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ABSTRACT

This annotated bibliography on global climate change contains 27 articles designed to expand the breadth and depth of information presented in the Global Change Information Packet. Most articles were chosen from journals likely to be available in most medium-sized public or college libraries. The articles cover a variety of topics related to global warming; greenhouse warming; agriculture, forestry, and food security; energy technology; climate and history; global carbon budget; greenhouse gases; "Global Releaf" project; sulfate pollutants; weather; science and policy; deforestation; hydrogen as an alternative to fossil fuels; and environmental monitoring and modeling. (LZ)

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GLOBAL CLIMATE CHANGE SELECTED ANNOTATED BIBLIOGRAPHY

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The following articles have been carefully selected to expand the breadth and depth of information presented elsewhere in the Global Change Information Packet. Most articles have been chosen from journals likely to be available in most medium-sized public or college libraries.

Abelson, Philip H. Uncertainties about Global Warming. *Science*, p. 1529, March 30, 1990.

Abelson critically examines the quality and reliability of key evidence relating to global warming. He finds that "[i]f the situation is analyzed applying the customary standards of scientific inquiry one must conclude that there has been more hype than solid facts." The estimates of the 14 or so groups attempting to model global climate show a range of 1.5 to 5.0 degrees Celsius (C). Most agree that the models are deficient. For example, the models do not adequately account for the effects of clouds which "have both negative and positive effects on warming." He goes on to note that while many researchers cite a 0.5° C. increase in temperature since 1880, the change really depends on the time interval chosen. Temperature increased from 1880-1940, but then dropped from 1940 until the 1960's to the extent that a new ice age was predicted. A recent study looking at the 1979-1988 period using precise satellite data showed no obvious trend. Abelson concludes, however, by stating that despite the uncertainties and even if there were a "negligible greenhouse effect, we should be taking actions" such as inducing conservation and energy efficiency by raising taxes on fuels, and expanding efforts to develop renewable resources. Whatever is done "should be based on well-thought-out long-range goals."

Barnwell, George. Your Contribution to Global Warming. *National Wildlife*, p. 53, February-March 1990.

Barnwell examines the relationship between electric energy used in the home and the carbon dioxide (CO_2) produced by a coal-fired electric generating plant. For example, a 100-watt bulb used as a night light 365 days a year would result in 675 pounds of carbon dioxide being released into the atmosphere as a result of coal burned to produce the necessary electricity. A brief table gives similar information for a variety of common household appliances.

Beardsley, Tim. Not So Hot: New Studies Question Estimates of Global Warming. *Scientific American*, p. 17-18, November 1989.

Predictions about global climate - whether warming or cooling - are based on two fundamental components. First is the recognition and understanding of the complex interactions which create climate, the scientific basis. Second are the models which attempt to manipulate that information in a realistic way to make predictions. Beardsley examines many of the current weaknesses in both components. For example, it's not clear what role clouds play since they both absorb heat from the earth and reflect heat from the sun. Recent studies show that ice clouds may have a much greater reflectance than water clouds. In another piece of related research "data suggest that sulfate aerosols formed from pollutants... can significantly increase the earth's albedo." Ocean circulation and heat exchange is also a complex process which has not been adequately accounted for in many models. Other factors such as fluctuations in the brightness of the sun may also play a role. More research and the development of more sophisticated models are necessary to provide better answers.

Crosson, Pierre. Greenhouse Warming and Climate Change - Why Should We Care? *Food Policy*, p. 107-118, May 1989.

Crosson provides a careful and well-documented review of greenhouse warming and its likely effects on climate. Special attention is given to the impact on agriculture and the overall economic and environmental costs of world agricultural production. The scientific conclusion is that less than half the current annual carbon emissions are captured by the oceans and terrestrial sinks, and the increasing concentrations of greenhouse gases will certainly affect climate, although the full effect may not be evident for several decades. The social conclusion is that we must care enough to take action now for three reasons. "First, the potential threats of climate change to human welfare are at least as severe as many of those we now take seriously. Second, the moral imperative of intergenerational equity imposes on out generation the obligation to consider seriously the consequences of our actions on the welfare of future generations. Third, by beginning to mobilize now to reduce greenhouse gas emissions...we have a chance...to hold future climate change within limits..."

Evans, Gary R. Agriculture, Forestry, and Food Security in Relation to Global Change. *Marine Technology Society (MTS) Journal*, p. 30-37, v.25, no.4, Winter 1991-1992.

Evans, Special Assistant for Global Change Issues in the U.S. Department of Agriculture, asserts that the greatest threat posed by global change is from the potential effects on our ability to produce food and fiber. Acknowledging that more research needs to be done, he proposes a comprehensive approach which would permit maximum flexibility in selecting responses while achieving global results. He proposes two general types of strategies: Mitigating strategies could be used to limit or offset emissions of greenhouse gases such as promoting no-tillage farming and reduction in the burning of trees and other forms of biomass. Adaptation strategies facilitate natural and societal adjustment to the effects of global change such as genetic improvement, bioengineering stress tolerance, or altering agricultural management systems.

Fulkerson, William, *et al.* Global Warming: An Energy Technology R & D Challenge. *Science*, p. 868-869, November 17, 1989.

Fulkerson asserts that there are two major uncertainties with regard to "future energy technology needs: (i) growth of energy demand and (ii) the seriousness and urgency of the greenhouse effect." To accommodate these uncertainties he proposes a broad-based research and development (R & D) effort which addresses both improving energy sources and improving the efficiency of energy use. The major non-fossil fuel technologies are evaluated with respect to performance, cost, and social acceptance plus an estimate of how much R & D funding would be required to make them competitive. The proposed increased spending on energy R & D is likened to an insurance policy in which the risk is small and the likelihood for success large.

Gribbin, John and Mary Gribbin. Climate and History: the Westvikings'Saga. *New Scientist*, p. 52-5, January 20, 1990.

This interesting article shows how warming and cooling trends of only 1-2 degrees over the last 1200 years have affected the settlement patterns of Iceland and Greenland by Europeans. The Greenland colonies, for example, survived for approximately 500 years from 1000 to 1500 A.D. but were ultimately "frozen out" because of increasing cold and their failure to modify their traditional European clothing and agricultural practices.

de Groot, Peter. Are We Missing the Grass For the Trees? *New Scientist*, p. 29-30, January 6, 1990.

Much attention has been focused on the role of forests and plankton in the global carbon budget; de Groot reviews new findings from a study by the United Nations Environment Programme (UNEP) which shows that grasslands convert more carbon dioxide into carbohydrates than was previously believed, perhaps equalling - or exceeding - the productivity of tropical rainforests. Previous estimates apparently did not take into account roots or the differences in growth patterns between temperate and tropical grasses. They also found that "when grasslands are cleared for agriculture, the new crops are likely to be less productive than the original species of wild grasses." In a related finding, de Groot notes that 700 million hectares of savanna are burned each year, often to kill pests and encourage new growth. Paul Crutzen of the Max Planck Institute for Chemistry has calculated that the savanna burning may contribute "three times as much carbon dioxide to the atmosphere as burning the rainforests."

Hammond, Allen L., Eric Rodenburg, and William R. Moomaw. Calculating National Accountability for Climate Change. *Environment*, p. 11-15, 33-35, v.33, no.1, January/February 1991.

As one component of an international agreement aimed at limiting man-caused emissions of greenhouse gases, the authors propose a Greenhouse Index based on each country's "greenhouse forcing contribution." This index could then be used as "a measure of national accountability for contribution to the greenhouse effect" and could guide international and national decisionmaking. For example, using 1988 data, their analysis showed that the largest contributors to greenhouse forcing were the United States (17.1%), USSR (13.5%), China (8.1%), and Brazil (5.7%). In assigning responsibility, the authors hope the index will "promote discussion, argument and action."

Matthews, Samuel W. Under the Sun - Is Our World Warming? *National Geographic*, v.178, no4, October 1990, p. 66-99.

In this heavily illustrated article Matthews focuses on the effects of man's activities and the sun's radiant energy on Earth's atmosphere. Data collected and projections made by scientists at agencies such as NOAA, NASA, and the National Center for Atmospheric Research are presented. The data indicate that temperatures worldwide have increased approximately one degree Fahrenheit since the late 1800s. Matthews predicts a warming of three to nine degrees by the middle of the next century, if atmospheric carbon dioxide doubles as many predict. He also touches on other variables affecting climate such as the influence of the oceans, the cooling effect of clouds, volcanic eruptions, and fluctuations in the sun's output as well as other "greenhouse gases." He concludes that human activities are probably affecting our climate and includes suggestions from several scientists as to actions that should be taken now.

McInerney, Susan. ReLeafing the World. *Country Journal*, p. 22-3, January/February 1990.

The author provides an overview of the "Global ReLeaf" project sponsored by the American Forestry Association, a Washington, D.C.-based conservation organization. In addition to directly reducing atmospheric carbon dioxide, trees can be used to conserve energy and reduce fossil fuel consumption. For example, "[t]hree trees properly planted around the home can produce enough shade to cut air conditioning costs by 10 to 15 percent. Those planted as windbreaks can reduce heating costs considerably."

Night Heat: Sulfate Pollutants May Slow Daytime Warming. *Scientific American*, February 1992, p. 21,24.

The results of a new study by Thomas R. Karl of the National Climatic Data Center suggest that most of the temperature increase recorded in the last century, at least in the Northern Hemisphere, is the result of higher daily minimum temperatures which means the nights are getting warmer. Daily maximum temperatures usually recorded during the daytime have hardly increased at all. One possible explanation is that tiny sulfate articles from the burning of fossil fuels reflect sunlight during the daytime. At night, with no sunlight to scatter, the atmosphere absorbs the heat radiated by the earth, thus concentrating the increase in nighttime temperatures. Sulfate aerosols may also play a role in cloud seeding but it is not yet clear what role increasing cloudiness may have on global warming.

The Once and Future Weather. *Economist*, p. 95-100, April 7, 1990.

Provides a careful and readable review of climate history over approximately the past 100,000 years, including the various chemical, tree-ring, and fossil records. Irregularities in the earth's shift ("wobble") on its axis of rotation and variation in the shape of its orbit around the sun produce the Milankovitch cycles which have a profound, and apparently predictable, effect on climate. Apparent changes in the circulation patterns of the oceans, which move shallow waters to deep ocean depths, significantly affect the CO_2 absorbing activities of the oceans and, therefore, climate. Given these large, epochal changes, it is not clear what effect, if any, the current increase in atmospheric CO_2 will have on global climate.

Page, Jake. A Question of Degree: Parks Forecast the Effects of Global Warming. *National Parks*, p. 24-29, July/August 1989.

Page reviews the current and anticipated effects of global climate change with special emphasis on the role of the National Park Service. The impact on the regional ecosystems in the temperate and higher latitudes is expected to be especially great. He notes, for example, the "paleobotanists have determined that beech forests followed the retreating ice of the last ice age at a rate of 20 kilometers a century." If temperatures rise at some of the predicted rates, beeches would have to move 500 kilometers north to find suitable climate. Even modest increases in sea level will have significant impacts on low-lying areas such as the Florida Everglades and coral reefs.

Rosenzweig, Cynthia. How It Might Be: Agriculture. *EPA Journal*, p. 9-10, January/February 1989.

Rosenzweig opens by observing that climate and agriculture are inextricably linked so the projected increase in temperatures and changes in precipitation patterns are likely to have large impacts on U.S. agriculture. A variety of factors such as better acclimated crop varieties may mitigate some of the negative climate effects. Increased carbon dioxide may directly benefit crops by increasing size and yield. On the other hand, warmer climates may mean that many crops will no longer be able to grow in the South, Midwest and Great Plains while agricultural production in Minnesota and the Great Lakes states may expand significantly. As agricultural regions shift northward with the warmer weather, crop pests and livestock diseases will follow. In warmer, drier regions increased demand for irrigation may produce (or increase) groundwater overdrafts. With these shifts will probably come dislocation of people, jobs, and environmental habitats.

Schell, Jonathan. Our Fragile Earth. *Discover*, p. 44-50, October, 1989.

This non-technical article begins with a brief review of the history and scientific background of the greenhouse effect. Schell goes on to discuss "the quandary of the scientists" who, on one hand, try to describe and predict climate change which is very complex and imperfectly understood, while on the other hand, understand that the only way to know certainly what will happen is to watch a global experiment which might bring about immense, catastrophic change.

Schneider, Claudine (R-R.I.) Turning Down the Heat: A Plan to Check the Rate of Global Warming. *National Parks*, p. 16-17, 42, July/August, 1989.

The author briefly reviews the basis for concern and a variety of possible effects of global warming. Included are descriptions of recent efforts at the international level such as the 1987 Montreal Protocol to reduce ozone-depleting chemicals; at the national level such as the proposed Global Warming Prevention Act (H.R.1078); and at the individual level such as participating in the Global Releaf program, recycling, and energy conservation in the home.

Schneider, Stephen H. The Changing Climate. *Scientific American*, p. 70-79, September, 1989.

Schneider presents an excellent overview of the greenhouse effect and carefully describes what is known as well as what is still to be learned about the dynamics of climate change. He then describes what current climate models are able to predict and reviews the effects in various sectors including agriculture. Finally, a variety of possible responses are examined with an assessment of the positive and negative aspects of each. At the present time the author foresees global warming of at least 1 to 2 degrees C because no plausible policies are available to prevent it. However, he is hopeful that some demonstrable change may in fact catalyze international cooperation.

Schneider, Stephen H. The Greenhouse Effect: Science and Policy. *Science*, p. 771-81, February 10, 1989.

This article describes in considerable detail the science behind the greenhouse effect and the state of knowledge (in 1989) about the complex dynamics which determine climate change. Increased concentrations of greenhouse gases, most apparently caused by human activity, will affect climate; the questions are how? and how much? Schneider also discusses the state of global climate modeling, both what can and cannot be done. Given the possible scenarios, he describes possible environmental and societal impacts. Finally, appropriate policy responses are outlined. The 77 references cited in the paper represent a significant review of the literature.

Sedjo, Roger A. Forests to Offset the Greenhouse Effect: If 'Planting Trees' Could Save Us, How Many Trees Would We Have To...? *Journal of Forestry*, p. 12-15, July 1989.

Trees and other plants play an important role in the climate process by converting the carbon component of carbon dioxide into biomass and releasing the oxygen into the atmosphere. This ability to sequester carbon means that the forests serve as a 'sink' for the carbon dioxide. Of course, if a tree burns or decays, it releases carbon dioxide back into the atmosphere. Also, while mature forests that experience little growth hold carbon, they sequester little additional carbon and are therefore not a major sink for atmospheric carbon. Current estimates suggest that atmospheric carbon dioxide is increasing at a rate of approximately 2.9 billion tons per year. Sedjo estimates that it would take approximately 465 million hectares of new fast-growing plantations to sequester that much carbon dioxide. Land requirements and economic costs are discussed. The author observes that such an approach would offer a means of postponing for 30-50 years the build-up of carbon dioxide.

Shukla, J., C. Nobre, and P. Sellers. Amazon Deforestation and Climate Change. *Science*, p. 1322-5, March 16, 1990.

In an effort to investigate the potential effects of Amazon deforestation on the regional physical climate system, the authors used a realistic model of the biosphere coupled with a realistic model of the atmosphere. Assuming that the deforested areas would be replaced by grasses, the simulation suggests a significant increase in surface temperature, reduced evapotranspiration and a decrease in precipitation. In addition, the model shows an increase in the length of the dry season which would make re-establishment of the forests very difficult.

Spencer, Roy W. and John R. Christy. Precise Monitoring of Global Temperature Trends from Satellites. *Science*, p. 1558-1562, March 30, 1990.

Atmospheric temperature data from satellite-based microwave sounding units were analyzed for a 10-year period, 1979-1988. These data are especially useful because they provide nearly complete earth coverage including the oceans and southern continents compared to the very limited and uneven distribution of surface thermometer sites. In addition, they provide measurements from various levels of the atmosphere. The authors conclude that while there was considerable temperature variability on time scales from weeks to several years, there was no obvious trend for the 10-year period.

Stein, Jay. Hydrogen: Clean, Safe, and Inexhaustible. *Amicus Journal*, p. 33-36, Spring 1990.

Among the many alternatives to fossil fuels now being examined is hydrogen. The product of hydrogen combustion is pure water and by using electrolysis, the process can be reversed to produce hydrogen and oxygen. Despite these advantages, however, more research needs to be done to find a more cost-effective means of producing hydrogen and a safer means of storing it on-board vehicles.

Trefil, James. Modeling Earth's Future Climate Requires Both Science and Guesswork. *Smithsonian*, v.21, p. 29-37, December, 1990.

Writing in a clear, jargon-free style, Trefil reviews what is known and what is not known about climate prediction and modeling. His insightful discussion of various models, assumptions, and our limited - though increasing - stock of climate knowledge help the reader to understand the conflicting predictions about global warming. General Circulation Models (GCMs) contain "minimodels' for each of the Earth's systems (ocean, atmosphere) each of which has its own set of assumptions as well as assumptions about how each system interacts. Nevertheless, despite all the defects and uncertainties, it is possible for scientists to come to some sort of consensus. The 200-300 scientists who contributed to the findings of the Intergovernmental Panel on Climate Change generally agree that a doubling of the greenhouse gases will result in a 3-to-8 degree warming.

Udall, James R. Turning Down the Heat. *Sierra*, p. 26-33. July/August 1989.

Udall cites a variety of U.S. and international authorities to demonstrate that there is widespread support for the idea that global warming is here. Included are two graphs which demonstrate a correlation between an increase in temperature and an increase in atmospheric carbon dioxide. Most of the article, however, addresses what should and can be done to reduce the emission of greenhouse gases. For those interested in figuring out what their own contributions are he provides a list of formulas for domestic calculations. According to Udall, the greatest difficulties in dealing with the problem are not the technological aspects but the political and social aspects which will require not only national resolve but genuine international cooperation.

White, David C., Clinton J. Andrews, and Nancy W. Stauffer. The New Team: Electricity Sources Without Carbon Dioxide. *Technology Review*, p. 42-50, January 1992.

The authors argue that researchers should stop "quibbling over how much global temperatures could rise," and put more effort into developing and implementing a mix of clean technologies. We could begin, for example, by using fossil fuels more efficiently with improved burning technologies. Next, we could work to improve carbon-free options such as nuclear fission; however, the authors note both political concerns and the as yet unresolved long-term storage issues. A third set of options would focus more research on renewable sources such as solar and hydrothermal energy. In order to bring about these changes, the authors suggest that funding agencies such as the U.S. Department of Energy should spread their budgets more uniformly to increase funding to renewable energy research from the current massive support for non-renewable energy research. Finally, the authors argue that environmental costs need to be figured into any energy investment strategies of government or business.

White, Robert M. Greenhouse Policy and Climate Uncertainty. *Bulletin American Meteorological Society*, p. 1123-1127, September 1989.

White provides an assessment of both the quantity and quality of information in the "knowledge base" on the impact of greenhouse gases on the climate system. He carefully distinguishes between scenarios that provide a range of credible possibilities, and forecasts that predict. He concludes with an examination of policy principles in an environment where "knowledge and information are being continually refreshed by new findings and interpretations and our assessment of risk and uncertainties are continually changing."