higher law, was well-suited to an industrializing "producer" society. By the beginning of the 20th century, however, the rise of a "consumer" society was accompanied by a new emphasis on personality. According to the new ideal, Fox writes, "adulthood was open-ended, always still to be grown into, and ever subject to renegotiation."

According to Fox, it was not, as some historians have insisted, that personality displaced character, but that the two were merged. And the merger was carried out partly under the auspices of Protestant thinkers. Thus Henry Ward Beecher, the celebrated preacher from Brooklyn, N.Y., believed, in Fox's words, that amid the routinization of industrial America "character could be sustained . . . only by the cultivation and spread of personality"—by which Beecher meant the ability of individuals to change, to adapt, and to assert themselves. Leaders of the Social Gospel movement, such as Washington Gladden, also spoke the new language of personality. But Gladden and others believed that individualism had gone too far, and their efforts to mold "personality" sometimes amounted to little more than old-fashioned character-building. Gladden, for example, was an enthusiastic supporter of the People's Tabernacle in Cleveland, where some 4,000 working folk were brought together for evenings of lectures, orchestral music, and other forms of genteel uplift.

Liberal Protestantism paid dearly for failing to "distinguish itself forcefully from various secular currents that it flirted with, incorporated, and baptized," Fox says. It was repudiated by liberal "realists" of the 1920s such as theologian Reinhold Niebuhr. Then it suffered "the much more significant cross-denominational evangelicalism which over the last half of the 20th century has displaced liberal Protestantism from its position of cultural dominance."

For preacher Henry Ward Beecher, the ideal of personality not only promoted individual vitality but permitted what he called "spiritual engineering."

SCIENCE, TECHNOLOGY & ENVIRONMENT

THE (BIO)DIVERSITY DEBATE

A Survey of Recent Articles

Rheobatrachus silus is what biologists call a species of frog found in an Australian rain forest. Other people might simply call the animal amazing. Writer Emily Yoffe describes in the *New York Times Magazine* (Dec. 13, 1992) the remarkable way in which it reproduces: "The Rheobatrachus female swallows her fertilized eggs, which then gestate in her stomach and are regurgi-

tated as tiny froglets six weeks later." Scientists hoped that since the frog somehow is able to turn off its gastric activity, research might reveal secrets that would help humans with stomach ailments. But in 1980, only six years after *Rheobatrachus silus*'s extraordinary reproductive strategy was discovered by Michael J. Tyler, a zoologist at the University of Adelaide in Australia, the gastric-brooding frogs disappeared for their normal winter hibernation—and have not been seen since. The species is presumed extinct.

It is far from the only one. "Just as the importance of all life forms for human welfare becomes most clear," biologists Paul R. Ehrlich of Stanford and Edward O. Wilson of Harvard write in *Science* (Aug. 16, 1991), "the extinction of wild species and ecosystems is . . . accelerating," largely as a result of the destruction of rain forests and other natural habitats. The two scientists are an odd couple. Ehrlich is the crusading prophet who warned in a famous 1968 book that the "population bomb" was about to explode, and Wilson is the father of sociobiology, a man whom liberals have anathematized. Joining forces, they calculate that tropical deforestation alone now causes the annual loss of at least 0.2 percent of all the species of plants, animals, and microorganisms in the forests—a loss of 40,000 species per year, assuming there are 20 million in the forests. Critics, however, point out that there is virtually no empirical evidence to support such claims.

Nobody really knows just how many species there are in the forests or elsewhere on the planet, Robert M. May of Oxford University notes in *Scientific American* (Oct. 1992). "Despite more than 250 years of systematic research, estimates . . . vary widely, all the way from three million to 30 million or more." (Ehrlich and Wilson believe that there may be as many as 100 million species.) Ever since the 18th-century Swedish scientist Carolus Linnaeus recorded some 9,000 species of plants and animals in his *Systema Naturae* (1758), taxonomists have been adding to the list. "By far the most attention has been lavished on animals endowed with the charm of feathers or fur," May says. For birds (9,000 known species) and mammals (4,000), and for butterflies (17,500), which many naturalists treat as honorary birds, the record is nearly complete. For many other creatures, it is not. Although the 900,000 known species of insects make up most of the estimated total of 1.5 to 1.8 million recorded species, May says, the true number of insect species may be two to three million.

What difference does a reduction in biodiversity make? Wilson and Ehrlich argue that biodiversity is essential to the working of natural ecosystems, that it provides precious sources of medicines, foods, and fuel, and that humans "have an absolute moral responsibility to protect what are our only known living companions in this universe." Indeed, Wilson is quoted in *U.S. News & World Report* (Nov. 30, 1992) as warning: "If we let too many species go, we face an enormous psychological and spiritual loss."

The only way to save "our fellow living creatures and ourselves in the long run," Wilson and Ehrlich claim, is "to reduce the scale of human activities," ceasing all development of "relatively undisturbed" land. "Every new shopping center built in the California chaparral, every hectare of tropical forest cut and burned, every swamp converted into a rice paddy or shrimp farm means less biodiversity."

Human beings are more than just "intruders, tramplers, and destroyers," asserts Thomas Palmer, author of *Landscape with Reptile: Rattlesnakes in an Urban World* (1992). And yet biodiversity is so narrowly construed, he complains in the *Atlantic* (Jan. 1992), that its defenders fail to recognize human contributions. "The possibility that [Bach] chorales and [three-masted] schooners might represent positive contributions to biotic richness—that they might, just as much as any rain-forest orchid, embody the special genius of this planet—is never admitted."

The controversy has very practical implications. When the northern spotted owl was listed as an endangered species in 1990, the result was a series of court cases that halted logging in millions of acres of ancient forest in the Pacific Northwest, contributing to the loss of tens of thousands of jobs. Brian F. Mannix, an economic consultant who did work on the issue for the timber industry, complains in the *American Enterprise* (Nov.–Dec. 1992) that the federal Endangered Species Act has become a sort of entitlement program. "It grants to the members of officially designated species an array of absolute and inalienable rights that would be the envy of advocates for the rights of the homeless, the disabled, or any other group needing help that consists of mere humans."

"It certainly makes no sense to save all species at any cost, any more than to attempt to save all human lives at any cost," assert University of Maryland economist Julian L. Simon and Berkeley political scientist Aaron Wildavsky in *Society* (Nov.–Dec. 1992). They suggest looking backward. "What were the species extinguished when the settlers cleared the [U.S.] Middle West? Are we the poorer now for their loss? Obviously, we cannot know in any scientific way. But can we even imagine that we would be enormously better off with the persistence of any hypothetical species?"

Maybe not. But defenders of biodiversity see the future in dire terms. "We don't know how many species can be lost before the system ceases to function," biologist Richard L. Wyman of the State University of New York at Albany told the *New York Times Magazine*'s Emily Yoffe. "But eliminate enough species and sooner or later it will cease to function."

Yet change, dramatic change, is a constant in the story of life on this planet, observes Thomas Palmer in the *Atlantic*, and the imminent end of the world has frequently been proclaimed in times past. "To say that the changes [humans] have brought, and will continue to bring, are somehow alien to the world, and are within a half inch of making its 'natural' continuance impossible, displays some contempt, I think, for the forces at work, along with a large dose of inverted pride . . . ."

"Few would deny that the effort to preserve and protect as many as possible of the millions of species now existing represents a fresh and heartening expansion of human ambitions," Palmer writes. "But to suppose that earthly diversity is past its prime, and that a strenuous program of self-effacement is the best contribution our species has left to offer, is neither good biology nor good history."

Fatal Glitches

"The Risks of Software" by Bev Littlewood and Lorenzo Strigini, in *Scientific American* (Nov. 1992), 415 Madison Ave., New York, N.Y. 10017-1111.

Occasional computer failure is a familiar fact of modern life. The usual result is inconvenience, a day's work lost or a file destroyed. When computers are used in critical applications, however, flaws in the software can spell disaster. During the Persian Gulf War, for example, the Patriot missile system failed to track an Iraqi Scud missile that killed 28 U.S. soldiers. The apparent problem: The Patriot computer was kept on so long that minor inaccuracies in its internal clock accumulated and threw off its timing.

As complex computer programs are used in more and more critical applications, from nuclear reactors to antilock brakes in automobiles, the danger of computer-generated catastrophe spreads. The solution might seem to be simply to search out and eliminate all the "bugs" lurking in a computer program. In theory, that can be done, but in practice, it is not always easy, warn Littlewood, a computer scientist who directs the Center for Software Reliability, in London, and Strigini, a researcher at the Institute for Information Processing of Italy's National Research Council.

"Despite rigorous and systematic testing, most large programs contain some residual bugs when delivered," they write. "The reason for this is the complexity of the source code." A computer program with only a few hundred lines of code may permit thousands of alternative "paths" of decisions—and programs written for critical applications can have *millions* of lines of code. A "wrong" decision can result from a particular "input" not foreseen by the program's designer or not used during testing of the program. There are many other routes to error. Specifications often change during a system's development, and the changes can introduce bugs into previously designed parts. Or the system may be used in unintended ways, as in the Patriot missile case. Its designers expected that it would be turned off and restarted often enough to prevent the accumulated error in timekeeping from ever becoming dangerous.

Digital systems intrinsically make creation of reliable software difficult, the authors say. Changing only one "bit" from 0 to 1, for instance, may make a radical difference. A single incorrect character in the control program for the Atlas rocket carrying the first U.S. interplanetary spacecraft, *Mariner 1*, in 1962, caused it to veer off course soon after launch. The craft had to be destroyed.