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The Complexity of Crops

Farmer's Bounty: Locating Diversity in the Contemporary World. Stephen Brush. Yale University Press, New Haven, CT, 2004. 327 pp., illus. $32.56 (ISBN 0300100493 cloth).

Farmer's Bounty: Locating Diversity in the Contemporary World is intended to evaluate and give a scholarly assessment of the state of crop diversity in the world and the potential for its future preservation. It will be an essential text for those interested in crop diversity, genetic erosion, sustainability, farmer knowledge, and the thorny problems regarding ownership of genetic resources. Stephen Brush's descriptions of recent academic research and policy initiatives on crop diversity bring the book up to date. Most readers will find the book easy to understand, although occasionally some technical terms used by anthropologists and other specialists may cause confusion for the uninformed reader. The book is a rich source of the literature, past and present, on the complex issues of crop diversity.

Brush is a professor in the College of Agricultural and Environmental Science, Department of Human and Community Science, University of California, Davis. Trained as an anthropologist, he has several decades of field experience and research in the cradles of domestication of potatoes in Peru, maize in Mexico, and wheat in Turkey. Most of his work centers on a subject dear to my heart: the humble potato. In 1949 Redcliffe Salaman, in his book *The History and Social Influence of the Potato,* wrote, "Indeed, there have not been wanting those who have regarded these activities (potato improvement) with a shake of the head and an indulgent smile, indicating that nothing short of mental instability could excuse a lifelong attachment to the study of so banal a subject." I am certain that readers will disagree with the head shakers after reading Brush's book, in which he uses his extensive knowledge of potato growing in the Peruvian Andes to answer questions such as "Why are crop species so diverse?"



The author brings together the knowledge and the literature of the numerous disciplines concerned with the multiple aspects of crop diversity. Included is the work of anthropologists, agricultural scientists, ecologists, geneticists, ethnobotanists, and sociologists. As a plant pathologist, I had hoped for more content on diseases and pests, but considering the immense scope of the book, this omission is understandable. Brush concentrates on farmers' knowledge and provides an in-depth treatment of how it may contribute to an agenda for future research. He concludes that the vast amount of research on crop diversity since the pioneering work of Nikolai Ivanovich Vavilov has been "balkanized" into "different disciplines, technical language, and popular understandings." The author's own rigorous research with diversity in potatoes in the Peruvian Andes adds solid authenticity to the book.

The book is divided into sections and chapters that discuss in detail the various aspects of diversity. Four chapters cover the dimensions of crop diversity and the many questions surrounding it. They are followed by a history of human knowledge about crop diversity, going as far back as Theophrastus. Brush notes that although scientists have studied biological diversity in agriculture for 150 years, two puzzles remain unsolved. First, why is there so much variation, and second, why is variation within crop species distributed unevenly? He further notes that although originally a scientific curiosity, the issue of crop diversity has recently emerged as an important policy area with implications for agricultural development, environmental protection, resource conservation, and the rights of cultural minorities and poor farmers. Also described is the interaction of human ecologists with the study of diversity.

The book charts the fascinating history of the early searches for diversity, not only by plant collectors and naturalists but also later by more "scientific" groups. Brush describes the organized explorations for new plants, from the voyage of Captain Bligh in the *Bounty* to the expeditions of later explorers such as Humboldt, Darwin, and Vavilov. He also considers the contributions of the ethnobotanists and economic botanists who have developed methods for describing knowledge about crop diversity and the selection and maintenance of types of crops and crop populations. Studies by human ecologists have examined crop diversity in the context of environmental and social change.

The book describes and lists the various ways crop diversity, especially in potatoes, has been defined and measured, a subject of particular interest to me because I spent 11 years working on potatoes in the Andes of Colombia. Brush describes in detail folk practices, which emphasize the useful parts of the plant. He notes that this complex folk knowledge has guided the selection and maintenance of diversity for millennia. The names farmers give to potato varieties in the Andes can often provide humor. For example, one extremely knobby variety, which was difficult to peel, was named *lumchipamundana,* which translates as "the potato that makes brides weep." Genetic measures discussed consist of both qualitative and quantitative traits and genetic markers. Ecological measures address population structure and distribution and analyze the relation between crop diversity and changes in agricultural environments.

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The next portion of the book describes the scientific issues the author has concentrated on in his research. He first introduces the three crops and farming regions he has worked with during the last three decades: potatoes in the Peruvian Andes, maize in Mexico, and wheat in Turkey. He includes examples of how anthropological research can contribute to an overall understanding of the ecology and evolution of a crop in its center of origin. The nature of farmer selection is described using wheat diversity in Turkey as an example.

Brush describes the main issues around genetic erosion and offers a theoretical framework to improve the reader's understanding of the concept. The literature on the subject is considerable, and he evaluates and analyses it. As he notes, the hypotheses that provide the logical underpinning of the genetic erosion concept are disputed in ecological and cross-sectional analysis, and this indicates the need for improving the theory and methods relied on today for understanding crop, environment, and human interactions.

Other chapters of the book ponder the question of how to conserve diversity in crops. The pros and cons of *in situ* versus *ex situ* methods are discussed in depth. Mankind's rather dismal attempts at conservation to date are described in detail. Some efforts, such as gene banks, are of great importance and value, but will probably no longer continue as the only means by which crop genetic resources are preserved. Brush considers *in situ* or on-farm conservation to be a viable alternative. Enthusiasm for the concept has waxed and waned. Brush describes the past neglect of *in situ* conservation, its scientific basis, and strategies for its use. The addition of lessons learned from FSR (farming systems research), such as farmer participation, strengthen the concept of *in situ* conservation.

"Rights over Genetic Resources and the Demise of the Biological Commons" is the longest chapter in the book and raises many problematic issues that are yet to be resolved. The questions of ownership of genetic resources, plant breeders' rights, farmers' rights, biopiracy, and open access to crop resources are explored but hardly settled. As I wrote this review, I received a copy of an article in Spanish from the newspaper *El Peruano,* published in Lima on 24 February 2005. The article stated that the Peruvian government has established 30 May as the first annual "National Potato Day" in recognition of the potato's genetic riches and the government's obligation to preserve its biological diversity.

The final chapter ponders the future of crop diversity in a world with 11 billion people (the population projection for 2050), and ends on an optimistic note by deciding that the case histories of conservation efforts in developed societies are beneficial for the future of diversity. The vast amount of material covered and the scholarly thoroughness with which it is written ensure that *Farmer's Bounty: Locating Diversity in the Contemporary World* will become a major text for all those interested in crop diversity, sustainability, traditional knowledge, and the difficult problems that surround ownership of genetic resources.

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BUILDING A NOAH'S ARK FOR PLANTS

Ex Situ Plant Conservation: Supporting Species Survival in the Wild. Edward O. Guerrant Jr., Kay Havens, and Mike Maunder, eds. Island Press, Washington, DC, 2004. 504 pp., illus. $80.00 (ISBN 1559638745 cloth).

In 1984, Frank Thibodeau and Donald Falk, fresh from graduate school at Tufts University, founded a new conservation organization, the Center for Plant Conservation, whose goal was to federate US botanical gardens and other horticultural institutions to hold a Noah's Ark–like collection of endangered plants as a last resort against extinction in the wild. Recognizing the considerable but untapped expertise and facilities that these institutions represented, they sought to complement land-based conservation efforts and to ensure the survival of the increasingly threatened national flora. Ten gardens (including my own, the North Carolina Botanical Garden) took part in those early discussions. Some 20 years later, the network has expanded to 33 gardens. Today, the center is housed at one of its participating institutions—the Missouri Botanical Garden—and is led by Kathryn Kennedy, one of the 29 contributing authors of the volume reviewed here.

"*Ex situ* conservation" describes those activities that take place off site or away from wild populations (that I have to define the phrase points out my only quibble with the book—the title!). Such activities face several hurdles if they are to truly contribute to conservation. Most important, they make their highest contribution not by merely holding germ plasm in storage, but by using that germ plasm to support restoration in the wild. Further, the germ plasm collections must capture the original genetic variation, must be stored in a way that maintains viability for years or decades (or longer), must be appropriate to the sites where reintroduction will take place, and must be held in a way that avoids both genetic drift and selection pressures (either in storage or for plants grown in the experimental beds).

I hope that this gives some idea of the complexities of this program and the subjects covered by *Ex Situ Plant Conservation: Supporting Species Survival in the Wild.* It's been noted that Noah's selection criterion (a male and a female of each species) is not genetically sufficient, and that his time frame (40 days) is short compared with a continuing century of habitat loss and fragmentation, as well as likely environmental change. *Ex situ* conservation and restoration are also important for the very reason that we are running out of intact wild populations to protect.

Over the past 20 years, the National Collection of Endangered Species has increased from 50 to 610 species, with some

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13 million seeds accessioned and some 8000 plant occurrences documented by member institutions. Seventy reintroductions have been carried out to date, and in the last year alone, there were 260 research projects and 67 peer-reviewed publications. In one of the most important recent successes, Kennedy has successfully negotiated partnerships with several federal agencies, including the Bureau of Land Management (part of the US Department of the Interior, or USDOI), the National Park Service (USDOI), and the Forest Service (US Department of Agriculture). As it passes its 20th anniversary, the center has become a major player in plant conservation in the United States and is collaborating with similar conservation efforts across the globe.

It is a tribute to its founders, member institutions, and current leadership that, from its earliest days, the center has played an active role in synthesizing existing scientific information and identifying important new research questions, thus promoting the growth of the field of conservation biology itself. Along the way, three landmark books have been produced. The first volume, *Genetics and Conservation of Rare Plants,* edited by Donald Falk and Kent Holsinger (New York: Oxford University Press, 1991), brought together top-notch scientists to address two questions: (1) how is genetic diversity distributed within and among plant populations, and (2) how do we create representative samples of the genetic diversity of rare plants? The second volume, *Restoring Diversity: Strategies for Reintroduction of Endangered Plants,* edited by Falk, Constance I. Millar, and Margaret Olwell (Washington, DC: Island Press, 1996), focused on the use of *ex situ* collections to support conservation in the wild.

The third volume, *Ex Situ Plant Conservation: Supporting Species Survival in the Wild,* based on an international symposium at the Chicago Botanic Garden in 1999, shows the maturation of the center's program and is surely the strongest and most important of the set. Before I say more about this volume, I want to point out a truly important aspect of all three books: Each book, based on the scientific content and practical experiences contained, presents appendices that serve as practical guidelines for those carrying out *ex situ* conservation and restoration. *Genetics and Conservation of Rare Plants* devoted an appendix to protocols for genetic sampling of wild populations. *Restoring Diversity* devoted an appendix to guidelines for use of *ex situ* collections in restoration. The third volume presents three rigorous and practical guides as appendices: (1) revised genetic sampling guidelines for conservation collections of rare and endangered plants, (2) guidelines for seed storage, and (3) guidelines for *ex situ* conservation collection management. These are a must-read for any institution working in this conservation area.

Ed Guerrant, the first editor of *Ex Situ Plant Conservation,* holds a PhD in botany from the University of California at Berkeley and has been the conservation director of the Berry Botanic Garden. Kay Havens holds a PhD from the University of Indiana and served as a conservation biologist at the Missouri Botanical Garden before moving to her present position as director of the Institute for Plant Conservation at the Chicago Botanic Garden. Mike Maunder holds a PhD from the University of Reading and is director of conservation for the National Tropical Botanical Garden in Hawaii. The institutions at which the editors now work are all participating institutions of the center.

What I most admire about this book is the leadership and drive the editors put into it. Often edited volumes produce uneven chapters. Since this is not the case here, it could only be because the editors pushed authors to critically analyze existing information and to press beyond current knowledge to new questions. The book is divided into four parts. The first presents an overview of *ex situ* programs and potentials. The second part presents "tools of the trade," including state-of-the-art overviews of gene banks, seed storage, pollen storage, tissue culture, and storage of germ plasm for lower plants. This section also includes Carol and Jerry Baskin's fine chapter on dormancy and germination. Although the contributions of part II are fundamentally important, the most important section of the book is surely part III, which sets *ex situ* conservation in a larger ecological and evolutionary context. If the proof is in the pudding, it is the interaction of germ plasm banks with the ecological and evolutionary fate of populations that is the critical problem. Chapters in this section address population genetics, hybridization, sample decline during storage and reintroduction, and modeling of the effects of seed collection on extinction risk in wild populations. The final section of the book consists of a single chapter in which the editors and one additional author (Kingsley Dixon, the director of an *ex situ* conservation and research program in Australia) explore the future potential and limitations of *ex situ* plant conservation.



This book should be owned by every botanical institution that aspires to *ex situ* conservation and by zoos that have plant and animal conservation programs. It would make a great set of readings for a graduate student course in plant conservation and is an essential reference for academic libraries. *Ex Situ Plant Conservation* should be widely available not only because it describes important work but because it is so well done. We have here insightful and sometimes novel questions, science that is not only reviewed but synthesized, a broad ecological and evolutionary context, lessons learned, and practical guidelines.

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YOU CAN'T TELL A BOOK BY ITS COVER

Nature and Design. M. W. Collins, M. A. Atherton, and J. A. Bryant, eds. WIT Press, Boston, 2005. 360 pp., illus. $213.00 (ISBN 185312852X cloth).

The first in an intended series of at least six, *Nature and Design* explores "the parallels between human design and nature." That's hot stuff in an era when it seems the mere inclusion of the word "biomimetics" attracts attention and facilitates funding. Two engineers (M. W. Collins and M. A. Atherton, from London South Bank University) and a biologist (J. A. Bryant, from the University of Exeter) edit the series, a promising conjunction. And this particular book promises something at once broadly relevant and soundly grounded. According to the blurb on the back cover and on the publisher's Web site, "this volume provides a comprehensive introduction to the common scientific laws of both the natural and engineered worlds. As well as straightforward engineering design and biology, it also features mathematics, physics, chemistry, thermodynamics, biomimetics, medical engineering and history of science."



Caveat emptor! Or perhaps I should say "*cave canem.*" The problems with this description go beyond commercial hype and the verbal redundancy of the second sentence—in my opinion, it's bogus. Were this book just another nonstarter, it could be left to sink without notice; but before reading *Nature and Design,* both this reviewer and the book review editor—and doubtless other reviewers and editors—succumbed to its promises.

Although the book's introductory chapter runs a fine flag up the pole, no contributor salutes. The remaining chapters are a scattershot lot, with no serious attempt at either thematic unification or consistency in degree of specialization. A chapter on the mathematics of nature follows one devoted to vaporous speculations on the nature of design, and another speculates in a similar manner about mechanisms that maintain complexity—neither can be considered competent reviews of literature-rich fields. One chapter on thermodynamics will be clear only to the reader sufficiently familiar with the subject to work around the chapter's deficiencies. A superficial treatment of plant structures segues into a cursory look at physical factors that might be relevant; one on trees does somewhat better. Still, what should one make of a treatment of trees as mechanical structures that doesn't mention the work of Roland Ennos, or of one on the adaptive growth of bone that fails to refer to John Currey's excellent books? Or, for that matter, one on the design of shell structures that begins with an especially vitalistic definition of homeostasis—"when any living creature is attacked by an external agent, it reacts intelligently to recover its vital functions"—and makes no further biological allusion or specific reference? A book such as this should, at the least, steer the reader to the relevant contemporary literature.

Two chapters are biographical pieces, looking at people the authors consider, one can only guess, of especial present significance. The first provides a hagiographic summary of the life and work of Leonardo da Vinci, glossing over the fact that his technical work remained unpublished and unknown for several hundred years, thus limiting his historical importance. D'Arcy Thompson, treated still less critically, is described as the first biomathematician. I'd have thought a better case could be made for, say, Samuel Haughton (1821–1897) or Francis Galton (1822–1911), each of whom tackled matters of life or death. Haughton, doing biomechanics, calculated the length of drop needed to ensure that a hanging killed immediately rather than just initiated slow strangulation. And Galton, introducing statistics, did the first quantitative study on the efficacy of prayer on longevity. But then each blotted his copybook, Haughton by rejecting evolution and Galton by starting eugenics.

The book's presentation is no better than its content. The introduction remains unpaginated; the reference style varies from chapter to chapter; typographical and simple factual errors are rife and occasionally serious; worst, it lacks an index. Its capitalization and punctuation are, to put it mildly, eclectic.

A reviewer ought to find something praiseworthy. But all that comes to mind is a tale about a boy attending his first dance. Advised always to say something nice, he racks his brain when dancing with an especially corpulent young lady. Finally, he declares with relief, "For a fat girl, you sure don't sweat much." In fact, although I detect no connection between it and the declared mission of the book, the chapter on changing designs for land-based vehicles was a fine page-turner. And my consciousness of matters too often ignored was raised by the section on reflection and interference colors in animals—another scattershot account, but this one with a good set of references. In general, the chapters that read best are the ones with the narrowest and thus least appropriate focus, such as one that describes a particular muscle-powered ventricular assisting scheme.

In a sense, the deficiencies of *Nature and Design* provide object lessons that illustrate the various traps into which a book, especially an interdisciplinary one, can fall. My first rule for writing about science, once posted with some mild profanity above my desk, takes few words—"explain, don't just mention."

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Consider, further, the potential readership: if a book deals with two fields, its explanations must work for readers in both fields, not in neither. Consider the role of the book as an entry point for readers in one field looking toward the other: it should provide appropriate guidance and specific references. Consider, finally, the role of the editors: besides recruiting writers and reminding laggards of deadlines, they have to ride herd on those contributors to achieve uniformity of level, organization, and degree of specialization; above all, they must ensure that contributions integrate into a clear, coherent, and useful product.

The bottom line, here quite a literal one, is the astonishing price of $213, a Brobdingnagian bill for such Lilliputian content. I worry that too many academic libraries will be drawn in, spending all-too-valuable resources on the basis of the title and cover blurb. Indeed, I find it hard to guess for whom, if anyone, the book (or any part of it) might be a must-read. And we are promised five more volumes.

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NEW TITLES

The Domestic Horse: The Evolution, Development, and Management of Its Behaviour. Daniel Mills and Sue McDonnell, eds. Cambridge University Press, New York, 2005. 249 pp., illus. $43.00 (ISBN 0521891132 paper).

The Epistemology of Development, Evolution, and Genetics: Selected Essays. Richard Burian. Cambridge University Press, New York, 2005. 274 pp. $75.00 (ISBN 0521836751 cloth).

Evolution in Four Dimensions: Genetic, Epigenetic, Behavioral, and Symbolic Variation in the History of Life. Eva Jablonka and Marion J. Lamb. MIT Press, Cambridge, MA, 2005. 462 pp., illus. $34.95 (ISBN 0262101076 cloth).

Gene Transfer to Animal Cells. R. M. Twyman. Taylor and Francis Group, Independence, KY, 2005. 249 pp., illus. $59.95 (ISBN 1859962041 paper).

Information Theory, Evolution, and the Origin of Life. Hubert P. Yockey. Cambridge University Press, New York, 2005. 259 pp. $60.00 (ISBN 0521802938 cloth).

Key Experiments in Practical Developmental Biology. Manuel Mari-Beffa and Jennifer Knight, eds. Cambridge University Press, New York, 2005. 382 pp., illus. $100.00 (ISBN 0521533159 cloth).

Principles and Techniques of Biochemistry and Molecular Biology. 6th ed. Keith Wilson and John Walker, eds. Cambridge University Press, New York, 2005. 783 pp., illus. $70.00 (ISBN 0521535816 paper).

Psychobiology of Personality. 2nd ed. Marvin Zuckerman. Cambridge University Press, New York, 2005. 322 pp., illus. $50.00 (ISBN 0521016320 paper).

A Student Handbook for Writing in Biology. 2nd ed. Karin Knisely. Sinauer Associates, Sunderland, MA, 2004. 237 pp., illus. $14.25 (ISBN 0716767091 paper).

Whose View of Life? Embryos, Cloning, and Stem Cells. Jane Maienschein. Harvard University Press, Cambridge, MA, 2005. 342 pp. $15.95 (ISBN 0674017668 paper).



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