ISSUE 1

Is the Precautionary Principle a Sound Approach to Risk Analysis?

YES: Nancy Myers, from "The Rise of the Precautionary Principle: A Social Movement Gathers Strength," *Multinational Monitor* (September 2004)

NO: Bernard D. Goldstein, from "The Precautionary Principle: Is It a Threat to Toxicological Science?" *International Journal of Toxicology* (January/February 2006)

ISSUE SUMMARY

YES: Nancy Myers, communications director for the Science and Environmental Health Network, argues that because the Precautionary Principle "makes sense of uncertainty," it has gained broad international recognition as being crucial to environmental policy.

NO: Bernard D. Goldstein, professor of Environmental and Occupational Health at the University of Pittsburgh, argues that although the Precautionary Principle is potentially valuable, it poses a risk that scientific (particularly toxicological) risk assessment will be displaced to the detriment of public health, social justice, and the field of toxicology itself.

The traditional approach to environmental problems has been reactive. That is, first the problem becomes apparent—wildlife or people sicken and die, or drinking water or air tastes foul. Then researchers seek the cause of the problem, and regulators seek to eliminate or reduce that cause. The burden is on society to demonstrate that harm is being done and that a particular cause is to blame.

An alternative approach is to presume that *all* human activities—construction projects, new chemicals, new technologies, etc.—have the potential to cause environmental harm. Therefore, those responsible for these activities should prove in advance that they will not do harm and should take suitable steps to prevent any harm from happening. A middle ground is occupied by the "Precautionary Principle," which has played an increasingly important part in environmental law ever since it first appeared in Germany in the mid-1960s. On the international scene, it has been applied to climate change, hazardous waste management, ozone depletion, biodiversity, and fisheries management. In 1992 the Rio Declaration on Environment and Development, listing it as Principle 15, codified it thus:

> In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. When there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Other versions of the principle also exist, but all agree that when there is reason to think—not absolute proof—that some human activity is or might be harming the environment, precautions should be taken. Furthermore, the burden of proof should be on those responsible for the activity, not on those who may be harmed. This has come to be broadly accepted as a basic tenet of ecologically or environmentally sustainable development. See Marco Martuzzi and Roberto Bertollini, "The Precautionary Principle, Science and Human Health Protection," *International Journal of Occupational Medicine and Environmental Health* (January 2004).

The Precautionary Principle also contributes to thinking in the areas of risk assessment and risk management in general. Human activities can damage health and the environment. Some people insist that action need not be taken against any particular activity until and unless there is solid, scientific proof that it is doing harm, and even then risks must be weighed against each other. Others insist that mere suspicion should be grounds enough for action.

Since solid, scientific proof can be very difficult to obtain, the question of just how much proof is needed to justify action is vital. Not surprisingly, if action threatens an industry, that industry's advocates will argue against taking precautions, generally saying that more proof is needed. Those who feel threatened by an industry or a new technology are more likely to favor the Precautionary Principle; see John S. Dryzek, Robert E. Goodin, et. al., "Promethean Elites Encounter Precautionary Publics: The Case of GM Foods," *Science, Technology & Human Values* (May 2009). The "Promethean Elites" are those who—like the Prometheus of myth—favor progress over the status quo and may argue that the Precautionary Principle holds back progress; see Helene Guldberg, "Challenging the Precautionary Principle," *Spiked-Online* (July 1, 2003) (http://www.spiked-online.com/Articles/00000006DE2F.htm). Yet, says Charles Weiss in "Defining Precaution," a review of *The Precautionary Principle*, UNESCO's World Commission on the Ethics of Scientific Knowledge and Technology Report, *Environment* (October 2007), the principle "is an important corrective to the pressure from enthusiasts and vested interests to push technology in unnecessarily risky directions."

In the following selections, Nancy Myers argues that the precautionary principle has gained broad international recognition as crucial to environmental policy for good reason. "The essence of the Precautionary Principle is that when lives and the future of the planet are at stake, people must act on . . . clues and prevent as much harm as possible, despite imperfect knowledge and even ignorance." Bernard Goldstein argues that although the Precautionary Principle is potentially valuable, it poses a risk that scientific (particularly toxicological) risk assessment will be displaced to the detriment of public health, social justice, and the field of toxicology itself.

YES

Nancy Myers

The Rise of the Precautionary Principle: A Social Movement Gathers Strength

Ed Soph is a jazz musician and professor at the University of North Texas in Denton, a growing town of about 100,000 just outside Dallas, Texas. In 1997, Ed and his wife Carol founded Citizens for Healthy Growth, a Denton group concerned about the environment and future of their town. The Sophs and their colleagues—the group now numbers about 400—are among the innovative pioneers who are implementing the Precautionary Principle in the United States.

The Sophs first came across the Precautionary Principle in 1998, in the early days of the group's campaign to prevent a local copper wire manufacturer, United Copper Industries, from obtaining an air permit that would have allowed lead emissions. Ed remembers the discovery of the Wingspread Statement on the Precautionary Principle—a 1998 environmental health declaration holding that "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically"—as "truly a life-changing experience." Using the Precautionary Principle as a guide, the citizens refused to be drawn into debates on what levels of lead, a known toxicant, might constitute a danger to people's health. Instead, they pointed out that a safer process was available and insisted that the wise course was not to issue the permit. The citizens prevailed.

The principle helped again in 2001, when a citizen learned that the pesticides 2,4-D, simazine, Dicamba and MCPP were being sprayed in the city parks. "The question was, given the 'suspected' dangers of these chemicals, should the city regard those suspicions as a reassurance of the chemicals' safety or as a warning of their potential dangers?" Ed recalls. "Should the city act out of ignorance or out of common sense and precaution?"

Soph learned that the Greater Los Angeles School District had written the Precautionary Principle into its policy on pesticide use and had turned to Integrated Pest Management (IPM), a system aimed at controlling pests without the use of toxic chemicals. The Denton group decided to advocate for a similar policy. They persuaded the city's park district to form a focus group of park users and organic gardening experts. The city stopped spraying the four problem chemicals and initiated a pilot IPM program.

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The campaign brought an unexpected economic bonus to the city. In the course of their research, parks department staff discovered that corn gluten was a good turf builder and natural broadleaf herbicide. But the nearest supplier of corn gluten was in the Midwest, and that meant high shipping costs for the city. Meanwhile, a corn processing facility in Denton was throwing away the corn gluten it produced as a byproduct. The parks department made the link, and everyone was pleased. The local corn company was happy to add a new product line; the city was happy about the expanded local business and the lower price for a local product; and the environmental group chalked up another success.

The citizens of Denton, Texas, did not stop there. They began an effort to improve the community's air pollution standards. They got arsenic-treated wood products removed from school playgrounds and parks and replaced with nontoxic facilities. "The Precautionary Principle helped us define the problems and find the solutions," Ed says.

But, as he wrote in an editorial for the local paper, "The piecemeal approach is slow, costly and often more concerned with mitigation than prevention." Taking a cue from Precautionary Principle pioneers in San Francisco, they also began lobbying for a comprehensive new environmental code for the community, based on the Precautionary Principle.

In June 2003, San Francisco's board of supervisors had become the first government in the United States to embrace the Precautionary Principle. A new environmental code drafted by the city's environment commission put the Precautionary Principle at the top, as Article One. Step one in implementing the code was a new set of guidelines for city purchasing, pointing the way toward "environmentally preferable" purchases by careful analysis and choice of the best alternatives. The White Paper accompanying the ordinance pointed out that most of the city's progressive environmental policies were already in line with the Precautionary Principle, and that the new code provided unity and focus to the policies rather than a radically new direction.

That focus is important; too often, environmental matters seem like a long, miscellaneous and confusing list of problems and solutions.

Likewise in Denton, the Precautionary Principle has not been a magic wand for transforming policy, but it has put backbone into efforts to enact truly protective and far-sighted environmental policies. Ed Soph points out that, in his community as in others, growth had often been dictated by special interests in the name of economic development, and the environment got short shrift.

"Environmental protection and pollution prevention in our city have been a matter, not of proactive policy, but of reaction to federal and state mandates, to the threat of citizens' lawsuits, and to civic embarrassment. Little thought is given to future environmental impacts," he told the city council when he argued for a new environmental code.

He added, "The toxic chemical pollution emitted by area industries has been ignored or accepted for all the ill-informed or selfish reasons that we are too familiar with. The Precautionary Principle dispels that ignorance and empowers concerned citizens with the means to ensure a healthier future."

The Precautionary Principle has leavened the discussion of environmental and human health policy on many fronts—in international treaty negotiations and global trade forums, in city resolutions and national policies, among conservationists and toxicologists, and even in corporate decision making.

Two treaties negotiated in 2000 incorporated the principle for the first time as an enforceable measure. The Cartagena Protocol on Biosafety allows countries to invoke the Precautionary Principle in decisions on admitting imports of genetically modified organisms. It became operative in June 2003. The Stockholm Convention on Persistent Organic Pollutants prescribes the Precautionary Principle as a standard for adding chemicals to the original list of 12 that are banned by the treaty. This treaty went into force in February 2004.

Making Sense of Uncertainty

Understanding the need for the Precautionary Principle requires some scientific sophistication. Ecologists say that changes in ecological systems may be incremental and gradual, or surprisingly large and sudden. When change is large enough to cause a system to cross a threshold, it creates a new dynamic equilibrium that has its own stability and does not change back easily. These new interactions become the norm and create new realities.

Something of this new reality is evident in recently observed changes in patterns of human disease:

- Chronic diseases and conditions affect more than 100 million men, women, and children in the United States—more than a third of the population. Cancer, asthma, Alzheimer's disease, autism, birth defects, developmental disabilities, diabetes, endometriosis, infertility, multiple sclerosis and Parkinson's disease are becoming increasingly common.
- Nearly 12 million children in the United States (17 percent) suffer from one or more developmental disabilities. Learning disabilities alone affect at least 5 to 10 percent of children in public schools, and these numbers are increasing. Attention deficit hyperactivity disorder conservatively affects 3 to 6 percent of all school children. The incidence of autism appears to be increasing.
- Asthma prevalence has doubled in the last 20 years.
- Incidence of certain types of cancer has increased. The age-adjusted incidence of melanoma, non-Hodgkins lymphoma, and cancers of the prostate, liver, testis, thyroid, kidney, breast, brain, esophagus and bladder has risen over the past 25 years. Breast cancer, for example, now strikes more women worldwide than any other type of cancer, with rates increasing 50 percent during the past half century. In the 1940s, the lifetime risk of breast cancer was one in 22. Today's risk is one in eight and rising.
- In the United States, the incidence of some birth defects, including male genital disorders, some forms of congenital heart disease and obstructive disorders of the urinary tract, is increasing. Sperm density is declining in some parts of the United States and elsewhere in the world.

These changes in human health are well documented. But proving direct links with environmental causative factors is more complicated.

Here is how the scientific reasoning might go: Smoking and diet explain few of the health trends listed above. Genetic factors explain up to half the population variance for several of these conditions—but far less for the majority of them—and in any case do not explain the changes in disease incidence rates. This suggests that other environmental factors play a role. Emerging science suggests this as well. In laboratory animals, wildlife and humans, considerable evidence documents a link between environmental contamination and malignancies, birth defects, reproductive disorders, impaired behavior and immune system dysfunction. Scientists' growing understanding of how biological systems develop and function leads to similar conclusions.

But serious, evident effects such as these can seldom be linked decisively to a single cause. Scientific standards of certainty (or "proof") about cause and effect are high. These standards may never be satisfied when many different factors are working together, producing many different results. Sometimes the period of time between particular causes and particular results is so long, with so many intervening factors, that it is impossible to make a definitive link. Sometimes the timing of exposure is crucial—a trace of the wrong chemical at the wrong time in pregnancy, for example, may trigger problems in the child's brain or endocrine system, but the child's mother might never know she was exposed.

In the real world, there is no way of knowing for sure how much healthier people might be if they did not live in the modern chemical stew, because the chemicals are everywhere—in babies' first bowel movement, in the blood of U.S. teenagers and in the breastmilk of Inuit mothers. No unexposed "control" population exists. But clearly, significant numbers of birth defects, cancers and learning disabilities are preventable.

Scientific uncertainty is a fact of life even when it comes to the most obvious environmental problems, such as the disappearance of species, and the most potentially devastating trends, such as climate change. Scientists seldom know for sure what will happen until it happens, and seldom have all the answers about causes until well after the fact, if ever. Nevertheless, scientific knowledge, as incomplete as it may be, provides important clues to all of these conditions and what to do about them.

The essence of the Precautionary Principle is that when lives and the future of the planet are at stake, people must act on these clues and prevent as much harm as possible, despite imperfect knowledge and even ignorance.

Environmental Failures

A premise of Precautionary Principle advocates is that environmental policies to date have largely not met this challenge. Part of the explanation for why they have not is that the dimensions of the emerging problems are only now becoming apparent. The limits of the earth's assimilative capacity are much clearer now than they were when the first modern environmental legislation was enacted 30 years ago.

Another part of the explanation is that, although some environmental policies are preventive, most have focused on cleaning up messes after the fact—what environmentalists call "end of pipe" solutions. Scrubbers on power plant stacks, catalytic converters on tailpipes, recycling and super-sized funds dedicated to detoxifying the worst dumps have not been enough. The Precautionary Principle holds that earlier, more comprehensive and preventive approaches are necessary. Nor is it enough to address problems only after they have become so obvious that they cannot be ignored—often, literally waiting for the dead bodies to appear or for coastlines to disappear under rising tides.

The third factor in the failure of environmental policies is political, say Precautionary Principle proponents. After responding to the initial burst of concern for the environment, the U.S. regulatory system and others like it were subverted by commercial interests, with the encouragement of political leaders and, increasingly, the complicity of the court system. Environmental laws have been subjected to an onslaught of challenges since the 1980s; many have been modified or gutted, and all are enforced by regulators who have been chastened by increasing challenges to their authority by industry and the courts.

The courts, and now increasingly international trade organizations and agreements like the World Trade Organization (WTO) and the North American Free Trade Agreement (NAFTA), have institutionalized an anti-precautionary approach to environmental controls. They have demanded the kinds of proof and certainty of harms and efficacy of regulation that science often cannot provide.

False Certainties

Ironically, one tool that has proved highly effective in the battle against environmental regulations was one that was meant to strengthen the enforcement of such laws: quantitative risk assessment. Risk assessment was developed in the 1970s and 1980s as a systematic way to evaluate the degree and likelihood of harmful side effects from products and technologies. With precise, quantitative risk assessments in hand, regulators could more convincingly demonstrate the need for action. Risk assessments would stand up in court. Risk assessments could "prove" that a product was dangerous, would cause a certain number of deaths per million, and should be taken off the market.

Or not. Quantitative risk assessment, which became standard practice in the United States in the mid-1980s and was institutionalized in the global trade agreements of the 1990s, turned out to be most useful in "proving" that a product or technology was not inordinately dangerous. More precisely, risk assessments presented sets of numbers that purported to state definitively how much harm might occur. The next question for policymakers then became: How much harm is acceptable? Quantitative risk assessment not only provided the answers; it dictated the questions.

As quantitative risk assessment became the norm, commercial and industrial interests were increasingly able to insist that harm must be proven "scientifically"—in the form of a quantitative risk assessment demonstrating

harm in excess of acceptable limits—before action was taken to stop a process or product. These exercises were often linked with cost-benefit assessments that heavily weighted the immediate monetary costs of regulations and gave little, if any, weight to costs to the environment or future generations.

Although risk assessments tried to account for uncertainties, those projections were necessarily subject to assumptions and simplifications. Quantitative risk assessments usually addressed a limited number of potential harms, often missing social, cultural or broader environmental factors. These risk assessments have consumed enormous resources in strapped regulatory agencies and have slowed the regulatory process. They have diverted attention from questions that could be answered: Do better alternatives exist? Can harm be prevented?

The slow pace of regulation, the insistence on "scientific certainty," and the weighting toward immediate monetary costs often give the benefit of doubt to products and technologies, even when harmful side effects are suspected. One result is that neither international environmental agreements nor national regulatory systems have kept up with the increasing pace and cumulative effects of environmental damage.

A report by the European Environment Agency in 2001 tallied the great costs to society of some of the most egregious failures to heed early warnings of harm. Radiation, ozone depletion, asbestos, Mad Cow disease and other case studies show a familiar pattern: "Misplaced 'certainty' about the absence of harm played a key role in delaying preventive actions," the authors conclude.

They add, "The costs of preventive actions are usually tangible, clearly allocated and often short term, whereas the costs of failing to act are less tangible, less clearly distributed and usually longer term, posing particular problems of governance. Weighing up the overall pros and cons of action, or inaction, is therefore very difficult, involving ethical as well as economic considerations."

The Precautionary Approach

As environmentalists looked at looming problems such as global warming, they were appalled at the inadequacy of policies based on quantitative risk assessment. Although evidence was piling up rapidly that human activities were having an unprecedented effect on global climate, for example, it was difficult to say when the threshold of scientific certainty would be crossed. Good science demanded caution about drawing hard and fast conclusions. Yet, the longer humanity waited to take action, the harder it would be to reverse any effect. Perhaps it was already too late. Moreover, action would have to take the form of widespread changes not only in human behavior but also in technological development. The massive shift away from fossil fuels that might yet mitigate the effects of global warming would require rethinking the way humans produce and use energy. Nothing in the risk-assessment-based approach to policy prepared society to do that.

The global meetings called to address the coming calamity were not helping much. Politicians fiddled with blame and with protecting national economic interests while the globe heated up. Hard-won and heavily compromised

agreements such as the 1997 Kyoto agreement on climate change were quickly mired in national politics, especially in the United States, the heaviest fossil-fuel user of all.

In the United States and around the globe, a different kind of struggle had been going on for decades: the fight for attention to industrial pollution in communities. From childhood lead poisoning in the 1930s to Love Canal in the 1970s, communities had always faced an uphill battle in proving that pollution and toxic products were making them sick. Risk assessments often made the case that particular hazardous waste dumps were safe, or that a single polluting industry could not possibly have caused the rash of illnesses a community claimed. But these risk assessments missed the obvious fact that many communities suffered multiple environmental assaults, compounded by other effects of poverty. A landmark 1987 report by the United Church of Christ coined the term "environmental racism" and confirmed that the worst environmental abuses were visited on communities of color. This growing awareness generated the international environmental justice movement.

In early 1998, a small conference at Wingspread, the Johnson Foundation's conference center in Racine, Wisconsin, addressed these dilemmas head-on. Participants groped for a better approach to protecting the environment and human health. At that time, the Precautionary Principle, which had been named in Germany in the 1970s, was an emerging precept of international law. It had begun to appear in international environmental agreements, gaining reference in a series of protocols, starting in 1984, to reduce pollution in the North Sea; the 1987 Ozone Layer Protocol; and the Second World Climate Conference in 1990.

At the Rio Earth Summit in 1992, precaution was enshrined as Principle 15 in the Rio Declaration on Environment and Development: "In order to protect the environment, the precautionary approach shall be widely applied by states according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

In the decade after Rio, the Precautionary Principle began to appear in national constitutions and environmental policies worldwide and was occasionally invoked in legal battles. For example:

- The Maastricht Treaty of 1994, establishing the European Union, named the Precautionary Principle as a guide to EU environment and health policy.
- The Precautionary Principle was the basis for arguments in a 1995 International Court of Justice case on French nuclear testing. Judges cited the "consensus flowing from Rio" and the fact that the Precautionary Principle was "gaining increasing support as part of the international law of the environment."
- At the World Trade Organization in the mid-1990s, the European Union invoked the Precautionary Principle in a case involving a ban on imports of hormone-fed beef.

THE U.S. CHAMBER OF COMMERCE: POLICY BRIEF AGAINST THE PRECAUTIONARY PRINCIPLE

Objective

To ensure that regulatory decisions are based on scientifically sound and technically rigorous risk assessments, and to oppose the adoption of the Precautionary Principle as the basis for regulation.

Summary of the Issue

The U.S. Chamber supports a science-based approach to risk management; where risk is assessed based on scientifically sound and technically rigorous analysis. Under this approach, regulatory actions are justified where there are legitimate, scientifically ascertainable risks to human health, safety, or the environment. That is, the greater the risk, the greater the degree of regulatory scrutiny. This standard has served the nation well, and has led to astounding breakthroughs in the fields of science, health care, medicine, biotechnology, agriculture, and many other fields. There is, however, a relatively new theory, known as the Precautionary Principle that is gaining popularity among environmentalists and other groups. The Precautionary Principle says that when the risks of a particular activity are unclear or unknown, assume the worst and avoid the activity. It is essentially a policy of risk avoidance.

The regulatory implications of the Precautionary Principle are huge. For instance, the Precautionary Principle holds that since the existence and extent of global warming and climate change are not known one should assume the worst and immediately restrict the use of carbon-based fuels. However the nature and extent of key environmental, health, and safety concerns requires careful scientific and technical analysis. That is why the U.S. Chamber has long supported the use of sound science, cost-benefit analysis, risk assessment and a full understanding of uncertainty when assessing a particular regulatory issue.

The Precautionary Principle has been explicitly incorporated into various laws and regulations in the European Union and various international bodies. In the United States, radical environmentalists are pushing for its adoption as a basis for regulating biotechnology, food and drug safety, environmental protection, and pesticide use.

U.S. Chamber Strategy

- Support a science-based approach to risk management, where risk is assessed based on scientifically sound and technically rigorous standards.
- Oppose the domestic and international adoption of the Precautionary Principle as a basis for regulatory decision making.
- Educate consumers, businesses, and federal policymakers about the implications of the Precautionary Principle.

> "Nations shall use the precautionary approach to protect the environment. Where there are threats of serious or irreversible damage, scientific uncertainty shall not be used to postpone cost-effective measures to prevent environmental degradation."

It is informative to compare this definition with the more recent Wingspread Statement:

> "When an activity raises threat [of harm] to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically."

Wingspread is notable for a number of differences from the earlier Rio declaration. The Rio declaration includes a statement that the threat of harm should be serious and irreversible, but no threat of harm is specified in Wingspread; the Rio declaration states that the action should be cost-effective, but cost-effectiveness is not part of the Wingspread statement; the whole thrust of the Wingspread statement is positive in that measures should be taken, whereas in Rio it is negative in that the lack of uncertainty should not postpone taking measures; and finally the Rio statement focuses solely on the environment whereas the Wingspread statement goes beyond the environment to the broad field of public health.

The problem of appropriately defining the Precautionary Principle is not simply academic. Like sustainable development, as a concept the Precautionary Principle is supportable by everyone. But the Precautionary Principle also has been adopted in various national and international treaties and by governmental entities in a way that provides legal teeth to what is otherwise a nebulous policy concept. The Wingspread approach is beginning to take hold in the United States where the Precautionary Principle has been approved by the San Francisco and Berkeley City Councils and is under consideration by other local authorities. Where laws and actions are at stake, definitions become very important. The European approach, which often infuriates its trading partners including the United States, is to state that the Precautionary Principle is enshrined within European policy—but to never define it. Rather, a policy or action is judged as to whether it will result in a precautionary approach. This has led to what Carruth and I call the Cynical American Definition:

> "The Precautionary Principle is a nebulous doctrine invented by Europeans as a means to erect a trade barrier against any item produced more efficiently elsewhere."

There are many different actions that can be taken under the heading of the Precautionary Principle, or the precautionary approach as it is often described. It is useful to consider such actions under the public health and prevention nomenclature of primary and secondary prevention. Simply put, primary prevention is an approach that focuses on there never being a problem in the first place; e.g., an individual does not start smoking or, even better, there are no cigarettes being produced. Secondary prevention depends upon the early

detection of a problem, such as detecting high blood pressure before someone has a stroke or is otherwise symptomatic. Much of what is done as a result of environmental risk assessment and risk management is secondary prevention, particularly when it is related to the standard approaches to dealing with known toxic chemicals. Many risk assessors would argue that the Precautionary Principle is already part of risk assessment. Among the potentially precautionary standard risk assessment practices are 10-fold "safety" factors; the 95% upper confidence limit; and the use of exposure models containing prudent default assumptions. The primary preventive approaches of the Precautionary Principle go well beyond more stringent risk assessment. Its components include taking preventive action in the face of uncertainty; shifting the burden of proof to the proponents of an activity such as industry of government; exploring a wide range of alternatives; and increasing public involvement in decision making.

The Precautionary Principle and World Trade

The implications of how to define the Precautionary Principle have nowhere been more evident than for some of the trade issues to which it is being applied. In order to keep a level playing field, various world trade agreements depend upon harmonizing risk assessments so that a nation cannot just arbitrarily decide that another nation's product is unhealthy. Unfortunately, there are a variety of examples in which it appears that the European community has used the Precautionary Principle as a means to exclude items from elsewhere in the world. Before describing these as inappropriate uses of toxicological science, let me first emphasize that we in the United States have much to learn from the EC as it wrestles with core issues of democracy that impact on the control of environmental hazards. The current debates about the governance relationships among citizens, states, and the multistate European confederation are unparalleled in the US since the Federalist Papers; and are of profound global importance.

As I do not want current broader EU-US issues to cloud the discussion, I will start with an issue that does not involve the United States. An example of action based upon the Precautionary Principle that fits under the heading of secondary prevention is the adoption by the EC of a very stringent standard for aflatoxin. This was done in essence by adding an additional safety factor for the genotoxicity of aflatoxins. For all nondairy products designated for human consumption, the EC standard is one-fifth that of the United States and for milk it is one-tenth of that of the United States. This has resulted in the exclusion of an estimated $700 million yearly of trade from Sub-Saharan Africa to the advantage of European growers. These Sub-Saharan nations are among the poorest in the world, with relatively fixed trade routes following old colonial patterns. The difference in risk is less than one cancer per year in Europe. The Joint FAO/WHO Expert Committee on Food Additives (JECFA), the expert body of the Food and Agricultural Organization and the World Health Organization, at the request of the Codex Alimentarius Commission, reviewed the difference between the US and European standard and found

that it was of no health significance. There is also concern that the EC standard is halting the usual harvesting of Brazil nuts in the Amazon area with the result that the trees are being cut down rather than providing resources for indigenous groups.

An example of a trade barrier related to primary prevention aspects of the Precautionary Principle is that of the EU's ban on beef from cattle that have previously been treated with estrogenic growth agents. Canada and the US brought this issue to the World Trade Organization (WTO) who decided in their favor. The EU argued that despite the lack of recognition of risk by JECFA, or even its own scientific bodies, the Precautionary Principle permitted them to ban beef from hormone-treated animals as a risk could not be ruled out, and that a formal risk assessment was not needed. Among the arguments advanced by Canada and the US were that the EC was inconsistent in not having limits on natural estrogens, and was inconsistent in permitting the use in swine of antibiotics whose residues in pork were carcinogenic in laboratory animals. The WTO ruling basically said that the Precautionary Principle was not yet generally accepted as a legal doctrine capable of supplanting risk assessment. Much of the subsequent EU activity in justifying the Precautionary Principle can be seen as a means of reversing the WTO opinion. The use of the Precautionary Principle as a trade barrier will likely be central to the forthcoming WTO hearings on the EU's ban of genetically modified foods.

The use of a primary preventive precautionary approach also frequently occurs in US law. An interesting example demonstrating a switch to primary precaution is the hazardous air pollutant (HAP) provisions of the *1990 Clean Air Act* amendments. Prior to 1990, to regulate a compound as a HAP, the Environmental Protection Agency (EPA) had to go through an involved and time-consuming process. It began by listing a compound as one reasonably anticipated to cause adverse health effects (and is not regulated by setting an ambient standard). After suitable hearings, the EPA would then use risk-based and other considerations to decide which sources of the listed compound to regulate. The burden of proof was on the government to show the potential for adverse consequences. Relatively few compounds had been regulated under this approach, primarily those believed to be human carcinogens. In 1990, faced with impatience at this slow approach, and the recognition that common air contaminants responsible for many tons of emissions were uncontrolled, Congress dramatically changed the HAP regulatory process. Congress listed over 180 compounds to be regulated for which the only rule-making procedure was the onerous one of attempting to remove them from the list by demonstrating safety, i.e., the burden of proof was switched to the industry. Further, Congress specified that emission sources should be required to use the maximum available control technology (MACT), reasoning that all sources should do as well as the best (defined operationally as the upper 12th percentile). Risk considerations are taken into account only secondarily. If, after MACT, there is still a one in a million risk to the maximally exposed individual (MEI), additional steps are to be taken. These steps are currently under consideration and likely will go through court challenges in the next few years. The use of the MEI as the target in a public health bill is problematic—it does not

matter whether the source is in the middle of a populous major metropolitan area or upwind of the Mojave Desert.

If a similar switch in the burden of proof, and away from risk based approaches, was under consideration today, the debate would be phrased in terms of the Precautionary Principle. As it is now 15 years from the passage of the *1990 Clean Air Act* amendments, the change in the HAP provisions allows an opportunity to consider the effectiveness of the Precautionary Principle in action. Carruth and I have pointed out potential public health shortfalls to the precautionary approach taken in the HAP amendments. From the vantage point of a toxicologist interested in understanding the mechanism of chemical effects, the most important is that once a compound is listed, why would there be any interest in studying it further? In fact, there does appear to be a decline in EPA's research interest in HAPs in recent years. Another issue is that the compounds on the HAP list have varying degrees of toxicity, e.g., benzene and toluene. But if they are both on the list and subject to the same controls, what is the incentive to use the least toxic agent? Also, nonlisted compounds are likely to be in the large universe of compounds for which there is less toxicological information and even more likelihood for unwanted surprise. Yet the HAP amendments may well push toward use of nonlisted compounds as it allows the industry source to avoid regulation. There is also a concern that the MACT standards, which have taken years and much debate to establish, will inhibit investment in even better technology—for example, air pollution control technology that might result from an advance in materials science. All of these concerns can be counteracted by provisions enacted into the 1990 HAP amendments—but whether they will be is uncertain. Accordingly, despite the *1990 Clean Air Act* HAP amendments likely leading to a decrease in tonnage of air pollutants emitted, it is still questionable whether there will be any significant lessening of toxicity directly caused by HAPs.

Registration Evaluation and Authorization of Chemicals (Reach)

Currently under consideration by the EU is a new far-reaching act that is firmly based upon the Precautionary Principle (Registration, Evaluation, and Authorisation of Chemicals 2005). It is a work in progress, with amendments being acted upon that may change the details. REACH does have provisions for prioritization of chemicals based upon exposure, or based upon hazard—but not based upon risk. In many ways, REACH is the antithesis of the *US Toxic Substances Control Act* through its requirement of a substantial amount of safety data for all chemicals, new or existing in commerce. Through this requirement it presumably will counteract the major problems we have had in the US with existing chemicals, such as the counterproductive move toward using MTBE and other oxygenated fuels without adequate toxicological testing. Also, through its insistence on the testing of all chemicals, REACH presumably will avoid the potential problem posed by unlisted chemicals in the HAP provisions. Like the *1990 US Clean Air Act* HAP amendments, REACH is justified by its proponents in part on the basis of frustration with the slowness

of existing regulatory approaches. This expectation of a speedier regulatory response has not been borne out for the US HAP amendments—15 years after the passage of the act much remains unfinished, including the inevitable court cases.

Alan Boobis has pointed out that there are far fewer toxicologists in Europe than in the US, and has questioned whether there are sufficient toxicologists to accomplish the task. Accordingly, REACH may greatly increase the demand for toxicologists; although in my view, much of these funds would be better spent on developing the scientific basis for newer equivalents of the Ames test that would be effective in primary prevention. A similar criticism can be made of the current approach to testing high production volume chemicals.

Toxicology as Primary Prevention

Toxicology should be given more recognition as a primary precautionary approach. An excellent example is the Ames test, which was developed based upon scientific advances in understanding basic bacterial genetics; the role of mutagenesis in carcinogenesis; and the importance of liver metabolism in activating indirect carcinogens. To develop new consumer and industrial products, the chemical industry routinely uses the Ames test, and similar tests, to weed out potentially harmful chemicals from their development processes. The focusing of new chemical development and marketing on less harmful products is an excellent example of a primary preventive precautionary approach achieved through advances in toxicological sciences.

Unfortunately, the contributions of toxicology to primary precautionary approaches through safety assessment are not well understood by many who advocate the Precautionary Principle. Some are distrustful of scientists and are opposed to what they see as a technocracy that is controlling their lives. This is not surprising, in view of the frequency with which industry or government has used scientific uncertainty as a basis to stall needed actions. The justifiable concern is that without a precautionary approach, industry will operate under the CATNIP principle—Cheapest Available Technology Not Involving Prosecution.

Communication with Those Who Advocate the Precautionary Principle

Potentially problematic is the lack of communication between those active in the field of toxicology or environmental risk assessment and those most strongly advocating the Precautionary Principle. Of note is that of the 34 signers of the Wingspread Statement on the Precautionary Principle described above, none appear to have been members of the Society of Toxicology or of the Society for Risk Analysis. This lack of communication among different disciplines concerned with environmental protection may well limit understanding of the role of toxicological science in preventing disease. As this could be of grave consequence to our field, our reaching out to those who are advocates of the Precautionary Principle is particularly important. Let me emphasize that

many, and perhaps most, active supporters of the Precautionary Principle are well aware of the role of science in preventing disease, and that there is a growing literature on the subject of science and the Precautionary Principle.

Conclusion

Among the major external threats to the field of toxicology are animal rights activists who would rather put humans and animal pets at risk rather than subject any laboratory animal to study; so called ethicists who seem opposed to any controlled experimental exposures of human subjects to chemical agents, even at levels at which we are exposed in our homes and in gasoline stations; the whole field of toxic torts; and, I would add, the Precautionary Principle. Each of these threats has their potentially valuable side in promoting the use of toxicology or developing new approaches—such as in vitro techniques that can replace laboratory animals. Similarly, although the Precautionary Principle can be a threat to the field of toxicology, it also challenges us to think carefully about the goals of toxicology and of the importance of broadly communicating about what we do and why we do it.

POSTSCRIPT

Is the Precautionary Principle a Sound Approach to Risk Analysis?

Ronald Bailey, in "Precautionary Tale," *Reason* (April 1999), defines the Precautionary Principle as "precaution in the face of any actions that may affect people or the environment, no matter what science is able—or unable—to say about that action." "No matter what science says" is not quite the same thing as "lack of full scientific certainty." Indeed, Bailey turns the Precautionary Principle into a straw man and thereby endangers whatever points he makes that are worth considering. One of those points is that widespread use of the Precautionary Principle would hamstring the development of the Third World. Roger Scruton, in "The Cult of Precaution," *National Interest* (Summer 2004), calls the Precautionary Principle "a meaningless nostrum" that is used to avoid risk and says it "clearly presents an obstacle to innovation and experiment," which are essential. Bernard D. Goldstein and Russellyn S. Carruth remind us in "Implications of the Precautionary Principle: Is It a Threat to Science?" *International Journal of Occupational Medicine and Environmental Health* (January 2004), that there is no substitute for proper assessment of risk. Jonathan Adler, in "The Precautionary Principle's Challenge to Progress," in Ronald Bailey, ed., *Global Warming and Other Eco-Myths* (Prima, 2002), argues that because the Precautionary Principle does not adequately balance risks and benefits, "the world would be safer without it." Peter M. Wiedemann and Holger Schutz, "The Precautionary Principle and Risk Perception: Experimental Studies in the EMF Area," *Environmental Health Perspectives* (April 2005), report that "precautionary measures may trigger concerns, amplify . . . risk perceptions, and lower trust in public health protection." Cass R. Sunstein, *Laws of Fear: Beyond the Precautionary Principle* (Cambridge, 2005), criticizes the Precautionary Principle in part because, he says, people overreact to tiny risks. John D. Graham, dean of the Frederick S. Pardee RAND Graduate School, argues in "The Perils of the Precautionary Principle: Lessons from the American and European Experience," Heritage Lecture #818 (delivered January 15, 2004, at the Heritage Foundation, Washington, D.C.), that the Precautionary Principle is so subjective that it permits "precaution without principle" and threatens innovation and public and environmental health. It must therefore be used cautiously.

The 1992 Rio Declaration emphasized that the Precautionary Principle should be "applied by States according to their capabilities" and that it should be applied in a cost-effective way. These provisions would seem to preclude the draconian interpretations that most alarm the critics. Yet, say David Kriebel et al., in "The Precautionary Principle in Environmental Science," *Environmental Health Perspectives* (September 2001), "environmental scientists should

be aware of the policy uses of their work and of their social responsibility to do science that protects human health and the environment." Businesses are also conflicted, writes Arnold Brown in "Suitable Precautions," *Across the Board* (January/February 2002), because the Precautionary Principle tends to slow decision making, but he maintains that "we will all have to learn and practice anticipation." Professor Goldstein mentions the European Union's REACH (Registration Evaluation and Authorization of Chemicals) program. It took effect on June 1, 2007. See http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm for details.

Does the Precautionary Principle make us safer? The January 23, 2009, issue of *CQ Researcher* presents a debate, under that title, between Gary Marchant, who believes that the principle "fails to provide coherent or useful answers on how to deal with uncertain risks," and Wendy E. Wagner, who contends that the existing chemical regulatory system shows the consequences of not taking a precautionary approach.

ISSUE 2

Is Sustainable Development Compatible with Human Welfare?

YES: **Jeremy Rifkin,** from "The European Dream: Building Sustainable Development in a Globally Connected World," *E Magazine* (March/April 2005)

NO: **Ronald Bailey,** from "Wilting Greens," *Reason* (December 2002)

ISSUE SUMMARY

YES: Jeremy Rifkin, president of the Foundation on Economic Trends, argues that Europeans pride themselves on their quality of life, and their emphasis on sustainable development promises to maintain that quality of life into the future.

NO: Environmental journalist Ronald Bailey states that sustainable development results in economic stagnation and threatens both the environment and the world's poor.

Over the last 30 years, many people have expressed concerns that humanity cannot continue indefinitely to increase population, industrial development, and consumption. The trends and their impacts on the environment are amply described in numerous books, including historian J. R. McNeill's *Something New Under the Sun: An Environmental History of the Twentieth-Century World* (W. W. Norton, 2000).

"Can we keep it up?" is the basic question behind the issue of sustainability. In the 1960s and 1970s, this was expressed as the "Spaceship Earth" metaphor, which said that we have limited supplies of energy, resources, and room and that we must limit population growth and industrial activity, conserve, and recycle in order to avoid crucial shortages. "Sustainability" entered the global debate in the early 1980s, when the United Nations secretary general asked Gro Harlem Brundtland, a former prime minister and minister of environment in Norway, to organize and chair the World Commission on Environment and Development and produce a "global agenda for change." The resulting report, *Our Common Future* (Oxford University Press, 1987), defined *sustainable development* as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." It recognized that limits on population size and resource use cannot be known precisely; that problems may arise not suddenly but rather gradually, marked by rising costs; and that limits may be redefined by changes in technology. The report also recognized that limits exist and must be taken into account when governments, corporations, and individuals plan for the future.

The Brundtland report led to the UN Conference on Environment and Development held in Rio de Janeiro in 1992. The Rio conference set sustainability firmly on the global agenda and made it an essential part of efforts to deal with global environmental issues and promote equitable economic development. In brief, sustainability means such things as cutting forests no faster than they can grow back, using groundwater no faster than it is recharged by precipitation, stressing renewable energy sources rather than exhaustible fossil fuels, and farming in such a way that soil fertility does not decline. In addition, economics must be revamped to take into account environmental costs as well as capital, labor, raw materials, and energy costs. Many add that the distribution of the Earth's wealth must be made more equitable as well.

Given continuing growth in population and demand for resources, sustainable development is clearly a difficult proposition. Some think it can be done, but others think that for sustainability to work, either population or resource demand must be reduced. Not surprisingly, many people see sustainable development as in conflict with business and industrial activities, private property rights, and such human freedoms as the freedoms to have many children, to accumulate wealth, and to use the environment as one wishes. Economics professor Jacqueline R. Kasun, in "Doomsday Every Day: Sustainable Economics, Sustainable Tyranny," *The Independent Review* (Summer 1999), goes so far as to argue that sustainable development will require sacrificing human freedom, dignity, and material welfare on a road to tyranny. Lester R. Brown, "Picking up the Tab," *USA Today Magazine* (May 2007), suggests that because governments currently spend some $700 billion a year subsidizing environmentally destructive activities such as automobile driving, one essential step toward sustainability is to end the subsidies.

In the following selections, Jeremy Rifkin, president of the Foundation on Economic Trends, argues that Europeans pride themselves on a quality of life that in some ways exceeds that of Americans, and their emphasis on inclusivity, diversity, sustainable development, social rights, and individual human rights promises to maintain that quality of life into the future. Ronald Bailey argues that preserving the environment, eradicating poverty, and limiting economic growth are incompatible goals. Indeed, vigorous economic growth provides wealth for all and leads to environmental protection.

YES

Jeremy Rifkin

The European Dream: Building Sustainable Development in a Globally Connected World

A growing number of Americans are beginning to wonder why Europe has leaped ahead of the U.S. to become the most environmentally advanced political space in the world today. To understand why Europe has left America behind in the race to create a sustainable society, we need to look at the very different dreams that characterize the American and European frame of mind.

Ask Americans what they most admire about the U.S.A. and they will likely cite the individual opportunity to get ahead—at least until recently. The American Dream is based on a simple but compelling covenant: Anyone, regardless of the station to which they are born, can leverage a good public education, determination and hard work to become a success in life. We can go from "rags to riches."

Ask Europeans what they most admire about Europe and they will invariably say "the quality of life." Eight out of 10 Europeans say they are happy with their lives and when asked what they believe to be the most important legacy of the 20th century, 58 percent of Europeans picked their quality of life, putting it second only to freedom in a list of 11 legacies.

While the American Dream emphasizes individual success, the European Dream emphasizes collective well-being. The reason for this lies in the divergent histories of the two continents. America's founders came over from Europe 200 years ago in the waning days of the Protestant Reformation and the early days of the European Enlightenment. They took these two streams of European thought, froze them in time, and kept them alive in their purest form until today. Americans are the most devoutly Christian and Protestant people in the industrial world and the fiercest champions of the capitalist marketplace and the nation-state.

Both the Protestant Reformation and the Enlightenment emphasized the central role of the individual in history. John Calvin exhorted the faithful that every person stands alone with his or her God. Adam Smith, in turn, argued that all individuals pursue their own self interest in the marketplace. This individualist strain fit the American context far better than it did the European setting. In a wide-open frontier, every new immigrant did indeed

From *E/The Environmental Magazine,* March/April 2005, pp. 34–39.

stand alone and had to secure his or her survival with little or no social supports. Americans, even today, are taught by his or her parents that to be free they must learn to be self-sufficient and independent, and that they cannot depend on others.

Europeans, however, never fully bought the idea of the individual alone in the universe. Europe was already densely populated and without a frontier by the late 18th century. Walled cities and tightly packed human settlement demanded a more communal way of life. While Americans defined freedom in terms of individual autonomy and mobility, Europeans defined freedom by their communal relationships.

In America there was enough cheap and free land and resources so that newcomers could become rich. In Europe, well-defined class boundaries—a remnant of the feudal aristocracy—made it far more difficult for an individual born in a lesser station of life to rise to the top and become wealthy. So while Americans preferred to pursue happiness individually, Europeans pursued happiness collectively by emphasizing the quality of life of the community. Today, Americans devote less than 11 percent of their Gross Domestic Product (GDP) to social benefits, compared to 26 percent in Europe.

Doing It Better

So, what does Europe do better than America? It works hard to create a remarkably high quality of life for all of its people. The European Dream focuses on inclusivity, diversity, sustainable development, social rights and universal human rights. And it works. While Americans are 28 percent wealthier per capita than Europeans, in many ways, Europeans experience a higher quality of life, clear evidence that, in the long run, cooperation rather than competition is sometimes a surer path to happiness.

Europe and the U.S. have nearly opposite approaches to the question of environmental stewardship. At the heart of the difference is the way Americans and Europeans perceive risk. We Americans take pride in being a risk-taking people. We come from immigrant stock, people who risked their lives to journey to the new world and start over, often with only a few coins in their pockets and a dream of a better life. When Europeans and others are asked what they most admire about Americans, our risk-taking, "can-do" attitude generally tops the list. Where others see difficulties and obstacles, Americans see opportunities.

Our optimism is deeply entwined with our faith in science and technology. It has been said that Americans are a nation of tinkerers. When I was growing up, the engineer was held in as high esteem as the cowboy, admired for his efforts to improve the lot of society and contribute to the progress and welfare of civilization.

On the other side of the water, the sensibilities are different. It's not that Europeans aren't inventive. One could make the case that over the course of history Europe has produced most of the great scientific insights and not a few of the major inventions. But with their longer histories, Europeans are far more mindful of the dark side of science and technology.

Saying No to GE Foods

In recent years, the European Union (EU) has turned upside down the standard operating procedure for introducing new technologies and products into the marketplace and society, much to the consternation of the United States. The turnaround started with the controversy over genetically engineered (GE) foods and the introduction of genetically modified organisms (GMOs). The U.S. government gave the green light to the widespread introduction of GE foods in the mid 1990s, and by the end of the decade more than half of America's agricultural land was given over to GE crops. No new laws were enacted to govern the potential harmful environmental and health impacts. Instead, existing statutes were invoked, and no special handling or labeling of the products was required.

In Europe, massive opposition to GMOs erupted across the continent. Farmers, environmentalists and consumer organizations staged protests and political parties and governments voiced concern. A defacto moratorium on the planting of GE crops and sale of GE food products was put into effect. Meanwhile, the major food processors, distributors and retailers pledged not to sell any products containing GE traits.

The EU embarked on a lengthy review process to assess the environmental and health risks of introducing GE food products. In the end, it established tough new protections designed to mitigate the potential harm. The measures included procedures to segregate and track GE grain and food products from the fields to the retail stores to ensure against contamination; labeling of GMOs at every stage of the food process to ensure transparency; and independent testing as well as more rigorous testing requirements by the companies producing GE seeds and other GMOs.

The EU is forging ahead on a wide regulatory front, changing the very conditions and terms by which new scientific and technological pursuits and products are introduced into the marketplace and the environment. Its bold initiatives put the EU far ahead of the rest of the world. Behind all of its newfound regulatory zeal is the looming question of how best to model global risks and create a sustainable and transparent approach to economic development.

Ensuring Safety

In May of 2003, the EU proposed sweeping new regulatory controls on chemicals to mitigate toxic impacts on the environment and human and animal health. The proposed new law would require new companies to register and test for the safety of more than 30,000 chemicals at an estimated cost to the producers of nearly eight billion Euros. Under existing rules, 99 percent of the total volume of chemicals sold in Europe have not passed through any environmental and health testing and review process. In the past, there was no way to even know what kind of chemicals were being used by industry, making it nearly impossible to track potential health risks. The new regulations will change all of that. The "REACH" system—which stands for Registration, Evaluation and Authorization of Chemicals—requires the companies

to conduct safety and environmental tests to prove that the products they are producing are safe. If they can't, the products will be banned from the market.

The new procedures represent an about face to the way the chemical industry is regulated in the U.S. In America, new chemicals are generally assessed to be safe and the burden is primarily put on the consumer, the public or the government to prove that they cause harm. The EU has reversed the burden of proof. Former EU Environmental Commissioner Margot Wallstrom makes the point: "No longer do public authorities need to prove they [the products] are dangerous. The onus is now on industry to prove that the products are safe."

Making companies prove that their chemical products are safe before they are sold is a revolutionary change. It's very difficult to conceive of the U.S. entertaining the kind of risk prevention regulatory regime that the EU has rolled out. In a country where corporate lobbyists spend millions of dollars influencing congressional legislation, the chances of ever having a similar regulatory regime to the one being implemented in Europe would be nigh on impossible.

BUILDING THE HYDROGEN ECONOMY

At the very top of the list of environmental priorities for the EU is the plan to become a fully integrated renewable-based hydrogen economy by mid-century. The EU has led the world in championing the Kyoto Protocol on Climate Change, and to ensure compliance it has made a commitment to produce 22 percent of its electricity and 12 percent of all of its energy using renewable sources by 2010. Although a number of member states are lagging behind on meeting their renewable energy targets, the very fact that the EU has set benchmarks puts it far ahead of the U.S. in making the shift from fossil fuels to renewable energy sources. The Bush administration has consistently fought Congressional attempts to establish similar benchmarks for ushering in a U.S.-based renewable energy regime.

In June of 2003, EU President Romano Prodi said, "It is our declared goal of achieving a step-by-step shift toward a fully integrated hydrogen economy, based on renewable energy sources, by the middle of the century." He added that creating this economy would be the next critical step in integrating Europe after the introduction of the Euro.

The European hydrogen game plan is being implemented with a sense of history in mind. Great Britain became the world's leading power in the 19th century because it was the first country to harness its vast coal reserves with steam power. The U.S., in turn, became the world's preeminent power in the 20th century because it was the first country to harness its vast oil reserves with the internal-combustion engine. The multiplier effects of both energy revolutions were extraordinary. The EU is determined to lead the world into the third great energy revolution of the modern era.—*J.R.*

GMOs and chemical products represent just part of the new "risk prevention" agenda taking shape in Brussels. In early 2003, the EU adopted a new rule prohibiting electronics manufacturers from selling products in the EU that contain mercury, lead and other heavy metals. Another new regulation requires the manufacturers of all consumer electronics and household appliances to cover the costs for recycling their products. American companies complain that compliance with the new regulations will cost them hundreds of millions of dollars a year.

All of these strict new rules governing risk prevention would come as a shock to Americans who believe that the U.S. has the most vigilant regulatory oversight regime in the world for governing risks to the environment and public health. Although that was the case 30 years ago, it no longer is today.

The EU is the first governing institution in history to emphasize human responsibilities to the global environment as a centerpiece of its political vision. Europe's new sensitivity to global risks has led it to champion the Kyoto Protocol on climate change, the Biodiversity Treaty, the Chemical Weapons Convention and many others. The U.S. government has refused, to date, to ratify any of the above agreements.

A New Era

In Europe, intellectuals are increasingly debating the question of the great shift from a risk-taking age to a risk-prevention era. That debate is virtually nonexistent in the U.S., where risk-taking is seen as a virtue. The new European intellectuals argue that vulnerability is the underbelly of risks. A sense of vulnerability can motivate people to band together in common cause. The EU stands as a testimonial to collective political engagement arising from a sense of risk and shared vulnerability.

What's changed qualitatively in the last half century since the dropping of the atomic bombs on Hiroshima and Nagasaki is that risks are now global in scale, open ended in duration, incalculable in their consequences and not compensational. Their impact is universal, which means that no one can escape their potential effects. Risks have now become truly democratized, making everyone vulnerable. When everyone is vulnerable, then traditional notions of calculating and pooling risks become virtually meaningless. This is what European academics call a risk society.

Americans aren't there yet. While some academics speak to global risks and vulnerabilities and a significant minority of Americans express their concerns about global risks, from climate change to loss of biodiversity, the sense of utter vulnerability just isn't as strong on this side of the Atlantic. Europeans say we have blinders on. In reality, it's more nuanced than that. Call it delusional, but the sense of personal empowerment is so firmly embedded in the American mind, that even when pitted against growing evidence of potentially overwhelming global threats, most Americans shrug such notions off as overly pessimistic and defeatist. "Individuals can move mountains." Most Americans believe that. Fewer Europeans do.

The EU has already institutionalized a litmus test that cuts to the core of the differences between America and Europe. It's called "the precautionary principle" and it has become the centerpiece of EU regulatory policy governing science and technology in a globalizing world.

The Precautionary Principle

In November 2002, the EU adopted a new policy on the use of the precautionary principle to regulate science and new products derived from technology innovations. According to the EU, reviews occur in "cases where scientific evidence is insufficient, inconclusive or uncertain and preliminary scientific evaluation indicates that there are reasonable grounds for concern that the potentially dangerous effects on the environment, human, animal or plant

THE TRANSITION TO ORGANIC AGRICULTURE

Europe is taking the lead in the shift to sustainable farming practices and organic food production. While the organic food sector is soaring in the U.S.—it represents the fastest-growing segment of the food industry—the government has done little to encourage it. Although the U.S. Department of Agriculture fields a small organic food research program, it amounts to only $3 million, less than .004 percent of its $74 billion budget. While American consumers are increasing their purchases of organic food, less than 0.3 percent of total U.S. farmland is currently in organic production.

By contrast, many of the EU member states have made the transition to organic agriculture a critical component of their economic development plans and have even set benchmarks. Germany, which has often been the leader in setting new environmental goals for the continent, has announced its intention to bring 20 percent of its agricultural output into organic production by the year 2020. (Organic agricultural output is now 3.2 percent of all farm output in Germany.)

The Netherlands, Sweden, Great Britain, Finland, Norway, Germany, Switzerland, Denmark, France and Austria also have national programs to promote the transition to organic food production. Denmark and Sweden enjoy the highest consumption of organic vegetables in Europe and both countries project that their domestic markets for organic food will soon reach or exceed 10 percent of domestic consumption.

Sweden has set a goal of having 20 percent of its total cultivated farm area in organic production by 2005. Italy already has 7.2 percent of its farmland under organic production while Denmark is close behind with seven percent.

Great Britain doubled its organic food production in 2002 and now boasts the second-highest sales of organic food in Europe, after Germany. According to a recent survey, nearly 80 percent of British households buy organic food. By comparison, only 33 percent of American consumers buy any organic food.—J.R.

health may be inconsistent with the high level of protection chosen by the EU." The key term is "uncertain." When there is sufficient evidence to suggest a potential negative impact, but not enough to know for sure, the precautionary principle allows regulatory authorities to err on the side of safety. They can suspend the activity altogether, modify it, employ alternative scenarios, monitor the activity or create experimental protocols to better understand its effects.

The precautionary principle allows governments to respond with a lower threshold of scientific certainty than in the past. "Scientific certainty" has been tempered by the notion of "reasonable grounds for concern." The precautionary principle gives authorities the flexibility to respond to events in real time, either before or while they are unfolding.

Advocates of the precautionary principle cite the introduction of halocarbons and the tear in the ozone hole in the Earth's upper atmosphere, the outbreak of mad cow disease in cattle, growing antibiotic resistant strains of bacteria caused by the over-administering of antibiotics to farm animals and the widespread deaths caused by asbestos, benzene and polychlorinated biphenyls (PCBs).

The precautionary principle has been finding its way into international treaties and covenants. It was first recognized in 1982 when the United Nations General Assembly incorporated it into the World Charter for Nature. The precautionary principle was subsequently included in the Rio Declaration on Environment and Development in 1992, the Framework Convention on Climate Change in 1992, the Treaty on EU (Maastricht Treaty) in 1992, the Cartagena Protocol on Biosafety in 2000 and the Stockholm Convention on Persistent Organic Pollutants (POPs) in 2001.

Valuing Nature

Americans, by and large, view nature as a treasure trove of useful resources waiting to be harnessed for productive ends. While Europeans share America's utilitarian perspective, they also have a love for the intrinsic value of nature. One can see it in Europeans' regard for the countryside and their determination to maintain natural landscapes, even if it means providing government assistance in the way of special subsidies, or foregoing commercial development. Nature figures prominently in Europeans' dream of a quality of life. Europeans spend far more time visiting the countryside on weekends and during their vacations than Americans.

The balancing of urban and rural time is less of a priority for most Americans, many of whom are just as likely to spend their weekends at a shopping mall, while their European peers are hiking along country trails. Anyone who spends significant time among Europeans knows that they have a great affinity for rural getaways. Almost everyone I know in Europe—among the professional and business class—has some small second home in the country somewhere—a dacha usually belonging to the family for generations. While working people may not be as fortunate, on any given weekend they can be

seen exiting the cities en masse, motoring their way into the nearest rural enclave or country village for a respite from urban pressures.

The strongly held values about rural life and nature is one reason why Europe has been able to support green parties across the continent, with substantial representation in national parliaments as well as in the European Parliament. By contrast, not a single legislator at the federal level in the U.S. is a member of the Green Party.

There is another dimension to the European psyche that makes Europeans supportive of the precautionary principle—their sense of "connectedness."

Because we Americans place such a high premium on autonomy, we are far less likely to see the deep connectedness of things. We tend to see the world in terms of containers, each isolated from the whole and capable of standing alone. We like everything around us to be neatly bundled, autonomous, and self contained. The new view of science that is emerging in the wake of globalization is quite different. Nature is viewed as a myriad of symbiotic relationships, all embedded in a larger whole, of which they are an integral part. In this new vision of nature, nothing is autonomous, everything is connected.

By championing a host of global environmental treaties and accords taking the precautionary approach to regulation, the EU has shown a willingness to act on its commitment to sustainable development and global environmental stewardship. The fact that its commitments in most areas remain weak and are often vacillating is duly noted. But, at least Europe has established a new agenda for conducting science and technology that, if followed, could begin to wean the world from the old ways and toward a second Enlightenment.

Ronald Bailey

NO

Wilting Greens

"It's clear that we've suffered a number of major defeats," declared Andrew Hewett, executive director of Oxfam Community Aid, at the conclusion of the World Summit on Sustainable Development, held in Johannesburg, South Africa, in September. Greenpeace climate director Steve Sawyer complained, "What we've come up with is absolute zero, absolutely nothing." The head of an alliance of European green groups proclaimed, "We barely kept our heads above water."

It wasn't supposed to be this way. Environmental activists hoped the summit would set the international agenda for sweeping environmental reform over the next 15 years. Indeed, they hoped to do nothing less than revolutionize how the world's economy operates. Such fundamental change was necessary, said the summiteers, because a profligate humanity consumes too much, breeds too much, and pollutes too much, setting the stage for a global ecological catastrophe.

But the greens' disappointment was inevitable because their major goals—preserving the environment, eradicating poverty, and limiting economic growth—are incompatible. Economic growth is a prerequisite for lessening poverty, and it's also the best way to improve the environment. Poor people cannot afford to worry much about improving outdoor air quality, let alone afford to pay for it. Rather than face that reality, environmentalists increasingly invoke "sustainable development." The most common definition of the phrase comes from the 1987 United Nations report *Our Common Future*: development that "meets the needs of the present without compromising the ability of future generations to meet their own needs."

For radical greens, sustainable development means economic stagnation. The Earth Island Institute's Gar Smith told Cybercast News, "I have seen villages in Africa . . . that were disrupted and destroyed by the introduction of electricity." Apparently, the natives no longer sang community songs or sewed together in the evenings. "I don't think a lot of electricity is a good thing," Smith added. "It is the fuel that powers a lot of multinational imagery." He doesn't want poor Africans and Asians "corrupted" by ads for Toyota and McDonald's, or by Jackie Chan movies.

Indian environmentalist Sunita Narain decried the "pernicious introduction of the flush toilet" during a recent PBS/BBC television debate hosted by Bill Moyers. Luckily, most other summiteers disagreed with Narain's curious

From *Reason Magazine,* vol. 34, no. 7, December 2002.

disdain for sanitation. One of the few firm goals set at the confab was that adequate sanitation should be supplied by 2015 to half of the 2.2 billion people now lacking it.

Sustainable development boils down to the old-fashioned "limits to growth" model popularized in the 1970s. Hence Daniel Mittler of Friends of the Earth International moaned that "the summit failed to set the necessary economic and ecological limits to globalization." The *Jo'burg Memo,* issued by the radical green Heinrich Böll Foundation before the summit, summed it up this way: "Poverty alleviation cannot be separated from wealth alleviation."

The greens are right about one thing: The extent of global poverty is stark. Some 1.1 billion people lack safe drinking water, 2.2 billion are without adequate sanitation, 2.5 billion have no access to modern energy services, 11 million children under the age of 5 die each year in developing countries from preventable diseases, and 800 million people are still malnourished, despite a global abundance of food. Poverty eradication is clearly crucial to preventing environmental degradation, too, since there is nothing more environmentally destructive than a hungry human.

Most summit participants from the developing world understood this. They may be egalitarian, but unlike their Western counterparts they do not aim to make everyone equally poor. Instead, they want the good things that people living in industrialized societies enjoy.

That explains why the largest demonstration during the summit, consisting of more than 10,000 poor and landless people, featured virtually no banners or chants about conventional environmentalist issues such as climate change, population control, renewable resources, or biodiversity. Instead, the issues were land reform, job creation, and privatization.

The anti-globalization stance of rich activists widens this rift. Environmentalists claim trade harms the environment and further impoverishes people in the developing world. They were outraged by the dominance of trade issues at the summit.

"The leaders of the world have proved that they work as employees for the transnational corporations," asserted Friends of the Earth Chairman Ricardo Navarro. Indian eco-feminist Vandana Shiva added, "This summit has become a trade summit, it has become a trade show." Yet the U.N.'s own data underscore how trade helps the developing world. As fact sheets issued by the U.N. put it, "During the 1990s the economies of developing countries that were integrated into the world economy grew more than twice as fast as the rich countries. The 'non-globalizers' grew only half as fast and continue to lag further behind."

By invoking a zero sum version of sustainable development, environmentalists not only put themselves at odds with the developing world; they ignore the way in which economic growth helps protect the environment. The real commons from which we all draw is the growing pool of scientific, technological, and institutional concepts, and the capital they create. Past generations have left us far more than they took, and the result has been an explosion in human well-being, longer life spans, less disease, more and cheaper food, and expanding political freedom.

Such progress is accompanied by environmental improvement. Wealthier is healthier for both people and the environment. As societies become richer and more technologically adept, their air and water become cleaner, they set aside more land for nature, their forests expand, they use less land for agriculture, and more people cherish wild species. All indications suggest that the 21st century will be the century of ecological restoration, as humanity uses physical resources ever more efficiently, disturbing the natural world less and less.

In their quest to impose a reactionary vision of sustainable development, the disappointed global greens will turn next to the World Trade Organization, the body that oversees international trade rules. During the summit, the WTO emerged as the greens' bête noire. As Friends of the Earth International's Daniel Mittler carped, "Instead of using the [summit] to respond to global concerns over deregulation and liberalization, governments are pushing the World Trade Organization's agenda." "See you in Cancun!" promised Greenpeace's Steve Sawyer, referring to the location of the next WTO ministerial meeting in September 2003. That confab will build on the WTO's Doha Trade Round, launched last year, which is aimed at reducing the barriers to trade for the world's least developed countries.

The WTO may achieve worthy goals that eluded the Johannesburg summit, such as eliminating economically and ecologically ruinous farm and energy subsidies and opening developed country markets to the products of developing nations. Free marketeers and greens might even form an alliance on those issues.

But environmentalists want to use the WTO to implement their sustainable development agenda: global renewable energy targets, regulation based on the precautionary principle, a "sustainable consumption and production project," a worldwide eco-labeling scheme. According to Greenpeace's Sawyer, nearly everyone at the Johannesburg summit agreed "there is something wrong with unbridled neoliberal capitalism."

Let's hope the greens fail at the WTO just as they did at the U.N. summit. Their sustainable development agenda, supposedly aimed at improving environmental health, instead will harm the natural world, along with the economic prospects of the world's poorest people. The conflicting goals on display at the summit show that at least some of the world's poor are wise to that fact.

POSTSCRIPT

Is Sustainable Development Compatible with Human Welfare?

The first of the Rio Declaration's 22 principles states, "Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature." Any solution to the sustainability problem therefore should not infringe human welfare. This makes any solution that involves limiting or reducing human population or blocking improvements in standard of living very difficult to sell. Yet solutions may be possible. David Malin Roodman suggests in *The Natural Wealth of Nations: Harnessing the Market for the Environment* (W. W. Norton, 1998) that taxing polluting activities instead of profit or income would stimulate corporations and individuals to reduce such activities or to discover nonpolluting alternatives. In "Building a Sustainable Society," *State of the World 1999* (W. W. Norton, 1999), he adds recommendations for citizen participation in decision making, education efforts, and global cooperation, without which we are heading for "a world order [that] almost no one wants." (He is referring to a future of environmental crises, not the "new world order" feared by many conservatives, in which national policies are dictated by international [UN] regulators.) Roodman's recommendations may actually be on the way to reality. Arun Agrawal and Maria Carmen Lemos, "A Greener Revolution in the Making? Environmental Governance in the 21st Century," *Environment* (June 2007), argue that budget cuts and globalization are eroding the power of the state in favor of international "hybrid" arrangements that stress public-private partnerships, markets, and community and local participation.

Julie Davidson, in "Sustainable Development: Business as Usual or a New Way of Living?" *Environmental Ethics* (Spring 2000), notes that efforts to achieve sustainability cannot by themselves save the world. But such efforts may give us time to achieve new and more suitable values. It is thus heartening to see that the UN World Summit on Sustainable Development was held in Johannesburg, South Africa, in August 2002. Its aim was to strengthen partnerships between governments, business, nongovernmental organizations, and other stakeholders and to seek to eradicate poverty and make more equal the distribution of the benefits of globalization. See Gary Gardner, "The Challenge for Johannesburg: Creating a More Secure World," *State of the World 2002* (W. W. Norton, 2002), and the United Nations Environmental Programme's Global Environmental Outlook 3 (Earthscan, 2002), prepared as a "global state of the environment report" in preparation for the Johannesburg Summit.

The World Council of Churches brought to the Johannesburg Summit an emphasis on social justice. Martin Robra, in "Justice—The Heart of

Sustainability," *Ecumenical Review* (July 2002), writes that the dominant stress on economic growth "has served, first and foremost, the interests of the powerful economic players. It has further marginalized the poor sectors of society, simultaneously undermining their basic security in terms of access to land, water, food, employment, and other basic services and a healthy environment."

Is social justice or equity worth this emphasis? Or is sustainability more a matter of population control, of shielding the natural environment from human impacts, or of economics? A. J. McMichael, C. D. Butler, and Carl Folke, in "New Visions for Addressing Sustainability," *Science* (December 12, 2003), argue that it is wrong to separate—as did the Johannesburg Summit—achieving sustainability from other goals such as reducing fertility and poverty and improving social equity, living conditions, and health. They observe that human population and lifestyle affect ecosystems, ecosystem health affects human health, human health affects population and lifestyle. "A more integrated . . . approach to sustainability is urgently needed," they say, calling for more collaboration among researchers and other fields. Yet there remains reason to focus on single threats. In February 2007, Sigma Xi and the United Nations Foundation released the Scientific Expert Group Report on Climate Change and Sustainable Development, *Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable* (http://www.sigmaxi.org/about/news/UNSEGReport.shtml) (Executive Summary, *American Scientist,* February 2007). Among its many points is that climate change from global warming is a huge threat to sustainability. Even in spite of feasible attempts at mitigation and adaptation, there is a serious risk of "intolerable impacts on human well-being."

Lester R. Brown, "Could Food Shortages Bring Down Civilization?" *Scientific American* (May 2009), warns that unsustainable agricultural practices and use of ground water, along with global warming, threaten to diminish food supplies to the point where society may actually break down. Underlining this concern, in October 2008, the European Environment and Sustainable Development Advisory Councils held a conference on "Sustaining Europe for a Long Way Ahead." The EEAC Web site (http://www.eeac-net.org/conferences/sixteen/sixteen_frame.htm) noted that "Addressing the very long term through the lens of sustainable development is now a matter of urgency. The prospect of highly damaging, and extremely costly, effects of global change in climate, in natural hazards caused by human intervention, the loss of biodiversity and disruption of food security, poses serious threats to personal and collective human health and wellbeing. . . . The long term is indeed here already." See also Timothy O'Riordan, "On the Politics of Sustainability a Long Way Ahead," *Environment* (March 2009).

ISSUE 3

Should a Price Be Put on the Goods and Services Provided by the World's Ecosystems?

YES: John E. Losey and Mace Vaughan, from "The Economic Value of Ecological Services Provided by Insects," *BioScience* (April 2006)

NO: Marino Gatto and Giulio A. De Leo, from "Pricing Biodiversity and Ecosystem Services: The Never-Ending Story," *BioScience* (April 2000)

ISSUE SUMMARY

YES: John E. Losey and Mace Vaughan argue that even conservative estimates of the value of the services provided by wild insects are enough to justify increased conservation efforts. They say that "everyone would benefit from the facilitation of the vital services these insects provide."

NO: Professors of applied ecology Marino Gatto and Giulio A. De Leo contend that the pricing approach to valuing nature's services is misleading because it falsely implies that only economic values matter.

Human activities frequently involve trading a swamp or forest or mountainside for a parking lot or housing development or farm. People generally agree that these developments are worthwhile projects, for they have obvious benefits. But are there costs as well? Construction costs, labor costs, and material costs can easily be calculated, but what about the swamp? The forest? The species living there?

How much is a species worth? One approach to answering this question is to ask people how much they would be willing to pay to keep a species alive. If the question is asked when there are a million species in existence, few people will likely be willing to pay much. But if the species is the last one remaining, they might be willing to pay a great deal. Most people would agree that both answers fail to get at the true value of a species, for nature is not expressible solely in terms of cash values. Yet some way must be found to weigh the effects of human activities on nature against the benefits gained from those

activities. If it is not, we will continue to degrade the world's ecosystems and threaten our own continued well-being.

Traditional economics views nature as a "free good." That is, forests generate oxygen and wood, clouds bring rain, and the sun provides warmth, all without charge to the humans who benefit. At the same time, nature has provided ways for people to dispose of wastes—such as dumping raw sewage into rivers or emitting smoke into the air—without paying for the privilege. This "free" waste disposal has turned out to have hidden costs in the form of the health effects of pollution (among other things), but it has been up to individuals and governments to bear the costs associated with those effects. The costs are real, but in general, they have not been borne by the businesses and other organizations that produced them. They have thus come to be known as "external" costs.

Environmental economists have recognized the problem of external costs, and government regulators have devised a number of ways to make those who are responsible accept the bill, such as instituting requirements for pollution control and fining those who exceed permitted emissions. Yet some would say that this approach does not help enough.

The *ecosystem services* approach recognizes that undisturbed ecosystems do many things that benefit us. A forest, for instance, slows the movement of rain and snowmelt into streams and rivers; if the forest is removed, floods may follow (a connection that recently forced China to deemphasize forest exploitation). Swamps filter the water that seeps through them. Food chains cycle nutrients necessary for the production of wood and fish and other harvests. Bees pollinate crops and make food production possible. These services are valuable—even essential—to us, and anything that interferes with them must be seen as imposing costs just as significant as the illnesses associated with pollution.

How can those costs be assessed? In 1997 Robert Costanza and his colleagues published an influential paper entitled "The Value of the World's Ecosystem Services and Natural Capital" in the May 15 issue of the journal *Nature*. In it, the authors listed a variety of ecosystem services and attempted to estimate what it would cost to replace those services if they were somehow lost. The total bill for the entire biosphere came to $33 trillion (the middle of a $16–54 trillion range), compared to a global gross national product of $25 trillion. Costanza et al. stated that this was surely an underestimate. Janet N. Abramovitz, "Putting a Value on Natures 'Free' Services," *WorldWatch* (January/February 1998), argues that nature's services are responsible for the vast bulk of the value in the world's economy and that attaching economic value to those services may encourage their protection.

In the following selections, John E. Losey, associate professor of entomology at Cornell University, and Mace Vaughan, Conservation Director at the Xerces Society for Invertebrate Conservation, argue that even conservative estimates of the value of the services provided by wild insects are enough to justify increased conservation efforts. Ecologists Marino Gatto and Giulio A. De Leo argue that the pricing approach to valuing nature's services is misleading because it ignores equally important "nonmarket" values.

YES

John E. Losey and Mace Vaughan

The Economic Value of Ecological Services Provided by Insects

Natural systems provide ecological services on which humans depend. Countless organisms are involved in these complex interactions that put food on our tables and remove our waste. Although human life could not persist without these services, it is difficult to assign them even an approximate economic value, which can lead to their conservation being assigned a lower priority for funding or action than other needs for which values (economic or otherwise) are more readily calculated. Estimating even a minimum value for a subset of the services that functioning ecosystems provide may help establish a higher priority for their conservation.

In this article we focus on the vital ecological services provided by insects. Several authors have reviewed the economic value of ecological services in general, but none of these reviews focused specifically on insects. Insects comprise the most diverse and successful group of multicellular organisms on the planet, and they contribute significantly to vital ecological functions such as pollination, pest control, decomposition, and maintenance of wildlife species. . . . Our twofold goal is to provide well-documented, conservative estimates for the value of these services and to establish a transparent, quantitative framework that will allow the recalculation of the estimates as new data become available. We also should clarify that by "value" we mean documented financial transactions—mostly the purchase of goods or services—that rely on these insect-mediated services.

We restrict our focus to services provided by "wild" and primarily by native insects; we do not include services from domesticated species (e.g., pollination from domesticated honey bees) or pest control from mass-reared insect biological-control agents (e.g., *Trichogramma* wasps). We also exclude the value of commercially produced insect-derived products, such as honey, wax, silk, or shellac, and any value derived from the capture and consumption of insects themselves. The main reasons for these exclusions are that domesticated insects that provide services or products have been covered in many other forums, and they generally do not require the active conservation that we believe is warranted by those undomesticated insects that provide services. Furthermore, in the case of products or food derived directly from wild insects, we simply do not have data to report and therefore wish to maintain a focus on ecological services.

From *BioScience*, by John E. Losey and Mace Vaughan, vol. 56, no. 4, April 2006, pp. 311–316, 318–322.

The four insect services for which we provide value estimates were chosen not because of their importance, but because of the availability of data and an algorithm for their calculation. Three of these services (dung burial, pest control, and pollination) support the production of a commodity that has a quantifiable, published value. To be consistent in our analysis for all three of these commodities, we calculated an estimate for the amount of each commodity that depends on each service or on the amount saved in related expenses (e.g., the cost of fertilizer in our analysis of dung burial). We did not perform an in-depth analysis of how service-dependent changes in the quantity or quality of each commodity may have affected its per-unit price.

One way of looking at the economic implications of the removal of a service was provided by Southwick and Southwick, whose study involved crop pollination by honey bees. Because per-unit cost theoretically increases as supplies decrease, thus mitigating monetary losses, the costs of the service removal in the Southwick and Southwick study were lower than those calculated using our approach. However, all reported values are still within an order of magnitude of each other and, although our approach may not reflect what a consumer would pay for a commodity when these ecological services are *not* being performed, our calculations do provide a measure of the value of these crops at current estimated levels of service.

In the case of insect support of wildlife nutrition, we use a different approach to estimate costs. Instead of basing calculations on the money paid to producers for raw commodities, we use census data to find out how US consumers spent their money. By looking at the consumer end of this system, we immediately see an order-of-magnitude increase in the value reported. We believe it is important for this difference to be understood up front, because it both significantly affects our reported results and provides at least a hint of what happens when raw commodities are converted into value-added products. For example, consumers will spend potentially an order of magnitude more on jellies, pasta sauce, or hamburgers than the price paid to producers for blueberries, tomatoes, or beef.

Using the methods we describe in detail in the following sections, we estimate the annual value of four ecological services provided by primarily native insects in the United States to be more than $57 billion ($0.38 billion for dung burial, $3.07 billion for pollination, $4.49 billion for pest control of native herbivores, and $49.96 billion for recreation). We consider this estimate very conservative. If data were available to support more accurate estimates of the true value of these services (e.g., inclusion of value-added products and wages paid to those who produce such products) or to allow estimation of the value of other services, the results of our calculations would be much higher. In addition to the role of insects in the systems we analyze here, other potentially important services that insects provide could not be quantified, including suppression of weeds and exotic herbivorous species, facilitation of dead plant and animal decomposition, and improvement of the soil. Calculating the value of any of these services could add billions of dollars to our overall estimate. Nevertheless, we hope that even this minimum estimate for a subset of services provided by insects will allow these animals to be more correctly

factored into land management and legislative decisions. In the following sections, we present a detailed description of how we calculated these estimates and discuss the implications of our results.

Dung Burial

Confining large mammals in small areas creates challenging waste-management problems. Cattle production in the United States provides a particularly pertinent example, because nearly 100 million head of cattle are in production, and each animal can produce over 9000 kilograms (kg), or about 21 cubic meters, of solid waste per year. Fortunately, insects—especially beetles in the family Scarabaeidae—are very efficient at decomposing this waste. In doing so, they enhance forage palatability, recycle nitrogen, and reduce pest habitat, resulting in significant economic value for the cattle industry.

Dung beetles process a substantial amount of the cattle dung accumulated annually in the United States. . . .

The importance of this service is illustrated by the success of dung beetles introduced into Australia to deal with the dung of nonnative cattle brought to that continent in 1788. Before the introduction of dung beetle species that were adapted to feed on cattle dung, Australia had no insect fauna to process cattle feces. Consequently, rangeland across the country was fouled by slowly decomposing dung. In addition, this dung provided fodder for pest species. Recent research in western Australia has revealed that populations of the pestiferous bush fly (*Musca vetustissima*) have been reduced by 80% following dung beetle introductions. . . .

Using data from Anderson and colleagues, we calculate that the average persistence—or time until complete decomposition—of an untreated dung pat on rangeland in California is 22.74 ± 0.64 months, while the average persistence of a pat treated with insecticides is 28.14 ± 0.71 months. This indicates that dung beetle activity results in a 19% decrease in the amount of time the average pat of dung makes forage unpalatable, which translates into substantial monetary savings. Note that, for the sake of this analysis, we must assume that the 19% decrease applies broadly across the United States, even though the rate of dung burial by beetles probably varies greatly depending upon the location.

Forage fouling. Fincher estimated a potential value for enhanced palatability based on the concept that cattle will not consume plant material that is fouled with dung. If dung beetles were totally absent, forage fouling by dung would cause estimated annual losses of 7.63 kg of beef per head of cattle (L_{nb}). This level of loss is in comparison with the theoretical zero loss of production if no forage were ever fouled by dung. Fortunately, the cattle industry is not saddled with the full force of this potential loss because range fouling is reduced by the current action of dung beetles.

If we assume that the 19% decrease in dung persistence translates into a 19% decrease in lost beef, then, for cattle whose dung is processed by dung beetles, the per-animal loss would be 6.18 kg (L_b) each year as a result of

forage fouling. This assumption seems justified, since for each increment of time a given patch of forage remains fouled, it also remains unavailable for grazing. By applying these estimated losses to the 32 million head that are untreated and on pasture or rangeland, we estimate that in the absence of dung beetles, beef losses due to forage fouling would be 244 million kg of beef per year ($C_p \times L_{nb}$), whereas losses at current levels of dung beetle function would be 198 million kg ($C_p \times L_b$). With an average price over 34 years (1970–2003, corrected for inflation) of live beef cattle at \$2.65 per kg (V_c), losses would be \$647 million ($V_c \times [C_p \times L_{nb}]$) in the absence of dung beetles and \$525 million ($V_c \times [C_p \times L_b]$) in the presence of dung beetles. Subtracting the estimated value at current levels of dung beetle activity from the theoretical value if no dung beetles were active, we estimate the value of the reduced forage fouling (V_{rf}) to be approximately \$122 million.

Nitrogen volatilization. Another important service provided by dung beetles is promoting decomposition of dung into labile forms of nitrogen that can be assimilated by plants and thus function as fertilizer when the dung is buried. In the absence of dung beetles, cattle feces that remain on the pasture surface until they are dry lose a large proportion of their inorganic nitrogen to the atmosphere. Experiments in South Africa and the United States have shown that approximately 2% of cattle dung is composed of nitrogen, and that 80% of this nitrogen is lost if the pats dry in the sun before they are buried.

Using Gillard's estimate of 27 kg of nitrogen produced annually per animal and assuming that 80% of this nitrogen is lost in the absence of dung beetle activity, we estimate that 21.6 kg would be lost per animal each year if dung beetles were not functioning (L_{nb}). On the basis of our interpretation of decomposition rates, we assume that these losses will be reduced 19% by the current level of dung beetle activity, compared with the estimate for no beetle activity. Thus, we estimate a loss of 17.5 kg per year (L_b) at current activity levels. Multiplying these per-animal values by the total number of cattle whose dung can potentially be buried by dung beetles (C_p, or 32 million), 691 million kg of nitrogen would be lost annually in the United States in the absence of dung beetle activity, compared with the 560 million kg lost at current levels of activity. With nitrogen valued at \$0.44 per kg (V_n), we estimate the value of nitrogen lost in the absence of dung beetles to be \$304 million and the value of nitrogen lost at current levels of dung beetle activity to be \$246 million. Subtracting the estimated value at current levels of dung beetle activity from the theoretical value if no dung beetles were active, the value of the reduction in nitrogen loss is approximately \$58 million.

Parasites. Many cattle parasites and pest flies require a moist environment such as dung to complete their development. Burying dung and removing this habitat can reduce the density of these pests. From field observations that reflected current levels of removal, Fincher estimated the annual losses due to mortality, morbidity, and medication of beef cattle, dairy cattle, and other livestock with internal parasites. To estimate the value of dung burial for reducing these losses, we will use only the losses associated with beef cattle,

FORMULAS USED TO ESTIMATE INSECT SERVICES

Formula used to estimate the number of cattle in the United States whose dung can be processed by dung beetles:

$$C_p = (C_t \times P_r) \times P_{nt},$$

where

C_p = head of cattle producing dung that can be processed by dung beetles,

C_t = total head of cattle produced annually in the United States,

P_r = the proportion of cattle that are raised on range or pasture, and

P_{nt} = the proportion of cattle not treated with avermectins.

Formula used to estimate the value of beef saved because of reduced range fouling resulting from dung burial by dung beetles:

$$V_{rf} = [V_c \times (C_p \times L_{nb})] - [V_c \times (C_p \times L_b)],$$

where

V_{rf} = value of reduced forage fouling,

V_c = value of cattle (per kilogram),

C_p = head of cattle producing dung that can be processed by dung beetles,

L_{nb} = losses (per animal) with no dung beetle activity, and

L_b = losses (per animal) at current levels of dung beetle activity.

Formula used to estimate the value of native insects for suppressing populations of potentially pestiferous native herbivorous insects:

$$V_{ni} = (NC_{ni} - CC_{ni}) \times P_i,$$

where

V_{ni} = the value of suppression of native insect pests by other insects,

NC_{ni} = the cost of damage from native insect pests with no natural control,

CC_{ni} = the cost of damage from native insect pests at current levels of natural control, and

P_i = the proportion of herbivorous insects controlled primarily by other insects.

because we do not have a good estimate for the proportion of dairy cattle or other livestock that live on open pasture or rangeland. Fincher reported that beef cattle ranchers lost \$428 million annually because of parasites and pests.

Corrected for inflation, this is equal to $912 million in 2003 dollars. Given that 85% of beef cattle are on range or pasture and 44% of these cattle are not treated with insecticides, we calculate that 37% of the beef cattle in the United States have fewer parasites because of the facilitation of dung decomposition by dung beetles.

We go on to assume that cattle whose dung is processed by dung beetles suffer 19% fewer losses because of parasites, on the basis of our previous calculation that dung beetles accelerate decomposition by 19%. We also assume that cattle on rangeland, pasture, and feedlots all face the same level of loss from parasites in the absence of dung beetles. Following this logic, we estimate that damage from parasites is only 93% (100% – [37% × 19%]) of what it would be if dung beetles were not providing this service. In the absence of dung beetle activity, estimated losses would be $981 million instead of the current $912 million, and thus this service saves the cattle industry an estimated $70 million per year.

Pest flies. Using a similar algorithm, we can calculate a value for the reduction in losses due to pest flies. Fincher estimated that losses due to horn flies and face flies cost ranchers $365 million and $150 million, respectively, for a total of $515 million. Corrected for inflation, this is the equivalent of $1.7 billion in 2003. Using the calculation described above for parasites, we assume that, as a result of the processing of dung by insects, damage from parasites is only 93% of what it would have been if the service were not being provided. We estimate that losses in the absence of dung beetle activity would be $1.83 billion instead of the current $1.7 billion, and thus this service is saving the cattle industry an estimated $130 million per year.

Adding the individual values of increased forage, nitrogen recycling, and reduced parasite and fly densities due to dung processing by beetles, we arrive at a combined annual total of $380 million. This is certainly an underestimate, since these same services are being provided to an unknown proportion of pasture-raised dairy cows, horses, sheep, goats, and pigs. Furthermore, what is said for dung recycling can also be said for burying beetles and flies that decompose carcasses. While the density of carcasses is much lower than the density of dung pats, their removal is important in rangeland, natural areas, and other public areas for returning nutrients to the soil, reducing potential spread of diseases, and increasing site utility.

Pollination by Native Insects

Pollination, especially crop pollination, is perhaps the best-known ecosystem service performed by insects. McGregor estimates that 15% to 30% of the US diet is a result, either directly or indirectly, of animal-mediated pollination. These products include many fruits, nuts, vegetables, and oils, as well as meat and dairy products produced by animals raised on insect-pollinated forage. While this estimate is probably high, it presents one of the best published measures of pollinator-dependant food in the US diet.

Here we attempt to calculate an estimate of the value of crops produced as a result of pollination by wild (i.e., unmanaged) native insects. The US government keeps records of the production of crops and, because of their value, their insect pollinators have been given some attention, especially pollination by managed insects such as the European honey bee (*Apis mellifera L.*). From these studies and personal accounts of crop scientists and entomologists, several authors make generalizations about the proportion of pollination attributed to various insect groups, mostly honey bees. These generalizations are essentially educated guesses of the percentage of necessary pollination provided by insects, and as such, they are likely to be inaccurate. The proportions that could be attributed to native, as opposed to managed, pollinators will vary widely for each crop, depending on geographic location, availability of natural habitat, and use of pesticides. In addition, cultivars of the same species can have drastically different dependencies on insect pollinators, further complicating any calculation of the value of pollinator insects.

To conduct a truly accurate economic analysis of the role of native insects in crop pollination, we would need a much better accounting of current levels of pollination by different species of managed bees (e.g., honey bee [*A. mellifera*], alfalfa leaf-cutter bee [*Megachile rotundata*], blue orchard bee [*Osmia lignaria*], alkali bee [*Nomia melanderi*]), and wild bees (e.g., bumble bees [*Bombus* spp.], southeastern blueberry bee [*Habropoda laboriosa*], squash bee [*Peponapis pruinosa*]) in crop pollination. . . . Although we still lack much of this information, the estimate we provide here for the value of crops produced as a result of wild native bee–mediated pollination is informative.

Several scientists have estimated the value of insect-pollinated crops that are dependent on honey bees, or the financial loss to society that could be expected if managed honey bees were removed from cropping systems. These authors make a variety of assumptions and take different approaches to calculating a value for honey bees. For example, Southwick and Southwick take into account the reduced crop output stemming from a lack of managed honey bees, adjusting their figures for the changes in value of each commodity as demand increases because of reduced supply. They also present a range of possible values based on assumptions of the pollination redundancy of managed honey bees and other bee pollinators, including feral honey bees and other native and normative bees. Taking all of this into account, they give a range of $1.6 billion ($2.1 billion when adjusted for inflation to represent 2003 dollars) to $5.2 billion ($6.8 billion in 2003 dollars) for the value of honey-bee pollinators. The lower estimate included effective pollination by other bees, making the managed honey bees redundant in some localities and thereby reducing their absolute value. On the high end, Southwick and Southwick estimate that honey bees are worth $5.2 billion if few or no other bees visit insect-pollinated crops.

Robinson and colleagues and Morse and Calderone take a simpler approach, summing the value of each commodity that they estimate is dependant on honey-bee pollinators. From this they generate a portion of the overall value of each crop that they attribute to pollination by honey bees and report values of $8.3 billion and $14.6 billion ($12.3 billion and $16.4 billion, respectively, when adjusted for inflation to represent 2003 dollars). This approach is

more consistent with our other calculations of the value of ecosystem services, and so we choose to use it here to calculate the value of crop production that relies on native insect pollinators.

When we sum the average value of pollinator-dependent commodities reported in Morse and Calderone, we find that native pollinators—almost exclusively bees—may be responsible for almost $3.07 billion of fruits and vegetables produced in the United States. Here we must incorrectly assume that the proportion of honey bees to native species is constant in all settings. In some systems, such as agriculturally diverse, organic farms with nearby pockets of natural or seminatural habitat, native bees may be able to provide all of the pollination needs for certain crops. For example, Morse and Calderone assume that 90% of the insect pollinators of watermelon are honey bees. While this is probably true in most farms, some organic growers can rely on native bees for 100% of their melon pollination.

Pest Control

The best estimate available suggests that insect pests and their control measures cost the US economy billions of dollars every year, but this is only a fraction of the costs that would accrue if beneficial insects such as predators and parasitoids, among other forces, did not keep most pests below economically damaging levels. We calculate the value (V) of these natural forces by first estimating the cost of damage caused by insect pests at current levels of control (CC) and then subtracting this value from the estimated higher cost that would be caused by the greater damage from these insect pests if no controls were functioning (NC). Finally, we calculate a value for the specific action of insect natural enemies by multiplying the value of these natural forces by an estimate of the proportion (P_i) of pests that are controlled by beneficial insects as opposed to other mechanisms (e.g., pathogens or climate).

Because of data limitations, we restrict our estimate to the value derived from the suppression of insect pests that attack crop plants. Beneficial insects certainly suppress populations of both weeds and insects that attack humans and livestock, but the data were not available to calculate the value of these services. As with the rest of our analysis, we also limit our calculations to pest and beneficial insects native to the United States.

Our first step was to calculate the cost of damage due to insect pests at current levels of control from natural enemies. Drawing on previously published estimates, Yudelman and colleagues presented monetary values for total production of eight major crops and for the losses to these crops attributable to insects. Using these values, we calculated a ratio of insect loss to actual yield that allowed estimation of losses due to insects for any period for which yield values have been published. Assuming $50.5 billion for total production and $7.5 billion for losses due to insects in North America from 1988 through 1990, we calculated a ratio of 0.1485. . . .

Calkins found that only 35% of the exotic pests in the United States are pests in their home range. Extending this finding, we assume that the same relationship holds true in the United States, and thus only 35% of potential

insect pest species that are native to the United States reach damaging levels. In other words, we assume that 65% of the potential damage from native pest species is being suppressed, and that 65% of the potential financial cost of this damage is being saved. We make this assumption based on (a) the abundant evidence of a strong correlation between pest density and the magnitude of loss due to pest damage, and (b) the lack of evidence of a correlation between the destructiveness of a pest and the probability that it will be suppressed.

To clarify, the pool of potential pest species—from which we assume 35% actually reach pest levels—is significantly smaller than the 90,000 described insect species in the United States, because many of the described species are not herbivores, and many of those that are herbivores do not feed on cultivated plants. Only 6000 (7%) of the described species in the United States and Canada cause any damage. For our estimate, we assume that these 6000 species, although they make up only 7% of the total species, account for 35% of the species that would be pests if they were not controlled. Following this logic, we assume that the pool of potential pests would be about 17,000 species, 11,000 of which (65%) are being kept below damage levels by biological or climatic controls.

These native species are estimated to comprise 39% of all pest species in the United States. Since native pests vary greatly in the amount of damage they cause, and include some of the most damaging pests in the United States (e.g., corn rootworm, Colorado potato beetle, and potato leafhopper), we assume that they are responsible for 39% of the cost of damage from all pests in the United States. Hence, we estimate that the cost associated with native pest species at current levels of suppression by natural enemies is 39% of $18.77 billion, or $7.32 billion. We designate this value current control by native insects (CC_{ni}).

On the basis of these assumptions, we estimate that the $7.32 billion lost annually to native insect pests (CC_{ni}) is 35% of what would be lost if natural controls were not functioning. If no natural forces were functioning to control native insect pests, we estimate that they would cause $20.92 billion in damage in the United States each year (NC_{ni}). By subtraction, the value of pest control by our native ecosystems is approximately $13.60 billion.

However, not all of this value for natural control of insect pests is attributable to beneficial insects. Some pest suppression comes from other causes, such as pathogens, climatic conditions, and host-plant resistance. One review of the factors responsible for suppression of 68 herbivore species reported that insects (e.g., predators and parasitoids) were primarily responsible for natural control in 33% of cultivated systems. On the basis of these findings, we estimate that insects are responsible for control of 33% of pests that are suppressed by natural controls, while pathogens or bottom-up forces control the rest. Using this average, we estimate the value of natural control attributable to insects to be $4.5 billion annually (33% of $13.6 billion).

Recreation and Commercial Fisheries

US citizens spend over $60 billion a year on hunting, fishing, and observing wildlife. Insects are a critical food source for much of this wildlife, including many birds, fish, and small mammals. Using 1996 US census data on the

spending habits of Americans, adjusted for inflation to 2003 dollars, we estimated the amount of money spent on recreational activities that is dependent on services provided by insects. In this case, the predominant service is concentrating and moving nutrients through the food web.

Small game hunting. Since most large game are either obligate herbivores or omnivores that are not substantially dependent on insects as a source of nutrition, we restrict our estimate of the value of insects for hunting to small game species. In 1996, expenditures for small game hunting totaled $2.5 billion ($2.9 billion in 2003 dollars). To calculate the proportion of this expenditure that is dependent on insects, we use the proportion of days spent hunting for each insectivorous small game species and the dependence of these birds on insects for food.

On the basis of published reports that most galliform chicks rely on insects as a source of protein and that many cannot even digest plant material, we assume that quail, grouse, and pheasant could not survive without insects as a nutritional resource. Therefore, multiplying the proportion of hunting days spent on each of these small game birds (0.15, 0.13, and 0.23, respectively, for a total of 0.51) by the total value for small game ($2.9 billion), we estimate that insects are required for $1.48 billion in expenditures.

Migratory bird hunting. Insectivory in migratory birds—primarily waterfowl such as ducks and geese in the order Anseriformes—is not as predominant as in the primarily terrestrial galliform birds discussed above. According to Ehrlich and colleagues, 19 (43%) of the 44 species in this order are primarily insectivorous. Multiplying the total money spent on migratory bird hunting ($1.3 billion) by the 43% of species that are primarily insectivorous, we estimate the value of insects as food for hunted migratory birds at $0.56 billion in hunter expenditures.

Sport and commercial fishing. The census also provides values for sport or recreational fishing. Since most recreational fishing is in fresh water and a majority of freshwater sport fish are insectivorous, we assume that the entire value of recreational fishing ($27.9 billion) is dependent on insects. In contrast to recreational fishing, the target of most commercial fishing is saltwater fish. There are very few marine insect species, but many fish that are caught in marine systems spend part of their life cycle in fresh water, and insects are often critical sources of nutrition during these periods. Commercial fishing is not covered by the census, but data are available on the number and value of fish landed annually in the United States by commercial operations. Twenty-five of these fish species are primarily insectivorous during at least one life stage. Summing their individual values, we estimate the total value of insects for commercial fishing to be approximately $225 million. Insectivorous fish account for more than 15% of the overall value of commercial fish.

Wildlife observation (bird watching). The 1996 census reports that Americans spent $33.8 billion on wildlife observation. The census also asked

respondents to note which types of wildlife they were watching (e.g., birds, mammals, reptiles, amphibians, insects). Because respondents were allowed to choose more than one category of wildlife, it was impossible to separate out observed groups of organisms that were dependent on insects from those that were not. Bird watching is the most inclusive category, with 96% of respondents indicating that they included birds in their observations. Thus, we assume that 96% of the budget for wildlife observation stems directly from birds, many of which are at least partly dependent on insects as a source of nutrition. Thus, we assume that bird watching accounts for 96% of $33.8 billion spent, or $32.4 billion a year, providing a conservative starting point for calculating the dependency of wildlife observation expenditures on insects.

Our next step is to estimate what proportion of this figure for bird observation was dependent on and attributable to insects. Using data from Ehrlich and colleagues, we calculate that 61% of the bird species known to breed in the United States are primarily insectivorous, and another 28% are at least partially insectivorous. To be conservative, we consider only bird species that are primarily insectivorous. This probably underestimates the importance of insectivory for birds, since many passerine and galliform birds that are listed as partially insectivorous could not survive without the vital protein that insects provide young chicks. This estimate is conservative also because it is based on bird species numbers rather than population numbers, and the passerines, which are overwhelmingly insectivorous, have relatively high population densities. Taking these factors into account, we estimate that insects are responsible for $19.8 billion, which is 61% of the $32.4 billion spent on bird observation annually in the United States.

Discussion

We estimate the value of those insect services we address to be almost $60 billion a year in the United States, which is only a fraction of the value for all the services insects provide. The implication of this estimate is that an annual investment of tens of billions of dollars would be justified to maintain these service-providing insects, were they threatened. And indeed, these beneficial insects are under ever increasing threat from a combination of forces, including habitat destruction, invasion of foreign species, and overuse of toxic chemicals.

Fortunately, no evidence suggests a short-term drastic decline in the insects that provide these services. What the evidence does indicate, however, is a steady decline in these beneficial insects, associated with an overall decline in biodiversity, accompanied by localized, severe declines in environments heavily degraded by human impacts. New evidence indicates that in some situations, the most important species for providing ecosystem services are lost first. The overall, gradual decline in species, coupled with nonlinear changes in service levels, makes it difficult to pinpoint an optimal level of annual investment to conserve beneficial insects and maintain the services they provide. . . .

[E]ven though we provide an estimate of the total value of certain insect services, the complications of redundancy and nonlinearity make it impossible

to quantitatively gauge the level of resources that are justified for efforts aimed at conserving the services that insects provide. However, our findings lead us to espouse three qualitative guidelines. First, cost-free or relatively inexpensive measures are almost certainly justified to maintain and increase current service levels. Examples include volunteer construction of nest boxes for wild pollinators and the inclusion of a diverse variety of native plant species in plantings for bank or soil stabilization and site restoration. Second, actions or investments that are estimated to have an economic return at or slightly below the break-even point, such as the use of less toxic pesticides, are probably justified because of their nontarget benefits. Third, actions that lead to substantial decreases in biodiversity should be avoided because of the high probability of a major disruption in essential services.

Finally, although we cannot provide a quantitative formula to determine the optimal level of investment in the conservation of beneficial insects that provide essential services, we do feel justified, on the basis of our estimates, in making some specific recommendations. First, we recommend that conservation funding allocated via Farm Bill programs—such as the Conservation Security Program, Conservation Reserve Program, Wetlands Reserve Program, and Environmental Quality Incentives Program—pay specific attention to insects and the role they play in ecosystems. In particular, funding to provide habitat for beneficial insects such as predators, parasitoids, and pollinators in natural, seminatural, unproductive, or fallow areas in agricultural landscapes not only provides direct benefits to growers but, by focusing on the ecological needs of insects, results in habitat that supports a great diversity of wildlife.

Second, we recommend that ecosystem services performed by insects be taken into account in land-management decisions. Specifically, maintaining ecosystem services should be a goal of land management. With this goal in mind, specific practices such as grazing, burning, and pesticide use should be tailored to protect insect biodiversity. . . .

We believe it is imperative that some federal and local funds be directed toward the study of these beneficial insects and the vital services they provide so that conservation efforts can be optimally allocated, either through the agricultural programs listed above or through other means.

These steps are just a beginning. With greater attention, research, and conservation, the valuable services that insects provide can not only be sustained but increase in capacity. As a result, growers will be able to practice a more sustainable form of agriculture while spending less on managing pest insects or acquiring managed pollinators; ranchers will get more productivity out of their land; and wildlife lovers will find that the birds and fish they hunt occur in greater abundance than in the past few decades. In less direct but no less important ways, everyone would benefit from the facilitation of the vital services that insects provide. Judging from our estimate of the value of these four services, increased investment in the conservation of these services is justified.

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Pricing Biodiversity and Ecosystem Services: The Never-Ending Story

In 1844, the French engineer Jules Juvénal Dupuit introduced cost–benefit analysis to evaluate investment projects. . . . The application of cost–benefit analysis to ecological issues fell out of favor three decades ago, and it was gradually replaced by multicriteria analysis in the decision-making process for projects that have an impact on the environment. Although multicriteria analysis is currently used for environmental impact assessments [EIA] in many nations, [recently] the concept of cost–benefit analysis has again become fashionable, along with the various pricing techniques associated with it, such as contingent valuation methods, hedonic prices, and costs of replacement of ecological services. . . . Economists have generated a wealth of virtuosic variations on the theme of assessing the societal value of biodiversity, but most of these techniques are invariably based on price—that is, on a single scale of values, that of goods currently traded on world markets.

Perhaps the most famous recent study on the issue of pricing biodiversity and ecological services is that by Costanza et al., who argued that if the importance of nature's free benefits could be adequately quantified in economic terms, then policy decisions would better reflect the value of ecosystem services and natural capital. Drawing on earlier studies aimed at estimating the value of a wide variety of ecosystem goods and services, Costanza et al. estimated the current economic value of the entire biosphere at $16–54 trillion per year, with an average value of approximately $33 trillion per year. By contrast, the gross national product of the United States totals approximately $18 trillion per year. The paper, as its authors intended, stimulated much discussion, media attention, and debate. A special issue of *Ecological Economics* (April 1998) was devoted to commentaries on the paper, which, with few exceptions, were laudatory. Some economists have questioned the actual numbers, but many scientists have praised the attempt to value biodiversity and ecosystem functions.

Although Costanza et al. acknowledged that their estimates were crude and imperfect, they also pointed the way to improved assessments. In particular, they noted the need to develop comprehensive ecological economic models that could adequately incorporate the complex interdependencies between ecosystems and economic systems, as well as the complex individual dynamics

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of both types of systems. Despite the authors' caveats and the fact that many economists have been circumspect in applying their own tools to decisions regarding natural systems, the monetary approach is perceived by scientists, policymakers, and the general public as extremely appealing; a number of biologists are also of the opinion that attaching economic values to ecological services is of paramount importance for preserving the biosphere and for effective decision-making in all cases where the environment is concerned.

In this article, we espouse a contrary view, stressing that, for most of the values that humans attach to biodiversity and ecosystem services, the pricing approach is inadequate—if not misleading and obsolete—because it implies erroneously that complex decisions with important environmental impacts can be based on a single scale of values. We contend that the use of cost–benefit analysis as the exclusive tool for decision-making about environmental policy represents a setback relative to the existing legislation of the United States, Canada, the European Union, and Australia on environmental impact assessment, which explicitly incorporates multiple criteria (technical, economic, environmental, and social) in the process of evaluating different alternatives. We show that there are sound methodologies, mainly developed in business and administration schools by regional economists and by urban planners, that can assist decision-makers in evaluating projects and drafting policies while accounting for the nonmarket values of environmental services.

The Limitations of Cost–Benefit Analysis and Contingent Valuation Methods

Historically, the first important implementation of cost–benefit analysis at the political level came in 1936, with passage of the US Flood Control Act. This legislation stated that a public project can be given a green light if the benefits, to whomsoever they accrue, are in excess of estimated costs. This concept implies that all benefits and costs are to be considered, not just actual cash flows from and to government coffers. However, public agencies (e.g., the US Army Corps of Engineers) quickly ran into a problem: They were not able to give a monetary value to many environmental effects, even those that were predictable in quantitative terms. For instance, engineers could calculate the reduction of downstream water flow resulting from construction of a dam, and biologists could predict the river species most likely to become extinct as a consequence of this flow reduction. However, public agencies were not able to calculate the cost of each lost species. Therefore, many ingenious techniques for the monetary valuation of environmental goods and services have been devised since the 1940s. These techniques fall into four basic categories.

- **Conventional market approaches.** These approaches, such as the replacement cost technique, use market prices for the environmental service that is affected. For example, degradation of vegetation in developing countries leads to a decrease in available fuelwood. Consequently, animal dung has to be used as a fuel instead of a fertilizer, and farmers must therefore replace dung with chemical fertilizers. By computing the cost of these chemical fertilizers, a monetary value for the degradation of vegetation can then be calculated.
- **Household production functions.** These approaches, such as the travel cost method, use expenditures on commodities that are substitutes or complements for the environmental service that is affected. The travel cost method was first proposed in 1947 by the economist Harold Hotelling, who, in a letter to the director of the US National Park Service, suggested that the actual traveling costs incurred by visitors could be used to develop a measure of the recreation value of the sites visited.
- **Hedonic pricing.** This form of pricing occurs when a price is imputed for an environmental good by examining the effect that its presence has on a relevant market-priced good. For instance, the cost of air and noise pollution is reflected in the price of plots of land that are characterized by different levels of pollution, because people are willing to pay more to build their houses in places with good air quality and little noise. . . .
- **Experimental methods.** These methods include contingent valuation methods, which were devised by the resource economist Siegfried V. Ciriacy-Wantrup. Contingent valuation methods require that individuals express their preferences for some environmental resources by answering questions about hypothetical choices. In particular, respondents to a contingent valuation methods questionnaire will be asked how much they would be willing to pay to ensure a welfare gain from a change in the provision of a nonmarket environmental commodity, or how much they would be willing to accept in compensation to endure a welfare loss from a reduced provision of the commodity.

Among these pricing techniques, the contingent valuation methods approach is the only one that is capable of providing an estimate of existence values, in which biologists have a special interest. Existence value was first defined by Krutilla as the value that individuals may attach to the mere knowledge that rare and diverse species, unique natural environments, or other "goods" exist, even if these individuals do not contemplate ever making active use of or benefiting in a more direct way from them. The name "contingent valuation" comes from the fact that the procedure is contingent on a constructed or simulated market, in which people are asked to manifest, through questionnaires and interviews, their demand function for a certain environmental good (i.e., the price they would pay for one extra unit of the good versus the availability of the good). . . .

The limits of cost–benefit analysis were discussed in the 1960s, after more than two decades of experimentation. In particular, many authors pointed out that cost–benefit analysis encouraged policymakers to focus on things that can be measured and quantified, especially in cash terms, and to disregard problems that are too large to be assessed easily. Therefore, the associated price might not reflect the "true" value of social equity, environmental services, natural capital, or human health. In particular, economists themselves recognize that the increasingly popular contingent valuation methods are undermined by several conceptual problems, such as free-riding, overbidding, and preference reversal.

When it comes to monetary valuation of the goods and services provided by natural ecosystems and landscapes specifically, a number of additional problems undermine the effectiveness of pricing techniques and cost–benefit analysis. These problems include the very definition of "existence" value, the dependence of pricing techniques on the composition of the reference group, and the significance of the simulated market used in contingent valuation.

The definition of "existence" value A classic example of contingent valuation methods is to ask for the amount of money individuals are willing to pay to ensure the continued existence of a species such as the blue whale. However, the existence value of whales does not take into account potential indirect services and benefits provided by these mammals. It is just the value of the existence of whales for humans, that is, the satisfaction that the existence of blue whales provides to people who want them to continue to exist. Therefore, there is a real risk that species with very low or no aesthetic appeal or whose biological role has not been properly advertised will be given a low value, even if they play a fundamental ecological function. Without adequate information, most people do not understand the extent, importance, and gravity of most environmental problems. As a consequence, people may react emotionally and either underestimate or overestimate risks and effects.

Therefore, it is not surprising that five of the seven guidelines issued by the National Oceanic and Atmospheric Administration [NOAA] about how to conduct contingent valuation discuss how to properly inform and question respondents to produce reliable estimates (e.g., in-person interviews are preferred to telephone surveys to elicit values). Of course, acquisition of reliable and complete information is always possible in theory, but in practice strict adherence to NOAA guidelines makes contingent valuation methods expensive and time consuming.

Difficulties with the reference group for pricing Pricing techniques such as contingent valuation methods provide information about individual willingness to pay or willingness to accept, which must be summed up in the final balance of cost–benefit analysis. Therefore, the outcome of cost–benefit analysis depends strongly on the group of people that is taken as a reference for valuation—particularly on their income. Van der Straaten noted that the Exxon *Valdez* oil spill in 1989 provides a good example of this dependence. The population of the United States was used as a reference group to calculate the damage to the existence value of the affected species and ecosystems using contingent valuation methods. Exxon was ultimately ordered to pay $5 billion to compensate the people of Alaska for their losses. This huge figure was a consequence of the high income of the US population. If the same accident had occurred in Siberia, where salaries are lower, the outcome would certainly have been different.

This example shows that contingent valuation methods simply provide information about the preferences of a particular group of people but do not necessarily reflect the ecological importance of ecosystem goods and services. Moreover, the outcome of cost–benefit analysis depends on which individual willingness to pay or willingness to accept are included in the cost–benefit analysis. If the quality of the Mississippi River is at issue, should the analysis be restricted to US citizens living close to the river, or should the willingness to pay of Californians and New Yorkers be included too? According to Krutilla's definition of existence value, for many environmental goods and ecological services that may ultimately affect ecosystem integrity at the global level, the preferences of the entire human population should potentially be considered in the analysis. Because practical reasons obviously preclude doing so, contingent valuation methods will inevitably only provide information about the preferences of specific groups of people. For many of the ecological services that may be considered the heritage of humanity, contingent valuation methods analyses performed locally in a particular economic situation should be extrapolated only with great caution to other areas. The process of placing a monetary value on biodiversity and ecosystem functioning through nonuser willingness to pay is performed in the same way as for user willingness to pay, but the identification of people who do not use an environmental good directly and still have a legitimate interest in its preservation is problematic.

Significance of the simulated market Contingent valuation methods are contingent on a market that is constructed or simulated, not real. It is difficult to believe in the efficiency of what Adam Smith called the "invisible hand" of the market for a process that is the artificial production of economic advisors and does not possess the dynamic feedback that characterizes real competitive markets. Is it even possible to simulate a market where units of biodiversity are bought and sold? As Friend stated, "these contingency evaluation methods (CVM) tend to create an illusion of choice based on psychology (willingness) and ideology (the need to pay) which is supposed, somewhat mysteriously, to reflect an equilibrium between the consumer demand for and producer supply of environmental goods and services."

Many additional criticisms of pricing ecological services are more familiar to biologists. For many ecological services, there is simply no possibility of technological substitution. Moreover, the precise contribution of many species is not known, and it may not be known until the species is close to extinction. . . . In addition, specific ecosystem services, as evaluated by Costanza et al., should not be separated from one another and valued individually because the importance of any piece of biodiversity cannot be determined without considering the value of biodiversity in the aggregate. And finally, the use of marginal value theory may be invalidated by the erratic and catastrophic behavior of many ecological systems, resulting in potentially detrimental effects on the health of humans, the productivity of renewable resources, and the vitality and stability of societies themselves.

Despite the efforts of many economists, we believe that some goods and services, especially those related to ecosystems, cannot reasonably be given a monetary value, although they are of great value to humans. Economists coined the term "intangibles" to define these goods. Cost–benefit analysis cannot easily deal with intangibles. As Nijkamp wrote, more than 20 years ago, "the only reasonable way to take account of intangibles in the traditional

cost–benefit analysis seems to be the use of a balance with a debit and a credit side in which all intangible project effects (both positive and negative) are represented in their own (qualitative or quantitative) dimensions" as secondary information. In other words, the result of cost–benefit analysis is primarily a single number, the net monetary benefit that comprises all the effects that can be sensibly converted into monetary returns and costs.

Commensurability of Different Objectives and Multicriteria Analysis

Cost–benefit analysis includes intangibles in the decision-making process only as ancillary information, with the main focus being on those effects that can be converted to monetary value. This approach is not a balanced solution to the problem of making political decisions that are acceptable to a wide number of social groups with a range of legitimate interests. . . .

However, even if the attempt to put a price on everything is abandoned, it is not necessary to give up the attempt to reconcile economic issues with social and environmental ones. Social scientists long ago developed multicriteria techniques to reach a decision in the face of multiple different and structurally incommensurable goals. The most important concept in multicriteria analysis was actually conceived by an Italian economist, Vilfredo Pareto, at the end of the nineteenth century. It is best explained by a simple example. Suppose that a natural area hosting several rare species is a target for the development of a mining activity. Alternative mining projects can have different effects in terms of profits from mining (measured in dollars) and in terms of sustained biodiversity (measured in suitable units, for instance, through the Shannon index). Profit from mining can be corrected using welfare economics to include those environmental and social effects that can be priced (e.g., the benefit of providing jobs to otherwise unemployed people, the cost of treating lung disease of miners, and the cost of the loss of the tourists who used to visit the natural area). . . .

The methods of multicriteria analysis are intended to assist the decision-maker in choosing among . . . alternatives . . . (a task that is particularly difficult when there are several incommensurable objectives, not just two). Nevertheless, the initial step of determining [these] alternatives is of enormous importance, for three reasons. First, [doing so] makes perfect sense even if there is no way of pricing a certain environmental good because each objective can be expressed in its own proper units without reduction to a common scale. Second, the determination of all the feasible alternatives . . . requires the joint effort of a multidisciplinary team that includes, for example, economists, engineers, and biologists and that must predict the effects of alternative decisions on all of the different environmental and social components to which humans are sensitive and which, therefore, deserve consideration. Third, the determination of [feasible alternatives] allows the objective elimination of inadequate alternatives because [they are] independent of the subjective perception of welfare . . . [and] in essence describe the tradeoff between the various incommensurable objectives when every effort is made to achieve the best results in all respects; the attention of the authority that must make the final decision is thus directed toward genuine potential solutions because nonoptimal decisions have already been discarded.

It should be noted that a cost–benefit analysis does not elicit tradeoffs between incommensurable goods because it also gives a green light to projects . . . , provided that the benefits that can be converted into a monetary scale exceed the costs. . . . Cost–benefit analysis, however, is not useful for eliciting the tradeoffs between two incommensurable goods, neither of which is monetary. For instance, there might be a conflict between the goals of preserving wildlife within a populated area and minimizing the risk that wild animals are vectors of dangerous diseases. A multicriteria analysis can describe this tradeoff, whereas a cost–benefit analysis cannot.

Another philosophical point concerning the issue of commensurability is the question of implicit pricing. Economists often argue that to make a decision is to put an implicit price on such intangibles as human life or aesthetics and, therefore, to reduce their value to a common scale (as pointed out also by Costanza et al.). . . .

Environmental Impact Assessment and Multiattribute Decision-Making

Because of the flaws of cost–benefit analysis, many countries have taken a different approach to decision-making through the use of environmental impact assessment legislation (e.g., the United States in 1970, with the signing of the National Environmental Policy Act, NEPA; France in 1976, with the act 76/629; the European Union in 1985, with the directive 85/337). Environmental impact assessment procedures, if properly carried out, represent a wiser approach than setting an a priori value of biodiversity and ecosystem services because these procedures explicitly recognize that each situation, and every regulatory decision, responds to different ethical, economic, political, historical, and other conditions and that the final decision must be reached by giving appropriate consideration to several different objectives. As Canter noted, all projects, plans, and policies that are expected to have a significant environmental impact would ideally be subject to environmental impact assessment.

The breadth of goals embraced by environmental impact assessment is much wider than that of cost–benefit analysis. Environmental impact assessment provides a conceptual framework and formal procedures for comparing different alternatives to a proposed project (including the possibilities of not development a site, employing different management rules, or using mitigation measures); for fostering interdisciplinary team formation to investigate all possible environmental, social, and economic consequences of a proposed activity; for enhancing administrative review procedures and coordination among the agencies involved in the process; for producing the necessary documentation to enhance transparency in the decision-making process and the possibility of reviewing all the objective and subjective steps that resulted in a given conclusion; for encouraging broad public participation and the input of different interest groups; and for including monitoring and feedback

procedures. Classical multiattribute analysis can be used to rank different alternatives. . . . Ranking usually requires the use of value functions to transform environmental and other indicators (e.g., biological oxygen demand or animal density) to levels of satisfaction on a normalized scale, and the weighting of factors to combine value functions and to rank the alternatives. These weights explicitly reflect the relative importance of the different environmental, social, and economic compartments and indicators.

A wide range of software packages for decision support can assist experts in organizing the collected information; in documenting the various phases of EIA; in guiding the assignment of importance weights; in scaling, rating, and ranking alternatives; and in conducting sensitivity analysis for the overall decision-making process. This last step, of testing the robustness and consistency of multiattribute analysis results, is especially important because it shows how sensitive the final ranking is to small or large changes in the set of weights and value functions, which often reflect different and subjective perspectives. It is important to stress that, although the majority of environmental impact assessments have been conducted on specific projects, such as road construction or the location of chemical plants, there is no conceptual barrier to extending the procedure to evaluation of plans, programs, policies, and regulations. In fact, according to NEPA, the procedure is mandatory for any federal action with an important impact on the environment. The extension of environmental impact assessment to a level higher than a single project is termed "strategic environmental assessment" and has received considerable attention.

Conclusions

An impressive literature is available on environmental impact assessment and multiattribute analysis that documents the experience gained through 30 years of study and application. Nevertheless, these studies seem to be confined to the area of urban planning and are almost completely ignored by present-day economists as well as by many ecologists. Somewhere between the assignment of a zero value to biodiversity (the old-fashioned but still used practice, in which environmental impacts are viewed as externalities to be discarded from the balance sheet) and the assignment of an infinite value (as advocated by some radical environmentalists), lie more sensible methods to assign value to biodiversity than the price tag techniques suggested by the new wave of environmental economists. Rather than collapsing every measure of social and environmental value onto a monetary axis, environmental impact assessment and multiattribute analysis allow for explicit consideration of intangible nonmonetary values along with classical economic assessment, which, of course, remains important. It is, in fact, possible to assess ecosystem values and the ecological impact of human activity without using prices. Concepts such as Odum's eMergy [the available energy of one kind previously required to be used up directly and indirectly to make the product or service] and Rees' ecological footprint [the area of land and water required to support a defined economy or population at a specified standard of living], although

perceived by some as naive, may aid both ecologists and economists in addressing this important need.

To summarize our viewpoint, economists should recognize that cost–benefit analysis is only part of the decision-making process and that it lies at the same level as other considerations. Ecologists should accept that monetary valuation of biodiversity and ecosystem services is possible (and even helpful) for part of its value, typically its use value. We contend that the realistic substitute for markets, when they fail, is a transparent decision-making process, not old-style cost–benefit analysis. The idea that, if one could get the price right, the best and most effective decisions at both the individual and public levels would automatically follow is, for many scientists, a sort of Panglossian obsession. In reality, there is no simple solution to complex problems. We fear that putting an a priori monetary value on biodiversity and ecosystem services will prevent humans from valuing the environment other than as a commodity to be exploited, thus reinvigoraing the old economic paradigm that assumes a perfect substitution between natural and human-made capital. As Rees wrote, "for all its theoretical attractiveness, ascribing money values to nature's services is only a partial solution to the present dilemma and, if relied on exclusively, may actually be counterproductive."

POSTSCRIPT

Should a Price Be Put on the Goods and Services Provided by the World's Ecosystems?

In "Can We Put a Price on Nature's Services?" *Report From the Institute for Philosophy and Public Policy* (Summer 1997), Mark Sagoff objects that trying to attach a price to ecosystem services is futile because it legitimizes the accepted cost-benefit approach and thereby undermines efforts to protect the environment from exploitation. The March 1998 issue of *Environment* contains environmental economics professor David Pearce's detailed critique of the 1997 Costanza et al. study. Pearce objects chiefly to the methodology, not the overall goal of attaching economic value to ecosystem services. Costanza et al. reply to Pearce's objections in the same issue. Pearce and Edward B. Barbier have published *Blueprint for a Sustainable Economy* (Earthscan, 2000), in which they discuss how governments worldwide are now applying economics to environmental policy.

Despite the controversy over the worth of assigning economic values to various aspects of nature, researchers continue the effort. Gretchen C. Daily et al., in "The Value of Nature and the Nature of Value," *Science* (July 21, 2000), discuss valuation as an essential step in all decision making and argue that efforts "to capture the value of ecosystem assets . . . can lead to profoundly favorable effects." Daily and Katherine Ellison continue the theme in *The New Economy of Nature: The Quest to Make Conservation Profitable* (Island Press, 2002). In "What Price Biodiversity?" *Ecos* (January 2000), Steve Davidson describes an ambitious program funded by the Commonwealth Scientific and Industrial Research Organization (CSIRO) and the Myer Foundation that is aimed at developing principles and methods for objectively valuing "ecosystem services—the conditions and processes by which natural ecosystems sustain and fulfil human life—and which we too often take for granted. These include such services as flood and erosion control, purification of air and water, pest control, nutrient cycling, climate regulation, pollination, and waste disposal." Jim Morrison, "How Much Is Clean Water Worth?" *National Wildlife* (February/March 2005), argues that ecosystem services such as cleaning water, controlling floods, and pollinating crops have sufficient economic value to make it profitable to spend millions of dollars to protect natural systems.

Stephen Farber, et al., "Linking Ecology and Economics for Ecosystem Management," *Bioscience* (February 2006), find "the valuation of ecosystem services . . . necessary for the accurate assessment of the trade-offs involved in different management options." Ecosystem valuation is currently being used to justify restoration efforts, "linking the science to human welfare," as shown

(for example) in Chungfu Tong, et al., "Ecosystem Service Values and Restoration in the Urban Sanyang Wetland of Wenzhou, China," *Ecological Engineering* (March 2007). See also J. R. Rouquette, et al., "Valuing Nature-Conservation Interests on Agricultural Floodplains," *Journal of Applied Ecology* (April 2009), and Z. M. Chen, et al., "Net Ecosystem Services Value of Wetland: Environmental Economic Account," *Communications in Nonlinear Science & Numerical Simulation* (June 2009). John W. Day, Jr., et al., "Ecology in Times of Scarcity," *Bioscience* (April 2009), report that "In an energy-scarce future, services from natural ecosystems will assume relatively greater importance in supporting the human economy." As a result, the practice of ecology will become both more expensive and more valuable, and ecological engineering (ecoengineering) and restoration will become more common and necessary. Perhaps the connection between ecosystem services and economic value will become less debatable.