A Second Environmental Science: Human-Environment Interactions

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A distinguished collection of scientists, concerned that human activities are putting us on a collision course with the natural world, recently signed a *World Scientists' Warning to Humanity* that advocates policies they believe are necessary to change that course (*1*). The document is as significant for what it says about environmental science as for what it says about the environment. For although the signers endorsed only solidly established statements about what is happening to the environment, they were willing to attach their reputations to projections of human demands on the environment and to policy strategies that are no more than plausible. For instance, the document calls for an end to population growth and poverty, though there is no convincing evidence that a stable human population with newly acquired affluence would treat the environment better than affluent populations have in the past. It predicts "conflicts over increasingly scarce resources," even though economic substitution may continue for quite some time to foil predictions of scarcity.

The document identifies serious concerns, but to understand and respond to them, we need more than plausible scenarios of human behavior. Policy failures repeatedly result from faith in intuitively attractive but mistaken ideas about behavior: That people will accept experts' risk analyses at face value; that firms will accept and fully implement regulations; that consumers will act on relevant information; and that the free market or quasi-market incentives will work in practice as they do in theory.

We need a second environmental science—one focused on human-environment interactions—to complement the science of environmental processes by analyzing key questions such as these: What forces drive the human activities that are major contributors to environmental degradation and how do these forces operate? What are the future trends that follow from these forces? How will particular scenarios of environmental degradation affect human well-being after adaptation is taken into account? Which interventions are most effective for changing environmentally destructive activities?

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Driving Forces

Such questions define three main fields of inquiry. One is the study of the human causes of environmental change—not only proximate causes, such as burning coal, releasing heavy metals into rivers, and clearing forests, that immediately change a part of the environment but especially indirect causes or driving forces, such as population growth, economic development, technological change, and alterations in social institutions and human values, that must be understood to forecast trends in environmentally destructive human activity and, if necessary, to change those trends.

Scientific progress has been slowed by a futile debate about which of these factors is the most important driving force, a debate that rests on the erroneous assumption that the contributions of these forces to anthropogenic change can be assessed independently. For example, in decades of sharp debate about the impact of population growth on the environment, some have argued that population growth is the primary cause of environmental degradation (*2*), others that population growth is environmentally neutral or even beneficial (*3*), and others that population is secondary to technological or socioeconomic factors (*4*). Despite the lengthy and often heated debate, there have been few empirical studies assessing the relationship (*5*). Systematic research can advance understanding and put the debate on a sounder footing (*6*).

What has become clear is that the driving forces interact—that each is meaningful only in relation to the impacts of the others and that the environmental consequences of increased population are highly sensitive to the economic and technological conditions of that population (*7*). For example, the United States releases almost 30 times as much carbon dioxide per capita as India; consequently, 1 year's natural population increase in the United States (1.3 million) adds about twice as much CO_2 to the atmosphere as 1 year's natural increase in India (18 million) (*8*).

Would Indians release as much CO_2 as Americans if they had as much money? We know that internationally, the correlations of energy consumption with both economic activity and quality of life have weakened in the past two decades (*9*). For example, the energy intensity of the advanced Western industrial economies declined by about 25% from 1970 to 1988, while progress continued to be made in indices of the quality of life (*10*). A key question for the global environment is whether, and how quickly, a similar transition can be accomplished in developing countries like India and China. To answer the question, we first need to understand how the transition was accomplished in the West. The relative contributions of prices, structural shifts in national and global economies, life-styles, policy, and other forces are not yet known, but the tools for systematic research are available.

A second field of inquiry concerns the effects of environmental change on things people value—both proximate effects, such as on growing seasons and rainfall in agricultural areas, soil fertility, endangered species, and so on, and indirect effects, such as on population migrations, international conflict, agricultural markets, and government policies. The importance of these issues is widely recognized, and there is a useful empirical base in research on responses to natural and technological disasters and to past climatic change (*11*).

Human Responses to Environmental Change

The third field is the study of the feedbacks between humanity and the environment—the ways individuals, organizations, and governments act on the basis of experienced or anticipated environmental change to manage human activity and preserve environmental values. These feedbacks provide the greatest challenge for scientists and policy-makers, partly because there are so many ways people can intervene in the system (*7*). Energy consumption is a key area in which feedbacks operate and where careful analysis is yielding nonobvious knowledge. Numerous examples come from policy research on the effects of incentives for residential energy conservation.

Incentives follow the well-known economic principle that anyone who must pay the social costs of environmental degradation will curtail activities that have high social costs. Putting this principle into practice, however, is a new and experimental enterprise. Experience supports a number of general conclusions, some of them common sense and others not yet common sense. Among the unsurprising conclusions are that increasing the financial cost of an environmentally destructive behavior generally decreases its frequency and that financial incentives, both price increases and tax credits, often have distributional effects favoring upper-income consumers (*12*). Other important findings are less obvious.

One is that nonfinancial factors sometimes make much more difference to behavior than money. Small investments in program implementation can be more effective than much larger investments in changing the financial incentives.

The U.S. energy system responded very differently to the price shocks of 1973 and 1979. In both cases, the real price of energy increased around 50% in a 3- or 4-year period. But the economy increased its energy productivity (measured as dollars of output per unit of energy consumption) much more after the second shock than after the first. The difference was probably a result of multiple factors, including changed perceptions, increased foreign competition in energy-intensive industries, policy choices, development of new energy-efficient technology, and changes in industrial structure (*7*). These findings imply that price responsiveness, or elasticity, may be subject to external influence, such as by government policies that can make consumers and the overall economy either more or less price-responsive.

Evaluation studies of financial incentive programs show that when identical incentives are administered by several organizations, the most effective program typically attracts at least ten times as much consumer interest as the least effective (*13, 14*). Four nonfinancial factors help explain the variation: promotion, simplification, reliability, and trust.

For example, when electric utilities institute time-of-use pricing to give consumers a strong incentive to use electricity in off-peak periods, they normally announce the incentive through direct mailings to customers. Experimentally enhanced promotion that added more frequent reminders and information about the rates, letters from the state Consumer Advisory Council, advice on how to monitor home energy use, and other information led to reductions in peak-period energy use of 16% below the level attained with the utility's information package (*15*). This promotion relied on frequent, detailed information, some of it coming from widely trusted institutional sources. Many programs enhance success by relying on face-to-face communication through friendship and neighborhood networks to get people to accept free or low-cost weatherization services (*13, 16*).

A comparison of a range of major utility- and government-sponsored incentive programs from the early 1980s shows the importance of simplicity. Across seven programs in the United States, there was a clearly discernible effect of incentive size on participation, but five programs that operated in Canada, Denmark, Britain, and the Netherlands were even more effective, although they generally used smaller incentives. The one consistent difference between the U.S. and foreign programs was that the U.S. programs all used a two-step procedure, in which consumers first had to request a home energy audit and then, after waiting for the audit to be scheduled and conducted, act on the auditor's recommendations and file a claim for the rebate or loan. The audits were required to ensure that people were not being rewarded for installing uneconomic energy improvements. The non–U.S. programs simply offered a list of recommended improvements and paid the incentive on receipt of proof that the improvements had been installed (*13*).

An 1984 experiment in Minnesota demonstrates the importance of nonfinancial factors, particularly trust. Homeowners were offered a free energy audit, free installation of the recommended conservation measures, and a guarantee that from that time on, their monthly utility bills would decrease. A private energy service company planned to profit by collecting a portion of savings over the first 5 years produced by the energy improvements it installed, after which the improvements would revert to the homeowner. The program attracted the interest of up to 20% of eligible households in only a few months—a strong showing. But that was not the whole story.

The county government conducted a small experiment in marketing, trying three ways of introducing the program to its audience: letters from the energy service company on its letterhead; the same letter with added mention that the county government was cosponsoring the program; and a substantially identical letter from the chairman of the county Board of Commissioners, which introduced the company as the county's selected contractor. The letter from the county government was over five times as effective as the company's letter that did not mention the government, both in encouraging energy audits and in getting contracts signed (*17*). The most likely explanation is trust: The letter from the county government provided much greater reassurance that the program was in the public interest, and the consumer's.

These studies and others have accumulated a body of knowledge about human responses to incentives and other interventions intended to promote energy conservation (*14, 18*). Some general principles are emerging. One is that consumer behavior needs to be analyzed in terms of limiting factors. Technology, attitudes, knowledge, money, convenience, attention, and trust are all needed for behavior change, and attempts to provide any of these will fall short to the extent that others are missing. This principle usually implies that interventions should have multiple features. Limiting factors can vary with the consumer and the situation and so must be identified empirically. Another principle is that behavior must be understood from the consumer's perspective, a principle that implies involving consumers in some way in programs intended to change their behavior. The most important point is probably that human beings are continually responsive to interventions—even to the point of organizing to repeal some of them—so that it will never be possible to write a cookbook for behavior change. It is absolutely essential to treat interventions as dynamic and to monitor and revise them continually.

These principles often go unused in energy policy. Policy-makers often expect too much of programs and design them too poorly. They tend to overlook problems of policy implementation, particularly with incentives, which are usually considered only in terms of their size. They assume implicitly that programs can be designed optimally in advance, with the result that when evaluation is used, it is used for final judgment rather than as a tool in the implementation process. In short, when policy-makers apply common sense, they are often led into error. A scientific approach can do for environmental policy what science generally does for policy—separate common sense from common nonsense and make uncommon sense more common.

Development of the Science

Research, basic as well as applied, is proceeding on many problems of human-environment interaction. Significant progress has been made in understanding how people perceive and judge environmental risks (*19*); how societies create institutions for managing common-property resources, such as fisheries, grasslands, and the atmosphere (*20*); what brought about anthropogenic environmental changes in the past (*21*); the dynamics of public concern about the environment (*22*); and the economic forces affecting natural resource availability (*23*). Work in such areas illustrates how the scientific study of human-environment interactions can advance human knowledge, correct misconceptions, and inform vital policy decisions. Progress depends on building on these bodies of knowledge. The new science has the potential to travel along a path similar to that of ecology, which has moved within one human generation from an inchoate science to one that has produced sound knowledge and useful principles.

Although the science of human-environment interactions has been developing for decades, it has progressed slowly for both scientific and institutional reasons (*7*). It has all the scientific problems of other interdisciplinary fields, but more intensely because it involves all the disciplines of environmental science and those of social science as well. It is difficult in such a field to do high-quality interdisciplinary work, integrate separate disciplinary projects, and set productive research agendas, and some are tempted to proceed without the requisite background knowledge. There are also significant institutional barriers in academia and government. Universities are reluctant to give institutional support to interdisciplinary fields that do not yet have widespread recognition or a proven ability to attract resources; young researchers risk their futures working in such fields; interdisciplinary self-training is difficult; and aspiring researchers must struggle to gain recognition because the leading journals tend to be disciplinary. Human-environment interactions does not yet identify itself as one science: Although there are thriving subdisciplinary areas and small interdisciplinary journals and societies, the field does not have a unifying society or journal, university departments, or the other conventional signs of a cohesive intellectual community.

In government, "there is an almost complete mismatch between the roster of federal agencies that support research on [environmental] change and the roster of federal agencies with strong capabilities in social science" [page 232 in (*7*)]. (The National Science Foundation is cited as an exception.) Federal agencies with resource management responsibilities typically have few or no social scientists on staff and support human-environmental science only sporadically and on narrowly applied questions. Environmental mission agencies want policy advice but rarely invest in building knowledge about the human systems in which they intervene. In short, government support is spotty, inadequate, and, for basic research, almost entirely lacking. The institutional impediments to training and to basic and applied science reinforce each other.

What can be done to break out of this bind? The National Research Council report's recommendations for global change research (*7*) seem equally appropriate for other areas of human-environmental science. They focus on the need for increased support for (i) investigator-initiated basic research; (ii) targeted or focused research, including basic research supported by environment-related agencies with responsibilities in the targeted areas; (iii) graduate and postdoctoral fellowships to enhance interdisciplinary training; (iv) new interdisciplinary research centers; (v) improved acquisition, management, and availability of data related to human-environment interactions; and (vi) environmental research activities of disciplinary associations in social science.

Such a program could attack the intertwined problems of training, career paths, institution building, community building, and the development of basic human-environmental science and might attract some additional universities to become actively involved. We need such a program to develop an identifiable scientific field of human-environment interactions that can help humanity to understand the roots of its environmental problems and to respond effectively to them.

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