Eugene Skolnikoff <ebskol@mit.edu>
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THE ROLE OF SCIENCE IN POLICY: THE CLIMATE CHANGE DEBATE IN THE UNITED STATES

by Eugene B. Skolnikoff

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Climate change is on the international policy agenda primarily because of warnings from scientists. Their forecasts of a potentially dangerous increase in the average global temperature, fortuitously assisted by unusual weather events, have prompted governments to enter into perhaps the most complicated—and most significant—set of negotiations ever attempted. Key questions—the rapidity of global climate change, its effects on the natural systems on which humans depend, and the options available to lessen or adapt to such change—have energized the scientific and related communities in analyses that are deeply dependent on scientific evidence and research.

At both the national and international levels, the policy debate over climate change is unfolding rapidly. But it is also becoming increasingly mired in controversy, and nowhere more so than in the United States. This raises a crucial question: Why is it that this country—the undisputed leader of the world in science and technology—is finding it so difficult to agree on policies to address an ecological threat that, if it materializes, could have catastrophic consequences for itself and the rest of the world?

The perhaps surprising answer is that in the U.S. policy process, climate change is not now a scientific issue.1 Although much of the controversy appears to revolve around scientific principles, political and economic forces actually dominate. In a sense, this is not surprising: In dealing with possible climate change, policymakers, stakeholders, and the public have to confront competing economic interests, significant political change, and such difficult issues as intergenerational equity, international competition, national sovereignty, and the role (and competence) of international institutions.2 What are the primary factors that determine policy outcomes on this complex subject? Detailing them vividly demonstrates how scientific knowledge interacts with the formulation of policy on a significant issue in the United States.

The Policy Setting

Governments first formally addressed the issue of global warming in the Framework Convention on Climate Change (FCCC), which was negotiated at the Earth Summit in Rio de Janeiro in 1992 and subsequently ratified by 175 countries (including the United States). This agreement called for voluntary reductions in emissions of carbon dioxide and other greenhouse gases from the arbitrary base year of 1990, but there has been little response to these commitments. As a result, a process was set in motion to develop mandatory reductions. This culminated in Kyoto, Japan, in 1997, when representatives from more than 160 countries negotiated what has been called the Kyoto protocol. Under this protocol, all Annex I countries (i.e., the members of the Organisation for Economic Cooperation and Development (OECD) plus those of the former Soviet bloc) would face mandatory reductions in greenhouse gas emissions, while other countries would be encouraged to reduce their emissions but not actually required to do so. The United States would have to reduce its average emissions for the period 2008–12 by 7 percent relative to their 1990 level. The protocol targets six greenhouse gases3 for reduction, making allowance for the creation of "sinks" (such as newly planted forests) to absorb them. It also provides various "flexibility mechanisms" (emissions trading, joint implementation, and a "Clean Development Mechanism") for reducing the overall cost of emissions

reductions.4

The protocol's entry into force requires that 55 countries ratify—not just sign—it and that the emissions of these countries represent at least 55 percent of the total for all Annex I countries. As of March 1999, 84 countries had signed the agreement; however, only 7 had ratified it, which is well below the number required for entry into force. Although the United States was instrumental (at the last moment) in bringing about agreement at Kyoto, it did not sign the protocol for many months. The Clinton administration has indicated that it currently has no intention of submitting the agreement to the Senate, where the prospects for ratification are quite dim. Many key issues remain unresolved, including the sinks, the various trading ideas, the Clean Development Mechanism, noncompliance procedures, and financial assistance to developing countries. These issues were discussed at a preparatory meeting in Bonn in June 1998 and at the Fourth Conference of the Parties to the FCCC in Buenos Aires in November 1998. No formal agreements have yet been reached, however, and the issues will require further consideration at future Conferences of the Parties. (An analysis of the outcome of the Buenos Aires meeting and subsequent discussions is forthcoming in Environment.)

The Role of Scientific Evidence

Of the many factors that can affect the role scientific evidence plays in questions of public policy, six appear to be most important in the case of climate change: the uncertainty of the scientific evidence; the structure of government; debatable economic assessments; the international framework; the media; and partisan politics. Although they are all significant, the uncertainty of the evidence on this issue permeates all the others.

Uncertainty

At its core, the climate change issue hinges on scientific evidence and forecasts. To date, there has been no conclusive demonstration that global warming is occurring. Rather, the entire subject is on the world's agenda because scientists have forecast that such warming will occur if the greenhouse gases produced by humans continue to accumulate as they have since the beginning of the Industrial Revolution. Concerns grew when a series of hot summers in the 1980s and 1990s appeared to the public to confirm these forecasts, and continuing assessments by the Intergovernmental Panel on Climate Change (IPCC) have strengthened the general perception that the phenomenon is real. In fact, the last IPCC assessment in 1995 cited the increase in the Earth's mean surface temperature and the changes in the patterns of atmospheric temperatures to justify its assertion (in its summary statement) that "the balance of evidence . . . suggests that there is a discernible human influence on global climate."5

But the evidence on climate change is not clear-cut. There is considerable uncertainty both about the basic conclusion of a demonstrable anthropogenic "fingerprint" and, at least as important, about the scale and timing of any warming that might take place. Forecasting the scale and timing of climate change is crucial to estimating its effects and assessing the resulting costs and benefits—and thus to identifying the interests that would be affected and designing measures to reduce emissions.

Such uncertainty is always a serious problem in the formulation of public policy. It gives full play to those who oppose taking corrective action, allowing them to question the legitimacy of the forecast risks and to argue that regulation may be harmful if the risks are overestimated. It also leaves the door open to alternative scientific analyses (in fact, it stimulates such analyses) by those who perceive that their interests are threatened, thus increasing the perception that the science is uncertain.

In the case of climate change, moreover, the uncertainty is not limited to the evidence on warming, as there are even greater doubts about the ecological, physical, and economic consequences of a significant change in climate. The costs of the measures to mitigate warming are equally contentious because they are affected by different assumptions about technological change, the temporal sequencing of mitigation

policies, and the basic policy framework (e.g., which countries will participate in efforts to reduce emissions and whether or not emissions trading will be allowed).

It will be a decade or more before these uncertainties are substantially reduced. In fact, for a while they may actually grow as evidence accumulates that at times seems to support one view and at other times another; as computer simulations take a larger and larger number of variables into consideration; and as the participants in the debates become more articulate in defending their positions.6 For the present, at least, the United States will find it very difficult to reach agreement on a climate change policy. Major industries have taken strong positions against ratifying the Kyoto protocol, labor unions have expressed reservations, and scientific "skeptics" have challenged the IPCC's basic position.7

Another area of uncertainty that is of central importance to this issue is the role technological change can play in reducing greenhouse emissions through increases in the efficiency of energy production and use, the development of noncarbon energy sources, and reductions in the cost of adaptation. The assumptions that analysts make about these matters are critical to their forecasts of the extent of climate change and the costs of responding to the problem. The difficulty, however, is that advances in knowledge cannot be "known" in advance. Moreover, technological change depends on policies that are explicitly designed to support research and development in both the public and private sectors. The Clinton administration has made this avenue its first response to the Kyoto commitments, proposing a 5-year, $6.3 billion program of R&D and incentives for improving the efficiency of energy production and use.8

The Structure of Government

The structure of government in the United States makes it harder for this country to reach closure on an issue with such major implications and levels of uncertainty than it is for any other industrial democracy. With a fundamental division of power between the executive and legislative branches and an adversarial approach to resolving policy differences, the government necessarily finds itself in deep conflict over any issue that touches major interests and ideologies. To compound matters, almost every agency in the executive branch has some legitimate interest in the climate issue, while most congressional committees are (or will be) involved in the debate—each with turf to defend or expand and each with a limited vision of the national interest. Moreover, as a result of the fragmented committee structure in Congress and weak party discipline, interest groups have easy access to the levers of power.

In this setting, scientific evidence has a long row to hoe to have a decisive impact on policy. Although that evidence may be crucial in placing an issue on the political agenda, or in influencing how that issue evolves as new knowledge is acquired, at any given time its role in the actual determination of policy is usually far less important than that of the political, economic, and other interests involved. Or, if the level of uncertainty is high enough, science may become the principal lever that all sides use to justify positions reached primarily on other grounds.

The problem is magnified when the issue has high visibility and the economic stakes are large, as is the case with climate change. Those who stand to lose from efforts to reduce emissions find it more acceptable to question the science than to defend their interests directly. Challenging the science is also more effective because most of the public cannot judge the attacks critically and thus can be easily misled or confused. As a result, disagreements among scientists are amplified and the science itself appears more uncertain—to both the public and Congress—than would be the case with a less prominent issue or one with fewer consequences.

Scientific analysis is likely to play a larger role in the executive branch than in Congress because the former has a formal structure for conducting analyses and determining policy choices. In addition, the White House has its own science adviser to evaluate scientific assessments and present conclusions in the highest policy councils. It would be a mistake, however, to assume that science plays the dominant role in determining an administration's position on a complex issue. Administrations do have many other factors to consider, as well as other influences on them, including pressure from industry, concerns over the state

of the economy and the public's reaction to their positions, tradeoffs with other policy goals, relations with other nations, and, not least, the need to sell a particular policy to Congress when there are many other items on the agenda. Finally, there are the partisan factors of a party's electoral prospects and personal electoral ambitions as well.

Adding substantially to the difficulties that science faces in the political arena is the fact that the benefits of present expenditures may not be realized until far in the future. No politician likes to be in the position of advocating such expenditures when there are more immediate needs to be addressed—and especially when the case for such expenditures can be challenged as "not proven."9

Congress is in an even more politicized position because it is structurally more exposed to the interests of influential stakeholders. Moreover, Congress has no adequate analytical capability of its own to assess the validity and implications of scientific evidence.10 Committees must rely on staff work and hearings to acquire and assess the knowledge produced by the executive branch and other interested parties. In such a situation, it is all too easy for individual members or their staffs (the latter of whom are often influential as a consequence of the organization and constitutional role of Congress) to judge the validity of evidence as their own politics or ideology dictate. Even highly convincing scientific cases are often overridden when important interests or influential constituents will be adversely affected.

Congress's handling of the global warming issue illustrates this only too well. The threat of higher prices for fossil fuels or regulatory measures that would force greater efficiency in energy use has led to hearings in which the selection of witnesses is heavily biased toward those who disavow any scientific basis for concern. In fact, efforts by the Clinton administration to promote mild policies that would make sense even without the threat of global warming (e.g., emissions trading and R&D to improve the efficiency of energy production and use) have been attacked as "end-runs" around the Kyoto protocol ratification process.11

Of course, those who would benefit from lower emissions of carbon or higher energy efficiency are also able to influence the policy process.12 But in a Congress dominated since 1995 by a Republican Party with a strong (even radically) conservative wing, the influence of environmentalists has been quite modest. Some manufacturing companies and trade organizations have also lobbied in favor of policy actions to limit greenhouse gas emissions,13 but their influence, though symbolically important, has been marginal so far and will remain so as long as the uncertainty about the science remains high.

The range of policy options is further constrained by the attitudes of U.S. voters, particularly their antipathy toward additional taxes. This is serious because measures to limit or reduce greenhouse gas emissions may well have to include some form of tax on fossil fuels. Even if such taxes are obscured by calling them fees or some other neutral term or offset by reductions in other taxes, they can easily be attacked in a political atmosphere in which any tax "increase" is unacceptable. Moreover, because those who would be harmed by a carbon tax are likely to be clearly focused and politically powerful while those who would benefit are widely dispersed (and the benefits themselves fairly distant), any tax proposal is doubly in danger.

The separation of powers between the executive and the legislative branches, coupled with the bicameral structure of Congress and the decentralization of authority among numerous committees, further complicates the negotiations necessary to reach agreement on a consequential issue like global warming. Moreover, the tradeoffs implicit in such negotiations may be quite different from those encountered at the international level. At Kyoto, for instance, the bargaining was over emissions commitments and flexibility mechanisms; in the United States, the debate will be over the specific measures that are necessary and their economic implications.

Given all this, it may seem surprising that the Clinton administration agreed to a cut of 7 percent in U.S. emissions by 2008–12. It did so primarily because it (and particularly Vice President Al Gore) had made a prior commitment that could not be disregarded without political cost—particularly when the international negotiating process had developed so much momentum. By the end of the Kyoto

negotiations, the administration must have calculated that it would pay a higher political price at home if it scuttled the negotiations than it would by acceding to some commitment. In addition, the Kyoto protocol provides a number of possible loopholes (e.g., additional greenhouse gases that may be included, the "purchase" of unused emission allowances from Russia, and credit for creating sinks) that may facilitate compliance when the time comes. The administration may also have been willing to take some political risks because policy action well in advance of 2008 did not appear urgent on political grounds (even though a delay will in fact make the commitment almost impossible to meet). A decade may be a short time as far as climate change is concerned, but it is an eternity in politics when there are three presidential elections along the way.

Economic Impacts

As suggested above, the economic implications of global warming and the measures that might be taken to prevent it play a central role in the politics of the issue. The key questions are the costs (to both the United States and the rest of the world) of climate change and the comparable costs of controlling or reducing greenhouse gas emissions;14 the effects on international competitiveness if the commitments made by nations are uneven (as they will be because major developing countries have not accepted binding commitments); and the effects on employment and growth in specific industries or sectors.

Unfortunately, the economic dimension of global warming is more speculative than the scientific dimension and even less amenable to convincing analysis. Even the element that is most directly tied to science, i.e., the advances in alternative energy technologies that can be expected, cannot be determined in advance. The canonical figure usually used by economists, that technological change will lead to improvements in productivity (indicated by primary energy consumption per unit of GDP) of 1 percent per year, is only an assumption made for modeling purposes. And in any case, increases in productivity depend on the extent to which resources are committed to R&D.

There have been a number of attempts to analyze the economic costs of global warming and to design policies to minimize them.15 These analyses are necessarily based on a variety of assumptions and estimates that by their very nature are uncertain. They have also tended to support policies that are desirable from an analytic standpoint but questionable politically. For example, most analyses suggest that an efficient emissions trading system would minimize the cost of reducing greenhouse emissions over the next century. But the likelihood of creating even a marginally satisfactory trading system—let alone an optimal one prior to 2008—is slim indeed. The conditions that would have to be met (e.g., agreement on national caps on emissions, an effective emissions monitoring capability, and an initial allocation of permits that would appear to reward existing patterns of consumption, among others) would not only be difficult to negotiate but in many cases politically inflammatory as well.

Even with a strong economy and low fuel prices, neither the Clinton administration nor Congress (nor the public, for that matter) wishes to adopt policies that might dampen growth when there is no evidence of an imminent ecological crisis. As far as the politics of the issue is concerned, it is irrelevant whether mitigation measures would entail only minor economic costs in the long run (and possibly benefit some sectors); whether the policies would apportion the burden equitably; and whether additional tax revenues would be used to offset other taxes. Because such measures appear to endanger the present economic prosperity (or can easily be made to), it is difficult for a politician to press for them without convincing evidence of imminent danger.

Further bedeviling the issue is the fact that fossil fuel prices have fallen steadily in recent years due to a worldwide glut of oil and (after adjustment for inflation) are now about what they were at the time of the oil shocks in the 1970s. Low prices, of course, simply encourage consumption of these fuels, which are the major source of anthropogenically produced carbon dioxide. Higher fossil fuel prices, which would be achieved by the imposition of a carbon tax, would both reduce consumption and create incentives for

improving energy efficiency throughout the economy. But in the current political climate, such a policy is politically unthinkable whatever its merit.

The United States' Inward Focus

Climate change is a quintessentially global problem, and in many ways the international response to it has been astonishing. In a relatively short time, the nations of the world have created an organizational structure to deal with this problem, launched a massive scientific assessment effort, and negotiated binding emissions reduction targets and timetables. A whirlwind of further study, meetings, and negotiations is now under way. At the same time, however, several of the international aspects complicate the debate within the United States.

One of the most contentious issues is the role of developing countries. It is clear that some of the larger ones, especially China, Brazil, India, and Indonesia, will become major emitters of greenhouse gases as their economies grow. Yet the Kyoto protocol specifically exempts all developing countries from binding emissions reductions. That exemption was agreed to in 1995 when the Berlin mandate (the negotiating process that led to the Kyoto protocol) was adopted. Its purpose was to place most of the responsibility for reducing emissions on the richer countries that had created the problem in the first place. However, without commitments from the developing countries, opponents of the Kyoto protocol can easily argue that the agreement means little and would unfairly penalize U.S. companies and workers. The Senate— which will have to ratify the protocol—has already passed a resolution (by a vote of 95 to 0) stating that the president should not submit the treaty for ratification unless it "also mandates new specific scheduled commitments to limit or reduce greenhouse gas emissions for Developing Country Parties within the same compliance period."16

Perhaps the most disturbing hindrance to international action on climate change is the reluctance of the United States to participate in any effort in which the United Nations (UN) and other international bodies will play a central role. In recent years, there has been a growing climate of xenophobia in Congress, which is partly reflected in the electorate and which is challenging the role of the nation in world affairs and particularly the work of the UN and organizations such as the World Bank and the International Monetary Fund. Although the mindless fears of UN "black helicopters" are an extreme example, a vocal portion of the public is turning away from international efforts unless they are U.S. led and rejecting policies that they perceive as in any way infringing U.S. sovereignty. In this context, any agreement negotiated under the auspices of the UN that would affect the U.S. economy is immediately suspect. The scientific evidence is of little moment in this situation, especially as one cannot claim that without an agreement ecological disaster is certain.

These international issues can overshadow the science because the Kyoto protocol may in fact be a flawed approach to the threat of global warming. The agreement sets a target the United States will almost certainly be unable to meet, especially given the increased emissions resulting from the country's robust economic growth since 1990. By focusing attention on near-term targets, the protocol detracts from the essential task of creating the institutions and policies that will be necessary to meet a century-long goal that includes determining an acceptable final concentration of carbon dioxide in the atmosphere, establishing a trading system that will minimize costs, mounting a sensible R&D program, and finding ways to enlist developing countries.17 These and other tasks will take time and experimentation to bring to fruition; failure to meet the rather arbitrary and costly goal of reducing emissions in 10 years may well undermine the long-term effort to curb emissions.

The United States agreed to the negotiations that led to the Kyoto protocol even though the ground rules were clearly deficient.18 Now there is the danger that the whole international process will be tainted by the unrealistic actions of its supporters as well as its opponents. If the United States refuses to ratify the protocol—or cannot fulfill the commitments that it made under it—the resulting disillusionment could severely impede the development of the international structure that may well prove to be essential in

the next century.

The Media

The way the media presents an issue is at least as important to public attitudes as scientific evidence and economic analyses. The media prefers issues that are either controversial or apocalyptic, and global warming can fit both criteria. Hence, the largely empty debate between the small band of climate "skeptics" (who are certain that climate change is not a threat) and most of the scientific community receives substantial press. This implies that there is something of a standoff between the two sides, a considerable misreading of the actual situation. In the same vein, unusual weather events tend to receive a lot of attention, the implication being that global warming is beginning or, if temperatures are abnormally low, that the theory is not valid. In both cases, the implied conclusions are an artifact of the way the media handles the issue rather than a true reflection of the scientific evidence and debate. This is hardly surprising, as the evidence is fuzzy and most reporters are not able to evaluate it critically.

In this situation, the public cannot help but be confused,19 and all the more so when the information presented by the media is used to support the differing positions of different groups. Without more clear-cut scientific evidence, this is simply unavoidable. Unfortunately, the science of climate change will not be sufficiently certain to short-circuit these divisions for many years into the future.

The other side of that coin, however, is that severe climatic events may lead to public acceptance of the reality of global warming whether or not those events are actually related to such warming. For example, the very destructive El Niño events of 1997–98 had such an effect even though El Niños long predate global warming. The succession of 100° F days that occurred in Texas in the summer of 1998 may be taken as another indicator that global warming is real. In any case, it will probably take a catastrophic ecosystem event that can readily be linked to global warming to lead to public support for policies to reduce greenhouse emissions. Otherwise, the debate in the United States is likely to turn not on the science but on the myriad other issues raised by the subject.

Partisan Politics

Finally, partisan politics is of central importance to the way in which science influences climate policy. The Republicans in Congress tend to see global warming as a Democratic issue, even though it was first placed on the agenda by the Bush administration. In particular, they associate it with Vice President Al Gore, who wrote a well-known book on the subject when he was a senator and who—not irrelevantly—may be the Democratic candidate for president in 2000.20 This situation is ready made for a partisan conflict in which the Republicans emphasize the social and economic costs of the Kyoto protocol while the Democrats play those costs down. The uncertainty of the scientific evidence makes it easy for both parties to take their respective tacks; in fact, it has led the Clinton administration to exaggerate the impending danger to make its case for early action.21

Though much of the debate appears to turn on the scientific evidence, this is largely a convenient cover for the pursuit of political goals. In fact, the issue of climate policy is likely to be pressed by the more conservative elements of the Republican Party because it offers many opportunities to exploit public opposition to new taxes and the export of jobs as well as its desire for smaller government and a minimal role for the United Nations.

The Clinton administration will find it very difficult to persuade the Senate to ratify the Kyoto protocol. The task will not be made any easier by the disproportionate number of senators from states rich in natural resources. In fact, the administration will probably not even submit the treaty until after the presidential election of 2000, even though the congressional elections of 1998 may actually have improved the prospects for ratification. (Although the party lineup in the Senate remained unchanged, two prominent Republican opponents—Lauch Faircloth (N.C.) and Alphonse D'Amato (N.Y.)—were defeated.)

Thus, the treaty will remain prominently on the agenda well into the future, masquerading as a scientific issue though in fact an integral part of long-standing political controversies.

Conclusion

Global warming is an issue with potentially enormous environmental, political, and economic consequences that was put on the national and international agendas by scientists. It has stimulated an intense international process of institution building, interaction, and negotiations on the part of governments, their citizens, and the United Nations. Yet in the United States, it has become entwined in internal political and economic debates made possible by the degree of uncertainty surrounding the science. As long as that uncertainty persists, other factors will bedevil efforts to agree on a policy direction.

The uncertainty does not have to be removed entirely to permit a new political consensus to be attained, however. Continuing research on the forces at work, the indicators of climate change, and the available policy options is essential and it should gradually lead to greater knowledge about the issue and the development of real policy choices. However, in a situation that is so dominated by extraneous pressures, it is especially important that the scientific and engineering communities (including economists and other social scientists) maintain their professional integrity and objectivity.

Maintaining objectivity—and the perception of it—is often not as easy as it sounds. Many scientists are tempted to intervene in the policy arena because of their personal views about climate change. Although it may be appropriate for some to do this, one cannot overstate the importance of maintaining a credible scientific basis for policy measures and their acceptance by the public. At a time when many argue that the scientific community should play a greater role in this and other policy matters, it is critical that the scientific community remain objective and not slant its results according to personal prejudices. This applies not only to individual scientists but also to endeavors such as those being carried out by IPCC. The somewhat sloppy procedure for drafting the "Summary for Policymakers" in the second IPCC assessment, in which the summary appeared to go beyond the report without adequate review, allowed accusations of bias to be made. This must not be allowed to recur;22 the stakes are simply too large.

In the end, a growing scientific consensus will be only one factor in eventually achieving a political consensus on climate policy. A crisis that can plausibly be linked to global warming, such as the El Niño events of 1997–98, the heat wave and floods in Texas, and the damaging hurricanes of the 1998 season, will probably be equally important. Though none of the events that have occurred so far has been devastating enough to shift public opinion, a more dramatic one, such as a major shift in the climate of northern Europe, could do so, especially if the media were to link it forcefully to climate change. In time, a succession of less spectacular events, such as hot summers accompanied by more numerous and intense storms, might also convince the public that the issue cannot be ignored even if addressing it will be costly.

Whether the body politic comes to understand the climate change issue through the gradual emergence of a scientific consensus or through environmental crises, the research must continue and it must be adequately communicated to both the public and policymakers—designing and implementing the policy measures that may be necessary depend on it. This implies not only continuing study of the fundamental phenomenon of climate change but also of the effects of that change, ways to reduce emissions at minimum cost, and (because there will be a substantial accumulation of greenhouse gases in the next century whatever actions are taken) the options that are available to adapt to climate change. It will greatly ease the political difficulties of taking action if there are policy options that will reduce the costs both generally and to the major stakeholders.

The menu for the scientific and technological communities is large, even if at present political factors dominate the issue. Eventually, however, the work of these communities will provide the necessary underpinnings for policy decisions. But it is important not to assume that current research and analysis will automatically determine policy. They will enrich the debate, to be sure, but that debate will hinge on a

different calculus for some time to come. Disillusionment with this situation is not useful; realistic assessment of the role of knowledge is.

Eugene B. Skolnikoff is an emeritus professor of political science at the Massachusetts Institute of Technology (MIT) in Cambridge, Massachusetts. This article was written in conjunction with MIT's Joint Program on the Science and Policy of Global Change. The author may be contacted at the Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139-4307 (telephone: 617-253-3140; e-mail: ebskol@mit.edu).

Notes

1. In this article, the term science refers only to the physical sciences, not to economics and other social sciences.
2. See E. B. Skolnikoff, "The Policy Gridlock on Global Warming," *Foreign Policy* 79 (1990): 77.
3. Carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.
4. See L. D. D. Harvey and E. J. Bush, "Joint Implementation: An Effective Strategy for Combating Global Warming?," *Environment*, October 1997, 14; and J. Lanchbery, "Expectations for the Climate Talks in Buenos Aires," *Environment*, October 1998, 16.
5. J. T. Houghton et al., eds., *Climate Change 1995: The Science of Climate Change, Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change* (New York: Cambridge University Press, 1996), 5. A review of this report by William C. Clark and Jill Jäger appears in the November 1997 issue of *Environment*.
6. Even if the uncertainties were less pronounced, the issue would still raise the difficult ethical questions of intra- and intergenerational equity, which are highly charged politically.
7. For a typical example of industry's reactions to the Kyoto protocol, see J. M. Broder, "Auto Makers See Nothing but Trouble in a Warmer World," *New York Times*, 16 October 1997, 19. Some companies, however, have responded more positively. See, for example, the full-page ad entitled "It's Time to Step Up to the Plate on Climate Change" that the Business Environmental Leadership Council ran in the national weekly edition of the *Washington Post* on 9 November 1998 (page S6). The council has 18 members, including such major corporations as BP America, DuPont, and Boeing. One attempt to discredit the IPCC's conclusions was rather astonishing in its brazenness: A former president of the U.S. National Academy of Sciences distributed an article appearing to be a reprint from the Academy's highly respected, peer-reviewed journal that debunked the scientific basis of global warming. In fact, the article had never been peer-reviewed or even submitted for publication. The current president of the Academy severely criticized this move.
8. Council of Economic Advisors, *The Kyoto Protocol and the President's Policies to Address Climate Change: Administration Economic Analysis* (Washington, D.C., 1998), 7.
9. Benefit-cost analysis compounds the problem of justifying current costs by means of future benefits because it discounts values that occur in the future. For more details, see S. Farrow and M. Toman, "Using Benefit-Cost Analysis to Improve Environmental Regulations," *Environment*, March 1999, 12.
10. Congress's most authoritative research arm, the Office of Technology Assessment, was abolished in 1995, and the other support agencies (the Congressional Research Service, the General Accounting Office, and the Congressional Budget Office) are not well suited to provide in-depth analysis on scientific issues.
11. U.S. House of Representatives, Government Reform and Oversight Committee, Subcommittee on National Economic Growth, Natural Resources, and Regulatory Affairs, "McIntosh to Monitor Clinton Regulatory 'End-Run' on Kyoto," press release, 2 March 1998.
12. For them, the scientific evidence is already compelling enough to justify a precautionary approach involving strong measures to reduce greenhouse gas emissions. Several major European countries have

taken that position, at least rhetorically. See E. B. Skolnikoff, Same Science, *Differing Policies: The Saga of Global Climate Change, MIT Joint Program on the Science and Policy of Global Change*, Report No. 22 (Cambridge, Mass., 1997).

13. Business Environmental Leadership Council, note 7 above.

14. See H. D. Jacoby, R. G. Prinn, and R. Schmalensee, *The Road from Kyoto*, MIT Joint Program on the Science and Policy of Global Change, Report No. 32 (Cambridge, Mass., 1998), 3.

15. There is a large and growing literature on the economics of climate change. One of the best analyses is A. S. Manne and R. G. Richels, *Buying Greenhouse Insurance: The Economic Costs of CO2 Emissions Limits* (Cambridge, Mass.: MIT Press, 1992). See also W. D. Nordhaus, *Managing the Global Commons: The Economics of Climate Change* (Cambridge, Mass.: MIT Press, 1994); and H. D. Jacoby et al., "CO2 Emissions Limits: Economic Adjustments and the Distribution of Burdens," *Energy Journal* 18, no. 3 (1997).

16. Expressing the Sense of the Senate regarding the Conditions for the United States Becoming a Signatory to Any International Agreement on Greenhouse Gas Emissions under the United Nations, 105th Cong., 1st sess., S.R. 98.

17. For a balanced view of the problems that the Kyoto approach may lead to, see H. D. Jacoby, R. G. Prinn, and R. Schmalensee, "Kyoto's Unfinished Business," *Foreign Affairs*, July/August 1998, 54.

18. The countries in the European Union pushed hard for the process, taking positions determined more by internal politics and economics than by realistic environmental concerns. In doing so, they engaged in a good deal of posturing, knowing that the United States would save them from having to actually achieve the substantial emissions reductions that they first proposed. In the long run, however, this may well set back rather than advance their avowed goals. See Skolnikoff, note 12 above.

19. See W. Kempton, "How the Public Views Climate Change," *Environment*, November 1997, 12.

20. A. Gore, *Earth in the Balance: Ecology and the Human Spirit* (Boston, Mass.: Houghton Mifflin, 1992).

21. As one congressional staffer noted, "The reality is that anything with Gore's name on it is dead on arrival up here." C. Macilwain, "Gore Calls for Action on Climate Change as Congress Stalls," *Nature* 394 (23 July 1998): 305. In the same article, Gore was quoted as saying (in reference to the heat wave in Texas and forest fires in Florida) that "[t]he evidence of global warming keeps piling up."

22. See E. Masood and A. Ochert, "UN Climate Change Report Turns Up the Heat," *Nature* 378 (9 November 1995): 119.