Letters

Conservation and Agricultural Economics

R. M. Goodman *et al.* (Articles, 3 Apr., p. 48) overlook a major—but avoidable—indirect environmental threat posed by genetic engineering. Tropical wildlands and most of the earth's contemporary species still exist because humanity has not had organisms capable of converting all tropical land surfaces to profitable agriculture and animal husbandry. Within one to three decades, organisms modified through genetic engineering will be capable of making agriculture or animal husbandry, or both, profitable on virtually any tropical land surface. Agricultural inviability, the single greatest tropical conservation force, will be gone.

Where the soil is fertile and the climate good, almost all tropical forest has been lost. However, fertile soil and good climate are not intrinsic traits. Those descriptors mean that a plant or animal of use to humans can be profitably grown there. The earth's tropical forests were once about 40% rain forest and 60% dry forest. Today, the dry forest is essentially obliterated by agriculture and anthropogenic fires, while we still anguish over the ever-increasing loss of rain forest. Where dry forest once stood is where tropical humanity grows cotton, corn, rice, peanuts, cassava, sorghum, millet, beans, cows, and horses in high-yield lowland fields and pastures. When genetic engineering gives us crop plants and animals that thrive in the various tropical rain forest habitats, it is "goodbye, rain forest." The power to finally obliterate the wildlands that have always been an integral part of our intellectual and economic lives has finally appeared and is undergoing intense development.

Today's tropical wildland reserves were established by arguments that were not economically robust. These reserves are almost always on lands that have been subject to low pressure for agroconversion: steep slopes, inaccessible terrain, swamps, cation-poor soils. Now, the question changes to which and how much wildland acreage is to be explicitly unavailable for use by the next wave of genetically engineered plants and animals to sweep across the tropics. Such wildlands must be evaluated for conservation on a basis other than their potential cash production. No matter how valuable a park or reserve may be at the moment, a time will come when the potential cash production by agriculture on that land exceeds the cash production from that land in a wildland state (through tourism, seed and gene banks, education, intellectual stimulation, and so forth). The economic flush that will be generated in the tropics by genetic engineering will wash away most of the wildlands that are today protected only by economic inviability.

While the tropics will be a very dull place once the wildlands—their species and their fragile assemblages—have been removed, there is also a major economic concern. The new and self-replicating organisms will be in the hands of billions of tropical farmers and entrepreneurs. An enormous amount of wildland genetic information will be obliterated overnight. And it is precisely this diverse and exotic genetic information that will be most eagerly sought by the genetic engineering industry once we are past the stage of simply making better beef, beans, and corn. It is very much in the selfish interests of this growing industry to join forces with the conservation community. Goodman *et al.* anticipated this point with their statement: "We must preserve the raw material from which our successors will work" (p. 54).

This is not a call for the cessation of genetic engineering. Humanity has been using genetic engineering since the first grandmother saved the biggest bean seeds for next year's crop and a more docile wolf was kept as a camp animal. This is a call for mutualism between the forces of conservation and those of agricultural economics. Humanity cannot exist without its coevolved mutualists or without the wildlands from which they came.

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Response: We share with Janzen a profound concern about the future stability of tropical (and nontropical) habitats—for genetic, aesthetic, climatic, and many other reasons. The loss of wildlands, at least in part to agriculture, over the past century is a well-established fact. We are less certain than Janzen about the actual causes of this loss. And we are far less sanguine than he appears to be about the imputed power of genetic engineering to "obliterate the wildlands" and generate an "economic flush" in the tropics. Nevertheless, we agree that if the success of new genetic technology makes possible productive agriculture on lands now considered (for agriculture) marginal or inhospitable, we must find other compelling ways to prevent further losses of the treasures that wildlands represent to the future of humanity.

If we overlooked this "indirect environmental threat," it was frankly because we consider it so unlikely. A more likely scenario, in our view, would be that improvements in productivity and efficiency and reduction in production risks and postharvest losses might decrease the total amount of land needed to support a given population, thereby relieving rather than creating added pressure on land use. We may be naïve in thinking so, but we suspect that it is politics and population pressures more than agricultural technology that have actually caused the lamentable loss of dry forest wildlands in the past.

We wholeheartedly agree that agriculture and the conservation community should be allies. The recent reaction, especially in rural America, to agriculture's contribution to chemical pollution of the environment and the attention agriculture is now getting from national and international policy communities are two indications of movement in that very direction. And we think new genetic technology will have a central role in making possible what will become necessary—a steady movement toward long-term, sustainable, highly productive agriculture that will reliably support a stabilized world population.

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Biotechnology and the Environment

Frances E. Sharples' Policy Forum (13 Mar., p. 1329) is based mainly on selected analogies that have alarmist consequence, while the companion piece by Bernard D. Davis (13 Mar., p. 1329) is based on firm evolutionary and microbiological principles. Sharples ends by stating that she is not an alarmist; but she uses the example of the AIDS problem to indicate that a recombinant microorganism may produce something "with 'new' and unanticipated properties." At no time in the many decades of experience with mutated organisms and 15 years of experience with recombinant organisms has there been any evidence of a laboratory-altered organism causing a problem even remotely comparable to the AIDS virus.

Most of the examples Sharples uses to argue the "dangers" from testing recombinant microorganisms in the field are not relevant. For instance, feral goats and rabbits are not problems resulting from man's alteration of the animal's genes. Undomesticated goats or rabbits released in these same environments probably would survive better and do as much damage as, or more than, their feral cousins. The same argument applies to the analogy of domestic predatory cats.

Sharples' comments about the size of a pathogen pool affecting progress of a disease deflect from the issue. The focus should be on the chance of an unpredicted problem occurring, not on how many bacteria are necessary for a problem if the bacterium is a pathogen. Scientists do not test in the field microorganisms with the potential to cause epidemic disasters. Microbiologists have an excellent record of safety with field tests of thousands of different microorganisms in many countries over many decades.

The calculations Sharples presents to counter the argument that "all possible gene combinations have already been tested in nature" are irrelevant to the issue of laboratory-altered recombinant organisms. Genetic engineers are not trying, and will be unlikely to achieve, complex gene combinations (for example, 3000 specific human genes plus 1000 *Bacillus* genes plus 6000 *Drosophila* genes, and so forth, to make a desirable organism for use in agriculture). The best a genetic engineer can do will be to add a few specific genes to an organism. Calculations should therefore be based on an example such as estimating the chance that an *Escherichia coli* in an individual's intestine will pick up the human insulin gene from dying human cells. Many of us would predict, but cannot prove, that this could happen daily on this planet; however, the insulin gene does not appear to give *E. coli* any specific selectivity advantage; thus, random native *E. coli* strains do not contain the human insulin gene.

While Sharples does not support the analogy of our safe experience demonstrated over decades with release of wild-type and mutant bacteria, she makes unsupported statements, such as, "relocation to a new environmental setting could produce unintended negative results. . . ." Sharples states that "only two or three taxa [*E. coli* and *Rhizobium*] . . . have been studied well enough to qualify for the 'domesticated' label." Such "domesticated" organisms presumably are the only ones she believes to be safe to disseminate in the environment. In the dairy industry, for example, mutant strains are continually being used. All of those strains reach our environment, including our intestines and our woodlands (after a picnic). Are the following bacteria, used in the food, chemical, agriculture, and mining industries, not "domesticated"? *Streptococcus cremoris, Lactobacillus plantarum, Bacillus stereothermophilis, Pediococcus cerevisiae, Acetobacter aceti, Clostridium acetobutylicum, Nitrosomonas europea, Azospirillum brasilense, Azotobacter vinelandii, Thiobacillus ferrooxidans*, and *Propionibacterium shermanii*. It would be fruitless to require a major ecological study for each new mutant strain of these organisms.

No one argues that all products or experiments from biotechnology will be absolutely trouble free. Analogies related to the frequency and seriousness of problems from genetically engineered plants should be with what we have experienced from plants genetically altered by traditional means (not introduced "new" plants). Likewise, problems that will occur from field use of recombinant microorganisms will be similar to those we have experienced from a century's worth of testing microorganisms and their mutants in the field. Another relevant analogy for predicting the frequency and types of problems is the well-known alteration of microbial populations from the use of chemical herbicides and pesticides, which are routinely added to farms, gardens, and golf courses. Microbial mutants arise with increased ability to degrade such chemicals. There are many cases of new, bacterial plasmid-coded degradative enzymes appearing in sites where chemicals have been introduced. These altered microorganisms spread, transfer genes, and grow; however, the only problem known to occur is decreased efficacy of the chemical. These microorganisms usually are unclassified with regard to genus or genetic alteration, and no one seems to be worried about health or environmental problems where they are found in high concentrations over millions of acres. Released recombinant microorganisms are well defined with respect to classification and genetic alteration. Sharples' examples of feral goats and the AIDS virus do not help to focus scientific debate on the issue of potential harm by adding one or several foreign genes to an organism that, in its nonrecombinant state, has been of no serious concern when tested in the field.

I agree with Sharples that regulation of biotechnology products is, at this time, justified; however, regulations not based on relevant scientific principles but, rather, on alarmist views, will only hinder research and development and U.S. competitiveness in projects that are expected to help agriculture and the environment. The Environmental Protection Agency's regulations are already inhibiting research progress, and Sharples' arguments will be used to make the regulations even more severe.

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The arguments advanced by Sharples that "new" microorganisms might have devastating effects on the terrestrial biosphere are reminiscent of the fears voiced 10 to 15 years ago of dangers that could be caused by samples returned from Mars (*1*). Alexander (*2*), who is quoted by Davis as proposing a complex series of tests for estimating "the probability of environmental harm" from new strains, entertained us in 1972 by proposing that fungal plant pathogens could be a danger in samples returned from outer space (*3*). The U.S. Department of Agriculture subsequently undertook examination of lunar materials for wheat rust spores.

I contended (*1*) that, if it is hazardous to return a surface sample from Mars, then a sample of soil from Antarctica should be more dangerous than one from Ohio. Davis argues along similar lines.

Fear of "new" DNA sequences expressed by Sharples was anticipated by apprehensions I cited (*1*) that if Martian species were brought to the earth there would be risks of catastrophic pathologies by the spread of nonterrestrial genes. But evolution shows that genes have not tended to "jump" during the past 200 million years to vertebrates from bacteria, including the much maligned pseudomonads. Instead, a slow process of divergence and modification of genes from a common ancestor has taken place.

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REFERENCES

1. T. H. Jukes, *Life Sci. Space Res.* 15, 9 (1977).
2. M. Alexander, *Issues Sci. Technol.* 1, 57 (1985).
3. ———, *Theory and Experiment in Exobiology* (Wolters-Noordhoff, Groningen, 1972), vol. 2, p. 121.

Tanker "Dumping" Regulations

P. Dee Boersma (Letters, 10 Apr., p. 135) cites a study of oiled penguins in Argentina and asserts that "Because it is cheaper to dump oil-contaminated ballast water into the ocean, most tankers still dump untreated waste water." She goes on to suggest that "policies to prohibit [this] dumping should be instituted."

Such policies already exist. The International Convention for the Prevention of Pollution from Ships, 1973, as amended in 1978, 1984, and 1987, is a treaty adopted by the International Maritime Organization, which is the maritime agency of the United Nations. The Convention has been ratified