Guest Editorial

Planting Flowers and Assembling Complex Systems

Environmentalists and ecologists tend to emphasize the negative. Restoration ecology provides the basis for a more hopeful story with important implications for science, as well as for the environment and our relationship with it.

by Stuart L. Pimm

What are restoration ecology and conservation biology? Are they sciences, or are their practitioners just a bunch of naturalists who enjoy flowers and birds? Is ecology a real science? Real science, surely, has men in white lab coats running large, complex machines, or whole teams of scientists running experiments that cost millions of dollars. *Real* scientists understand differential equations and solve the problems of the universe. But restoration and conservation seem different. Do they merely constitute the unfashionable, applied end of an already soft, descriptive, and intellectually fuzzy discipline? If you have not felt the need to address these questions, then you have led a sheltered life. I give a lot of seminars in response to requests to convince other ecologists that restoration ecology and conservation biology are respectable and—not incidentally—worthy of institutional and financial support.

There is more to addressing these concerns than playing psychiatrist to a profession that seems to suffer from deep feelings of insecurity. Some of the most important challenges our society faces fall within the charge of ecology. They include:

- the biological consequences of global climate change,
- issues involving the inventory, loss, and restoration of biological diversity,
- the biological control of plant and animal pests,
- the sustainable use of natural resources,
- the spread of infectious diseases in humans (HIV is just one example) and other organisms, and the spread of introduced organisms, including invasive weeds and other pests as well as genetically modified organisms.

Yet a question nags at us. Are these topics really important to society or are "big science" projects such as the sequencing of the human genome or the construction of the super-collider more important? It is true that projects like these have a certain appeal. One promises insight into the structure of matter, the other the decoding of the blueprint of human life. It seems reasonable to ask, however, whether these issues are really more important—or interesting—than those facing ecologists, who are currently funded at lower levels.

I seem to have missed the importance of the super-collider for our society. Though the theories it will test are undoubtedly of importance, none of them has the stark urgency of any of the challenges to ecology listed above.

Of course, if we know the entire sequence of human DNA, we may understand more about genetic diseases. But genetic diseases, though individually devastating, account for only a tiny fraction of human mortality. Suppose that, using some technology or other, we could save really large numbers of human lives: what would be the consequences? As a matter of fact, medicine already has the technology to save millions of lives. Cheap, widely available, oral re-hydration packets have the potential to save the lives of millions of children who die annually from disease. The dilemma this poses is whether those millions will be able to find enough food, or will they survive now only to die of starvation later?

Science, then, has already made it possible for humans to live longer and for children to have much better chances of surviving to become adults. Our population has grown to over five billion, and it is certain to continue to grow within our lifetime. While science has in the past promoted exponential population growth, in the future it must tackle the consequences of this growth and the limits that will be placed upon it. Science has taken the admonition of Genesis 1:26 very seriously: we have been fruitful and multiplied, have subdued the Earth, and have dominion over every living thing. In the future, we shall have to pay more attention to the next piece of advice, (Genesis 1:28)—that is, to replenish the Earth. In short, research into human genetic diseases, the justification for sequencing the human genome, is noble; but it is pointless without a comparable effort to find ways in which we numerous humans can coexist with our planet.

Now, I have been deliberately unkind to these "big science" projects. But my point is that they are not unassailable; it is not self-evident that these are the most important challenges for 21st Century science. What we should learn from them is how to sell science to the public and to the politicians who control the purse strings. This is an important concern, because ecology broadly defined is charged by society with some serious responsibilities. Yet ecology is funded in the United States and elsewhere at a pitifully low level. (As yet, there is no National Institutes for the Environment, though many ecologists—and many prominent restoration ecologists—are pushing hard for one.) Ecological research is crippled because of this lack of funding, and the societal consequences of our failure to deal with ecological issues become worse each year. How can we successfully investigate these problems, and how can we dramatically increase our funding of research, when doubts exist both within and outside of ecology about the value of our own work and our ability to deal with the problems we set ourselves?

Everyone has his or her explanation for the startling mismatch between ecology's importance and the level of funding it receives. My explanations, as you will have guessed, have to do with how we view ourselves. There

Stuart L. Pimm is Professor of Ecology at the Department of Zoology and Graduate Program in Ecology, The University of Tennessee, Knoxville, Tennessee 37996; (615) 974-1981 FAX (615) 974-0978.

are at least three problems here, and in view restoration ecology (and closely allied disciplines such as conservation biology and landscape ecology) can help solve them.

First, ecologists are a pretty dismal lot, always complaining about how bad things are.

Reading about yet another billion human lives added to the planet, another state-sized piece of rainforest destroyed and the demise of yet another dozen species, is not for the easily-depressed. Of course, all this is an important part of the environmental story. But it is only part of it. I cannot help but wonder whether the officials who justify the large budget of the National Institutes of Health would enjoy that budget if they constantly pointed out how many people are dying. Their news can be pretty bleak, too: with some notable exceptions, mortality rates from some kinds of cancer are not much lower than they were a generation ago, to mention just one example. In their public announcements, however, the medical people long ago learned to emphasize the lives that they—practitioners as well as researchers—are saving, rather than those they lose.

We should take the hint. Along with the bad news (which we certainly cannot ignore), we should be telling people the good news—that we can and have saved a large number of species (bison, whooping cranes, Guam rails and so on) and that we can and have restored nature in many areas. We are more competent than we think we are—and certainly more competent than we say we are.

This is where restoration comes in. Restorationists acknowledge environmental damage—but they go on to do something about it. They personify an ecology that is on the offensive, a can-do, let's engineer-an-ecosystem attitude that injects a much-needed vitality into ecology and could inject a much-needed positive note into our pronouncements. But how often do we talk about our successes? Clearly, not often enough. Recently, I have been involved in an attempt to return to the wild the Guam rail, a bird that survived only in zoos. A consortium of agencies, zoos, conservation groups, and my university had rescued the last Guam rails, increased their numbers in zoos, and then returned them to an island near Guam, where, as I write, they are calling from the deep cover in which they live. So far at least, this project appears to have been successful. Yet I myself have given many times more seminars on how Hawaii has lost 75 percent and Guam 100 percent of its terrestrial bird species than I have about this tentative success. It's time we begin projecting a more positive attitude.

Second, ecologists seem to spend most of their time telling us how little they know.

Certainly, ecological systems are complex, and there is a lot we don't understand about them. On the other hand, there is a lot we *do* understand about them, and we do not necessarily need to know everything about them in order to restore and manage them effectively. Given a "sick" or "injured" ecosystem, I suspect ecologists could restore "health" in as good a proportion of cases as the medical profession manages with sick or injured humans. (And give good advice about prevention, too: don't smoke, don't pollute. . .) Moreover, ecological restoration provides valuable opportunities to extend and refine what we do know.

Finally, there seems to be a general impression that ecology is an intellectually fuzzy discipline and that its problems are intellectually less compelling than those encompassed by "big science".

I think the problem here is the tendency to confuse what is somehow glamorous (and often highly reductionist) with what is interesting. I consider the sequencing of the human genome to be stupefyingly boring. It may produce some intellectual rewards by good luck, but the same could be true if we made a serious effort to inventory the animal and plant kingdom. It seems to me that the only difference is that human genomes will around a century from now, while the inventory of plants and animals will be significantly depleted.

So where is the intellectual content of ecology? The ways densities of populations change over time, or the ways in which species interact within ecological communities, for example, just seem messy compared with sequences of base pairs or the precise clockwork of planetary motion. I suspect that the fact that trees, clouds, and mountains are not cones, spheres or cubes justifies a prejudice that those who study them are intellectually fuzzy, too. In fact, as we now from the pictures of Mandelbrot and others, the geometry of nature is not fuzzy, but fractul. Within population changes we find limit cycles, strange attractors, and mathematical chaos, all wonderful, dynamic entities described by a rich mathematics developed partly by an ecologist—Robert May. And the structure of community interactions may appear confused (recall Darwin's famous comment about an "entangled bank"), but we now know that the food web structure that describes these interactions has a remarkably regular topology. It is we ecologists who have the theoretically exciting geometries and dynamics!

So what is the restoration ecologist? Someone who sows seed, or releases birds? Well, yes. But he or she is also a member of the experimental branch of the science that deals with the assembly of very complex systems. That's not just a plant, it is a system component. And whether it survives or not is a test of whether we can assemble that system in a given way, or indeed assemble it at all. The amount of effort required to keep that small fragment of prairie from being overgrown by alien weeds is a measure of the system's persistence—its dynamic integrity, if you like. Whatever the nature of everyday activities of restorationists, and whatever commonplace tools they use, we should still remember that in reassembling a prairie, perhaps making a prairie national park or re-constructing a tropical forest, we are conducting a giant experiment in complex systems. When the restoration work, we know that we are succeeding in an important task, that we understand the system adequately, and that we have wrestled successfully with a tough practical—and intellectual—problem.