1491: New Revelations of the Americas before Columbus

Author: Costanza, Robert

Source: BioScience, 56(10) : 846-847

Published By: American Institute of Biological Sciences

URL: https://doi.org/10.1641/0006-3568(2006)56[846:AEEIHD]2.0.CO;2

An Extraordinary Experiment in Human Development

1491: New Revelations of the Americas before Columbus. Charles C. Mann. Knopf, New York, 2005. 478 pp., illus. $30.00 (ISBN 140004006X cloth).

In studying the complex ways that human societies on Earth have interacted with their environments, we only have one experiment to observe—or do we? There were at least 14 millennia of Earth history during which two separate, isolated experiments in the development of agriculture, complex states, trade, disease, resource exploitation, empires, sustainability, and collapse were running in parallel in the Eastern and Western Hemispheres. In 1492 these two experiments were joined, with disastrous consequences for the inhabitants of the Western Hemisphere. But new revelations of the history of this hemisphere before 1491 are significantly expanding our understanding of the factors that shaped human and environmental coevolution.

In *1491: New Revelations of the Americas before Columbus,* science writer Charles Mann takes his readers on a compelling and readable tour of the Western Hemisphere as it would have looked in 1491. Fifty years ago, almost all historians would have provided a very short and simple tour. According to Mann, they would have described "two continents of wilderness, populated by scattered bands whose ways of life had changed little since the Ice Age. The sole exceptions would have been Mexico and Peru, where the Maya and the ancestors of the Inka were crawling toward the foothills of Civilization." This vision of the pre-Columbian Western Hemisphere still pervades common understanding. But our knowledge of the state of the Americas in 1491 has expanded dramatically, and Mann's tour conjures a hemisphere that is almost unrecognizable compared with the picture painted by earlier historians.

In 1492 Columbus arrived bearing European pathogens. This and subsequent pathogen deliveries would ultimately devastate the huge human population of the Americas and leave subsequent European explorers and settlers with the mistaken impression that the entire hemisphere was a lightly populated wilderness. Mann presents the accumulating evidence that, because of the uniquely susceptible genetic makeup of the pre-Columbian human population in the Americas, huge portions (as much as 95 percent in some cases) of native populations were lost to European diseases they had never before encountered. It turns out that Native Americans have far less diversity than Europeans in their human leukocyte antigens (HLAs), molecules inside most human cells that are essential to one of the body's main defenses against pathogens. European populations in the 1400s had diverse HLA profiles, and this allowed a large percentage of them to resist most diseases, even the plague. But Native American populations had HLA profiles dominated by a very small number of types. The result was that they were unusually susceptible to Old World diseases.

The "wilderness" that Europeans discovered in America was the result of millennia of extensive and intensive interactions between the environment and human populations as large as those in Europe at the time.

Using this information, along with reports of the sizes of the decimated native populations remaining when settlers arrived, leads to much larger estimates of the human population of the Americas in 1491. For example, Mann argues that in 1491, the central valley of Mexico was the most densely populated place on Earth, and that the Amazon basin was home to a human population in the millions, thriving on a complex, stable agroforestry rather than slash-and-burn agriculture.

The details of these and many other newly emerging stories about the histories of societies large and small across the Americas, from the Iroquois in the northeastern United States to the Inka along the southern Pacific coast, make for compelling and engaging reading. One of the more interesting stories has to do with the development of maize (corn) as a staple grain in the Americas. Europeans domesticated wild grasses through selective breeding of a common mutation that causes the seeds not to shatter (release from the stem) until they can be harvested, but unlike European grains, corn's direct wild ancestor has never been found. And unlike European grains, maize cannot propagate itself but requires human intervention. The most likely explanation, according to Mann, is that domestic corn was created, almost from scratch, either as a hybridization of two related species or as the determined selection over at least a decade of what seems to be the closest existing ancestor of maize (teosinte, a plant with no food value in its wild state). The details of this story are fascinating and still not settled. Mann expertly weaves together both the technical details of the research and the personal details of the individuals involved in the continuing search for the origins of maize.

Another insight that flows from Mann's synthesis is that the idea of "wilderness" that has motivated environmentalists needs to be rethought. The "wilderness" that Europeans discovered in America was the result of millennia of extensive and intensive interactions between the environment and human populations as large as those in Europe at the time. The emerging history of both hemispheres is one that leads toward a more integrated view of humans as major components of the ecosystems they were part of over a range of spatial and temporal scales.

But what is perhaps most compelling about this emerging overall history of the Americas is its degree of parallel with the history of the Eastern Hemisphere. Even though there were huge differences in the biogeography, native plant and animal resources, and other features of the two hemispheres (Diamond 1997), the development of human societies followed roughly similar and parallel paths, and at roughly the same rates. Mann marshals the accumulating evidence that rather than lagging by several centuries to millennia, as previously thought, human societies in the Western Hemisphere were at roughly the same state of development as in the Eastern Hemisphere in 1491. Had populations in the Western Hemisphere not been especially susceptible to eastern pathogens, things may have turned out quite differently. Had the germs not done such a thorough job, it is doubtful, in Mann's view, whether the guns and steel of the Europeans could have overcome the Native Americans.

Of course, these two grand hemispherical experiments in human development were not controlled or well monitored, and we have to piece together the results from the partial fragments left behind. We cannot test hypotheses directly and must rely on comparative analysis, "experiments of opportunity," and a "weight of evidence" approach. But this synthesis can now make use of a growing ability to assemble an integrated human and environmental history. For example, reconstructions of global climate based on ice core data now reveal that the period from about 14 thousand years ago was an exceptionally warm and stable period in Earth's climate history (Dahl-Jensen et al. 1998). Why is it that, even though biologically modern humans were around for more than a hundred thousand years, agriculture did not arise until a few thousand years into this stable period? And it arose more or less simultaneously and independently (according to Mann's synthesis) in both the Eastern and Western Hemispheres. It is clear that simple linear cause-and-effect explanations are insufficient to explain complex phenomena like the emergence of agriculture, but it is also clear that a key prerequisite for agriculture is a relatively stable and predictable climate.

Continuing efforts to synthesize and integrate human and environmental history will shed more light on this and many other questions about the emergence, development, and sustainability or collapse of human societies (Flannery 1994, Diamond 2004, Costanza et al. 2006). Mann has made a substantial contribution to this important field of inquiry, a field that will help us create a more sustainable and desirable future by better understanding the complex ways humans have interacted with their environment in the past.

ROBERT COSTANZA
Robert Costanza (e-mail: Robert.Costanza@uvm.edu) is Gordon Gund Professor of Ecological Economics and director of the Gund Institute of Ecological Economics, Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT 05405.

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LIVING WITH LARGE CARNIVORES

Coexisting with Large Carnivores: Lessons from Greater Yellowstone. Tim W. Clark, Murray B. Rutherford, and Denise Casey, eds. Island Press, Washington, DC, 2005. 290 pp., illus. $27.95 (ISBN 1597260053 paper).

Unlike a large number of recent books on large carnivore biology, *Coexisting with Large Carnivores* is about carnivore management—or, more accurately, management of people who interact with carnivores. Although the book covers some biology, its main focus is on long-standing problems in conserving wolves, cougars, and grizzly bears south of Yellowstone National Park (YNP) in Wyoming. The three-county area of Lincoln, Sublette, and Fremont is a 57,000-square-kilometer wildland of world-renowned conservation significance. Combined with YNP, it is considered one of the most important temperate-zone ecosystems on the planet. It is inhabited by all of the North American large carnivores, as well as one of the most diverse arrays of ungulates found in the western United States.

As editors Tim W. Clark, Murray B. Rutherford, and Denise Casey explain, the problem centers on a clash between the "old West" and the "new West." The "old West" view has long supported removing carnivores from the landscape, mainly to establish livestock but also, later, to reduce human hunters' competition for game. In the old West, agriculture, mining, logging, hunting, and other resource extraction industries were predominant. The "new West" view, created by an influx of immigrants from other regions, values primarily a nonextractive economy featuring scenery, wildlife observation, outdoor recreation, and open space. To this group, large carnivores symbolize wilderness and a healthy ecosystem.

Finding common ground between these two positions has been nearly impossible, and much of the discussion lacks reasonableness. The institutions in place—both state and federal—have struggled. Thus, the single overarching goal of Clark and colleagues' book is to break this logjam using an enlightened approach that involves more people, taking part more equally, in decisionmaking. This places a huge responsibility for administrative restructuring on the agencies that manage wildlife.

Wolves, cougars, and grizzly bears are special wildlife management cases. All of them live over large areas, have low population density, are hard to count, and kill other animals people value. Data gathering is difficult and expensive; the data that are available are often misused, and in other cases dismissed because some people claim the studies are rigged. Wyoming is also unique. With its vast open spaces and the smallest human population of any state, Wyoming is the way the West once was, some say (Wilson 1997). Rugged individualism is admired and outsiders are not, and the government is disliked.

Coexisting with Large Carnivores covers each carnivore separately and then offers common solutions. Each carnivore has its own special set of issues. For cougars, which are normally shy and reclusive, it was an especially visible family outside of Jackson Hole, Wyoming, that touched off the debate. A female and her three kittens were remarkably visible in a rock cave a short distance from town. Over 15,000 people saw them

during a 42-day period. At about the same time, the Wyoming Game and Fish Department raised the harvest quota of cougars in the area. When questioned, the department had trouble explaining the rationale for the change, especially because no one knew how many cougars there were. Public meetings proved to be ineffective, as it seemed the course of action was predetermined, so the meeting was perceived as a presentation of information rather than solicitation of input. To justify the approach, the department stated that management of cougars should not be based on public opinion. The end result? People became alienated, opposition hardened, a foundation supporting cougars sprang up, and overall trust was lost.

Grizzly bears present similarly intractable issues. According to one estimate, only 25 to 50 bears were living outside YNP in 1970. In 1975, bears were listed as threatened and given protection under the Endangered Species Act (ESA), an action that stockmen claimed would bankrupt them. Since the listing, the population has grown and conflicts have increased. Livestock have been killed, sometimes in substantial numbers, and occasionally people are attacked, injured, and even killed. The disposal of garbage is regulated, which some people consider government meddling. The future availability of key natural foods for bears is debated, and any reduction would increase bears' consumption of garbage. Three counties have passed ordinances banning grizzlies. Regulations on how stock-killing grizzlies are dealt with are unsatisfactory to livestock producers (not enough lethal control), and some grazing allotments have been lost.

Fearing that "rewilding" initiatives are designed to "kick people off the land," resistance movements have formed. Conservationists, on the other hand, believe that recovery has just begun and that the bear needs more room to roam to secure its population. The US Fish and Wildlife Service (USFWS) is planning to remove ESA protection for the grizzly bear, a move that is opposed by some and embraced by others.

Wolves were reintroduced to YNP under the ESA in 1995 and 1996. Since then the population has expanded into areas outside YNP. Some livestock have been killed. A private group compensates producers for verified losses, but not for suspected losses or for the difficulties of having wolves around. Concern has arisen about the impacts of wolves on elk and moose populations. Hunting enthusiasts have formed groups in all three states that make up YNP (Idaho, Montana, and Wyoming) requesting wolf control or complete removal of wolves. Wyoming's wolf management plan—a requirement to delist—was rejected by the USFWS. Wyoming sued and lost and now contemplates its next move. Delisting has been delayed indefinitely.

So what to do? Clark and colleagues recommend three main courses of action: (1) working from the bottom up rather than from the top down; (2) changing the perceived "meaning" of carnivores, moving away from their historic and symbolic associations; and (3) rearranging the structure of wildlife management agencies to reflect changing human values. If the book can be criticized for anything, it is that it is repetitious, though perhaps intentionally so, to convey the main message: Involve more people in real decisionmaking—don't just inform them of the decisions. Their second recommendation deals with ridding carnivores of the baggage loaded on them by the government and the environmentalists. Finally, Clark and his coauthors criticize the current emphasis in Wyoming wildlife management on consumptive and traditional uses of wildlife, the command-and-control administrative structure, and the inordinate weight given to expert opinion.

Would these recommendations work? I am most familiar with wolves, which seem to be uniquely hated. I have seen the anger and emotion of local people. What emerges from my experience is the value of one-on-one contact. But who has the time? Just as important, when talking one-on-one, you need to be very good at what you do, which means being knowledgeable about details, articulate, and able to roll with the punches. This will get you a modicum of respect, but the skills come only from time on the job. One summer's work will barely get the locals familiar with your name. You have to know as much about the animals as they do. So even if money were available to hire more people, few would have the skill and fortitude to confront the controversy. The USFWS and the Wyoming Game and Fish Department have some veterans whom the public trusts, a vital point that the book only lightly touches on. How we can get more people who function like this is still unanswered.

One of the most successful programs I am involved with is horseback riding into the big-game hunting camps that dot the boundary of YNP in the fall to talk about wolves. Although I have changed few minds, I have opened lines of communication, reaching out deep in the wilderness far from government offices. On a one-week trip I can visit only two or three hunter camps, as they are widely spaced. Carnivore recovery and management will take a lot of work indeed. This book charts the course; its lessons need wide acceptance and implementation.

DOUGLAS W. SMITH
Douglas W. Smith (e-mail: doug_smith@nps.gov) is leader of the Wolf Project, Yellowstone National Park, WY 82190.

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WHY ARE ANIMALS SO HONEST?

The Evolution of Animal Communication: Reliability and Deception in Signaling Systems. William A. Searcy and Stephen Nowicki. Princeton University Press, Princeton, NJ, 2005. 270 pp., illus. $39.50 (ISBN 0691070954 paper).

A campus mockingbird sits outside my window on a No Parking sign and pours out a nearly continuous stream of song for hours. Such behavior exposes

him to predators and interferes with other things he might be doing (such as foraging), and anything that loud must consume a lot of energy. How has such an extraordinary and costly display evolved? We all know that birdsong is a form of communication, but who is he talking to, what is he saying, and what do his listeners have to gain from paying attention to him?

The Evolution of Animal Communication addresses these perennial questions. The book is part of a consistently interesting series of publications from Princeton University Press, Monographs in Behavior and Ecology, edited by John Krebs and Tim Clutton-Brock. The two authors of this volume, Steve Nowicki from Duke University and Bill Searcy from the University of Miami, have distinguished careers and hold endowed professorships at their respective universities. They approach animal (primarily bird) communication from different perspectives, Nowicki by studying the mechanisms and neural substrates of song learning and production, and Searcy by examining the function of communication in mating systems. Together they have a long-term, collaborative research program to study the proximate mechanisms and evolution of birdsong. In the present effort, they address one of the thorniest problems in animal communication: To what extent are animal signals reliable or deceptive, and how can we possibly know the difference?

Those studying animal communication have shifted their view over the years, from assuming that signals are cooperative to arguing that they are self-serving, exaggerated, and manipulative, akin to unregulated political advertising. The perspective matters because different suites of traits evolve depending on whether signals are mutualistic or selfish. Today, scientists generally expect animals—even parents and offspring or members of a mated pair—to behave selfishly, so we expect a lot of lying and deception. The problem is that, contrary to these general expectations, signals are usually honest (i.e., they are reliable indicators of the signaler's qualities or reliable predictors of the signaler's behavior, which the receiver benefits from knowing). Deceptive signals, or cases in which the signaler benefits from giving misinformation to the receiver, are rare. As with human communication, "truth in advertising" appears to be the rule, but unlike human societies, most animals do not have obvious policing mechanisms to enforce truthfulness (although some do!). So how does honest communication evolve, and how is it maintained, in populations?

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Behavioral ecologists have converged on one theoretical framework for understanding the evolution of honest signaling: Selection favors costly signals because only high-quality individuals can afford to pay the costs of producing an honest signal. In *The Evolution of Animal Communication,* Searcy and Nowicki carefully explore this idea. They evaluate predictions from theory using a number of carefully chosen, well-researched case studies, such as badges of status in birds (e.g., the bib on house sparrows); weapon display in shrimp; and dominant call frequency in frogs and toads (lower calls are given by larger males). In each case, they evaluate the evidence that the signal contains information that is of value to the receiver and that the receiver responds. Since the receiver's response may arise from some factor that is correlated with the signal, rather than from the signal itself, experimental manipulations are required to make the study convincing. Next, Searcy and Nowicki determine whether the information contained in the signal is reliable (for example, whether the signal is a significant indicator of body size, which is correlated with the ability of the signaler to win fights). In each case, the difficulty comes in trying to understand why cheating (the deceptive use of the signal) is so uncommon. In some cases the signals are clearly costly in a way that explains their reliability, but in other cases the evidence for costs is just not there, and yet the signaling system persists. It is conceivable that ongoing studies may rescue the costly-signal theory, but the book left me with the impression that the present models are inadequate. Searcy and Nowicki argue that no one explanation is sufficient to understand signal reliability and that multiple mechanisms are needed.

The field of animal communication is filled with metaphors, and it is hard to get away from using loaded terms like "deception," "honesty," "skepticism," and "retaliation" when talking about signals and their evolution. Although a little distracting at times, the use of metaphors is widespread in this field, and it would be too cumbersome to develop separate, neutral terms for each idea or hypothesis. "Skepticism," carefully defined and consistently used, is a perfectly good way to describe the behavior of hens as they quickly learn to distinguish those roosters whose calls provide reliable information about the presence of food from those that are unreliable. Nonetheless, the reader must remember not to infer humanlike cognition to the animals using these signals. One always needs to know the technical meaning of each metaphor and how it is being used. This book does not examine either the moral or the cognitive implications of reliable or deceitful signals; it only tries to establish how evolution has acted on signaling systems.

In *The Evolution of Animal Communication,* the authors cover a wide range of signal types, including begging, alarm calls, food calls, mating displays, and aggressive signals, and they discuss the evidence for honesty, deceit, and costs in each case. This is a clearly written, thoughtful, evenhanded treatment that provides a shortcut into a vast and complex literature. It is also quite technical, with explicit definitions of terms, descriptions of alternative models, and discussions of experimental results. The book is a fascinating evaluation of the present state of reliability and deception in animal signaling systems. It would

make a perfect, albeit somewhat controversial, focus for an honors biology or graduate seminar course on animal communication.

H. JANE BROCKMANN
H. Jane Brockmann (e-mail: hjb@zoo.ufl.edu) is a professor of zoology at the University of Florida, Gainesville, FL 32611.

THE EMERGENCE OF SHAPE

Mechanisms of Morphogenesis: The Creation of Biological Form. Jamie A. Davies. Elsevier Academic Press, Burlington, MA, 2005. 374 pp., illus. $99.95 (ISBN 012204651X paper).

Jamie A. Davies is a reader in developmental cell biology at the University of Edinburgh and editor in chief of the journal *Organogenesis.* His research focuses on mammalian organs and integrates practical, theoretical, and bioinformatics approaches to the subject.

In *Mechanisms of Morphogenesis,* Davies presents a detailed analysis of up-to-date literature on the mechanisms of morphogenesis (the generation of shape). He describes experimental examples from animals, plants, and fungi. The book is organized by scale, beginning with the self-assembly of supramolecular complexes and the adaptive self-organization and morphogenesis of individual cells, moving upward in size toward tissues and organs, and briefly touching on embryos. Chapters 2 and 3 are dedicated to examples of cellular processes, including the formation of cell shape, the migration of cells using chemotaxis and galvanotaxis, cell-to-cell communication, and the condensation of cells to form new structures. Chapter 4 covers several well-understood examples of epithelial morphogenesis, including the closure of holes, the making of tubes and folds, fusion, and branching. Chapter 5 discusses morphogenesis by cell proliferation and death. There is a wealth of information packed between the book's covers. The chapters present a broad array of the better-understood processes, tied together under the themes of adaptive self-organization and emergence.

"Emergence" is a term used in physics, biology, economics, mathematics, philosophy, and robotics. Davies uses the term with respect to embryonic behavior to mean the way in which systems that involve only simple interactions can give rise to complex morphogenetic form. The introductory chapter illustrates this principle using "The Game of Life," a cellular automaton devised by the British mathematician John Horton Conway and available on the Web as a computer simulation. "The Game of Life" demonstrates that the behavior of a few cells on a grid can vary tremendously and nonintuitively even though their movements are dictated by only four simple rules. The game illustrates the power of simple, local processes that result in highly complex behaviors, ultimately giving rise to a rich diversity of form. The simulation demonstrates that understanding the mechanism alone is insufficient for understanding biological form.

A unique contribution of this book is that it concentrates solely on mechanisms of morphogenesis; it takes for granted the processes of differentiation and of signaling and pattern formation covered in other works.

Davies hopes that the concept of emergence will unite the reductionist view of biochemistry and molecular biology with the holistic view of systems biology. *Mechanics of Morphogenesis* aims to explain the morphogenesis of macromolecular and cellular processes, of epithelial tissue morphogenesis, and of the construction of the early embryo. Because biological form is ultimately based on interactions among molecules, Davies begins by discussing self-assembly: the coming together of subunits to make a structure because their association is energetically favored. An example of this is actin monomers assembling to form microfilaments.

Moving upward in biological complexity, he then introduces the term "adaptive self-organization," the process by which structures are assembled under the guidance of feedback loops and thus modified and optimized for a specific function. For example, the orientation, quantity, and location of the animal cell cytoskeleton are constructed when information, in the form of mechanical tension, is applied to the cell. Examples of morphogenesis using feedback loops are provided at several "layers" of development (genes, proteins, cells, tissues, and so on). I was left with an appreciation of the morphogenesis of form not as a bottom-up, scalar process but as a process whereby any "layer" of development may dictate change either up or down the chain of complexity.

Davies considers the idea of hierarchy in biological systems as heresy because communication in development does not flow solely from one level (the gene level) up. The presence of many layers that communicate through feedback loops can make them amenable to modification by the environment and thus confer selective advantage on morphogenetic systems.

A unique contribution of this book is that it concentrates solely on mechanisms of morphogenesis; it takes for granted the processes of differentiation and of signaling and pattern formation covered in other works. So, if the reader is looking for an update on body plan development or the development of structures involving several cell types, such as a limb, this book may not be appropriate. Moreover, the book has little to offer the reader hoping to get a better feel for the evolution of form. It nicely covers many conserved cellular and tissue processes and almost completely omits the morphogenetic processes that result in divergent organisms. The great advantage of this narrow but detailed approach is that it immediately brings the reader up to date with recent reports and reviews that are central to the field.

In the closing chapter, Davies stresses the importance of the multilayered organization of morphogenetic processes, sends up warning flares on the metaphor of modularity, and addresses the inappropriate use of the word "hierarchy" in development. This struck me as an odd or at least incomplete selection of topics. My feeling is that if Davies wants to explore developmental concepts then they should be discussed more completely. I would have liked to see a brief discussion of homology, homoplasy, phenotypic plasticity, canalization, co-option, and evolvability, because these topics are touched on, albeit implicitly, in the earlier text. They relate directly to work in the field today and would have made a natural extension to the book. The little that Davies does offer in the closing chapter is quality scholarship, but I wished I could have read more of his thoughts.

Mechanisms of Morphogenesis is written in accessible prose. Each chapter outlines experiments that explore a basic central concept. The book is richly illustrated with drawings and well supported by an impressive, up-to-date literature base. Young scientists could profit immensely from this book, as it points to potential avenues of further fruitful research. For the established researcher, the book will provide an excellent update on current advances, and several simple exercises provided in footnotes will be useful in the classroom. Davies wisely makes no attempt to provide comprehensive coverage, but uses persuasive logic to draw out the robust argument that although form is ultimately dependent on cells constructing tissues, complexity in biological systems can and does arise by simple mechanisms at the cellular level. The result is a unique perspective on a set of problems of fundamental importance to molecular, cell, and developmental biologists.

CHRIS B. CAMERON
Chris B. Cameron (e-mail: c.cameron@umontreal.ca) is an assistant professor in the Department of Biological Sciences at the University of Montreal, Quebec H3C 3J7, Canada.

THINK ECOLOGICALLY, ACT ETHICALLY

René Dubos, Friend of the Good Earth: Microbiologist, Medical Scientist, Environmentalist. Carol L. Moberg. ASM Press, Washington, DC. 2005. 260 pp. $29.95 (ISBN 1555813402 cloth).

Carol Moberg's authoritative and compassionate biography of René Dubos is an important and timely work. Dubos's two dozen books and nearly a thousand papers continue to shape our thinking about antibiotics, bacterial cells, medicine, and sustainability. His accomplishments and ideas are as profound as those of Louis Pasteur, Aldo Leopold, or Rachel Carson. Dubos demanded solutions to life's problems that went beyond science and technology to ecology, ethics, and the human search for meaning. His work is especially relevant today as we navigate through science wars and culture clashes. Dubos offers a compassionate, moderate, deliberative message to a world paralyzed by polarization.

Dubos was a successful experimental scientist, an insightful theorist, and a sought-after social critic and policy advisor. He succeeded brilliantly at bench science, as evidenced by his discovery of gramicidin, one of the first antibiotics. He also excelled at communication, having the ability to convey complex ideas to diverse audiences spanning many disciplines, as evidenced by his coining household phrases such as "Think globally, act locally" and winning the Pulitzer Prize for *So Human an Animal* (New York: Scribner, 1968). He brought an ecological orientation and an ethical obligation to his studies that produced new questions, new methods, new theories, and new directions for science and society.

Dubos's ecological approach to soil bacteria revealed complexities and interactions that explain how life functions at the basic, microbiological level. It also led him to issue early warnings about the now common problem of antibiotic resistance. His ecological approach to medicine focused on promoting health rather than curing disease. Infections and diseases become acute, he argued, because of environmental stresses, poor diet, emotional challenges, and other contextual factors—not just the presence of a bacterium or virus. Medicine now accepts Dubos's paradigm as dogma, but still struggles toward realizing his vision of a more holistic approach to health care.

His ecological orientation also forced Dubos to rethink the prevailing philosophy of science. He advocated a humanistic biology that went beyond reductionism and value-neutral facts to interconnected systems and contextual truths. He recognized that science and technology alone cannot solve societal problems. Solutions require philosophy, aesthetics, and ethics, and they must emerge from democracy and deliberation as well as technology. Perhaps most important, Dubos was a "despairing optimist" about environmental sustainability at a time when population bombs, mass extinction, and toxic wastes dominated a preventative, preservationist, misanthropic environmental movement. He believed humans were special and could be creative partners with nature in the odyssey of evolution.

Moberg is well qualified for the important task of capturing the nuances of Dubos's life. She assisted Dubos in the last decades of his career while he wrote his major works on the environment; she has a PhD in comparative literature from Columbia University; and she is on the faculty of Rockefeller University, where Dubos spent much of his professional life. She has access to his personal papers, rapport with his close peers, insight into his thinking, and sympathy for his philosophy.

The story is told, in part, using Dubos's own words and work. The reader is treated to a tour through the early 20th-century culture of science practiced at the Rockefeller Institute, the methods of microbiology and antibiotic research, the culture of medicine, the ecology of infection and disease, the biology of human nature, and the politics and philosophy of human ecology, environmentalism, and sustainability. Details abound, and the reader's appreciation for them may wax and wane depending on where the

reader's interests overlap Dubos's broad reach. Insights also abound for readers engaged in one or more of the three main topics: microbiology, medicine, or environmentalism. But the book's appeal is broader still. René Dubos should be known by everyone who cherishes, celebrates, and hopes to sustain human life on earth.

R. BRUCE HULL
R. Bruce Hull (e-mail: hullrb@vt.edu) is the author of Infinite Nature *(Chicago 2006) and a professor in the College of Natural Resources at Virginia Tech, Blacksburg, VA 24061.*

SHORT-TERM FRESHWATER ENVIRONMENTS

Vernal Pools: Natural History and Conservation. Elizabeth A. Colburn. McDonald and Woodward, Blacksburg, VA, 2004. 426 pp., illus. $29.95 (ISBN 0939923912 paper).

The goal of writing *Vernal Pools: Natural History and Conservation* was, in the words of author Elizabeth Colbum, to provide "an authoritative synthesis of the current understanding of the habitat characteristics of vernal pools, the plants and animals that live in them, and the factors that govern the interactions among pool organisms and their environment." Temporary pools are ubiquitous in their distribution; sadly, however, most ecologists have ignored their role in the diversity of aquatic *and* terrestrial systems. This book is a good start, albeit focused exclusively on vernal pools of the glaciated southeastern Canada and northeastern United States. It is organized into 14 chapters that define vernal pools; describe them as aquatic habitats, with an emphasis on seasonal hydrologic patterns; address their natural history, dominant organisms, and ecology; and describe the endangered status of northeastern North American woodland vernal pools, threats to their existence, and governmental mechanisms to stem their disappearance. The last chapter on conservation is especially valuable in that it addresses key limiting factors of forest vernal pools, chief mechanisms of their change and decline, strengths and weaknesses of protective legislation, and efforts to incorporate vernal pools into the framework of natural resources management.

Vernal Pools is a text reminiscent of early natural history works. Reading it, I recalled how Stephen Forbes's 1887 paper "The Lake as a Microcosm" engendered my early interest in aquatic systems, the organisms that lived there, and what those organisms did. Colburn's volume offers valuable source material for a module on these unique water bodies, but not the detail required for a complete aquatic ecology course. It is a natural history book building on Ann Haven Morgan's 1930 classic, *Field Book of Ponds and Streams,* not a limnology text.

A key strength of *Vernal Pools* is its coverage of the diverse invertebrate and vertebrate fauna of these temporary water bodies, including discussions of life history and food chains. Colburn discusses adaptive strategies that are necessary for invertebrates to survive in these ephemeral environments. The detailed, referenced lists of faunal taxa will guide students as they assess these relatively unknown aquatic systems. These chapters not only capture the author's vast experience with vernal pools but also her enthusiasm for sharing their secrets with others.

The line drawings of aquatic invertebrates, largely from Morgan's work, are excellent. The black-and-white photographs of key taxa are of less than ideal quality, apparently because of light refraction and limited resolution. They detract from the book; more value would accrue from additional line drawings. The color plates, however, provide effective ecosystem overviews.

With her eastern focus, Colburn defines vernal pools as always associated with timberlands; but certainly roadside ditches and prairie ponds often fit hydrological criteria of vernal pools (here today, gone tomorrow) and are vital as refugia or genetic corridors between woodland-associated pools. Given the title, I expected that *Vernal Pools* would at least briefly describe vernal pools that exist in other North American regions (e.g., woodland pools in the southeastern Piedmont and the foothills of the Appalachians, vernal pools in prairie pothole ecosystems of the upper US Midwest and Canadian prairie provinces, vernal pools that form during wet cycles in the arid Southwest, vernal pools in lowland forests among the coastal mountains of the Pacific Northwest, and vernal pools in the interior Rocky Mountain foothills). Neither should we ignore the springtime roadside ditches across the continent that for three months explode with complex algal and zooplankton communities, supporting myriad amphibians before sending them off to complete their life cycles on the uplands. At a minimum, expansion of the color plates to include representative examples of these systems would be very helpful. Considering the book's broad targeted audience, I consider a wider perspective essential.

Vernal Pools provides little in-depth coverage of habitat mechanisms, physical–chemical cycles, and controlling mechanisms of aquatic populations. Even in an introductory text, it's difficult to address aquatic populations and communities without some quantitative, physical- and chemical-specific coverage of their controlling factors. The book offers weak coverage of habitat descriptions—the physical–chemical environment interacting with pool biota. It provides no trend analyses of key habitat descriptors (temperature, dissolved oxygen, plant nutrients, and total organic carbon, a key measure of heterotrophic activity in woodland vernal pools). There is very little quantification of organism density, frequency of occurrence, seasonal patterns of populations, or metrics of ecological integrity, all measures that contribute to a system overview.

The brief chapter "Energy Flow, Seasonal Cycles, and Variations in Community Composition" limits its coverage of energy flow to an effective but generic illustration of woodland vernal pool components. The role of detrital-based food webs is recognized, but nowhere in the chapter is there any measure of energy flow and production rates between system components.

A significant contribution is the 63-page appendix, "An Annotated List of the Fauna of Vernal Pools and Seasonal Ponds in and near the Glaciated Northeast." With its taxonomic organization and its comments on the physical and hydrologic setting of listed taxa, it should serve as a starting point for other workers to add to this ecological database.

C. MICHAEL FALTER
C. Michael Falter (e-mail: cmfalter@uidaho.edu) is a professor emeritus of aquatic ecology and limnology at the College of Natural Resources, University of Idaho, Moscow, ID 83843.

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