Earth Matters

The Earth Sciences, Philosophy, and the Claims of Community

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Science and Environmental Policy: An Excess of Objectivity

Daniel Sarewitz

Daniel Sarewitz is senior research scholar at Columbia University's Center for Science, Policy, and Outcomes, and author of Frontiers of Illusion: Science, Technology, and the Politics of Progress *(Temple University Press, 1996). He received his Ph.D. in the Geological Sciences from Cornell University in 1985. At the same time, Sarewitz reports that he noticed a widening chasm between the technical knowledge that he was acquiring, and his personal experience in the surrounding world.*

In 1989 Sarewitz left science to work for the U.S. Congress—an institution that he describes as being in many ways the antithesis of academe. Congress made clear to him what science had sought to obfuscate or even deny: that reality operates on many levels simultaneously, that these multitudinous realities are often conflicting and incommensurable, and that there is no possible long-term equilibrium state in which such tensions are resolvable. For four years, Sarewitz worked for Congressman George E. Brown, Jr., Chairman of the House of Representatives Committee on Science, Space, and Technology.

In this essay, Sarewitz looks at the capacity of science to help resolve environmental conflicts. Scientists and decision makers alike tend to view the role of science in environmental policy as prescriptive. The goal is to create objective information that can cut through the morass of politics and enable wise decisions. Sarewitz claims that in the real world this happy result rarely emerges. What one finds instead are politicians using science to back their political positions; or even arguing over the technical merits of the science, rather than about the societal merits of the politics. But rather than seeing this as a problem caused by politicians distorting the scientific facts for partisan purposes, Sarewitz suggests another possibility: that nature itself resists unitary characterization. The appeal to science to resolve our environmental questions thus presents us with an "excess of objectivity."

In the mid-1980s, a nasty academic conflict flared up over the very existence of objective, scientific knowledge. Later dubbed the "science wars," this conflict apparently pitted the natural sciences against the social sciences in a debate not just about the process of research, but also the nature of scientific facts. As in many academic battles, genuine intellectual discourse was quickly overwhelmed by a rising tide of rhetoric. In the heat of battle, all nuance was lost in the quest for victory, and a single, black-and-white question came to dominate the contest: Does science achieve an objective view of nature, or are all scientific facts constructed by social interactions? The latter, "constructivist" view considers "the 'truth' or 'falsity' of scientific claims...as deriving from the interpretations, actions, and practices of scientists rather than as residing in nature."1 More contentiously still, "the settlement of a [scientific] controversy is the cause of Nature's representation, not its consequence."2 Like red capes before bulls, such pronouncements drove some natural scientists to rage: "[The] logic of cultural constructivists seems to us sloppy and full of holes...their evidence dubious, and their case corrupted by special pleading and covert appeal to emotion."3

As for the public debate, the natural scientists, not suprisingly, soon had the constructivist social scientists on the run. Mostly famously, the physicist Alan Sokal managed to perpetrate a humiliating hoax on social scientists when his patently nonsensical constructivist critique of quantum physics was published by the non–peer-reviewed journal *Social Text*.[4] This triumph was duly debated in the pages of the *New York Times*.[5] Other "victories" included the resignation of *Science* magazine's book review editor, reportedly in response to criticism she received after printing a negative review[6] of *The Flight From Science and Reason*,[7] a collection of anti-constructivist polemics; and the decision by the Institute for Advanced Study at Princeton not to offer a job to a highly regarded historian of science with a known sympathy for the constructivist position, even though he had been approved by a hiring panel. The constructivists were no match for the institutions of modern natural science; invoking imagery of the Spanish Inquisition, *The Economist* wryly observed: "You hear at times the sound of butterflies being broken in cyclotrons."[8]

Lost in the din of battle was the possibility that both sides were right. In the real world, the success and impact of science is argument enough for the validity of its method and results, socially constructed as they may be. As David Hull writes: "No amount of debunking can detract from the fact that scientists do precisely what they claim to do."[9] Nor can it be denied that science generates reliable knowledge that can be used, for example, in the design of technology. Yet this observation can and does coexist side-by-side with another reality: Society and culture create a context within which knowledge is pursued and used, and they influence both the types of facts, and portrayal of the facts, that we acquire.[10] The history of geology after World War II illustrates this observation. Would there have been a plate tectonics revolution if the Cold War had not subsidized the seafloor mapping and global seismic arrays that led to the recognition of mid-ocean spreading and plate subduction?

Facts are both objective (that is, representations of something real) and constructed (that is, products of social context). In this essay, I will discuss the interaction of the objective and the constructed (without, I hope, resort to more social science jargon) in the arenas of politics in general, and environmental policy in particular. This interaction is of growing importance in a world where the character of environmental problems becomes ever more global, more severe, and more divisive—and where science is increasingly called upon to mediate and solve these problems.

A fundamental observation is that a desired goal of science in environmental policy—to help provide answers that can resolve political controversies—can rarely if

ever be achieved. I will argue that this goal is illusory not because science fails to contribute objective facts to our arsenal of knowledge, but because it does so all too well. Science is so effective at generating facts that we are saturated with objectivity, to the point that, in the political world, science often does us very little good at all, and sometimes makes considerable mischief.

7.1 SCIENCE TO THE RESCUE?

In developing this argument, we must first establish that science is called upon to help society resolve difficult and contentious environmental problems. And in fact, the federal government spends billions of dollars on research aimed at solving or clarifying or providing guidance on environmental or natural resource controversies. The $1.8 billion per year U. S. Global Climate Change Research Program (USGCCRP) is only the largest and most conspicuous of these efforts. And the expenditures for this program are explicitly justified in terms of their value for making policy:

> The U.S. Global Change Research Program was conceived and developed to be policy-relevant and, hence, to support the needs of the United States and other nations by addressing significant uncertainties in knowledge concerning natural and human-induced changes in the Earth's environment....The USGCCRP is designed to produce a predictive understanding of the Earth system to support national and international policymaking activities across a broad spectrum of environmental issues.11
>
> A better understanding of the science of climate change is critical to determining the appropriate global mitigation and adaptation policy.12

Similar rationales underlie or have underlain research programs on acid rain, nuclear waste disposal, oil and gas reserve estimates, endangered species, air quality, and a host of other environmental and natural resource controversies. Central to these rationales is the idea that by introducing science, and the objective information that science can produce, into an environmental controversy, rational policy solutions will be facilitated. This idea is illustrated in Figure 7.1, which depicts how the process of integrating science into environmental policy supposedly works. As suggested in this flowchart, the process is linear and progressive, starting with the identification of a problem and proceeding in an orderly fashion through scientific research and predictive modeling, at which point the science is introduced into the political process, policies are developed, and solutions are reached.

Central to this scenario is the apparently self-evident idea that scientific research can provide the basis for political action. This notion is deeply embedded both in the science and the policy communities, to the extent that when a new environmental controversy begins to emerge—sometimes as a result of scientific research—the instinctive reaction is to call for more research. Such a seemingly involuntary response was on display recently when the U.S. Environmental Protection Agency (EPA) tried to promulgate new regulations governing the emission of very fine particulate air pollution. Congress reacted in an entirely predictable fashion: Those who were opposed to the regulations called for more research.[13] Of course, such a reaction is, to some extent, a tactic aimed at delaying implementation of environmental regulations without appearing to be obstructionist, but it also reflects a strong faith that, at some point in the

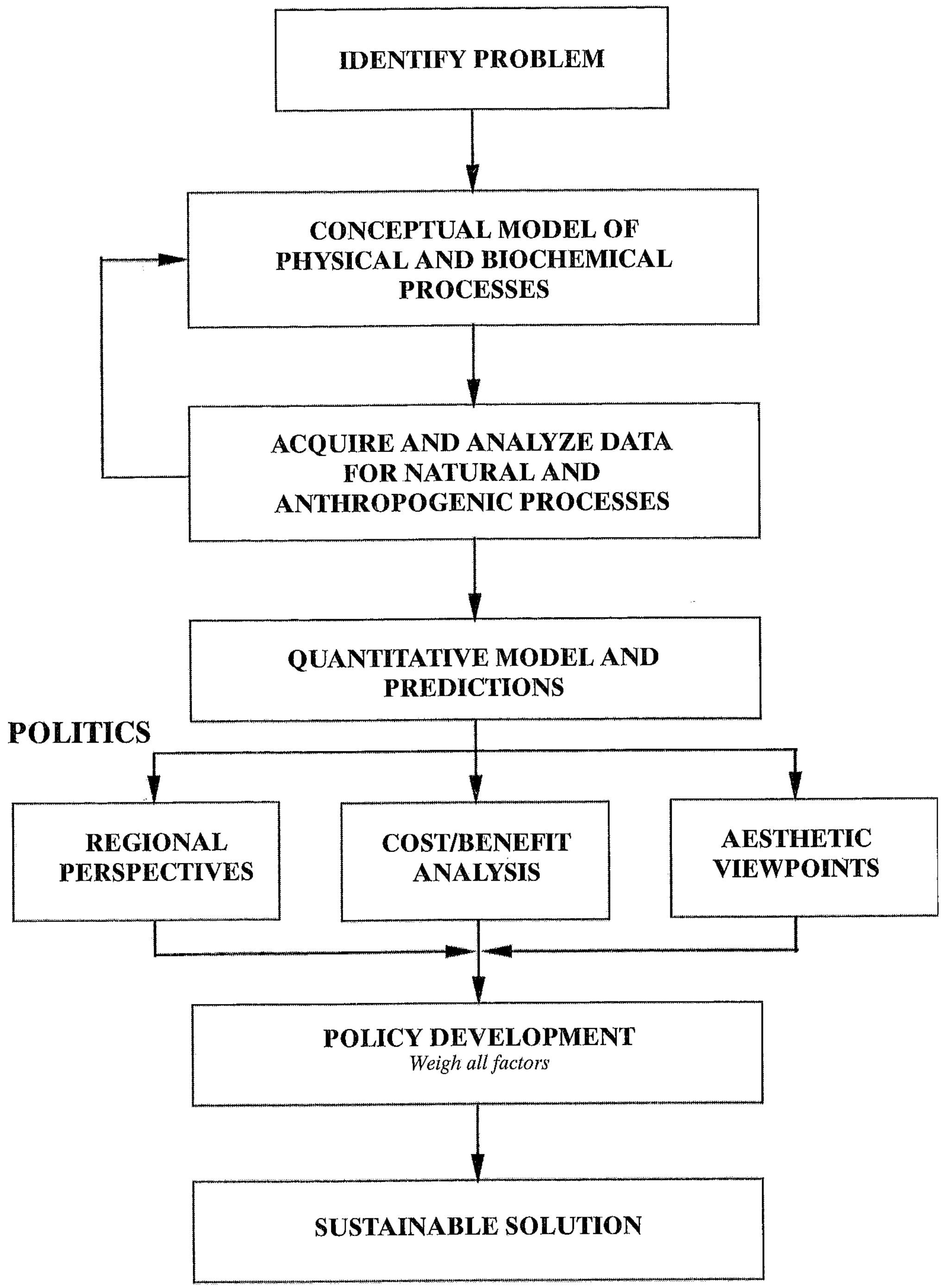

Figure 7.1 Traditional model ("physics view") of the linear and sequential relationship between science and politics in environmental decision making.

future, sufficient new knowledge will be acquired to stimulate the necessary action to resolve the problem "rationally."

This mental model of how science can contribute to environmental policy-making is consistent with the norms of a culture that places great faith in science and the rationality that science can deliver. Yet, in the real world, our expectations for science in policy-making are often confounded. Rather than resolving political debate, science often becomes ammunition in partisan squabbling, mobilized selectively by contending sides to bolster their positions. Because science is highly valued as a source of reliable information, disputants look to science to help legitimate their interests. In such cases, the scientific experts on each side of the controversy effectively cancel each other out, and the more powerful political or economic interests prevail, just as they would have without the science. This scenario has played out in almost every environmental controversy of the past 25 years. Even when science is alleged to have played a decisive role in resolving a policy dispute, as in the case of the international ban on production of chemicals that deplete stratospheric ozone, a closer look at the politics usually shows not that the science convinced policymakers to take the correct action, but that the science and the prevailing political interests fortuitously converged.[14] Indeed, in the area of global warming, where a highly touted (but, as will be shown, illusory) "consensus" of experts has publicly warned of the need to take international action to curtail greenhouse gas emissions, powerful opposing interests in the United States have ensured that no meaningful action has been taken.

However, my point is not that money or vested interest wins out over science and "rationality" every time. The plethora of environmental laws and regulations that were implemented in the United States from the late 1960s through the 1970s, despite the often energetic opposition of private industry, shows that widespread popular support for environmental action can defeat powerful monied interests. But it would be a mistake to suggest that this support was underlain or created by a strong and irrefutable scientific base, and that environmental policies adopted by the government were always dictated by science. Rather, these policies were a response to a wave of popular support that reflected evolving aesthetic, ideological, and ethical perspectives about the preservation of nature and the protection of environmental assets such as clean water, clean air, and endangered species. The science that was used to support such perspectives was often suggestive but rarely if ever uncontestable. At the same time, the growing public commitment to environmental protection was itself a major stimulus of new scientific research. That is, the politics behind environmentalism was probably more important for furthering the science than the science was for advancing the politics.

Nor is it productive to blame politicians for manipulating or distorting objective science to support partisan positions. Naturally, politicians will look for any information or argument they can find to advance their agendas—that is their job. While politicians may not be above playing loose with scientific truth, more often they can and will simply search out—and find—a legitimate expert or two who can marshal a technical argument sympathetic to the desired political outcome. It is the job of politicians to play politics, and this—like the second law of thermodynamics—is not something to be regretted, but something to be lived with. Given this reality, while scientists and politicians will often, as a matter of course, prescribe "more research" to resolve a political dispute about the environment, their prescription rarely has its desired effect over the relatively short time scales within which political decisions must be made—from a few weeks to a few years—and may in fact make things worse by providing more fuel to enflame debate.

7.2 THREE OBSTACLES TO BEING RESCUED BY SCIENCE

The idea that facts provided by science can help resolve political controversies related to the environment falters on three obstacles at the interface of politics and science. First, the goals of politics and science are different and often contradictory. Second, politics expects predictive certainty from science, but the complexity of nature invariably confounds this expectation. Third, the scientific view of nature is sufficiently rich and diverse to support a diversity of strongly held and often conflicting political interests and public values.

THE GOALS OF POLITICS AND SCIENCE

In a democracy, the political process is aimed at resolving conflicts and thus enabling action. This is not a process driven by rational analysis or expert judgment, but by public debate over competing interests and values. Politics, as described by Harold Lasswell,

> is the process by which the irrational bases of society are brought out into the open....[It] is the transition between one unchallenged consensus and the next. It begins in conflict and ends in a solution. But the solution is not the "rationally best" solution, but the emotionally satisfactory one.[15]

Lasswell's use of the words "irrational" and "emotionally satisfactory" is not pejorative; rather, he is acknowledging the innate complexity and diversity of a dynamic society, and thus the irreducible messiness of the political process. People have legitimately different interests and perspectives that they will naturally attempt to protect and promote. Democratic politics gives them a forum for doing so. Not only is there nothing wrong with the consequent messiness, but all historical indications suggest that there is no viable alternative in a society that values freedom and justice and seeks to balance individual rights with the collective good. (Technocracy—rule by technical expertise—is not a viable alternative. As the history of the former Soviet Union demonstrated, technocracy is not only inherently authoritarian, it is even more irrational than democracy. This irrationality derives from the effort to impose rigid technical solutions on problems that reflect conflicting values and interests. The intrinsic diversity of human interests cannot be accommodated, so it must be suppressed.[16]

Thus, the goal of politics is the achievement, through democratic debate, of an operational consensus that enables action. This is a very different goal from that of science, which seeks to expand insight and knowledge about nature through an ongoing process of questioning, hypothesizing, validation, and refutation. Science progresses when it generates new questions more quickly than it resolves old ones, when it probes existing problems with increasing depth and acuity, when it uncovers new problems that were previously unrecognized, and when it reveals the limitations and failures of previous research. Good science is always pushing into the realm of the uncertain and the unknown. When a scientific problem is contentious and the object of a vibrant research effort, consensus is extremely difficult to achieve—the process of scientific investigation intrinsically militates against, and is designed to inhibit, premature consensus. Thus, if scientists are doing their job, then "more research" in the short term is invariably a prescription for raising new questions, problems, and uncertainties—for preventing, not achieving, consensus.

THE DEMANDS OF POLITICS VERSUS THE REALITY OF NATURE

Of course, in the search for a consensus that can enable action, what politicians would really like from science are facts to bolster irrefutably their partisan political positions. But the types of environmental problems facing policymakers are rarely if ever amenable to traditional reductionist approaches that yield unambiguous, statistically well-constrained answers. Rather, these problems are multivariate and nonlinear, and they comprise the behavior not only of evolving natural systems but also of humans. The desire to dispose of nuclear waste through geological isolation, for example, requires an understanding of the evolution and interaction of radiogenic, climatic, hydrogeologic, tectonic, volcanic, and social systems over a period of tens of thousands of years. The scientific certainty that politicians crave—that a repository will be "safe" over a given period of time—simply cannot be delivered. Uncertainties about the behavior of the repository are difficult to quantify, and they increase the further one looks into the future.

If one expands the scale of the problem from a relatively small area designated for nuclear waste disposal, to the entire global climate system, then these difficulties are compounded. The U. S. Global Climate Change Research Program promises a predictive capability that will enable decision making, but fundamental aspects of the climate system, ranging from the operation of the global carbon cycle to the behavior of the coupled atmospheric-oceanic system, are not yet adequately understood even in the present.[17] Moreover, when debate focuses on national, regional, or local impacts, the political stakes begin to rise rapidly, while at the same time the uncertainties associated with the predictive models begin to increase, because the details of a complex system behavior are much more difficult to characterize than are general attributes. To make matters worse, predicting future anthropogenic contributions to global climate change requires an accurate characterization not just of complex climate dynamics, but also of societal processes such as technological advance, economic development, and societal responses. As daunting as it is to understand and predict fully the physical and chemical evolution of the climate system, it is even more difficult to forecast societal trends.[18] Who, for example, foresaw in the mid-1990s that gasoline prices in the United States only a year or so later would be at a fifty-year low (adjusted for inflation), thus undermining any political willpower to control consumption to reduce greenhouse gas emissions?

Policy-making is an inherently forward-looking activity, and politicians naturally enlist scientists to provide predictions that can enhance foresight, and thus contribute to policy development. However, in the realm of complex environmental controversies, the capacity of science to provide predictive information that serves the needs of policymakers has yet to be demonstrated. Predictive models are invariably fraught with assumptions, simplifications, and judgment calls introduced by the modelers themselves, who must make a trade-off between real-world complexity and scientific tractability. From a scientific perspective, such trade-offs are both necessary and justifiable, but they open the models up to debate and criticism among experts, and skepticism from nonexperts. Whether assessing the number and size of old-growth forest plots necessary to preserve the endangered northern spotted owl over the next century, or estimating the extent of global temperature rise (not to mention its regional impacts on, for example, agricultural production), the scientific methods used to generate predictions have themselves all too often become a subject of political dispute, rather than an aid to resolving dispute.[19]

PRUDISH POLITICS, PROMISCUOUS NATURE

A final reason why science might not help resolve environmental controversies is less obvious, and perhaps more intractable, than the previous arguments. One may tend to think of human values as mutable and lacking clarity, especially in contrast to the fixed scientific laws of nature, and the supposedly rational and orderly process of scientific research. Yet the basic issues at stake in political debate—allocations of power and resources; trade-offs between justice and equality, between individual and community freedoms—do not in their essence change much over time. In contrast to the rather fixed array of human concerns underlying politics, nature's richness is sufficient to provide insights that can give comfort to all sides of the typical environmental policy debate.

Science itself is spectacularly diverse. Consider a scientist engaged in research in high-energy physics as part of a large research group, dependent on the technology of a huge and expensive particle accelerator, searching for indirect evidence of fleeting subatomic particles whose existence would support a mathematically derived theoretical explanation of the fundamental structure of the universe. What does this work have in common with the activities of a field geologist, mapping in a wilderness, alone or in a small team, recording direct observational data by hand in a notebook, trying to understand the paleoecology represented in a sequence of sedimentary rocks? Everything is different about these activities—the social, physical, and institutional setting of the work, the intellectual skills and methods that are used, the role of technology and direct observation, the standards of success and reliability, the manner in which accrued knowledge will be communicated, the potential utility of this knowledge, even—especially—the mental picture of nature itself.

Distinct scientific frames of reference often lead to distinct and not necessarily reconcilable bodies of knowledge about nature. For example, a geological perspective on the history and evolution of climate change yields an entirely different set of insights from those derived from atmospheric sciences. The geological view of climate is filtered and integrated by time: Geology sees the consequences of climate—recorded in the geological record—not the causes. Geologists seek to reconstruct ancient climate patterns and trends using proxies—indirect geological indicators of climate conditions—such as isotope variations in sediments and glacial ice; changing volume and composition in the dust content of polar ice; changes in abundance and morphology of planktonic marine microorganisms; and patterns of terrestrial paleobiogeography. Such proxies yield information on characteristics such as water temperature, rainfall abundance, atmospheric carbon, and sea level, but, more importantly, they demonstrate the intimate relation among atmospheric, biospheric, and lithospheric processes over history. The geological view is necessarily integrative and retrospective; it is capable of imaging climate variability at time scales unavailable to direct observation; it recognizes the extreme contingency, and thus indeterminacy, of the dynamic atmospheric system.

In contrast, the atmospheric science view focuses on characterizing the physical and chemical state and dynamics of the present-day atmosphere, and on modeling possible future changes. Atmospheric science pursues knowledge about the climate system by investigating causal relations among the innumerable components of the system. These components, which can often be directly measured (albeit sometimes with great difficulty), include everything from moisture gradient and aerosol content in the atmosphere to heat and water fluxes at the ocean–atmosphere interface to patterns and processes of carbon sequestration. The atmospheric science view has a fundamentally reductionist and deterministic component. It is rooted in the search for causation; it seeks to combine theoretical "first principles" that govern the climate system (mathematical representations of basic physical principles) with quantified observational data to yield predictive and "retrodictive" models[20] of system evolution.[21]

Geologists struggle to piece together a historical record of atmospheric change, but there is little that they can say about causation, because the details of the complex climate system have been erased by time. Atmospheric scientists, in contrast, are awash in detailed observation and bolstered by theory, but they can never validate their models because climate is an open system, and is therefore unpredictable.[22] The views achieved by these two approaches cannot necessarily be integrated. Atmospheric models, for example, have not been able to account for rapid destabilizations of the climate system that are seen in the geologic record, and they will never predict such changes with certainty.[23] The models can only reproduce the contingent conditions that have triggered such rapid change in the past if the scientists who design the models make ad hoc assumptions about the future—assumptions that would undermine the scientific credibility of the models.[24]

Which view is more correct: the record of contingency and long-term indeterminacy revealed through reconstruction of past climate, or the evidence of causal relations between measurable system components determined by observation, measurement, and theory in the present? The question is meaningless; these are equally valid perspectives on nature, yielding their own sets of scientifically objective insights.

The great diversity of scientific approaches to understanding nature suggests a similar or, more likely, much greater diversity in nature itself. In other words, nature can be studied and understood by science on many levels, because nature operates on many levels. To be blunt: Despite the insistence of many scientists and philosophers that all is reducible to physics,[25] there is no empirical basis for such an assertion—the weight of evidence is thus far firmly on the other side. Although the progress of science shows that disparate activities can indeed coalesce (as spectacularly seen in the case of molecular genetics, which arose out of organic chemistry and genetics), in many other cases, once-coherent disciplines undergo an irrevocable shattering. The life sciences, for example, are clearly sundered along a line that separates reductionist, molecular perspectives (e.g., molecular genetics) from macroscopic, systemic views (e.g., ecology). The proliferation of specialty journals in the sciences,[26] in part reflecting an academic culture that rewards specialization over synthesis, must certainly bespeak, as well, of the inherent Humpty-Dumptyness of nature.

Again, consider global climate change research. The USGCCRP encompasses nearly 100 different research projects at ten federal agencies in areas ranging from "global ocean ecosystem dynamics" to "impacts of climate change on energy fluxes."[27] What is the likelihood that such a wonderfully diverse program will yield a unified picture of global climate change that can generate and support progress toward a political consensus? More likely, it will lead to numerous and perhaps conflicting perspectives that can be invoked by policymakers to support various sides of the issue and conflicting policy prescriptions.

A vivid example of this problem emerged from a recent exchange among prominent scientists concerned about climate change. The debate was triggered when a "Scientists' Statement on Global Climate Disruption" was distributed by E-mail to numerous researchers, in an effort to collect signatures prior to distribution to the media. The essence of the "Scientists' Statement" is captured in the following excerpt:

> We are scientists who are familiar with the causes and effects of the climatic disruption summarized recently by the Intergovernmental Panel on Climate Change (IPCC). We endorse those reports and observe that the further accumulation of greenhouse gases commits the earth irreversibly to further warming and to further destabilization of global climate. The risks associated with such changes justify preventive action through reductions in emissions of greenhouse gases. As the largest emitter of greenhouse gases, the United States must take leadership by fulfilling its commitment to reductions in its emissions.
>
> Global climatic disruption is under way. The IPCC concluded that global mean surface air temperature has increased by between 0.54 and 1.08 degrees Fahrenheit in the last 100 years and anticipates a further continuing rise of 1.8 to 6.3 degrees Fahrenheit during the next century. Sea-level has risen on average 4–6 inches during the past 100 years and is expected to rise another 6 inches to 3 feet by 2100. Warmer temperatures cause an amplified hydrological cycle with increased precipitation and flooding in some regions and more severe aridity in other areas. The warming is expanding the geographical ranges of malaria and dengue fever and can be expected to open large new areas to human diseases and plant and animal pests. Effects of the disruption of climate are sufficiently complicated for us to assume that there will be effects not now anticipated.
>
> Our familiarity with the scale, severity, and costs to human welfare of the disruptions that the climatic changes threaten leads us to introduce this note of urgency and to call for early domestic action to reduce U.S. emissions....28

The names of six prominent scientists appeared on the statement as initial signatories. Shortly after the statement was distributed, Tom Wigley of the National Center for Atmospheric Research, a leading climate modeler, responded by E-mail:

> While I hold the [signatories] in high regard, I do not consider them authorities on the climate change issue.
>
> Phrases like (my emphasis) "climate DISRUPTION is under way" have no scientific basis, and the claimed need for "greenhouse gas emissions (reductions) beginning immediately" is contrary to the careful assessment of this issue that is given in the IPCC reports.
>
> No matter how well meaning they may be, inexpert views and opinions will not help. In this issue, given that a comprehensive EXPERT document exists, it is exceedingly unwise for highly regarded scientists to step outside their areas of expertise. This is not good scientific practice....29

John Holdren of the John F. Kennedy School of Government, an initial signatory, responded directly to Wigley's message:

> Dr. Wigley's critique of the "6 scientists' statement" on global climatic disruption is surprising and, in all of its principal contentions, completely unconvincing....
>
> Dr. Wigley has written that he does not consider the signers of the "6 scientists' statement" to be "authorities on the climate change issue" and that "Inexpert opinions do not help." Since he is a climatologist, one supposes that he would have been at least somewhat less distressed if a statement of this sort had been issued by members of that profession. Do they hold the only relevant "expertise"? What part of "the climate change issue" is he talking about here?
>
> Understanding how the climate may change in the future, of course, depends on insights not only from climatologists but also from soil scientists, oceanographers, and biologists who study the carbon cycle; from energy analysts who study how much fossil fuel is likely to be burned in the future and with what technologies; from foresters and geographers who study the race between deforestation and reforestation; and so on....
>
> Now, as it happens, the signers of the "6 scientists' statement"—whom Dr. Wigley deems not to be "authorities on the climate-change issue" and, indeed, so "inexpert" as to render an expression of their opinion "not helpful"—include an atmospheric chemist who shared the 1995 Nobel Prize in chemistry for his work on chlorofluorocarbons and stratospheric ozone...; an ecologist widely recognized as one of the foremost analysts of the role of forests in the carbon cycle; two of the world's leading authorities on the structure, function, and vulnerability to disruption of the world's plant communities; a distinguished marine ecologist...; and (myself) an individual who has been studying for 30 years the local, regional, and global environmental impacts of the world energy system and the technical and policy options for meeting world energy needs in less damaging ways. Is our knowledge less relevant than Dr. Wigley's...to reaching a reasoned judgment on the seriousness of the climate-change issue and on what needs to be done about it? I think not.[30]

In response to this fusillade, Wigley expanded his critique in a second E-mail:

> Let me point out some specific problems with the "6 scientists' statement."
>
> 1. They state that "global climatic disruption is under way." The word "disruption" occurs on a number of occasions in the text, and in the title. In the two dictionaries I have looked at, disruption is defined as "the act of rending or bursting asunder" and "throwing into confusion and disorder."
>
> The above statement is incorrect. If you compare it with the IPCC statement that "the balance of evidence suggests a discernible human influence on global climate," you will notice a radical difference. The "6 scientists' statement" goes far beyond what IPCC says....This is not mere semantics: in issues like this, one must be very careful in one's choice of words....

> 2. They state that there is a need to produce "a substantial and progressive global reduction in greenhouse gas emissions beginning immediately"....I note that IPCC does not make any such statement and (more importantly) that the 6 scientists give no basis for their own categorical statement....
>
> 3. Item 1 [above] is in the area of climate data analysis. None of the 6 scientists has specific expertise in this area. Item 2 bridges the fields of carbon cycle modeling and economics. I do not think any of the 6 scientists have such expertise, although I admit that they, as a group, have some knowledge that impinges on carbon cycle modeling....[31]

Holdren's basic point—that climate change is the domain of many disciplines, all of which have important insights that can be brought to bear on the policy problem—is acute and indisputable, but does not overrule Wigley's argument that only climatologists can truly understand the intricacies of climate data analysis. They are talking about different things, Wigley adhering to a rather rigid definition of climate, Holdren referring in the broadest sense to the climate system and its interaction with biological and social systems. Each is an indisputable expert with an enthusiasm for brandishing his unimpeachable credentials in support of the legitimacy of his position. What, then, is a policymaker supposed to do?

7.3 AN EXCESS OF OBJECTIVITY

In other words, we are not suffering from a lack of objectivity, but from an excess of it. Science is sufficiently rich, diverse, and Balkanized to provide comfort and support for a range of subjective, political positions on complex issues such as climate change, nuclear waste disposal, acid rain, or endangered species.

This observation, if it is anything close to the mark, suggests that in the political arena, subjectivity and objectivity are not separate and immiscible realms that must always be kept apart, but rather that they are closely related attributes of any highly complex societal problem—opposite sides of the same coin. The science wars, by promoting a false distinction between "constructed" and "objective," have diverted attention from this fundamental problem. When an issue is both politically and scientifically contentious, then one's point of view can usually be supported with an array of legitimate facts that seem no less compelling than the facts assembled by those with a different perspective. In the midst of such controversy, the boundary between facts and values invariably becomes much fuzzier than we often make it out to be. The problem is not one of good science versus bad, or "sound" science versus "junk" science. The problem is that nature can be viewed through many analytical lenses, and the resulting perspectives do not add up to a single, uniform image, but a spectrum that can illuminate a range of subjective positions.

The above dialogue illustrates just this problem. To the climate modeler, a small, anthropogenic contribution to global temperature does not amount to climate "disruption," because the climate system is not fundamentally destabilized. To an ecologist, however, small temperature variations could stimulate significant changes in ecosystem function. The latter view might suggest the need for rapid policy action to control greenhouse gas emissions, even at high economic cost; the former might support a more cautious, less economically disruptive approach. Additional scientific insights add more complexity to the problem. Research on energy production shows that the United States is responsible for 24 percent of global carbon dioxide emissions.[32] This data could support the view that the nation has a responsibility to act decisively to limit emissions. Yet research on carbon cycling suggests that the United States may in fact sequester more carbon in its young forests than it emits from its massive industrial and transportation systems.[33] Such results could bolster an argument against U.S. action.

Or consider the example of acid rain. In the late 1970s and early 1980s, scientists, followed by environmental groups and the press, began reporting that acid rain was damaging many forests and lakes in the northeastern United States. Fingers were pointed at coal-burning power plants in the industrial Midwest, whose emissions were said to be the source of the problem. The politics of the controversy pitted the environmental and water quality of the Northeast against the economic health of the Midwest. Congress responded in the predictable fashion: A research program was created to determine the causes and assess the impacts of the problem, and to recommend actions—based on the science—to mitigate those impacts. Ten years and $600 million later, the National Acid Precipitation Assessment Program had generated copious quantities of excellent science on the causes and impacts of acid rain, but had failed to achieve any sort of consensus scientific view that could motivate a political solution to the problem. This failure was probably unavoidable—the issue encompasses so many different problems, from the costs of reducing power plant emissions, to the assessment of forest damage and its various causes (including natural soil acidity)—each with its attendant uncertainties—that there is simply no such thing as a "right way" to look at acid rain.[34] When a political solution was achieved, it reflected little of the knowledge gained from the research program, but instead made use of an economic tool—tradable permits for sulfur oxide emissions—that helped to allay the concerns of Midwestern lawmakers about adverse economic impacts of a more rigid emissions control scheme. Only when this political solution was implemented, as part of the Clean Air Act Amendments of 1990 (PL, 101–549) could a new role for science come into focus: to monitor the impacts and effectiveness of the policy decisions, and to provide feedback into a political process that had already decided upon a general course of action.[35]

The close linkage between the subjective and objective elements of environmental policy debate creates another, more insidious problem. If you were a policymaker, would you rather participate in a debate about the scientific aspects of a controversy, or about the interests and values that underlie the controversy? Arguing about science is a relatively risk-free business; in fact, one can simply mobilize the appropriate expert to do the talking, and hide behind the assertion of objectivity. But talking openly about values is much more dangerous, because it reveals what is truly at stake.

Again, global climate change exemplifies the point. Press coverage, congressional hearings and debate, proclamations by environmental groups and industry groups all focus on the science, and the science, as I have tried to show, can serve them all well. Hidden by this discourse are the underlying issues that drive the problem of climate change: the future economic path of the postindustrial world, population growth and distribution, patterns of land use, the distribution of wealth and resources among nations, and the vulnerability of poor nations to natural and anthropogenic hazards.

These very issues were conspicuously on display and just as conspicuously ignored in November 1998, when thousands of people converged in Buenos Aires, Argentina, to haggle over the details of an international agreement to control greenhouse gas emissions—an agreement that, even if widely adopted (which is unlikely) can make very little contribution to controlling climate change.[36]

Meanwhile, less than a week earlier and 6000 km to the northwest, Hurricane Mitch had killed more than 10,000 people in Central America while virtually wiping out the economies of Honduras and Nicaragua—impacts that could have been significantly reduced through effective emergency preparedness and land use planning. While anthropogenic climate change may or may not exacerbate the frequency and severity of future extreme weather events (a scientific question that will not soon be resolved), the indisputable fact is that such events are a historical and future reality, regardless of what climate change science reveals about their causes. But reducing the vulnerability of poor nations to natural disasters is not a politically attractive topic, and all sides of the global climate change controversy find it safer to fight over the science than the value-laden issues that the science conceals.

7.4 THE POLITICAL IMPLICATIONS OF A GEOLOGICAL VIEW OF NATURE

The prevailing mental model of how science can help resolve environmental controversies (Fig. 7.1) has intuitive appeal. Can we possibly imagine that scientific facts applied to political problems will not help to bring those problems to resolution? I have tried to show that we need to revise our intuitions, because we are demanding from both politics and science what they are least likely to deliver: rationally optimal decisions on the one hand; consensus over a diverse body of relevant facts on the other.

Our misplaced expectations for science derive in part, I believe, from an overly restrictive view of how science extracts truth from nature. This restrictive view assumes that the culmination of science is the ability to develop predictive hypotheses and theories through highly controlled experiments (real, or imagined). Experiment serves to hold nature's complexity in abeyance, so that nature can be parsed into its component parts and governing laws. This is the physics view, dominant in modern culture, and for very good reason: The character and quality of modern life are derived in no small part from the transforming impact of science and science-based technologies, which in turn reflects a perspective on nature and a method of research derived from the success of physics. But nature can be viewed from another angle that is no less scientific, which is to say, no less devoted to creating a true picture of what is really out there. This might be called the "geological view," and it recognizes that nature, as experienced by humans and as recorded in the lithosphere and cryosphere, is the evolving product of innumerable complex and contingent processes and phenomena, revealed through historical reconstruction, and through analogy with what we see in nature today.[37]

The physics view, when applied to policy-making, promises to relieve humans from responsibility by generating predictions that can dictate action. The geological view is more modest, offering insight into the importance of context and the limits of foreknowledge. The former makes freedom unnecessary; the latter renders it essential.[38]

If we look at nature from the geological perspective, then the appropriate role of science in politics may come into clearer focus. Diversity, change, and surprise are accepted as the normal state of affairs, and uncertainty is not viewed as a problem to be overcome, but instead as a reality to be embraced—a source of the richness in nature that is consistent with the human experience. From this perspective, science would not be viewed as an authoritative voice that can cure us of politics, but as a source of insight that can help us understand the inevitable constraints on our knowledge and foresight, and therefore point us toward policy approaches that favor adaptation and resilience over control and rigidity.

From such a perspective, what roles can science be expected to play in environmental policy? Of course, it can alert society to potential challenges and problems that lie ahead. In fact, the threat of stratospheric ozone depletion, acid rain, and global climate change were brought to public attention and political prominence in part through the work of scientists. But, once an environmental issue becomes politically contentious, the geological view of nature accepts that science itself can become an obstacle to action. At this point, the quest for a "rationally best" solution must be abandoned as absurd, and attention must focus on defining complex problems in ways that allow politics to arrive at solutions. Again, global climate change illustrates the point. A huge commitment of scientific, political, and diplomatic resources has been made to the negotiation of a comprehensive international treaty governing the reduction of greenhouse gas emissions. Although all parties to the debate argue that science must be the basis for action, a unified scientific view of the problem and its potential political solutions fails to emerge, and indeed becomes more elusive with time. An approach more in line with the reality of science and politics looks for areas of potential consensus centered around smaller, related or component issues—energy efficiency, pollution abatement, technology transfer, natural hazard mitigation, land use planning. Consensus—and beneficial action—in such areas is easier to achieve because it involves fewer entrenched interests, a greater degree of concreteness, a lower degree of political risk, a lower cost of action, and a reduced price to be paid in the event of inevitable mistakes.[39]

A second role for science in environmental controversies thus emerges: to help guide action *after* political consensus is attained. The standard, linear model of science and politics is thus turned on its head, as shown in Figure 7.2. Because consensus already exists, action can be taken along lines that all parties can more or less agree on—the problem of excess objectivity is at least partly allayed. Politics has been allowed to do its job, and science becomes a tool to help determine if implemented policies are working as intended and if progress is being made toward agreed upon political goals. Results from such research then can be used to refine and redesign policies and programs and assess future options. This monitoring and assessment function should form the central contribution of science to environmental policy, yet it has been severely neglected in the United States,[40] perhaps because it subordinates science to politics.

These two principal roles for science in environmental controversies—diagnosis and assessment—are consistent with a geological view of nature and eschew the unattainable goals promised by the physics view—foreknowledge and control. And in the United States there is evidence that the geological view is gradually taking hold. The

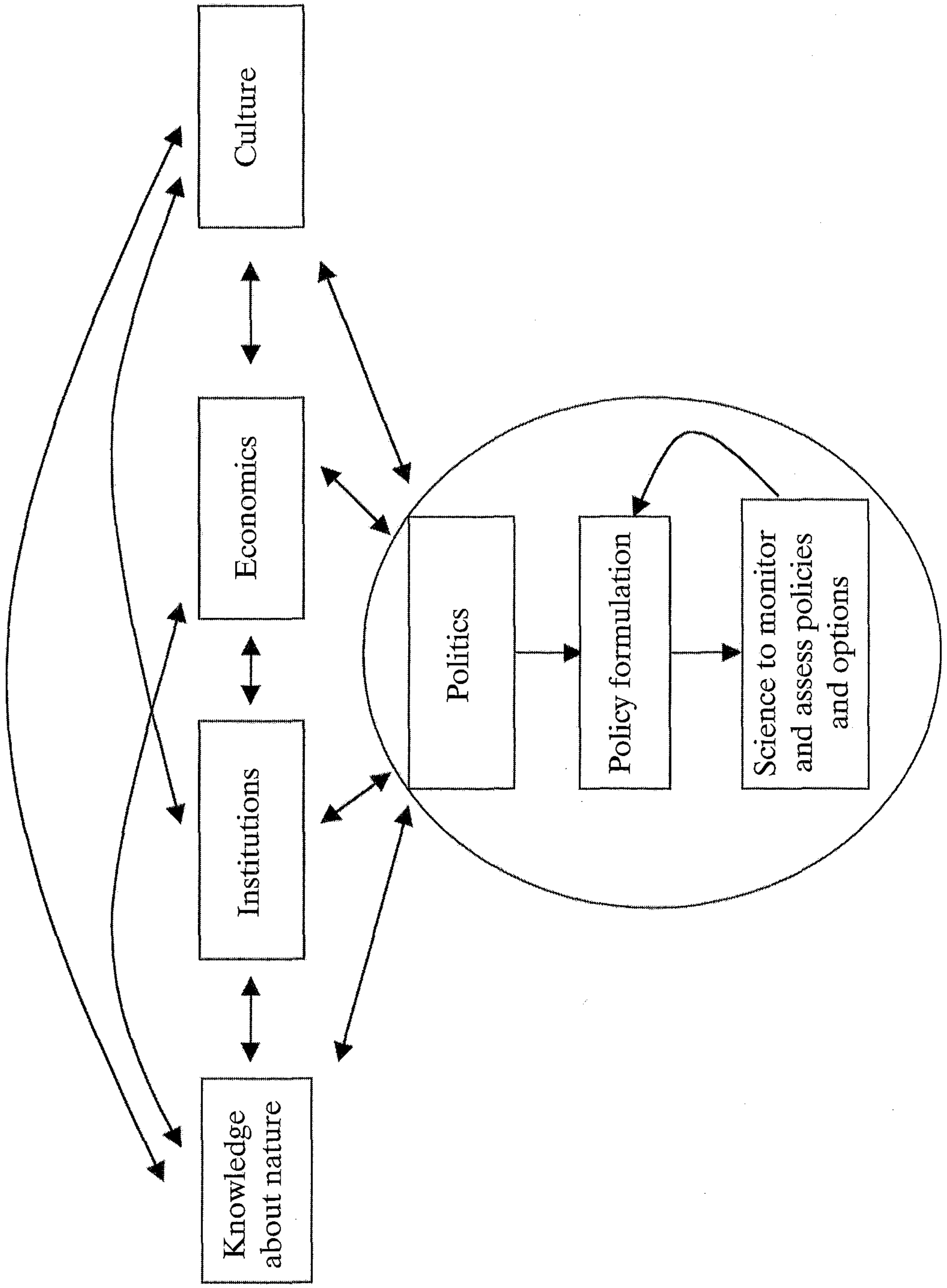

Figure 7.2 "Geologic view" of the relation among contingent variables in the search for solutions to environmental controversy. Scientific knowledge is one of many simultaneous inputs into the political process, but it cannot drive the process itself. The most important role for science comes after political consensus has been reached.

rise of participatory mechanisms for addressing environmental problems is beginning to replace top-down, command-and-control approaches that require authoritative knowledge as a precondition for action.[41] Participatory environmental decision making accepts that various stakeholders legitimately see reality in different ways; that there is no ultimate source of knowledge that can dictate the "correct" action under conditions of natural and societal complexity; and that the characterization of a problem, and consequences of any particular course of action aimed at addressing the problem, must always be uncertain. Policies are experiments; science can assess the success of the experiments and thus provide additional information that decision makers can integrate as they pursue longer-term goals. This feedback process is often called "adaptive management."[42]

In truth, adaptive management has become something of a buzzword in environmental policy circles, an idea with great theoretical appeal, much discussed and lauded but not yet proven in battle. This is not surprising. Frustration with the old approach to resolving environmental controversies demands change in the operation of political and scientific institutions—and such institutional change is always slow. A key step in this process requires the partial abandonment of a central tenet of modern society—the physics view of nature—and its replacement with a perspective that can encompass the multifaceted richness and diversity of reality as experienced by human beings—what I have here called the geological view. This view honors the reality of democratic politics and complex natural phenomena, and places science not outside this reality, but squarely within it.

NOTES

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2. Bruno Latour and Steve Woolgar, *Laboratory Life: The Construction of Scientific Facts* (Princeton, NJ: Princeton University Press, 1986), p. 275.
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4. Alan D. Sokal, "Transgressing the Boundaries: Towards a Transformative Hermeneutics of Quantum Gravity," *Social Text* 46/47 (Spring/Summer 1996): 960–968.
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8. "You Can't Follow the Science Wars Without a Battle Map," *The Economist* (December 13, 1997): 77–79.

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12. Committee on Earth and Environmental Sciences, *Our Changing Planet: The FY 1998 U.S. Global Change Research Program* (Washington, DC: Office of Science and Technology Policy, 1998), p. 32

13. "Moratorium proposed on clean air rules," *Issues in Science and Technology* (Fall 1997): 33–34; Jocelyn Kaiser, "Showdown Over Clean Air Science," *Science* 277 (July 25, 1997): 466–469.

14. See Daniel Sarewitz, *Frontiers of Illusion: Science, Technology, and the Politics of Progress* (Philadelphia: Temple University Press, 1996), pp. 89–92.

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30. May 2, 1997 message.

31. May 5, 1997 message.

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8

The Transparency and Contingency of Earth

Albert Borgmann

Albert Borgmann has been professor of philosophy at the University of Montana for more than 30 years. Stimulated by his persistent attempt to live and think in a land of high mountains and big sky, there has emerged what may be called a small Borgmann school in contemporary thought. Borgmann's work includes Technology and the Character of Contemporary Life: A Philosophical Inquiry *(Chicago: University of Chicago Press, 1984), and most recently* Holding On to Reality: The Nature of Information at the Turn of the Millennium *(Chicago: University of Chicago Press, 1999).*

The idea with which Borgmann is most often associated is the distinction between what he calls "things and devices." An archetypal thing, for Borgmann, is a wood heating stove, the function of which is clearly transparent and which easily becomes a center for human life. By contrast, the thermostatically controlled central heating system is a device that hides its inner workings and never stands out as significant in human interactions—unless, of course, it breaks down. In the world of things, humans orient themselves by realities other than themselves; in the world of devices, it is human wants and interests that come to the forefront as orienting principles, producing the consumer society.

In the essay below, Borgmann distinguishes between two tasks of geology, what he calls the "scientific" and the "disclosive." The scientific task seeks to account for geologic facts by subsuming these facts under the laws of physics and chemistry. In contrast, the disclosive task of geology seeks to reveal the ways of natural processes so that we can adjust ourselves to them, and by doing so come to be at home in the world. For Borgmann, such disclosure is fundamentally local in nature, revealed to us through understanding the characteristics of the landscape that we inhabit. Disclosure geology helps us regain a sense of reverence and depth missing in our lives.

Geology is entrusted with the study of the very ground whereon we walk; and being so fundamental a science, it is, not surprisingly, charged with basic tasks. It warns us of earthquakes. It informs us about the availability of groundwater, of fossil fuels, and of ores of various kinds. It tells us whether and how a construction site will support a building or a structure of civil engineering. These and similar responsibilities are as evident as they are crucial to our welfare. I will call them the "proximate tasks" of geology to distinguish them from the "profounder tasks" that are even more important to human well-being, if much less evident.