Time to Rethink Conservation Strategy

Gretchen C. Daily

Open *Win-Win Ecology* to discover what many in the conservation community do not dare admit even in their private thoughts, much less to the world. Author Michael Rosenzweig cushions his blow, waiting until chapter 10 (entitled "Fighting for Crumbs") to state a profoundly disturbing truth:

> Functioning by themselves, the traditional forms of conservation are running out of time. Although they sure feel good—and right—in the end, conservation as we now practice it will only delay the monumental forces humanity has deployed against the world's [bio]diversity. Increasingly, traditional forms of conservation are becoming little more than diversions that occupy the attention of concerned citizens while the real struggle goes largely ignored.

In thoughtful and elegant prose, peppered with humor and bits of philosophy, Rosenzweig (an ecologist at the University of Arizona) presents an alternative: a hopeful, fresh vision for "inventing, establishing, and maintaining new habitats to conserve species diversity in places where people live, work, or play." He proposes that this "reconciliation ecology" become the third "r" of conservation biology, after "reservation ecology" and "restoration ecology."

Win-Win Ecology
How the Earth's Species Can Survive in the Midst of Human Enterprise
by Michael L. Rosenzweig
Oxford University Press, New York, 2003. 221 pp. $27, £19.99. ISBN 0-19-515604-8.

Traditional conservation is guided by the notion that the world comprises two types of places: natural habitat and human-created non-habitat. Remnants of natural habitat are seen as Noah's arks of biodiversity, floating in a hostile sea of development. The underlying logic holds that organisms evolved tightly tuned to their native habitats; that few, therefore, are able to exploit areas devoted to human enterprise; and that those few—the rats and roaches of the world—do not merit attention, certainly not from a conservation standpoint. Thus, the preferred conservation strategy is to secure as nature reserves the biggest and most (bio)diverse a fleet of arks possible. And to bolster the fleet through restoration of some currently unseaworthy arks.

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Bats from the cracks. Tourists in Austin, Texas, flock to watch the evening departure of as many as 1.5 million Mexican free-tailed bats (*Tadarida brasiliensis*) from their roosts in expansion joints in the Congress Avenue bridge.

But, Rosenzweig asks rhetorically, "What kind of environmental insult is *Homo sapiens*? A 40-day quickie?" And he responds, "Not likely. Unlike the floodwaters, we will not recede. We have no plans to vacate what we have taken—not in the next 40 days, not in the next 40 years. Not ever."

So, how many species might a fleet of arks sustain? Maybe 5 percent, as Rosenzweig explains. Thus, "We must abandon any expectation that reserves by themselves, whether pristine or restored, will do much more than collect crumbs. They are the 5 percent. We need to work on the 95 percent."

Abandon reserves? Absolutely not (many species will survive nowhere else)—just our false expectations of them. Save biodiversity in the hostile sea of development? You bet. However absurd or offensive this idea might seem, it is the only option left.

Rosenzweig will make some people unhappy, even angry. That's because some devoted conservationists are uncomfortable with anything that smacks of compromise. But confronting reality is not giving in. With all due respect to those who might spurn Rosenzweig's message as cowardly compromise, they should read on after the first shock, because this book deals in a compelling way with a world we have already made.

Rosenzweig's point of departure is that we do, all of us, want Earth to remain home to more than a small fraction of its biodiversity, set apart in distant reserves. He then relates many successful, if largely accidental, instances of reconciliation. He has witnessed many of these himself, and he describes them in lively anecdotes.

> [I]f you visit Habima Square [in Tel Aviv] on a summer's eve and look upward, you will not believe what you see. The air will be filled with Egyptian fruit bats!…
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> Most of the people bustling about the square do not seem aware of the fruit bats flying only five or ten feet above their heads. Nor do the bats seem to mind that they are flying in and out of the bright lights of the buildings in full view of the world's most untrustworthy species.…I guess if a wild species can adapt itself to such an extreme human vision [the Bauhaus design of the square], there is hope for diversity yet.

The book is a wonderful source of motivation and inspiration, entertaining and thought-provoking for lay and professional audiences alike. Even the most skeptical readers will likely be convinced of the need to rethink conservation strategy. The author paints a broad-brush vision for a future world in which humans and biodiversity resplendently coexist. But we are left wondering how possibly to implement it. According to Rosenzweig, "Reconciliation ecology can save species without displacing people or their economic activities. In the process, it can reduce political conflict to a minimum." Such a result is the holy grail of conservation, but the road to it is not to be found in the book.

The devil is in the details. Which species and ecosystems could survive in the midst of human enterprise? Which most merit our attention? And what is the scientific basis for deciding these issues? Lastly, what strategies other than nature reserves will produce this "reconciliated" world? Major international efforts are presently under way to systematically address these crucial questions. Research in countryside biogeography is illuminating the functioning and fates of species and ecosystems in places devoted to human activities. Assessments of societal benefits ("services") derived from ecosystems are revealing the tradeoffs for biodiversity and human well-being associated with alternative scenarios of development. And around the world, new conservation finance

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schemes, honed to protect both biodiversity and other ecosystem services, are being implemented, aligning economic forces with conservation.

So far these marriages of human enterprise and conservation are small, localized efforts, often subsidized by external resources. Urgently needed are a scaling up of these experiments and a critical analysis of what works and what does not. With *Win-Win Ecology*, Rosenzweig provides the inspiration. What we now need is the hard work of implementing his vision, without surrendering too much in the process.

PHYSICS

Breaking Barriers to Quantum Computing

Andrew J. Landahl

Sometimes great barriers provide great opportunities. While we clamor for faster and faster computers, engineers are working harder than ever to miniaturize components to meet our demand. Before too long—some pundits predict by 2030—they will come face-to-face with the so-called "quantum limit." In this realm, electrons behave less like baseballs and more like weird waves of many possible baseballs. Even worse, any attempt to extract information from such quantum objects would necessarily disturb them via the famous uncertainty principle. Instead of this being seen as the fatal blow to miniaturization, a new and more productive viewpoint has emerged: why not coax the weird quantum waves themselves to compute? To the surprise of many, not only can this be done, but for some problems doing so is a radical improvement. As George Johnson writes in *A Shortcut Through Time*, "Quantum computing would be to ordinary computing what nuclear energy is to fire."

To better appreciate this comparison, imagine storing a bit, a 0 or a 1, in a system at the quantum limit. Quantum physics tells us that such a system can also store any superposition of both bit values; in essence it can store both a 0 and a 1 at the same time, a state Johnson denotes by ϕ. (That is, a 0 and 1 written in the same space, not the Greek letter phi.) Compute a function on such a quantum bit (or qubit), and the function is computed on both possibilities at the same time. Stranger still, compute a function on three qubits in the state ϕ ϕ ϕ, and the function is computed on all eight possible bit combinations at once. A little calculation shows a few hundred qubits would allow one to compute a function on more possibilities than there are atoms in the visible universe.

This exponential explosion seems less exciting once one learns that reading out the answer returns only one, randomly chosen function value of the many possible. The magic begins when the questions posed are more clever. Suppose, for example, one asks not what the function on a single input is, but what its periodicity over all inputs is. A quantum computer can solve such a problem extremely rapidly—and in less time than it would require to evaluate the function separately on each input. It is as though a quantum computer makes an end-run around all classical computations needed to find the answer—what Johnson calls "a shortcut through time."

Like computer engineers, Johnson also faces a great barrier. Challenged by a magazine editor to write "a short book explaining how [a quantum computer] would work," Johnson has no special expertise in either quantum physics or computer science. Yet some of the most conceptually abstract ideas from these fields are critical to understanding quantum computers. As with quantum computing, the presence of this barrier makes the final product better. Relying on his skills as a science writer for the *New York Times*, Johnson uses clocks, tops, and waves to explain a Tinkertoy version of quantum computing that quickly gets the reader involved and hungry to learn more.

The science in the book is fairly accurate, and the few minor lacunae are small enough to ignore when one considers the benefit: Johnson's powerful illustrative analogies and nearly kinesthetic accounts of how quantum computers function. Readers are privileged to hear "silently clattering switches" and witness "a number refracted through some kind of mathematical prism." Readers will also feel comforted by Johnson's personal and amiable tone. For example, when discussing computational universality, he relates his childhood experience with the Geniac Electric Brain, a toy he disappointingly learned was made of switches and bulbs instead of the colorful transistors and capacitors he had hoped for. One aspect of newspaper writing that is blessedly absent from the book is an overreliance on sensationalism: Johnson devotes a fair amount of space to the stiff challenges faced by those struggling to build large-scale quantum computers; the largest to date is only seven qubits large.

Form, not substance. Johnson describes his anticlimactic experience with the Geniac to emphasize that "a computer is...just a box with a bunch of switches."

In such a short popular book, it is impossible to cover every topic. Indeed, since Johnson began his book, quantum computing has blossomed into quantum information science. That field is now exploring the limits and speedups for many information-related tasks including communication, cryptography, metrology, compression, error-correction, and even, rather exotically, teleportation. Nevertheless, Johnson surveys quantum computing's demesne admirably, while delving every now and again into an aspect he finds particularly intriguing. My only criticism of this approach is that the rapid changes of subject are a bit jarring and haphazard. I had a hard time following this random walk, and when I reached the end of the book, I did not have a clear vision of where the field is going. Still, those who are unfazed by the zig-zag trip will find some true gems, including a particularly lucid description of Peter Shor's famous algorithm for number factoring on a quantum computer.

Despite some quibbles about its organization, I recommend *A Shortcut Through Time* to nonspecialists seeking to learn more about quantum computers. Don't miss Johnson's journey as he tears down technical barriers and brings the quantum fire from the mountain.

A Shortcut Through Time
The Path to the Quantum Computer
by George Johnson

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