ENDNOTES AND FURTHER READING

The Energy-Climate Challenge, John Holdren

1. In the early 1990s, a former member of the Council of Economic Advisors asserted to the contrary, that the U.S. economy cannot be very vulnerable to climate change because only 3 percent of the country's gross national product (GNP) depends on the environment. This member was apparently referring to the share generated by agriculture, forestry, and fishing. But in a fundamental sense, GNP all depends on the environment. The economist's assertion is akin to claiming that human beings should not worry about heart attacks insofar as the heart constitutes only 2 percent of the body mass.

2. World use of primary energy forms in 1998 amounted to 440 exajoules (EJ) (1 EJ = 1018 J = 0.95 quadrillion Btu = 22 million tons of oil = 33 million tons of UN standard coal). Of this total, 35 percent came from oil, 23 percent from coal, and 20 percent from natural gas—a total of 78 percent from fossil fuels. Nonfossil contributions were principally 13 percent from biomass fuels (fuelwood, charcoal, crop wastes, dung, and biomass-derived alcohol), 6 percent from nuclear energy, and 2 percent from hydropower. Renewable sources other than biomass and hydropower—notably geothermal, wind, and solar energy—contributed altogether less than 0.5 percent. In the United States, the 1998 primary energy supply of 100 EJ was derived 38 percent from oil, 24 percent each from coal and natural gas, 8.2 percent from nuclear energy, 3.8 percent from biomass, 1.2 percent from hydropower, and 0.4 percent from other renewables.

3. The scenario described here closely resembles scenario IS92a from the 1995 second assessment by the Intergovernmental Panel on Climate Change (IPCC), which was a middle-of-the-road scenario in that study and has been widely employed as a reference case in energy/climate discussions since. Scenarios are not predictions; they serve only to illustrate the consequences of the stated assumptions about the evolution of the contributing factors.

4. Atmospheric particulate matter cools the Earth's surface in some circumstances and warms it in others. The uncertainties associated with these complicated phenomena are considerable, and the investigation of the details—including the prevalence of particulate-warming circumstances versus that of particulate-cooling circumstances—is a vigorous focus of current research. A global-average net cooling effect of the magnitude indicated here was the best estimate of the 1995 assessment of IPCC.

5. This approach tends to underestimate the expected future warming insofar as the most likely deviation from its assumptions is a more rapid decline in particulate concentrations than was assumed as a result of more aggressive programs to control emissions of particulate matter and its gaseous precursors (mainly oxides of sulfur and nitrogen). The dilemma here is that better control of conventional pollutants makes the problem of greenhouse gas-induced climate change worse.

6. That is, the debate among respected analysts. There will always remain a few credentialed skeptics, as there are on such questions as whether cigarette smoking causes lung cancer. This is in the nature of science and the distribution of human characteristics among those who practice it. But the very small and continuously diminishing possibility that the dissidents are right cannot be given much weight in prudent public policy.

7. This means the dissidents have two difficult questions to answer: First, what is the alternative culprit that would account for the observed pattern of effects? Second, how can it be that the measured increase in greenhouse gas concentrations is not causing the pattern of effects that climate science predicts for it (because, by the dissidents' postulate, something else is causing this)? See, for example, Intergovernmental Panel on Climate Change, Climate Change 1995—The Science of Climate Change (U.K.: Cambridge University Press, 1996).

8. National Research Council, Reconciling Observations of Global Temperature Change (Washington, D.C.: National Academy Press, 2000).

9. S. Levitus, J. Antonov, T. Boyer, and C. Stevens, "Warming of the World Ocean," Science 287 no. 5,461 (2000): 2,225-29.

10. It is true, as climate change skeptics are fond of pointing out, that there is considerable natural variability in global climate (arising, for example, from variations in solar output, cycles in the Earth's orbital parameters, and "internal" climate-system oscillations involving the interactions of ice, oceans, and atmosphere). But the size of the climate change "signal" that has emerged over the last few decades from the "noise" of natural variability is large, and, as indicated in the text and in note 7 above, it fits too well the pattern expected from greenhouse gas-induced warming to be plausibly attributed to a hitherto unsuspected and undetected natural cause.

11. These figures take the realized temperature increase from pre-industrial times to 1990 to be 0.5 degrees C. The increase projected between 1990 and 2070 under the BAU scenario is 1.3 degrees C and that between 1990 and 2100 is 2 degrees C.

12. The seeming paradox of having more droughts as well as more floods is explained by the fact that, although a warmed world generates more precipitation with a larger part of it concentrated in extreme events, it also produces greater evaporation and hence more rapid drying out of the soil between precipitation events.

13. The agricultural projections in the IPCC assessment and subsequent ones, such as the recently released draft U.S. National Assessment of Climate-Change Impacts on the United States, are based on analysis of the effects of temperature, moisture, and increased CO2 (which is a plant nutri-

ent) only. They do not account for ecological effects, such as from changes of conditions favorable to plant pests and pathogens. When these ecological factors are taken into account, it seems likely that the net assessment of climate-change effects on agriculture will change from "better in some places, worse in others, balancing out on average" to "more harm than good."

14. The focus of the climate-science community and its literature on the consequences of a doubling, which resulted from an agreement to standardize analyses for the purpose of comparison rather than from any conviction that no more than a doubling is likely, seems to have deflected attention from the full implications of business-as-usual, which would carry the world past any realistic possibility of avoiding a tripling if it persisted through 2075 and past any realistic possibility of avoiding a quadrupling if it persisted through 2100.

15. The heat index combines temperature and humidity into a single measure of discomfort in hot weather. The figures given are 24-hour, 30-day monthly averages. The best way to make these numbers meaningful is to associate what you know to be the current Washington, D.C. climate in July with the figure 86 and then imagine what 109 would mean. See Geophysical Fluid Dynamics Laboratory, "Climate Impact of Quadrupling Atmospheric CO2," available at http://www.gfdl.gov/~fk/climate_dynamics/.

16. The Princeton group only calculated the sea-level rise from thermal expansion, considering that the then-current models were not capable of a credible calculation of the contribution from melting from the Greenland and Antarctic ice sheets.

17. This could also be achieved with other combinations of energy-intensity and carbon-intensity reductions, as long as the century-average reduction rates for the two ratios add up to 2.6 percent per year. Thus, instead of a 2.0 percent per year decline in energy intensity and a 0.6 percent per year decline in carbon intensity, one could do the same job with an energy intensity decline averaging 1.6 percent per year and a carbon intensity decline averaging 1.0 percent per year.

18. To pick but one item on this list for brief elaboration, the vulnerability of air travel to increased summer storminess (a likely consequence of warming and the more vigorous hydrologic cycle that goes with it) should be apparent to anyone who attempted much flying in the summer of 2000.

19. Ending deforestation and improving other land-management practices to reduce greenhouse gas emissions from the managed lands are, of course, forms of emissions control rather than means of removing greenhouse gases that are already in the atmosphere. But the effect is the same, and it is customary for obvious reasons to treat all of the land-use approaches to carbon management together.

20. It is conceivable that another 10 percent could be achieved by fertilizing the oceans to increase the amount of carbon stored in plant material there. But the biology involved is much less well understood than for terrestrial ecosystems, and the chance of unanticipated and unwanted side effects is correspondingly higher.

21. The details of the research programs that need to be pursued under these headings are abundantly spelled out in reports generated over the past few years by IPCC, the U.S. Global Change Research Program, and the U.S. National Academies complex, among others.

22. The merits and demerits of many of these approaches were treated in the two studies of energy strategy conducted by the President's Committee of Advisors on Science and Technology in the second term of the Clinton administration—Federal Energy Research and Development for the Challenges of the Twenty First Century (November 1997), available at http://www.whitehouse.gov/WH/EOP/OSTP/Energy/ and Powerful Partnerships: The Federal Role in International Cooperation on Energy Innovation (June 1999), available at http://www.whitehouse.gov/media/pdf/p2E/pdf—both available from the Office of Science and Technology Policy in the Executive Office of the President.

23. At least one well regarded economic model—that of Dale Jorgenson of Harvard University—indicates that a revenue-neutral carbon tax, wherein the revenues were used to reduce income and capital-gains taxes, would lead in the United States not only to a reduction in CO2 emissions below business-as-usual but to an increase in GDP compared to the reference (no carbon tax) case. This means that the benefits to the economy from reduced income and capital-gains taxes outweighed the damage to the economy from increased energy costs. See D. Jorgenson and P. J. Wilcoxen, "The Economic Effects of a Carbon Tax," in H. Lee ed., Shaping National Responses to Climate Change (Washington, D.C.: Island Press, 1995), 237–60.

24. A carbon tax of $20 per ton would add 5.5 cents per gallon to the price of gasoline (an increase of about 3 percent on a market price of $1.70 per gallon for regular unleaded); 32 cents per million Btu to the price of natural gas (an increase of about 5 percent on a market price of $6 per million Btu for residential gas); and $11 per short ton to the price of electric-utility coal (an increase of 28 percent on a market price of $40 per short ton). The increment on the price of natural gas would add 0.2 cents per kilowatt hour (kWh) to the 3.5 cents per kWh cost of electricity generation using natural gas in a combined-cycle power plant operating at 50 percent thermal-to-electric efficiency, and the increment on the price of utility coal would add 0.6 cents per kWh to the 6 cents per kWh cost of electricity generation with a conventional pulverized-coal power plant operating at 36 percent efficiency. But the one-tenth of the $30 billion per year total revenue from this tax that would be allocated, by hypothesis, to additional incentives for low-carbon energy choices would be five times larger than the $600 million per year in such incentives proposed in the Clinton administration's initial Climate Change Technologies Initiative.

25. President's Committee of Advisors on Science and Technology, Panel on Energy Research and Development, Federal Energy Research and Development for the Challenges of the Twenty-First Century (Washington, D.C.: Executive Office of the President of the United States, November 1999).

26. The principal recommended increases were (in descending order) in efficiency, renewable, and nuclear (fusion and fission) technologies; recommended initiatives in the fossil category, while they included increases for work on fuel cells, advanced coal technologies, and carbon capture/sequestration technologies, were largely offset by recommended phaseouts. The bipartisan panel that produced these recommendations contained experts in the full range of energy sources—from the private sector as well as from the academic and NGO communities. Its conclusions were all unanimous. Federal Energy Research and Development for the Challenges of the Twenty-First Century, note 25 above.

27. President's Committee of Advisors on Science and Technology, Panel on International Cooperation in Energy Research, Development, Demonstration, and Deployment, Powerful Partnerships: The Federal Role in International Cooperation on Energy Innovation (Washington, D.C.: Executive Office of the President of the United States, June 1999).

28. Most of the multi-hundred-billion dollar per year energy-supply-technology market is outside the United States—and increasingly in developing countries—and this will become even more true as the century wears on.

29. The United States was contributing about one-quarter of worldwide fossil-CO2 emissions at the end of the 20th century, while other industrialized countries contributed about one-half and developing countries the remaining quarter. In a BAU energy future, however, developing countries will become equal to the industrialized ones as emitters of fossil-fuel-derived CO2 by around 2030 and will increasingly dominate global CO2 emissions thereafter.

30. Climate Change Secretariat, UN Framework Convention on Climate Change (Geneva: UN Environment Programme Information Unit for Conventions, 1997).

31. This does not mean that per-capita emissions in all industrialized countries would necessarily have fallen this far by 2035 or that per-capita emissions in all developing countries would necessarily have risen this far; but, under a cap-and-trade scheme, the industrialized countries that had not gotten this low would need to buy emissions permits from the developing countries that had not gotten this high.

Controlling Emissions of Greenhouse Gases, David G. Victor

1. Most adaptation will occur within nations, but some international coordination is needed—for example, nations must work together to plan adaptation within international river basins. In addition, programs are needed to ease adaptation in developing countries, which bear little responsibility for climate change yet are generally more vulnerable to changing weather and less able to pay the costs of adaptation.

2. The most important arbitrary parameter in calculating GWPs is the "time horizon." Different values for the time horizon could raise the GWP for methane to 60 or reduce it to less than

7, with enormous consequences for where the economy focuses mitigation of greenhouse gases. There are no criteria for choosing a time horizon, so most scientists and diplomats choose 100 years for the same reason that Goldilocks made all the middle choices—of the three time horizons that are typically reported, 100 years is longer than 20 years and shorter than 500 years. A better system would compute the value of GWPs according to the goals of the climate treaty and the scenario for future emissions. If the world were approaching a particular goal then the value of short-lived and strong greenhouse gases (e.g., methane) would rise because controls on those gases would have a strong and immediate effect on the climate; if goals are more distant then long-lived gases (notably CO2) would become relatively more important because the short-term effects of short-lived gases do not matter. The point is simply that the GWP should not be treated as purely a geophysical concept. Rather, it should be adjusted to the political goals and the economic context for achieving those goals.

3. On average, U.S. emissions of carbon dioxide have risen 1% to 1.5% per year since the end of the 1991 recession. In 1998 emissions rose only about 0.1%, which led some analysts to conclude that the "new economy" was rapidly decoupling wealth from energy consumption and therefore it would be relatively easy for the United States to comply with the Kyoto targets. In reality, the slow growth in emissions for 1998 was the consequence of an unusually warm winter that reduced demand for heating; preliminary data for 1999 show a rise in emissions of about 1%, which is consistent with the historical rate. Indeed, the economy is slowly decoupling from fossil energy—economic growth of about 3% per year causes a rise in greenhouse gas emissions of only about one-third that amount. However, the decoupling process is slow and will not deliver much change by 2008; nor has it fully decoupled industrial wealth from emissions. Some new wealth goes to airplane trips, gas guzzling cars and other activities that cause emissions—the "new" economy has not eliminated old pleasures and needs.

4. Critics of this suggestion will argue that industrialized nations have already tried (without success) the nonbinding approach starting in 1988 with the nonbinding "Toronto Target" that urged countries to cut CO2 emissions 20% by 2005. But the Toronto Target was not a serious effort. Rather, the Toronto target was a symbolic goal invented with no attention to whether it was feasible—no advanced industrialized country has come close to achieving the Toronto limits. Nor did the Toronto conference include any effort to follow-up targets with plans for action and periodic reviews of those plans—yet experience in other areas of international environmental cooperation (e.g., the successful effort to clean up the North Sea) show that ambitious nonbinding plans work best when they are followed by serious efforts to develop national action plans and to review implementation of those plans.

5. Tackling these technical problems will also reveal that it is especially difficult for developing countries to make legally binding commitments to cap their emissions of greenhouse gases at particular levels—the approach taken in the Kyoto Protocol—because the development process is somewhat unpredictable and leads to unpredictable levels of greenhouse gas emissions. Instead, it would be better to codify commitments in terms that correspond more closely with the levers that

policy makers actually control—for example, targets could be set for improving energy efficiency, which can be measured as the ratio of energy consumption to economic output. By that measure, China is already making rapid improvement, but efficiency in Brazil and India is more stagnant.

6. We could make these property rights more secure by linking them with other benefits in the international system. For example, we could attempt to link compliance with the emission trading system with the benefits of the WTO. However, doing so would raise many problems—it could severely harm the WTO's mission of liberalizing trade, and it would encounter blistering opposition from developing countries who are already wary of efforts to link the WTO with environmental and labor standards.

7. In brief, the central problem is that countries would implement emission taxes on top of existing distortions in the tax code, such as existing energy taxes and subsidies. Thus it would be impossible to measure the practical effect of an emission tax and therefore impossible to determine whether a country was complying with its international commitments.

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Maintaining Diversiy in Our Oceans, J. C. Ogden

1. T. H. Huxley, Fisheries Exhibition Literature 4, Inaugural Address, 1884, 1–22. This quotation should be understood in context. A Practical Fishermen's Congress, organized at the same time, recommended that "the question of the destruction of immature fish is one of international importance. . .[it is] imperative. . .that an International Conference be held to consider the desirability of recommending legislation upon the subject."

2. At the time of its scientific discovery in 1741 on the ill-fated Russian Alaskan exploring expedition, the gigantic Steller's sea cow (more than 20 feet long and weighing 5 tons) was already reduced in range by hunting to two small subarctic islands. By 1768, it was extinct.

3. Although often thought of only as numbers of species, the term biodiversity refers to three components: species (i.e., the different kinds of animals and plants), their genetic material, and the habitats that sustain them.

4. E. O. Wilson, ed., Biodiversity (Washington, D.C.: National Academy Press, 1986); and M. L. Reaka-Kudla, D. E. Wilson, and E. O. Wilson, eds., Biodiversity II (Washington, D.C.: Joseph Henry Press, 1996).

5. National Research Council, Understanding Marine Biodiversity (Washington, D.C.: National Academy Press, 1995); and E. A. Norse, Global Marine Biodiversity: A Strategy for Building Conservation into Decision Making (Washington, D.C.: Island Press, 1993).

6. The total number of marine species is controversial. Some scientists suggest that it is as low as 200,000. See, J. C. Briggs, "Species Diversity: Land and Sea Compared," Systematic Biology 43 (1994): 130–35. On the other hand, others cite a figure of 10 million. See, J. F. Grassle, "Deep-Sea Benthic Biodiversity," BioScience 41 (1991): 464–69. There is no controversy about the higher order diversity of the ocean. See, G. C. Ray and J. F. Grassle, "Marine Biological Diversity," BioScience 41 (1991): 453–57.

7. F. S. Chapin III et al., "Consequences of Changing Biodiversity," Nature 405 (2000): 234–42. Keystone species are top predators that, when disturbed or removed, cause dramatic changes in prey species populations. See R. T. Paine, "Food Web Complexity and Species Diversity," American Naturalist 100 (1966): 65–75.

8. Coral bleaching occurs when unusually elevated or prolonged high seawater temperatures disrupt the relationship between corals and their intracellular symbiotic algae. The algae are expelled from the coral tissue causing it to turn pale or white in color. Bleached corals can recover, but prolonged temperature stress can kill them. B. E. Brown, "Coral Bleaching: Causes and Consequences," Coral Reefs 16 (Suppl.) (1997): S129–38; O. Hoegh-Guldberg, "Coral Bleaching, Climate Change, and the Future of the World's Coral Reefs," Marine and Freshwater Research 50 (1999): 839–66; and C. Wilkinson et al., "Ecological and Socioeconomic Impacts of 1998 Coral Mortality in the Indian Ocean: An ENSO Impact and a Warning for Future Change?" Ambio 28 (1999): 188–96. For a detailed discussion of biodiversity and functioning of the coral reef ecosystem

see T. J. Done, J. C. Ogden, W. J. Wiebe, and B. R. Rosen, "Biodiversity and Ecosystem Function of Coral Reefs," in H. A. Mooney, J. H. Cushman, E. Medina, O. E. Sala, and E. D. Schulze, eds., Functional Roles of Biodiversity: A Global Perspective (New York: John Wiley and Sons, 1996), 393–430. Documentation of warming of the global ocean was recently reported. See S. Levitus, J. I. Antonov, T. P. Boyer, and C. Stephens, "Warming of the World Ocean," Science 287 (2000): 2,225–29.

9. R. Costanza et al., "The Value of the World's Ecosystem Services and Natural Capital," Nature 387 (1997): 253–60; G. C. Daily et al., "The Value of Nature and the Nature of Value," Science 289 (2000): 395–96; and G. C. Daily, Nature's Services (Washington, D.C.: Island Press, 1997).

10. E. O. Wilson, Biophilia: The Human Bond with Other Species (Cambridge, Mass.: Harvard University Press, 1984).

11. Kam Schools Hawaiian Studies Institute, Life in Early Hawai'i, The Ahupua'a 3rd ed. (Kam Schools Hawaiian Studies Institute, 1994); J. C. Pernetta, and J. D. Milliman, eds., "Land-Ocean Interactions in the Coastal Zone: Implementation Plan," Global Change Report No. 33, International Geosphere-Biosphere Programme of ICSU, Stockholm, 1995; P. M. Vitousek et al., "Human Alteration of the Global Nitrogen Cycle: Sources and Consequences," Ecological Applications (1997): 737–50.

12. K. Kloor, "Everglades Restoration Plan Hits Rough Waters," Science 288 (2000): 1,166–67.

13. C. Safina, Song for a Blue Ocean: Encounters Along the World's Coasts and Beneath the Seas (New York: Henry Holt and Co., 1998).

14. D. Ludwig, R. Hilborn, and C. Walters, "Uncertainty, Resource Exploitation, and Conservation: Lessons from History," Science 260 (1998): 17, 36.

15. J. A. Estes and J. F. Palmisano, "Sea Otters: Their Role in Structuring Nearshore Communities, Science 185 (1974): 1,058–60; J. A. Estes et al., "Killer Whale Predation on Sea Otters Linking Oceanic and Nearshore Ecosystems," Science 282 (1998): 473–76; and D. Pauly, V. Christensen, J. Dalsgaard, R. Froese, and F. Torres Jr., "Fishing Down Marine Food Webs," Science 279 (1998): 860–63.

16. E. A. Norse, and L. Watling, "Impacts of Mobile Fishing Gear: The Biodiversity Perspective," American Fishing Society Symposium 22 (1999): 31–40.

17. S. N. Murray et al., "No Take Reserve Networks: Sustaining Fishery Populations and Marine Ecosystems," Fisheries 24 (1999): 11–25.

18. In the fall of 2000, major reports from the National Academy of Sciences and the National Center for Ecological Analysis and Synthesis will show that fully protected marine reserves can work to conserve fisheries and biodiversity.

19. R. L. Naylor et al., "Effect of Aquaculture on World Fish Supplies," Nature 405 (2000): 1,017–24.

20. The Oceans Act of 2000 contains action items relating to most of the points of this memorandum. For example, the act specifies the creation of a National Ocean Commission to make recommendations on a broad set of ocean issues, including changes in existing law to improve management, conservation and use of ocean resources; an assessment of ocean-related facilities and technologies; a review of federal ocean activities to eliminate duplication; a review of known and anticipated supply and demand for ocean resources; a review of the relationship between federal, state, and local governments in planning ocean activities; and a review of opportunities for the development of ocean products and technologies.

21. National Research Council, The Global Ocean Observing System: Users, Benefits, and Priorities, (Washington, D.C.: National Academy Press, 1997); and U.S. Coastal-Global Ocean Observing System, Challenges and Promise of Designing and Implementing an Ocean Observing System for U.S. Coastal Waters, Report No. 3,217 (University of Maryland, Center for Environmental Studies Contribution, 1999).

22. This proposal for an IPOH recognizes the Millennium Ecosystem Assessment (MEA), which is a 4-year international scientific assessment of the world's ecosystems. The MEA, reporting to the Convention on Biological Diversity, the Desertification Convention, and the Ramsar Convention, among others, will cover marine ecosystems in part, but does not involve the relevant audiences for the marine environment, such as the Intergovernmental Oceanographic Commission, the UN Environment Programme's Regional Seas Program, and the various fisheries conventions. The proposed IPOH will strengthen considerably the MEA in these critical areas.

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Red Tides and Dead Zones: Eutrophication in the Marine Environment, Andrew Solow—Further Reading

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2. United Nations, Population Division, World Population Prospects: The 1998 Revision (New York: United Nations, 1999).

3. K. Davis, "Population and Resources: Fact and Interpretation," in Resources, Environment and Population: Present knowledge, Future Options, K. Davis and M. S. Bernstam, eds.; supplement to Vol. 16, 1990 Population and Development Review (New York: Oxford University Press, 1990), 1–21.

4. Population Reference Bureau, 1997 World Population Data Sheet of the Population Reference Bureau (Washington, D.C.: Population Reference Bureau, 1997).

5. J. Bongaarts, "Population Policy Options in the Developing World," Science, 263: (1994), 771–776; J. Bongaarts and J. Bruce, "What Can Be Done to Address Population Growth?" (unpublished background paper for The Rockefeller Foundation, 1997).

6. National Research Council, Board on Sustainable Development, Our Common Journey: A Transition Toward Sustainability (Washington, D.C.: National Academy Press, 1999), pp.303-305.

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11. Wernick. and J. Ausubel, "National Materials Flow and the Environment," Annual Review of Energy and Environment, 20 (1995): 463–492.

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13. Historic data from L. R. Brown, H. Kane, and. M. Roodman, Vital Signs 1994: The Trends That Are Shaping Our Future (New York: W. W. Norton, 1994).

14. One of several projections from P. Raskin, G. Gallopin, P. Gutman, A. Hammond, and R. Swart, Bending the Curve: Toward Global Sustainability, a report of the Global Scenario Group, Polestar Series, Report No. 8 (Boston: Stockholm Environmental Institute, 1995).

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Environment, 1997); P. Vellinga, S. de Bryn, R. Heintz, and P. Mulder, eds., Industrial Transformation: An Inventory of Research. IHDP-IT No. 8 (Amsterdam: Institute for Environmental Studies, 1997).

22. A recent compilation of essays, R. Rosenblatt, ed., Consuming Desires: Consumption, Culture, and the Pursuit of Happiness (Washington, D.C.: Island Press, 1999)., explores many of these issues. These elegant essays by 14 well-known writers and academics ask the fundamental question of why more never seems to be enough, and why satiation and sublimation are so difficult in a culture of consumption. Indeed, how is the culture of consumption different for mainstream America, women, inner-city children, South Asian immigrants, or newly industrializing countries?

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America's National Interests in Promoting a Transition Toward Sustainability, William C. Clark

Prepared for the Aspen Environmental Forum, 8–11 July 2000. The text of this memo draws extensively on material appearing in the National Research Council's (NRC), Our Common Journey: A Transition Toward Sustainability (Washington, D.C.: National Academy Press, 1999), available at http://books.nap.edu/books/0309067839/html/index.html, a report emerging from a study Clark cochaired with Robert W. Kates for the NRC's Board on Sustainable Development. It also makes substantial use of the report of the Commission on America's National Interests, published as R. Ellsworth, A. Goodpaster, and R. Hauser, Cochairs, America's National Interests: A Report from The Commission on America's National Interests; G. T. Allison, D. K. Simes, and J. Thomson, executive directors. (Cambridge, Mass.: Belfer Center for Science and International Affairs, Harvard University, 2000), also available at http://ksgnotes1.harvard.edu/BCSIA/Library.nsf/pubs/Nat-Interest2. Early versions of portions of this paper were presented at The Ecology Law Quarterly's symposium "Environment 2000—New Issues for a New Century," 25–26 February 2000; and at a meeting of the

Overseas Development Council's project "America's National Interests in Multilateral Engagement: A Bipartisan Dialogue," 16 May 2000. The current draft has benefited greatly from comments of the participants in those meetings and the Aspen Forum itself, plus additional feedback from Joe H. Clark, Richard Falkenrath of Harvard, and John A. Riggs of the Aspen Institute.

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2. See, for example, B. L. Turner et al., eds., The Earth as Transformed by Human Action: Global and Regional Changes in the Biosphere over the Past 300 Years (New York: Cambridge University Press, 1990).

3. Ibid.; and P. Vitousek et al., "Human Domination of the Earth's Ecosystems," Science, 25 July 1997, 494–99.

4. NRC, note 1 above, page 1.

5. Ibid.; and World Commission on Environment and Development, Our Common Future (New York: Oxford University Press, 1987).

6. A. McDonald, "Combating Acid Deposition and Climate Change: Priorities for Asia," Environment, April 1999, 4–11, 34–41; and N. Nakicénovíc, A. Grubler, and A. McDonald, eds., Global Energy Perspectives (U.K.: Cambridge University Press, 1998).

7. NRC Committee to Evaluate Indicators for Monitoring Aquatic and Terrestrial Environments, Ecological Indicators for the Nation (Washington, D.C.: National Academy Press, 2000), also available at http://www.nap.edu/catalog/9720.html; Millennium Ecosystem Assessment, http://www.ma-secretariat.org/; The John H. Heinz III Center for Science, Economics and the Environment, Designing a Report on the State of the Nation's Ecosystems (Washington, D.C.: The Heinz Center, 1999), also available at http://www.us-ecosystems.org; see also R. O'Malley and K. Wing, "Forging a New Tool for Ecosystem Reporting," Environment, April 2000, 20–31.

8. NRC, note 1 above, page 8.

9. German Advisory Council on Global Change (WGBU), World in Transition: The Research Challenge (Berlin: Springer Verlag, 1997), also available at http://www.wbgu.de/wbgu_jg1996_engl.html.

10. NRC, note 1 above, page 4.

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12. For example, in the mid-1980s the U.S. Environmental Protection Agency (EPA) found that whereas an objective assessment of environmental risks to U.S. people, property, and ecosystems would have led them to focus on such issues as indoor air pollution, coastal and ocean degradation, pesticide risks, and stratospheric ozone depletion, public and congressional concerns had pushed them to focus instead on the relatively low risks posed by hazardous waste sites, underground storage tanks, and municipal land fills. See U.S. EPA, Unfinished Business: A Comparative Assessment of Environmental Problems (Washington, D.C.:

EPA, 1987); see also a summary by the study directors R. Morgenstern and S. Sessions, "Weighing Environmental Risks: EPA's Unfinished Business," Environment, July/August 1988, 15–17, 34–39. Our international priorities have been no more disciplined or consistent. An early interest in establishing a Law of the Sea, initiated under President Richard Nixon, was repudiated by President Ronald Reagan. The Carter administration's pioneering Global 2000 report made a strong case for America's national interests in addressing global environmental problems and then vanished along with the president who had requested it. Two decades later, Secretary of State Warren Christopher's much-heralded announcement that the United States would subsequently produce an "annual report on Global Environmental Challenges . . . setting U.S. priorities for the coming year" did not even require a change of administration to fall by the wayside—only one such report was ever produced. See Warren Christopher, U.S. Secretary of State, "American Diplomacy and the Global Environmental Challenges of the 21st Century," speech delivered at Stanford University on 9 April 1996. Available at http://dosfan.lib.uic.edu/ERC/briefing/dossec/1996/9604/960409dossec.html.

13. R. Ellsworth, A. Goodpaster, and R. Hauser, cochairs, America's National Interests: A Report from The Commission on America's National Interests, 2000. To offset something of a bias in the Commission's report toward a military security frame of reference, its approach can usefully be supplemented with Roger Porter and Raymond Vernon's appraisal of how basic values and abiding characteristics of the United States ought to figure in the U.S. approach to foreign economic policymaking. See R. Porter and R. Vernon, Foreign Economic Policymaking in the United States (Cambridge, Mass.: Center for Business and Government, John F. Kennedy School of Government, Harvard University, 1989).

14. United Nations Environment Programme (UNEP), Global Environmental Outlook–2000 (London: Earthscan, 1999); and R. Watson et al., Protecting Our Planet, Securing Our Future (Nairobi: UNEP, 1998).

15. Millennium Ecosystem Assessment, note 7 above.

16. WGBU, note 9 above; and NRC, note 7 above.

17. Most of the reports alluded to in notes 14–16 above discuss the usual suspects as threats to sustainability in the 21st century: overuse of renewable resources, climate change, physical transformation of landscapes and coastal zones with resultant loss of habitat for biodiversity, the degradation or depletion of freshwater supplies, the ubiquitous spread of persistent biocides and other chemicals throughout the environment, disruption of the major biogeochemical cycles (especially carbon, nitrogen, and sulfur), spread of exotic organisms, nuclear contamination, and ozone depletion.

18. NRC Committee on Global Change Research, Global Environmental Change: Research Pathways for the Next Decade (Washington, D.C.: National Academy Press, 1999).

19. See, for example, the reports of the Intergovernmental Panel on Climate Change, or P. Vitousek et al., "Human Alteration of the Global Nitrogen Cycle: Causes and Consequences," Issues in Ecology no. 1 (1997), available at http://esa.sdsc.edu/issues.htm.

20. NRC, note 1 above, pages 223–24.

21. NRC, note 18 above; and R. W. Kates and W. C. Clark, "Expecting the Unexpected?" Environment, March 1996, 6–11, 28–34; and UNEP, note 14 above, page 336.

22. On the globalizing dimensions of environmental disruptions, see W. C. Clark, "Environmental Globalization," forthcoming in J. Nye and J. Donahue, eds., Visions of Governance for the Twenty-First Century (Washington, D.C.: Brookings Institution Press, 2000).

23. D. J. Jacob, J. A. Logan, and P. P. Murti, "Effect of Rising Asian Emissions on Surface Ozone in the United States," Geophysical Research Letters 26, no. 14 (1999): 2,175–78, available at http://www.agu.org/GRL/articles/1999GL900450/GL110P01.html.

24. UNEP, Report of the Second Session of the Criteria Expert Group for Persistent Organic Pollutants UNEP/POPS/INC/CEG/2/3 (Vienna, Austria, 18 June 1999).

25. As one perceptive analysis has observed, "Human transport of species around the Earth is homogenizing the Earth's biota," Vitousek, et al., note 3 above.

26. Several excellent historical studies have traced the impacts on world affairs of transcontinental disease migrations. See W. McNeill, Plagues and Peoples (Garden City, New York: Doubleday, 1976); A. Crosby, Ecological Imperialism: The Biological Expansion of Europe, 900–1900 (U.K.: Cambridge University Press, 1986); and J. Diamond, Guns, Germs and Steel: The Fates of Human Societies (New York: Norton, 1997).

27. M. Rejmanek and J. Randall, Madrono 41 (1994): 161.

28. Vitousek et al., note 3 above.

29. R. N. Mack et al., "Biotic Invasions: Causes, Epidemiology, Global Consequences and Control," Issues in Ecology no. 5, available at http://esa.sdsc.edu/issues5.htm; J. A. Drake and H. A. Mooney, eds., Biological Invasions: A Global Perspective (New York: Wiley, 1986); and V. H. Heywood, ed., Global Biodiversity Assessment (New York: Cambridge University Press, 1995).

30. Thus, for example, climate variability plus excessive water withdrawals plus chemical pollution plus a minimal capacity for social response have come together to destroy the prospects for sustainable development in places like the Aral Sea. The German Advisory Committee on Global Change has identified more than a dozen such regional degradation "syndromes" occurring in multiple places around the world. See WGBU, note 9 above. Other studies have documented "critical zones" of enhanced vulnerability; see J. X. Kasperson, R. E. Kasperson, and B. L. Turner II, Regions at Risk: Comparisons of Threatened Environments (Tokyo: United Nations University Press, 1995).

31. See the "Project on Environmental Scarcities, State Capacity and Civil Violence" at http://www.utlink.utoronto.ca/www/pcs/state.htm. Many of the results of the project are summarized in T. Homer-Dixon, Environment, Scarcity, and Violence (New Jersey: Princeton University Press, 1999).

32. Center for Environmental Security http://www.pnl.gov/ces/dialogue/ww_5_f5.htm. In a recent speech on how the environment figures in foreign affairs, Secretary of State Madeleine K. Albright

stated with reference to the former Soviet Union, "(W)e know that easing that region's environmental challenges must be part of any real democratic transition there. We also know that regional conflicts pose a major threat to international stability, and that competition for natural resources can contribute to political extremism and civil strife. Somalia was an example of this, and the Congo now is another. And as we have seen in Africa, Haiti, and the Balkans, environmental problems slow recovery from conflict, and make the transition to stability that much harder." Madeleine K. Albright, U.S. Secretary of State, "An Alliance for Global Water Security in the 21st Century," remarks in recognition of Earth Day, 10 April 2000, http://secretary.state.gov/www/statements/2000/000410.html.

33. Gro Harlem Brundtland stressed in her foreword to the 1987 report of the World Commission on Environment and Development that "perhaps our most urgent task today is to persuade nations of the need to return to multilateralism . . . . The challenge of finding sustainable development paths ought to provide the impetus—indeed the imperative—for a renewed search for multilateral solutions and a restructured international economic system of cooperation." See G. H. Brundtland, foreword in the World Commission on Environment and Development, note 5 above, page x.

34. Kofi A. Annan, statement to the General Assembly on presentation of his millennium report, We the Peoples: The Role of the United Nations in the 21st Century, UN Doc. SG/SM/7343; GA/9705 (New York: 3 April 2000). The report is available at http://un.org/millennium/sg/report/summ.htm. See also, Kofi A. Annan, "Sustaining the Earth in the New Millennium," Environment, October 2000, 22–30.

35. U.S. Department of State, "Environmental Initiative for the 21st Century," available at http://www.state.gov/www/global/oes/init.html.

36. J. Baker, "Diplomacy for the Environment," address before the National Governors Association, Washington, D.C., 26 February 1990. U.S. Department of State Dispatch, 3 September 1990, 17–20.

37. J. S. Nye, Jr. Bound to Lead: The Changing Nature of American Power (New York: Basic Books, 1990).

38. NRC, note 1 above, pages 296–302; and Carnegie Commission on Science, Technology and Government, International Environmental Research and Assessment: Proposals for Better Organization and Decision Making (New York: Carnegie Commission, 1992).

39. T. Sandler, Global Challenges: An Approach to Environmental, Political and Economic Problems (U.K.: Cambridge University Press, 1997).

40. Social Learning Group, Learning To Manage Global Environmental Risk (Cambridge, Mass.: MIT Press, forthcoming 2001).

41. Nye, note 37 above.