disciplines spans centuries but has undergone rapid proliferation and integration in the past few decades (Anderson et al. 2021). Early roots in the United States are linked to John J. Audubon's spectacular yet

TABLE 1 Snippets of reflections on natural history as frequently applied to conservation at the wildlife-biodiversity interface across about 150 years. We included a brief title to illustrate the various topics.

Author	Date	Brief title	Focus
von Humboldt	1858	Reflection on climate, plants, animals	Connections of life
Darwin	1859	Origin of species	Global natural history, evolution
Wallace	1871	Essays on evolution	Global natural history, evolution
Leopold	1949	Interdependence of life	Natural history, philosophy
Coonen	1951	Archaic people and nature	Early humans and understanding of natural history
Matthiessen	1959	Wildlife in America	Natural history, extirpation, threats
Leopold	1959	Wildlife of Mexico	Natural history, extirpation
Carson	1962	Environmental challenge of earth	Nature compromised
Macnab	1983	Experiments in nature	Gaining reliable knowledge
Bartholomew	1986	Natural history as biology	Infusing description into theory
Greene and Losos	1988	Images of field biologists	Natural history, conservation
Liebenberg	1990	Nature, hunting, and science	Hunting and tracking with San!
Murphy and Noon	1991	Applying natural history to conservation	Hypothetical-deductive approaches and uncertainty
Quammen	1996	Biogeography in age of extinction	Natural history applied to theory
Herman	2002	Uniting natural history and wildlife biology	Loss of fascination with natural history
Wilson	2006	Naturalist	Natural history, biophlilia
Michaels et al.	2014	Natural history knowledge to *ex situ* conservation	Species bio-requirements must be understood
Greene	2016	Field biology as art	Science, inspiration, conservation
Barrows et al.	2016	Nature of natural history	Why we need to understand
Callaghan et al.	2018	Maintaining natural history for conservation	Contemporary reinvigoration needed
Miller et al.	2020	Museums and natural history collections	Building knowledge for the next century
McKeon et al.	2020	Natural history overview	A foundation for ecology
Anderson et al.	2021	Change across time in conservation	Trends in popularity of approaches
iNaturalist	2024	A community for naturalists	186,000,000 observations of natural world
eBird	2024	Advancing science and conservation	Avian global foci

controversial paintings that energized public interest, and those of George Catlin (1841), who raised serious concerns about the coupled destruction of bison (*Bison bison*) and Native American cultures. Another half century would pass before privileged hunters and zoological institutions fused interests to avoid massive reductions in the numbers, and even extirpations, of many species including bison. Hence, the connections between natural history appreciation and conservation consciences were emerging but still years away before engrained formally in agencies or universities.

Snippets of NGOs—involvement and change at the WBI

Following the influential roles of Theodore Roosevelt and George Bird Grinnell to establish the Boone and Crockett Club in 1887, the New York Zoological Society was formed in 1895. A portion of its formal decree was "to advance wildlife conservation [and] promote the study of zoology" (Wildlife Conservation Society 2024). In 1907, following creation of the American Bison Society housed at the Bronx Zoo, the New York Zoological Society reintroduced bison to Oklahoma's Wichita Mountains. Over the next few decades its nascent field programs investigated Caribbean marine life, pheasants in eastern Asia, Dall's sheep (*Ovis dalli*) in Alaska, and mammals of the Pinacate Desert realms of Sonora, Mexico. Natural history was central to these investigations (Conway 2013, Wildlife Conservation Society 2024). Across time, similar investigations expanded farther west and north, first to Jackson Hole, Wyoming, USA, in the 1940s. Subsequently and through engagement about land and wildlife, Olaus and Mardy Murie, then in Alaska, connected with George Schaller in an area that later would become the Arctic National Wildlife Refuge. The Wilderness Society and the New York Zoological Society, among other NGOs, played important roles through advocacy to develop government support and initiate policies for legal protection for land and wildlife.

Descriptive studies, many with international flavor, garnered public fascination. Schaller's initial studies of mountain gorillas (*Gorilla beringei beringei*), tigers (*Panthera tigris*), and African lions (*Panthera leo*) yielded significant information on ecology, life history, and social behavior of those iconic species (Schaller 1963, 1967, 1972). Calls, then, for serious conservation were of lesser concern because an understanding of the natural world through the eyes of animals was a clear and prime goal of programs into the 1970s. But, with greater insights into the lives of animals *per se*, new questions, techniques, and themes emerged. As a result, NGOs focused more strongly on conservation outcomes.

In 1993, the New York Zoological Society became the Wildlife Conservation Society, by which time some work already had transitioned into China and Central Asia and, with a strong natural history focus, conservation applications predominated for giant pandas (*Ailuropoda melanoleuca*) and Tibetan Plateau species (Schaller 1977, 1993). Elsewhere, Alan Rabinowitz concentrated on jaguar (*Panthera onca*) conservation, asking how many animals existed, describing demographics, and exploring how jaguars were distributed across unprotected landscapes. Simultaneously, Smithsonian Institution biologists were asking similar questions about tigers and greater one-horned rhinoceros (*Rhinoceros unicornis*), while the World Wildlife Fund was trying to map habitat for numerous other species (Wikramanayake et al. 2011). Studies of Amur tigers (*P. t. altaica*) in the non-glaciated sections of the Russian Far East were aimed at understanding densities, movements, and factors contributing to mortality and reproduction (Miquelle et al. 1996, Goodrich 2010). Conservation was largely based on animals but increasingly involved navigation of political landscapes (Redford et al. 2011).

A vastly different approach was emerging in Rwanda, Kenya, India, and beyond in the 1970s; the focus was less on animal ecology *per se*, but instead NGOs used a top-down approach involving strong engagements with people. Humans sharing landscapes with wildlife began to be viewed as important components of those systems (Berwick 1976). The biological needs of mountain gorillas for instance were blended with human livelihoods because agrarian landscapes interfaced or interfered with natural habitats. The prevailing fortress mentality of protecting animals by excluding humans was being supplanted by a blossoming argument recognizing that conservation would not succeed if human needs were not addressed (Weber and Vedder 2001). In Kenya's Amboseli ecosystem the commitment to respecting the cultural identities of Maasai herders resulted in enhanced coexistence between humans and wildlife (Western 2020). The NGO approaches to conservation came increasingly with a human face.

The big international NGOs in conservation (The Nature Conservancy, Conservation International, World Wildlife Fund, Wildlife Conservation Society; frequently referred to as BINGOS [Igoe and Brockington 2007, Jones and Solomon 2019]) all differ in mission and philosophy from that of universities and wildlife agencies. The Wildlife Conservation Society is not the wildlife science society. Conservation is the goal, but with an explicit recognition that science can play an important role in garnering protection for specific taxa and habitats or ensuring that essential ecological processes continue. In the United States, for example, it was not just the science, which played but a small role, that led to America's only federally protected migration corridor (i.e., the Path of the Pronghorn), but it was engagement with stakeholders and government (Berger and Cain 2014) that led to legal safeguards.

Overarchingly, conservation is not science in and of itself. Identification of the global human footprint (Sanderson et al. 2002), understanding the range-wide priority setting against a backdrop of urbanization (Sanderson et al. 2018), and scaling up to protect 30% of the earth's surface for 2030 (e.g., Global Biodiversity Framework) are some of the more recent approaches tackled by BINGOs and many lesser-known NGOs (Robinson et al. 2024).

In the United States, conservation likely has depended less on descriptive natural history than on political processes. For example, the aforementioned BINGOs and similar organizations have been successfully influencing policy through the strategic placement of their resources proximate to policy-making bodies, and particularly the United States Congress. While emphasizing conservation as the goal, the unified forces of natural and social sciences embolden conservation actions for the benefit of animals, ecosystems, and environmental health and, as a result, protection at the BWI has become more relevant.

Natural history is being de-emphasized, as are global field studies (Rios et al. 2018). An array of new technologies and synthetic approaches are enhancing scientific creativity while adding to the conservation agenda, among which is public outreach and chiefly through social media. There is no good nor bad here, it just is what it is as more knowledge is gained along different fronts. The NGOs in conjunction with some university and agency ecologists demand a dimension to the advocacy arena. Context will always play a role. So will job security, which in universities includes academic freedom and tenure. Depending on the organization and the issue at hand, spokespersons may be unleashed, tethered, or operate silently to avoid controversy. Speaking out carries costs including retribution such as being ignored (Jenkins 2023), silenced (Czech 2023), removed from their positions (Jenkins 2023), or *de facto* evicted from certain countries (Macilwain 1994, Horton et al. 2016). In the former cases, dedicated scientists were silenced because they voiced concerns about agency policies and concomitant impacts to environmental concerns. The latter example occurred during initial stages of dehorning Africa's white (*Ceratotherium simum*) and black rhinos (*Diceros bicornis*), a radical tactic designed to protect them from poaching until failures were exposed in the peer-reviewed literature (Berger and Cunningham 1994, Cunningham and Berger 1997). As a result, National Science Foundation and personal funds were frozen in a Namibian bank; these were released 8 months later and only after (then) Vice President Gore raised the issues of censorship to Namibian officials (Cunningham and Berger 1997).

An agency perspective on what we are losing and what society gains

At 91 years old, Maurice Hornocker, an innovator and leader of mountain lion (*Puma concolor*) research in North America who began fieldwork in the 1960s wrote, “My memories are remnants of what field research was but may never be again. Simplicity and intuition have been relegated if not lost. Feet on the ground have been replaced by the latest technology [and]… all the gadgets and gizmos of the digital era have made… the collection of quantitative data much easier…” (Hornocker 2023:91). In the epilogue he wrote, “I hope this tale I've told … will inspire young scientists to … lace up their boots, enter the world's remaining wild places, and experience the thrill of in-person discovery” (Hornocker 2023:282). Although we authors all have been in muddy boots and combining natural history knowledge with experiments and comparative approaches for decades, the times they are a-changin', as noted in 1964 by Bob Dylan. Our origins and initial interests were field based with unending curiosity at the WBI. Might we expect this of new generations? We'd wistfully say, “We hope so,” but we do not expect such to be the case.

We know more about wildlife and biodiversity than ever, and boots and binoculars are no longer what knowledge is about. At the time Hornocker began his work, there were about 190 million Americans, of which some 67% were urbanites. Currently, the population of Americans is >335 million, and more than 80% occupy urban areas (Sanderson et al. 2018, U.S. Census Bureau 2022). Do the questions asked and the ways in which knowledge about the WBI is gained shift across time? Some do and some do not; generalizations do not come easily. Reliance on some techniques may bias answers to the very questions they are attempting to resolve (Figure 2). Data obtained from study animals can be compromised by the methods used to the extent they may not be considered unbiased (White and Garrott 1990, Schaefer et al. 2000).

FIGURE 2 An illustration of the controversial nature of technological advances and how the questionable well-being of study animals in the race to marshal data has gone wild. This female desert bighorn sheep is burdened with 2 telemetry collars (one of which will remain with it throughout its life) and at least 2 (and possibly 3) prominent ear tags. Beyond the decorative colors, some females are burdened with a rumen-temperature transmitter, a vaginal implant transmitter, or both but may also be fitted with additional devices. (Photograph ©C. Gallinger; used with permission).

State wildlife agencies possess the responsibility for the conservation and management of most wildlife. During the past 50 years, however, an increase in well-intentioned legislation has complicated conservation because it has compounded efforts originally intended to benefit wildlife or wildlife habitat (Thomas 2004). This problem has proliferated at state and federal levels as noted through complexities associated with our demographic growth, added public interest in the WBI, changes in habitat availability, and strong economic incentives.

The first game law in the United States was in California in 1854 (Young 1961), with similar legislation following shortly in other states. These early laws addressed primarily season dates or waste of game, and enforcement was inconsistent across jurisdictions (McCabe and McCabe 1984). From 1930 to 1980, however, a conservation and management ethic evolved (Krausman 2000, Krausman and Bleich 2013) and important and meaningful legislation in the form of the Federal Aid in Wildlife Restoration Act was enacted. Researchers, managers, and the public in general benefitted from that and subsequent conservation legislation and the successes they facilitated (Kallman 1987, Schildwachter and Booher 2024).

Despite this, much legislation, has been problematic and has confounded numerous conservation efforts (Thomas 2004). As examples, the Wilderness Act (U.S. Congress 1964) contains mandates that in some cases have made it virtually impossible for managers to enhance populations or habitat for some species through activities consistent with the Endangered Species Act (U.S. Congress 1973); in another example, implementation of the Wild and Free-roaming Horses and Burros Act (U.S. Congress 1971) has been repeatedly stymied by political meddling that limits the efficacious management of feral equids. In a third example, the California Desert Protection Act (U.S. Congress 1994) designated >70 wilderness areas but principally ignored the importance of habitat connectivity, an omission that has confounded efforts to conserve populations of large, vagile mammals that move among those protected zones by leaving vast areas vulnerable to transportation corridors, energy development, feral animals, water projects, and recreational activities (Bleich 2005, 2022; Krausman 2017; Bleich et al. 2023).

To the consternation of managers, conservationists, and researchers alike, politicians continue to create additional obstructions as legislation, ancillary regulations, rules, policies, legal opinions, and fiscal controls,

rendering science-based prescience to lesser importance. During our respective careers, it has become increasingly clear that science, conservation, and politics navigate different courses; the former digs for facts, conservation transforms and uses those facts to better conserve or manage populations or habitats, and politics involve stakeholder preferences under an umbrella of human foible (Berger 2018) that is often influenced by an unending quest for votes (Bleich 2022). Similar concerns were raised around the time we were toddlers learning to walk and were voiced by other influential parties who noted that, "It is important to recognize mistakes of the Game and Fish Department in the past due largely to misguided efforts of political appointees. Emphasis on a new regime based on careful technical, biologically sound principles is important" (Lindzey 1950:93), and that "Biology plus politics equals biopolitics and this is what conservation departments are forced to play, often to the detriment of good game management" (Towell 1961:98). Such realities, and the weaknesses they generate, have guided agency biologists over the long term, and will do so for the foreseeable future. It is one price of democracy.

We perceive enthusiasm and support for natural history as important components of education among universities and recently minted graduates, and maintain that natural history provides the foundation for wildlife conservation. Herman's (2002) thoughtful definition of natural history incorporates most issues or subjects with which practicing wildlife researchers, biologists, managers, and advocates should be proficient: animals and their natural environments, levels of organization from individuals to ecosystem, identification, life histories, distribution, abundance, interspecific relationships, esthetic components, and re-wilding. Perhaps most importantly, each of the topics noted by Herman (2002) has an analogue at the WBI: protection, people, habitat, niche, systematics, adaptation, population dynamics, ecological processes, and human economics. Perhaps not everything changes with time.

Discoveries leading to meaningful conservation efforts sometimes have occurred simply through observations of previously unexplained phenomena and, perhaps, are best explained as a serendipitous happenstance (Estes 2016). Other meaningful natural history observations have occurred because of curiosity and interest in living organisms that naturalists and scientists from Von Humbolt to Leopold and Carson to Wilson maintained were essential attributes for those aspiring to conservation careers. Among examples were the discovery of an extant population of the Aleutian Canada goose (*Branta hutchinsii leucopareia*; Jones 1963), its recovery, and the subsequent delisting as a federally endangered taxon; rediscovery of the Amargosa vole (*Microtus californicus scirpensis*) as an extant taxon (Bleich 1979) and the subsequent protection afforded by state and federal governments; and recognition of the Tule greater white-fronted goose (*Anser albifrons elgasi*) as a distinct subspecies of the greater white-fronted goose (Yparraguirre et al. 2020) and regulatory adjustments based on that information. Another example is how the rapid distributional expansion of Woodhouse's toad (*Anaxyrus woodhousii*), an invasive and highly adaptable anuran known to breed with congeners, confounds conservation of the endemic Amargosa toad (*Anaxyrus nelsoni*; a threatened taxon; International Union for the Conservation of Nature 2004), which would not have been possible without descriptive natural history (Bleich 2021). These sorts of accounts arise because of investigator breadth in training, keen interest in natural history, and in these cases field work in whatever climate, topography, or physical discomfort was required. Follow-up investigations can result in previously inadequate protections by state and federal agencies or assure genetic integrity of these rare taxa.

Universities shape the future; pluralism adds to the global challenge of the BWI

The manner in which universities and colleges educate students has changed over the last 7 decades. Several spectacular accomplishments in space science by Russia (then the Union of Soviet Socialist Republics) in the late 1950s and 1960s triggered concern by the United States government that Russians were outstripping the scientific capabilities of the United States. The federal government responded, in part, by increasing scholarly investments beginning with the Higher Education Act (U.S. Congress 1965), which was designed specifically to strengthen universities and colleges (and ultimately make the United States more competitive scientifically). Moreover, states

contributed a relatively high proportion of the operating expenses necessary to fund the sciences and other disciplines at public institutions of higher learning. The overall result was a robust and well-rounded education system.

From the perspective of American students, universities and colleges offered comparatively inexpensive yet high-quality educational experiences in which those studying wildlife and related fields flourished. In the early 1970s, a student could attend a California community college for <$6/semester or a state university for $81/semester. Each of us obtained undergraduate degrees at these state institutions nearly for free. Not much remains static, especially the costs of an education, which have risen disproportionately to other commodities (Thelin 2013).

Funding of public institutions of higher learning is dependent upon 4 areas: state and federal monies, charitable contributions, tuition and other student fees, and research grants. Many universities also have endowments accumulated via those processes that can be drawn upon. Nonetheless, there have been huge declines in the contributions by states to funding higher education (Bound et al. 2019). Some states provide such marginal funding that university administrators question whether their institutions should still be referred to as state universities. The most expedient (and sometimes only) way for underfunded universities and colleges to meet their operating costs with balanced budgets is to eliminate employees, raise tuition, or both. Although universities may offer student support via scholarships, the current situation is largely untenable because many families cannot afford the tuition, and students often cannot earn enough money to meet those costs.

Some question the value of higher education because many students accumulate massive debts that are difficult to pay back expediently (Bowen and Fincher 2018). With respect to BWI, this conundrum is an often-overlooked component affecting the number of future wildlife biologists, especially those who may be marginalized and have poor educational backgrounds. Such funding difficulties have a pervasive influence on social (in)justice as to who can afford access to post-secondary education (Schell et al. 2020). For instance, increasing the ratio of administrators to full-time faculty or increasing teaching loads lower teaching quality and compromise time for research (Weinstein 2023). Yet the quality, interest, and enthusiasm of students is the linchpin in future efforts to conserve our natural resources.

The Wildlife Society and other professional societies have crafted guidelines to educate aspiring practitioners at the WBI, which is an important first step. Such coursework offers broad perspectives on educational components necessary to conserve nature and natural resources. Knowledge necessary for professors to offer essential coursework is arduous to acquire and even more difficult to maintain. The average growth rate of knowledge in the life sciences is about 5% annually and doubles every 14 years (Bormann et al. 2021). The amount of new information can be difficult to assimilate and incorporate into coursework yet is essential for educating wildlife and conservation professionals. Even new textbooks become rapidly out-of-date.

To remain current requires staying abreast of scientific literature, and the activity that best facilitates that endeavor is to plan and conduct research, including writing grant proposals, publishing results, and attending and presenting at professional meetings. Grants and other professional activities typically help support graduate students and their research projects. This relationship is a critically important link between teaching and research. Teaching, in addition to educating students, helps to distill scientific thought and provides broad perspectives on science. Somewhat ironically, even if this relationship is not lost on college and university administrators, the difficulty of trying to balance budgets means that students, professors, research, and ultimately conservation lose.

Administrative personnel at colleges and universities continue to increase (Weinstein 2023), with resultant effects on budgets. To overcome funding difficulties, universities and colleges often hire instructors (who possess the academic degrees necessary to offer coursework); these are not tenure-track faculty and typically do not have research responsibilities or a requirement to publish. Instructors often are paid nominal wages with little job security and incur heavy teaching loads typically at the introductory course level. Such appointments provide institutions of higher learning an economical, but often controversial, mechanism to offer required coursework while simultaneously helping to balance budgets. Very few departments could function effectively without the aid of instructors, especially when they are involved in the preparation of laboratory courses. Nevertheless, the ratio of

instructors to tenure-track faculty is an important index to the quality of education; a high ratio is an indication of a poor educational environment (Ehrenberg and Zhang 2005), which bodes poorly for training wildlife professionals and other scientists. This metric is among several that those seeking a higher education should heed.

At its core and regardless of whether one's interest is in science, conservation, or other aspects of the natural world, an understanding of how and why research is conducted is fundamental to facilitate curiosity and become a critical thinker in a functioning society. Teaching alone may not be a viable answer. A dean at a small undergraduate college once described his view of teachers who provided entertaining lectures with little robust content as similar to the adage that a dancing bear can be very entertaining but seldom provides much useful information. The upshot of this discussion is that universities and colleges must find mechanisms to improve funding if our existing system of education is to prosper and educate students adequately for the future. Administrators should seek an equilibrium between teaching and research that maintains the quality of education. The overall difficulty is that many in society do not currently value the importance of a university education in resolving our existing environmental and societal problems at a time when they are most in need of solutions.

There is an obvious difference between being smart and being educated, but these attributes are far from being mutually exclusive. Nevertheless, an education, especially in the sciences, requires specialized information and knowledge that no amount of intelligence will suffice to replace. Only a university education can easily impart that necessary background. Answers to questions and solutions concerning scientific problems can be quite counterintuitive and cannot be resolved only by using common sense. At least some societal undervaluation of a college education emanates from failures to understand that premise alone. We must do a better job of selling science and its value to biological conservation and environmental health to the public to maintain our educational system and promote the stewardship of our biosphere. If we are to adequately educate students and future leaders at the WBI, we need to do better. Additionally, females now compose nearly 60% of undergraduate students in the United States, a huge change over the last several decades (Causey et al. 2023). As more women enter colleges and universities, graduate, and become productive members of NGOs, agencies, and academic institutions, we must assure that they have had the opportunity to gain field experiences. This demographic is a bright spot in a litany of future difficulties that need special attention by our profession.

Many current wildlife students emanate from more urban backgrounds than in previous generations; their contact with and knowledge of natural systems are likely limited. This means that additional information concerning the natural world must be provided as part of their educational experience, some of which can be gained via internships with agencies or NGOs. More emphasis must be based on field experiences, especially some laboratory courses related to wildlife and their habitats. Muddy boots are still necessary.

It remains critically important to infuse the scientific method and demonstrate the excitement that this process can evoke. Many introductory courses conduct experiments in the laboratory component of required science coursework. These experiences can have little to do with experimentation; instead, they are, at best, demonstrations for which the outcomes are well known. Such demonstrations can illustrate important scientific principles but are not experiments and fail to adequately demonstrate the process of obtaining new knowledge. The process and excitement of making observations, formulating hypotheses, collecting and analyzing data, presenting results, and discussing the outcome of the experiment and its relevance to science should be standard across the curriculum.

Nonetheless, too often graduates fail to fully understand how to formulate interesting questions, falsify hypotheses, or interpret results from scientific studies. Indeed, methods of acquiring reliable knowledge are clearly focused on hypothesis testing (Romesburg 1981, Murphy and Noon 1991). Model selection techniques exist for investigating biological phenomena (e.g., Akaike's Information Criterion [AIC]; Akaike 1973); however, the selection of appropriate variables to be considered for inclusion in AIC models remains a fundamentally important component of such analyses (Arnold 2010). Moreover, methods exist for applying a hypothesis-testing approach to AIC model selection (Miller et al. 2023). Realizing that the scientific method requires investigators to be open to changing their minds when additional information becomes available is essential for interpreting scientific research,

for the growth of scientific thought, and perhaps most importantly for becoming a functioning, critically thinking member of society at large.

Understandably, current students have far stronger quantitative backgrounds and a better grasp of statistics, landscape metrics, and genomics than those in previous years, all of which are good signs of acquiring more knowledge. Some quantitative improvements in topics regularly dealt with by agencies, such as population ecology and concepts underpinning compensatory and additive mortality, however, require more attention. This background should be complemented by a basic familiarity and understanding of natural history and field methods, and how they can be better used to test hypotheses at the WBI. A more complete understanding of evolution, adaptation, and natural selection is critically important to preparing students for the future (Sinclair 1991, Parker et al. 2018) and should not be a casualty of the refrain that there are only so many courses offered. Such thematic arenas help students grasp scientific principles and better understand not just what happens but also why it happens. If we do not understand biodiversity, then how can we better conserve it?

Beyond knowledge and fascination *per se*, we, as humans, must survive and must have some modicum of financial resources. Ultimately, universities provide skills for employment for which paths lead to both agencies and NGOs (and for some, back to universities) with responsibilities associated with stewardship of the biosphere. All too often, leaders with responsibilities for wildlife resources possess strong legal, business, or other organizational expertise in lieu of a solid and meaningful background at the BWI, which was something bemoaned by Starker Leopold in the mid-1960s or earlier (Lindzey 1950, Towell 1961). Political appointments of those lacking even a basic background in science to leadership positions at the BWI or other natural resource fields are often an impediment to successful conservation. Moreover, such appointees will likely have allegiance to the individual (or group) that appointed them, rather than to the resources for which they are the responsible administrators. Such complications stem from a lack of understanding about the scientific method, how reliable knowledge is discerned, and how recommendations based on that knowledge are implemented.

Although university administrators and leaders now realize the climate challenge is upon us and act to include much in curricula on atmospheric global change, such views are short-sighted. Guided (and more appropriate) attention is needed to address the shortfall of focus on the sustainability of Earth's life support systems, attention not currently afforded by a myopic media. Despite media attention on climate challenges, global warming is not the source of our biodiversity crisis (Caro et al. 2022); too many people, coupled with habitat loss and poverty, are the issues (Bowyer et al. 2019). University administration should not be rewarding academic scholars only for publications, the currency of the trade, of which several million articles appear annually and fall far from the public radar (Strother and Fazal 2011). Universities should be converging with NGOs and management agencies (some already do, of course; Figure 1) to affect decision-makers such that sociocultural change is associated with environmental policy.

Thus, there is a continuing need to meld more traditional professorial activities with those of NGOS and agencies to obtain well-rounded approaches to guide WBI policy steeped in science. The pursuits might be non-academic, such as working with agencies and policymakers, writing editorials, and engaging in complicated conversations with multiple stakeholders (Berger et al. 2020, Berger and Lambert 2022). Communication beyond speaking out, whether by a biologist representing a NGO, a university, or an agency is needed to direct a rosier future for conservation (Kessler 1995, Wittemyer et al. 2018).

Ensuring a connection to nature as information accumulates at unprecedented speeds

Looking ahead, it might be easy to grow more cynical than optimistic given the global and local challenges to a healthy, biodiverse environment (Bowyer 2022, Bleich et al. 2023, Berger 2024). This should not be the case.

Inspiration is everywhere including paths chartered by underrepresented scientists, activists, and a diversity of other courageous leaders. The likes of Rachel Carson, Jane Goodall, Wangari Maathai, Ruth Buendía, and Sylvia

Earle have led the way but no less so than the popular writers Terry Tempest Williams and Elizabeth Kolbert. The passionate lyrics of Billy Eilish, Joni Mitchell, and Neil Young have brought forth images of Earth before more of it fades into obscurity. By far and large, however, it is nameless artists, cinematographers, photographers, journalists, educators, amateur naturalists, and guides who stimulate curiosity and valuation of nature.

Professionally, a zest to learn helps power a better understanding of the natural world. Artificial intelligence, bioacoustics sensors, eDNA, machine learning, identification networks, drones, thermal imaging, and a host of other technologies propel conservation forward (Krausman 2023, Self 2023, eBird 2024, World Economic Forum 2024). In the United States and other countries with well developed economies, deep databases exist for complex meta-modeling approaches; rarely is this true in fiscally strapped areas of the world with burgeoning human populations, and yet it is in these zones, especially in the Global South, where the bulk of the planet's biodiversity persists and where natural history knowledge is more limited than it should be (Olson and Dinerstein 2002). A throwback to natural history investigations here will continue to be essential in conservation implementation; however, insights into natural history *per se*, though important, will not achieve the gains needed to reverse the biodiversity crisis whether in the United States or beyond. Instilling an appreciation for the nature of living systems, understanding science, and continually molding this with technological appeal are among the steps needed to effectively propel the WBI forward, but real progress will come about only with requisite protective policies. Such challenges, whether in countries with high or low gross domestic productivity are going to remain until societies place a greater value on the bounties of the natural world.

We began this essay by reflecting on changes across time by the types of organizations representing our respective primary appointments (Figure 1). During our careers, the degree of overlap among our respective employers has gone from reasonably divergent to a tightening given the centrality of focus to challenges associated at the WBI. Although the goals of NGOs, universities, and agencies have grown closer, there are still differences in their missions and there is no reason to expect stronger convergence in the future. Universities educate, inspire students, and conduct research. State agencies do some of the same, but also depend on those learned graduates to implement practices consistent with wildlife conservation (Bailey 1982). Conservation NGOs do less with students *per se* and should have conservation gains as their metric of success, which largely they do.

The glue that binds all, we suspect, is natural history. Conservation and wildlife management each evolve in a myriad of ways. Reintroductions continue, and whether for right or wrong sometimes involves public ballots. Colorado, for instance, has already reintroduced lynx (*Felis lynx*) and wolves (*Canis lupus*), and in May of this year, the governor signed policy legislation for the reintroduction of wolverines (*Gulo gulo*). Progressive restoration extends beyond the United States with some overlap in global efforts (Egoh et al. 2021). In the United States, issues of the past with poaching and overharvest are not the issues of the current biodiversity crisis, which include habitat loss, invasive species, and disease. Internationally, we can add poaching and pollution, population isolation, and illegal wildlife trade. Human tolerance and economic gains will always drive humans because, by our nature, we are human.

In Bob Dylan's *All Along the Watchtower* the words, “Plowmen dig my earth. None of them … know what any of it is worth” resounds. Is that to be our fate too; that our once rich, and now imperiled, biological heritage will fade because it is underappreciated? If our connection to natural history fails to endure, what remains?

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The authors declare no conflicts of interest.

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ORCID

Vernon C. Bleich http://orcid.org/0000-0002-5016-1051

REFERENCES

Akaike, H. 1973. Information theory and an extension of maximum likelihood principle. Pages 267–281 *in* B. N. Petrov and F. Csaki, editors. International Symposium on Information Theory. Akademiai Kiado, Budapest, Hungary.

Alsaid, T., M. Alsinani, and S. Ross. 2024. The endangered Arabian tahr observed drinking seawater in Oman. Journal of Arid Environments 223:105177.

Anderson, S. C., P. R. Elsen, B. B. Hughes, R. K. Tonietto, M. C. Bletz, D. A. Gill, M. A. Holgerson, S. E. Kuebbing, C. McDonough MacKenzie, M. H. Meek, and D. Verissimo. 2021. Trends in ecology and conservation over eight decades. Frontiers in Ecology and the Environment 19:274–282.

Arnold, T. W. 2010. Uninformative parameters and model selection using Akaike's Information Criterion. Journal of Wildlife Management 74:1175–1178.

Bailey, J. A. 1982. Implications of "muddling through" for wildlife management. Wildlife Society Bulletin 10:363–369.

Barrows, C. W., M. L. Murphy-Mariscal, and R. R. Hernandez. 2016. At the crossroads: the nature of natural history in the twenty-first century. BioScience 66:592–599.

Bartholomew, G. A. 1986. The role of natural history in contemporary biology. BioScience 36:324–329.

Berger, J. 2018. Extreme conservation: life at the edges of the world. University of Chicago Press, Chicago, Illinois, USA.

Berger, J. 2024. Learning to listen—nature's hot and cold extremes. Pages 191–204 *in* B. Minteer and J. B. Losos, editors. Heart of the wild—essays on nature, conservation, and the human future. Princeton University Press, Princeton, New Jersey, USA.

Berger, J., and C. Cunningham. 1994. Active intervention and conservation: Africa's pachyderm problem. Science 263: 1241–1242.

Berger, J., and S. L. Cain. 2014. Moving beyond science to protect a mammalian migration corridor. Conservation Biology 28:1142–1150.

Berger, J., and J. E. Lambert. 2022. The Humpty Dumpty effect on planet Earth. Frontiers in Conservation Science 3:783138.

Berger, J., T. Wangchuk, C. Briceno, A. Vila, and J. E. Lambert. 2020. Disassembled food webs and messy projections: modern ungulate communities in the face of unabating human population growth. Frontiers in Ecology and Evolution 8:128.

Berwick, S. 1976. The Gir Forest: an endangered ecosystem. American Scientist 64:28–40.

Bleich, V. C. 1979. *Microtus californicus scirpensis* not extinct. Journal of Mammalogy 60:851–852.

Bleich, V. C. 2005. Politics, promises, and illogical legislation confound wildlife conservation. Wildlife Society Bulletin 33: 66–73.

Bleich, V. C. 2021. An endemic anuran and a horny toad: brief distributional histories, the potential for sympatry, and a cautionary note. California Fish and Wildlife Journal 107:8–20.

Bleich, V. C. 2022. Feral horses, feral asses, and professional politicians: broodings from a beleaguered biologist. Human-Wildlife Interactions 16:337–342.

Bleich, V. C., C. M. Aiello, C. W. Epps, and J. D. Wehausen. 2023. Green energy at odds with conservation. Science 380: 1021.

Bound, J., B. Braga, G. Khanna, and S. Turner. 2019. Public universities: the supply side of building a skilled workforce. RSF: The Russell Sage Foundation Journal of the Social Sciences 5:43–66.

Bowen, H. R., and C. Fincher. 2018. Is higher education worth the cost? Investment in Learning 517:431–448.

Bowyer, R. T. 2022. Sexual segregation in ungulates: ecology, behavior, and conservation. Johns Hopkins University Press, Baltimore, Maryland, USA.

Bowyer, R. T., M. S. Boyce, J. R. Goheen, and J. L. Rachlow. 2019. Conservation of the world's mammals: status, protected areas, community efforts, and hunting. Journal of Mammalogy 100:923–941.

Callaghan, C. T., J. M. Martin, R. T. Kingsford, and D. M. Brooks. 2018. Unnatural history: is a paradigm shift of natural history in 21st century ornithology needed? Ibis 160:475–480.

Caro, T., Z. Rowe, J. Berger, P. Wholey, and A. Dobson. 2022. An inconvenient misconception: climate change is not the principal driver of biodiversity loss. Conservation Letters 15:e12868. https://doi.org/10.1111/conl.12868

Carson, R. 1962. Silent spring. Houghton Mifflin, Boston, Massachusetts, USA.
Catlin, G. 1841. Letters and notes on the manners, customs, and condition of North American Indians. 1965 Reprint. Roos and Haines, Minneapolis, Minnesota, USA.
Conway, W. 2013. Act III in Patagonia: people and wildlife. Island Press, Covelo, California, USA.
Coonen, L. P. 1951. The prehistoric roots of biology. Scientific Monthly 73:154–165.
Cunningham, C., and J. Berger. 1997. Horn of darkness: rhinos on the edge. Oxford University Press, New York, New York, USA.
Darwin, C. 1859. On the origin of species. Cassell and Company, London, England.
Czech, B. 2023. Gag-ordered no more: the 800-pound gorilla in the U.S. Government. Steady State Press, Arlington, Virginia, USA.
Darwin, C. 1889. Journal of researches into the natural history and geology of the countries visited during the voyage of HMS "Beagle" round the world, under the command of Capt. Fitz Roy, R.N. Ward, Lock and Company, London, United Kingdom.
eBird. 2024. Discover a new world of birding. https://ebird.org/home. Accessed 24 May 2024.
Egoh, B. N., C. Nyelele, K. D. Holl, J. M. Bullock, S. Carver, and C. J. Sandom. 2021. Rewilding and restoring nature in a changing world. PlosOne 16:e0254249.
Ehrenberg, R. G., and L. Zhang. 2005. Do tenured and tenure-track faculty matter? Journal of Human Resources 40: 647–659.
Estes, J. A. 2016. Serendipity: an ecologist's quest to understand nature. University of California Press, Oakland, California, USA.
Fire, M., and C. Guestrin. 2019. Over-optimization of academic publishing metrics: observing Goodhart's Law in action. GigaScience 8:1–20. https://doi.org/10.1093/gigascience/giz053
Fleischner, T. L. 2011. Why natural history matters. Journal of Natural History Education and Experience 5:21–24.
Goodrich, J. M. 2010. Human–tiger conflict: a review and call for comprehensive plans. Integrative Zoology 5:300–312.
Greene, H. W. 2016. Tracks and shadows: field biology as art. University of California Press, Berkeley, USA.
Greene, H. W., and J. B. Losos. 1988. Systematics, natural history, and conservation: field biologists must fight a public-image problem. BioScience 38:458–462.
Grinnell, J. 1939. Extract from a paper read by president Joseph Grinnell at the 20th annual meeting of the society on July 21, 1938. Journal of Mammalogy 20:134–136.
Herman, S. G. 2002. Wildlife biology and natural history: time for a reunion. Journal of Wildlife Management 66:933–946.
Hornocker, M. 2023. Cougars on the cliff: one man's pioneer quest to understand the mythical mountain lion—a memoir. Lyons Press, Essex, Connecticut, USA.
Horton, C. C., T. R. Peterson, P. Banerjee, and M. J. Peterson. 2016. Credibility and advocacy in conservation science. Conservation Biology 30:23–32.
Igoe, J., and D. Brockington. 2007. Neoliberal conservation: a brief introduction. Conservation and Society 5:432–449.
iNaturalist. 2024. Observations. <https://www.inaturalist.org/observations>. Accessed 20 May 2024.
International Union for the Conservation of Nature. 2004. *Anaxyrus nelsoni* (Amargosa toad). <https://www.iucnredlist.org>. Accessed 16 May 2024.
Jenkins, D. 2023. Nature and bureaucracy: the wildness of managed landscapes. Routledge, New York, New York, USA.
Jones, Jr., R. D. 1963. Buldir Island, site of a remnant breeding population of Aleutian Canada Geese. Wildfowl Trust Annual Report 14:80–83.
Jones, M. S., and J. Solomon. 2019. Challenges and supports for women conservation leaders. Conservation Science and Practice 1:e36.
Kallman, H., editor. 1987. Restoring America's wildlife 1937–1987. United States Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA.
Kessler, W. B. 1995. Learning to play by nature's rules. Natural Resources and Environmental Issues 5:18–21. <https://digitalcommons.usu.edu/nrei/vol5/iss1/>
Krausman, P. R. 2000. Wildlife management in the twenty-first century: educated predictions. Wildlife Society Bulletin 28: 490–494.
Krausman, P. R. 2017. And then there were none: the demise of desert bighorn sheep in the Pusch Ridge Wilderness. University of New Mexico Press, Albuquerque, USA.
Krausman, P. R. 2023. Managing artificial intelligence. Journal of Wildlife Management 87:e22492.
Krausman, P. R., and V. C. Bleich. 2013. Conservation and management of ungulates in North America. International Journal of Environmental Studies 70:372–382.
Landhuis, E. 2016. Scientific literature: information overload. Nature 535:457–458. https://doi.org/10.1038/nj7612-457a
Lindzey, J. S. 1950. The white-tailed deer in Oklahoma: management and production. Federal Aid in Wildlife Restoration Project Number 37R. Oklahoma Game and Fish Department, Oklahoma City, USA.

Leopold, A. 1933. Game management. Charles Scribner's Sons, New York, New York, USA.
Leopold, A. 1949. A Sand County almanac and sketches here and there. Oxford University Press, Oxford, United Kingdom.
Leopold, A. S. 1959. Wildlife of Mexico: the game birds and mammals. University of California Press, Berkeley, USA.
Liebenberg, L. 1990. The art of tracking: the origin of science. David Philip Publishers Ltd., Claremont, South Africa.
Macilwain, C. 1994. Biologists out of Africa over rhino dispute. Nature 368:677.
Macnab, J. 1983. Wildlife management as scientific experimentation. Wildlife Society Bulletin 11:397–401.
Matthiessen, P. 1959. Wildlife in America (revised and updated in 1987). Viking, New York, New York, USA.
McCabe, R. E., and T. R. McCabe. 1984. Of slings and arrows. Pages 19–72 *in* L. K. Halls, editor. White-tailed deer ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.
McKeon, S., L. Weber, A. J. Adams, and T. L. Fleischner. 2020. Natural history as the innate foundation of ecology. Bulletin of the Ecological Society of America 10:e01656. https://doi.org/10.1002/bes2.1656
Michaels, C. J., B. F. Gini, and R. F. Preziosi. 2014. The importance of natural history and species-specific approaches in amphibian ex-situ conservation. Herpetological Journal 24:135–145.
Miller, S. D., D. K. Person, and R. T. Bowyer. 2023. Efficacy of killing large carnivores to enhance moose harvest: new insights for a long-term view. Diversity 14:939.
Miller, S. F., L. N. Barrow, S. M. Ehlman, J. A. Goodheart, S. E. Greiman, H. L. Lutz, T. M. Misiewicz, S. M. Smith, M. Tan, C. J. Thawley, et al. 2020. Building natural history collections for the twenty-first century and beyond. BioScience 70: 674–687.
Miquelle, D. G., E. N. Smirnov, H. G. Quigley, M. G. Hornocker, I. G. Nikolaev, and E. N. Matyushkin. 1996. Food habits of Amur tigers in Sikhote-Alin Zapovednik and the Russian Far East and conservation implications. Journal of Wildlife Research 1:138–147.
Murphy, D. D., and B. D. Noon. 1991. Coping with uncertainty in wildlife biology. Journal of Wildlife Management 55: 773–782.
Olson, D. M., and E. Dinerstein. 2002. The global 200: priority ecoregions for global conservation. Annals of the Missouri Botanical Garden 2002:199–224.
Parker, I. D., A. N. Facka, T. A. Catanach, and E. K. Lyons. 2018. The benefits of evolution education for natural resources managers. Perspectives in Ecology and Conservation 16:12–16.
Quammen, D. 1996. The song of the Dodo: island biogeography in an age of extinctions. Scribner's, New York, New York, USA.
Redford, K. H., J. C. Ray, and L. Boitani. 2011. Mapping and navigating mammalian conservation: from analysis to action. Philosophical Transactions of the Royal Society B: Biological Sciences 366:2712–2721.
Ríos-Saldaña, C. A., M. Delibes-Mateos, and C. C. Ferreira. 2018. Are fieldwork studies being relegated to second place in conservation science? Global Ecology and Conservation 14:e00389.593.
Robinson, J. G., D. LaBruna, T. O'Brien, P. J. Clyne, N. Dudley, S. J. Andelman, E. L. Bennett, A. Chicchon, C. Durigan, H. Grantham, and M. Kinnaird. 2024. Scaling up area-based conservation to implement the Global Biodiversity Framework's 30×30 target: the role of nature's strongholds. PLoS Biology 22:e3002613.
Romesburg, H. C. 1981. Wildlife science: gaining reliable knowledge. Journal of Wildlife Management 45:293–313.
Sanderson, E. W., M. Jaiteh, M. A. Levy, K. H. Redford, A. V. Wannebo, and G. Woolmer. 2002. The human footprint and the last of the wild: the human footprint is a global map of human influence on the land surface, which suggests that human beings are stewards of nature, whether we like it or not. BioScience 52:891–904.
Sanderson, E. W., J. Walston, and J. G. Robinson. 2018. From bottleneck to breakthrough: urbanization and the future of biodiversity conservation. Bioscience 68:412.
Sanjayan, M., K. R. Crooks, and L. S. Mills. 2020. Michael E. Soulé (1936–2020). Nature Ecology & Evolution 4:1296–1297.
Sarkar, S. 2021. Origin of the term biodiversity. BioScience 71:893.
Schaefer, R. J., S. G. Torres, and V. C. Bleich. 2000. Survivorship and cause-specific mortality in sympatric populations of mountain sheep and mule deer. California Fish and Game 86:127–135.
Schaller, G. B. 1963. The mountain gorilla. University of Chicago Press, Chicago, Illinois, USA.
Schaller, G. B. 1967. The deer and the tiger: study of wild life in India. University of Chicago Press, Chicago, Illinois, USA.
Schaller, G. B. 1972. The Serengeti lion: a study of predator-prey relations. University of Chicago Press, Chicago, Illinois, USA.
Schaller, G. B. 1977. Mountain monarchs. Wild sheep and goats of the Himalaya. University of Chicago Press, Chicago, Illinois, USA.
Schaller, G. B. 1993. The last panda. University of Chicago Press, Chicago, Illinois, USA.
Schaller, G. B. 2012. Tibet wild: a naturalist's journeys on the roof of the world. Island Press, Washington, D.C., USA.
Schell, C. J., K. Dyson, T. L. Fuentes, S. Des Roches, N. C. Harris, D. S. Miller, C. A. Woelfle-Erskine, and M. R. Lambert. 2020. The ecological and evolutionary consequences of systemic racism in urban environments. Science 369:eaay4497.
Schildwachter, G., and C. Booher. 2024. The wild sheep way for endangered species. Wild Sheep 12:30.

Self, R. 2023. How AI and data science support wildlife conservation. https://www.nathab.com/blog/how-ai-data-science-support-wildlife-conservation/. Accessed 22 May 2024.
Sinclair, A. R. E. 1991. Science and the practice of wildlife management. Journal of Wildlife Management 55:767–773.
Strother, J. B., and Z. Fazal. 2011. Can green fatigue hamper sustainability communication efforts? Institute of Electrical and Electronics Engineers International Professional Communication Conference 2011:1–6. https://doi.org/10.1109/IPCC.2011.6087206
Tewksbury, J. J., J. G. T. Anderson, J. D. Bakker, T. J. Billo, P. W. Dunwiddie, M. J. Groom, S. E. Hampton, S. G. Herman, D. J. Levey, N. J. Machnicki, et al. 2014. Natural history's place in science and society. BioScience 64:300–310.
Thelin, J. R., 2013. The rising costs of higher education: a reference handbook. Bloomsbury Publishing, London, United Kingdom.
Thomas, J. W. 2004. The management of the federal lands—where now? Fair Chase 19:12.
Towell, W. 1961. Page 98 *in* J. Madson. The white-tailed deer. Olin Mathieson Chemical Corporation, East Alton, Illinois, USA.
U.S. Census Bureau. 2022. Nation's urban and rural populations shift following 2020 census. https://www.census.gov/newsroom/press-releases/2022/urban-rural-populations.html. Accessed 11 May 2024.
U.S. Congress. 1964. Wilderness act of 1964. Public Law 88-577. 88th Congress of the United States, Washington, D.C., USA.
U.S. Congress. 1965. Higher education act of 1965. Public Law 89-329. 89th Congress of the United States, Washington, D.C., USA.
U.S. Congress. 1971. Wild free-roaming horses and burros act of 1971. Public Law 92-195. 92nd Congress of the United States, Washington, D.C., USA.
U.S. Congress. 1973. Endangered species act of 1973. Public Law 93-205. 93rd Congress of the United States, Washington, D.C., USA.
U.S. Congress. 1994. California Desert Protection Act. Public law 103-433. 103rd Congress of the United States, Washington, D.C., USA.
von Humboldt, A. 1858. Cosmos: a sketch of the physical description of the universe, I. Translated by E. C. Otte (1997). John Hopkins University Press, Baltimore, Maryland, USA.
Wallace, A. R. 1871. Contributions to the theory of natural selection: a series of essays. Macmillan, London, United Kingdom.
Weber, B., and A. Vedder. 2001. In the kingdom of gorillas: the quest to save Rwanda's mountain gorillas. Simon and Schuster, New York, New York, USA.
Weinstein, Jr., P. 2023. Administrative bloat at US colleagues is skyrocketing. Forbes 28 August 2023. <https://www.forbes.com/sites/paulweinstein/2023/08/28/administrative-bloat-at-us-colleges-is-skyrocketing/?sh=2d8ab69a41d2>. Accessed 5 June 2024.
Western, D. 2020. We alone: how humans have conquered the planet and can also save it. Yale University Press, New Haven, Connecticut, USA.
White, G. C., and R. A. Garrott. 1990. Analysis of wildlife radio-tracking data. Academic Press, San Diego, California, USA.
Wikramanayake, E., E. Dinerstein, J. Seidensticker, S. Lumpkin, B. Pandav, M. Shrestha, H. Mishra, J. Ballou, A. J. T. Johnsingh, I. Chestin, and S. Sunarto. 2011. A landscape-based conservation strategy to double the wild tiger population. Conservation Letters 4:219–227.
Wildlife Conservation Society. 2024. Archives: WCS history. https://library.wcs.org/en-us/Archives/WCS-History.aspx. Accessed 23 May 2024.
Wilson, E. O. 2006. Naturalist. Island Press, Washington, D.C., USA.
Wittemyer, G., J. Berger, K. R. Crooks, B. R. Noon, L. Pejchar, S. H. Reed, and J. A. Savidge. 2018. To advocate or not is no longer the question: paths to enhance scientific engagement. BioScience 68:13–14.
World Economic Forum. 2024. AI in conservation: where we came from—and where we are heading. https://www.weforum.org/agenda/2024/03/ai-in-conservation-where-we-came-from-and-where-we-are-heading/. Accessed 22 May 2024.
Young, S. P. 1961. The deer, the Indians, and the American pioneer. Pages 1–27 *in* W. P. Taylor, editor. The deer of North America. Stackpole Company, Harrisburg, Pennsylvania and Wildlife Management Institute, Washington, D.C., USA.
Yparraguirre, D. R., T. A. Sanders, M. L. Weaver, and D. A. Skalos. 2020. Abundance of Tule geese *Anser albifrons elgasi* in the Pacific Flyway 2003–2019. Wildfowl 70:30–56.

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