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United States Department of State

Bureau of Oceans and International
Environmental and Scientific Affairs

Washington, D.C. 20520

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Date: Feb 15, 1990

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FROM:Name: Jeff MiotheTEL. No. 647-4069Office Symbol/Number OES/EGCFax No. (202) 647-0191Document Description: Testimony/QiAs
Draft #3Pages to Follow: 15*****
*****TO:Name: PCC Working Group on Climate
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*****MESSAGE

I need your comment and clearance on this by COB
today since copies have to be delivered to the Hill
first thing next week. The QiAs are in response to
specific questions posed by Waxman.
Thanks



United States Department of State

Bureau of Oceans and International
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Washington, D.C. 20520

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PAGES TO FOLLOW

COMMENTS:

REMARKS OF ROBERT A. REINSTEIN
Deputy Assistant Secretary of State for
Environment, Health and Natural Resources
United States Department of State
before the

Subcommittee on Health and the Environment,
Committee on Energy and Commerce,
United States House of Representatives
February 21, 1991

Subcommittee on Environmental Protection,
Committee on Environment and Public Work,
United States Senate
March 5, 1991

FOR YOUR
COMMENTS/CLEARANCE

Thank you, Mr. Chairman. I am Robert A. Reinstein, the Deputy Assistant Secretary of State for Environment, Health and Natural Resources. I am also the United States negotiator for climate change. It is a pleasure to appear before this subcommittee to discuss the negotiations on a framework convention on climate change. I would like to discuss briefly with you the results of the negotiating session that just ended, the timetable for future sessions and the overall U.S. position in these negotiations.

Results of the First Session

At the President's invitation, the United States hosted the first session of these negotiations on February 4-14 just outside of Washington, DC. One hundred and one countries from every region of the world, representing both developing and industrialized nations, participated in this session. Reflecting our desire to have an open process, 65 non-

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governmental organizations (NGOs) also participated and will be able to provide input throughout the negotiations.

The United States entered these negotiations not content merely with hosting the first session, but eager to move the discussion forward substantively. We had hoped to develop a draft negotiating text during this session, albeit with numerous brackets reflecting the differences in positions to be expected at the start of any negotiations. Drafting some bracketed text would have clarified the positions of the negotiating parties and enabled them to consider those positions in the next few weeks, thus facilitating the discussions in subsequent sessions. Towards this end, we circulated draft sections of a framework convention and distributed a number of documents explaining the U.S. perspective on the contents of a framework convention. Unfortunately however, resolution of procedural matters required the full two weeks of the first session so no draft text was produced.

Nonetheless, we are hopeful that the organization and procedures on which we agreed in this session will pave the way for steady, substantive progress in the sessions to follow:

-- We agreed, for instance, to organize two working groups, one which will consider comprehensively all sources and sinks of all greenhouse gases, and one on mechanisms of implementation. This structure will provide for a comprehensive discussion of the issue and will provide for full consideration of the concerns common to the negotiating parties.

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- We reached agreement on Rules of Procedure which emphasize decision making by consensus and, as I have mentioned, will allow NGOs to play a viable role in the negotiations. The United States was a forceful advocate of NGO participation.
- There was also a great deal of discussion on ways to improve the participation of developing countries. These negotiations and any long term response to climate change, will only be effective if we have the participation of the the broadest spectrum of nations possible. As a result of these discussions, the number of developing countries participating should increase in later sessions and they should now be able to send appropriate experts from their capitals..
- Working with other nations, we produced an informal paper outlining the scientific, technical and economic research needs which the convention should address. Hopefully, this exchange of views will make it easier to conclude these sections of the convention at a later stage in the negotiations.
- We also reached agreement on the important role the IPCC will play in responding to the technical needs of the negotiations. We hope that, with this mandate, the IPCC will be in a position to provide information and resolve questions of a technical nature during the negotiations.

Perhaps most importantly, we have laid the foundation of a cooperative relationship with other national delegations. Such relationships will help to move the process along and will facilitate positive consideration of the United States position.

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This session was the first of four or five sessions of the negotiations established under the auspices of the United Nations General Assembly by Resolution 45/212 on the "Protection of Global Climate for Present and Future Generations." The next session is tentatively scheduled for May or June. Following that session, we will meet in September and once or twice thereafter, as necessary. The goal, as articulated in 45/212, is to complete the negotiations so that the framework convention will be open for signature during the UN Conference on Environment and Development in June 1992.

The U.S. View on the Negotiations

The United States is approaching these negotiations with several key principles in mind -- principles which we feel are the key to an effective convention and global response to climate change:

- o First, we believe we must take a comprehensive approach to climate change, one which considers all aspects of this complex issue and which addresses all greenhouse gases and their sources and sinks;
- o Second, we must not wait for all uncertainties to be resolved, but must pursue economically efficient and cost-effective actions - already justified on other grounds - which will limit net greenhouse gas emissions;
- o Third, we must continue to pursue aggressively our scientific and economic research efforts and our technology development programs in order to resolve uncertainties and

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- build a solid foundation for innovative responses;
- o Fourth, we must recognize the special needs of the developing countries and design mechanisms for assisting them in securing the scientific and technical tools necessary for their fullest participation in a truly global effort.
 - o Fifth, any response must be global. Emissions from developing countries are growing rapidly and action by industrialized nations alone would be ineffective at restraining emissions, as well as distort competitive positions. An effective response will require that all nations participate and meet obligations that are appropriate to their circumstances.

The United States will seek to translate these principles into an innovative and effective framework convention that will engage all nations in a concerted international response to climate change.

A Comprehensive Approach to Climate Change

The United States strongly supports a comprehensive approach, one which considers all sources and sinks of all greenhouse gases, for a number of reasons. This approach will ensure that we take advantage of the most cost-effective opportunities to limit net emissions across the range of sources and sinks of all greenhouse gases. The comprehensive approach also does not create incentives to shift the problem from one type of pollutant to another, as we know from experience can happen from narrowly focussed approaches.

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Further, a comprehensive approach ensures that research and technology development address all facets of the problem. Finally, a comprehensive approach provides the flexibility needed for each nation to address climate change in the context of its unique circumstances. A framework convention that reflects a comprehensive approach would thus not require any nation to take a specific, inflexible set of measures.

In addition, the IPCC First Assessment Report notes that we must consider both limitation and adaptation as part of an integrated response. Accordingly, we believe the framework convention, and any subsequent legal instruments, must be comprehensive and deal with the full array of greenhouse gases and their sources and sinks. It should also address both limitation and adaptation responses.

During the first session, the United States distributed a booklet and led an informal discussion on the comprehensive approach. The booklet received wide distribution and the seminar was attended by a significant number of delegations and NGOs. We will continue this effort to engage in open dialogue with the international community about the rationale and implications of this approach.

Actions that are Justified in Their Own Right

A major purpose of the framework convention should be to commit all nations to take measures that are justified in their own right, but also have climate change benefits. Specific measures of this nature form the cornerstone of the U.S. climate change strategy. As outlined in the brochure

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"America's Climate Change Strategy: An Action Agenda" which we distributed at the first session, this strategy that will result in U.S. greenhouse gas emissions in the year 2000 being equal to or below the 1987 level. The framework convention could commit all nations to develop similar national strategies, emphasizing attention to actions that are warranted for other reasons and that also limit net greenhouse gas emissions. This approach to the global response to climate change will provide a realistic, economically efficient, and cost-effective framework under which all countries can begin to implement measures with climate change benefits. At the same time, it would recognize that the appropriate measures available to different countries will vary depending on their social, environmental, and economic circumstances.

Research and Monitoring

Research and monitoring are essential to improving our understanding of climate change and helping us to tailor responses that are appropriate, efficient, effective, and sustainable over the long term. These research efforts will also provide the needed energy-efficient technologies that will be both economic and environmentally beneficial. For our part, we are pursuing a \$2 billion program of global change research and energy technology development that will provide the tools for devising innovative, long-term responses. Consistent with our own actions, the United States put forward a specific proposal during the first session for a strong program of scientific and economic research and monitoring as another

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cornerstone of the framework convention.

Implementation Issues

There are many other specific issues that must be addressed prominently in the framework convention. With regard to the developing countries, their desires and aspirations for economic growth are generally recognized. Achieving economic growth while minimizing the associated increase in greenhouse gas emissions is a difficult and complex problem. We believe that it is essential for developing countries to participate in any response to climate change in a manner that recognizes both their development needs and the greenhouse gas implications of such development. Thus, we believe the framework convention should include a general commitment to promote financial assistance to developing countries to study and address climate change. Existing bilateral and multilateral financial-assistance mechanisms and, in particular, the newly established Global Environmental Facility in the World Bank are the appropriate mechanisms for providing such assistance.

Technology transfer is essential to any effective global response, and there are many existing low cost technologies that can be transferred now. We stated in the first session our willingness to explore such ideas as energy efficiency centers and demonstration projects, as well as industry joint ventures with other countries to promote available technologies. Implementation of these concepts will need to be considered, of course, in the context of specific commitments to action, and special efforts will need to be made to match

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appropriate technologies to needs.

Over the long term, new technologies will play an increasingly important role in the response to climate change. Many of these technologies are still only ideas, or must undergo further development to become technologically and economically feasible. Therefore, the convention must provide the right incentives for the continual research, development, and dissemination of appropriate technologies. Since the private sector researches, develops and disseminates new technology most effectively, the convention should seek to remove barriers to effective commercial development and transfer of technology and should ensure that intellectual property rights are fully protected so as to provide the incentive necessary for continual development of new technology.

We should also discuss ways to transfer the knowledge necessary to understand, plan for and address climate change. The United States has traditionally provided a great deal of technical assistance in dealing with specific environmental problems, developing environmental institutions, and conducting country studies. During the first session, therefore, we stated that we are prepared to undertake, in cooperation with other nations, specific country studies to define appropriate technologies to reduce greenhouse gases. These studies will facilitate early implementation of any international response that results from these negotiations. The NGO community, including the business community, also has an important role to play in this regard.

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Mr. Chairman, procedural matters prevented us from developing a draft negotiating text during this first session. Nonetheless, we agreed on a negotiating process which will allow an expeditious, open and unbiased discussion of the issues surrounding climate change. In the sessions that follow, the United States will continue to seek an agreement that is comprehensive, that builds on actions which help to address climate change and are justified on other grounds, that provides for a strong scientific and economic research program, and that recognizes the special needs of the developing countries. You may rest assured that the United States will make every effort to conclude such an agreement before the June 1992 deadline that we have set. Such a convention is the crucial first step in what the United States has realized must be a sustained and long-term effort to address climate change.

Mr. Chairman, let me thank you again for the opportunity to appear before this subcommittee. I would be happy to entertain any questions that you might have.

DRAFT**Q&As FOR**

Subcommittee on Health and the Environment,
Committee on Energy and Commerce,
United States House of Representatives
February 21, 1991

Subcommittee on Environmental Protection,
Committee on Environment and Public Work,
United States Senate
March 5, 1991

**FOR YOUR
COMMENTS/CLEARANCE**

Q: What is your view on the nature and severity of global climate change?

A: IN ITS FIRST ASSESSMENT REPORT, THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC) STATED THAT EMISSIONS RESULTING FROM HUMAN ACTIVITIES WILL RESULT, ON AVERAGE, IN AN ADDITIONAL WARMING OF EARTH'S SURFACE. ACCORDING TO ONE SCENARIO IN THE IPCC REPORT, THE AVERAGE SURFACE TEMPERATURE WILL LIKELY INCREASE FROM 2 TO 5 DEGREES CENTIGRADE AND THE AVERAGE SEA LEVEL WILL PROBABLY RISE FROM ONE TO THREE FEET BY THE END OF THE NEXT CENTURY. HOWEVER, THE IPCC NOTED THAT SIGNIFICANT UNCERTAINTY REMAINS REGARDING THE TIMING, MAGNITUDE AND REGIONAL DISTRIBUTION OF CLIMATE CHANGE. ALTHOUGH THE IPCC NOTED THAT THESE CHANGES COULD HAVE SIGNIFICANT IMPACTS, PARTICULARLY ON AREAS ALREADY UNDER STRESS, OUR CONFIDENCE REGARDING THE IMPACTS OF CLIMATE CHANGE IS LOW. THIS LACK OF CONFIDENCE STEMS IN PART FROM THE UNCERTAINTIES REGARDING REGIONAL CLIMATE CHANGE BUT ALSO FROM OUR INCOMPLETE UNDERSTANDING OF THE DIRECT EFFECTS OF CO2 ON AGRICULTURE, VEGETATION GROWTH AND OTHER FACTORS.

Q: What is your view regarding the importance of international action to address the climate change problem?

A: INTERNATIONAL ACTION IS ABSOLUTELY ESSENTIAL IF WE ARE TO UNDERSTAND BETTER AND ADDRESS EFFECTIVELY CLIMATE CHANGE SINCE ACTIVITIES IN EVERY NATION IN THE WORLD CONTRIBUTE TO EMISSIONS OF GREENHOUSE GASES. NO ONE NATION, OR SMALL GROUP OF NATIONS, CAN HOPE TO ADDRESS THIS ISSUE EFFECTIVELY BY ACTING ALONE, PARTICULARLY OVER THE LONG TERM. ACCORDINGLY, THE UNITED STATES FIRMLY BELIEVES THAT AN EFFECTIVE RESPONSE TO CLIMATE CHANGE MUST BE GLOBAL.

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Q: Summarize the commitments and policies that other nations have adopted, or are planning to adopt, to reduce emission of GHGs, CO2 in particular.

A: MANY OTHER INDUSTRIALIZED NATIONS HAVE ANNOUNCED THEIR INTENTION TO STABILIZE CO2 EMISSIONS BY THE TURN OF THE CENTURY. A FEW OF THESE, LIKE AUSTRIA, AUSTRALIA, DENMARK, GERMANY AND NEW ZEALAND, HAVE STATED FURTHER THAT THEY HOPE TO REDUCE CO2 EMISSIONS BY THE YEAR 2005. THE BASELINE YEAR USED VARIES SOMEWHAT BETWEEN COUNTRIES AND SOME OF THESE NATIONS, SUCH AS FRANCE AND JAPAN, HAVE ADOPTED PER CAPITA TARGETS THAT ALLOW FOR CONTINUED GROWTH IN THEIR OVERALL EMISSIONS. ALL MAJOR CFC PRODUCERS HAVE ALSO COMMITTED UNDER THE MONTREAL PROTOCOL TO PHASE-OUT THEIR PRODUCTION OF OZONE DEPLETING SUBSTANCES, WHICH ALSO CONTRIBUTE TO CLIMATE CHANGE.

HOWEVER, WITH THE EXCEPTION OF AUSTRALIA, ICELAND AND CANADA, NONE OF THESE COUNTRIES HAVE SET QUANTIFIED EMISSION TARGETS FOR ANY OF THE OTHER GREENHOUSE GASES OR FOR TOTAL GLOBAL WARMING POTENTIAL, SUCH AS METHANE. REALIZING THEIR CO2 COULD THUS ALLOW AN INCREASE IN EMISSIONS OF METHANE AND OTHER GREENHOUSE GAS MORE POTENT THAN CO2. MOREOVER, NO DEVELOPING OR EASTERN EUROPEAN NATION HAVE SET ANY EMISSION TARGETS. THIS IS PARTICULARLY SIGNIFICANT IN THAT THESE COUNTRIES WILL PROBABLY ACCOUNT FOR OVER HALF OF THE GREENHOUSE GAS EMISSIONS BY EARLY IN THE NEXT CENTURY.

Q: Summarize the actions and legal authorities adopted by the major industrialized nations to implement these targets and timetables.

A: ALTHOUGH A FEW NATIONS, LIKE THE NETHERLANDS, DENMARK, FINLAND AND GERMANY, HAVE PREPARED PLANS FOR ACHIEVING THESE TARGETS, MOST ARE NOW CONSIDERING HOW THEY MIGHT BE ABLE TO REACH THESE GOALS. WE UNDERSTAND THAT HOW TO ACHIEVE THESE GOALS IS GENERATING SOME DEBATE IN A FEW OF THESE COUNTRIES. MOREOVER, MANY ARE STILL PERFORMING ECONOMIC ANALYSES OF THEIR TARGETS AND POSSIBLE MEASURES TO ACHIEVE THOSE TARGETS. FINALLY, A NUMBER HAVE QUALIFIED THEIR TARGETS, FOR EXAMPLE, BY STATING THAT THEIR ACTIONS DEPEND ON OTHER NATIONS ADOPTING SIMILAR TARGETS, THAT THEIR TARGETS ARE "INTERIM" OR FOR PLANNING PURPOSES, OR THAT THEIR EFFORTS WILL NOT BE ALLOWED TO INTERFERE WITH THEIR ECONOMIC GOALS.

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Q: Compare these actions and commitments with those of the United States.

A: THE UNITED STATES HAS DEVELOPED A COMPREHENSIVE CLIMATE CHANGE STRATEGY BASED ON CONCRETE ACTIONS THAT WILL RESULT IN OUR GREENHOUSE GAS EMISSIONS IN THE YEAR 2000 BEING EQUAL TO OR BELOW 1987 LEVELS. THIS ACTIONS INCLUDE:

- PHASING OUT CFCS AND OTHER OZONE DEPLETING COMPOUNDS THAT ARE ALSO GREENHOUSE GASES FASTER THAN REQUIRED BY THE MONTREAL PROTOCOL;
- ENCOURAGING ENERGY EFFICIENCY AND REDUCING GREENHOUSE GAS EMISSIONS BY CAPPING SULFUR DIOXIDE EMISSIONS AT SUBSTANTIALLY REDUCED LEVELS WHILE ALLOWING UTILITIES THE FLEXIBILITY TO MEET THIS CAP IN THE MOST ECONOMICALLY EFFICIENT MANNER POSSIBLE;
- REDUCING AIR POLLUTANTS WHICH ARE GREENHOUSE GASES OR GREENHOUSE GAS PRECURSORS, SUCH AS VOLATILE ORGANIC COMPOUNDS AND METHANE FROM MOBILE SOURCES AND LANDFILLS;
- INITIATING A PROGRAM TO PLANT A BILLION TREES A YEAR;
- SPEEDING THE ADOPTION OF ENERGY EFFICIENT TECHNOLOGIES AND PRACTICES IN HOMES AND BUSINESSES; AND
- PROMOTING THE USE OF, AND RESEARCH INTO, NON-FOSSIL FUEL ENERGY SOURCES.

Q: If the United States will hold its emissions stable through the turn of the century, why are we reluctant to commit to a CO2 target?

A: THERE ARE A NUMBER OF REASONS WHY A CO2 TARGET IS INAPPROPRIATE:

- FIRST, ANY RESPONSE TO CLIMATE CHANGE MUST BE GLOBAL IF IT IS TO BE EFFECTIVE. MOST PROPOSALS REGARDING A CO2 TARGET WOULD IMPOSE THE TARGET ON INDUSTRIALIZED COUNTRIES IMMEDIATELY BUT DELAY ITS APPLICATION TO DEVELOPING COUNTRIES TO GIVE THEM MORE TIME FOR INDUSTRIAL DEVELOPMENT. IMPOSING RESTRICTIONS ONLY ON INDUSTRIALIZED NATIONS IS LIKELY TO BE INEFFECTIVE DUE TO THE RELOCATION OF EMISSIONS-INTENSIVE ACTIVITIES TO OTHER COUNTRIES. SIGNALLING THAT THE INDUSTRIALIZED COUNTRIES CAN ADDRESS THIS ISSUE ALONE WOULD BE MISLEADING AND COULD DELAY THE CONCERTED GLOBAL RESPONSE THAT IS NEEDED.
- SECOND, WE BELIEVE A COMPREHENSIVE APPROACH IS A SOUNDER BASIS FOR INTERNATIONAL ACTION. CONCENTRATING JUST ON ONE GREENHOUSE GAS IGNORES THE POSSIBILITY OF OTHER, MORE COST-EFFECTIVE RESPONSES AIMED AT OTHER GREENHOUSE GASES. THE FOCUS OF ENVIRONMENTAL CONCERN SHOULD BE THE NET EFFECT ON RADIATIVE FORCING, NOT EMISSIONS OF ANY ONE GAS. IN FACT, CO2 IS THE WEAKEST GREENHOUSE GAS PER KILOGRAM.

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- THIRD, FOCUSSED NARROWLY ON CO2 COULD UNINTENTIONALLY INCREASE EMISSIONS OF OTHER GREENHOUSE GASES. FOR EXAMPLE, AN EARLY RESPONSE TO A CO2 TARGET WOULD BE FUEL-SWITCHING FROM COAL TO NATURAL GAS. THIS WOULD REDUCE CO2 EMISSIONS BUT INCREASE METHANE EMISSIONS FROM DISTRIBUTION LEAKS OF NATURAL GAS. METHANE IS A MORE MORE POTENT GREENHOUSE GAS THAN CO2 AND EVEN SMALL METHANE LEAKS CAN BE IMPORTANT IN MANY NATIONS.
- FOURTH, IMPOSITION OF RESTRICTIONS TO A LIMITED NUMBER OF NATIONS COULD CAUSE SIGNIFICANT DISTORTIONS IN THE INTERNATIONAL COMPETITIVENESS OF THOSE NATIONS.
- FIFTH, THE ECONOMIC CONSEQUENCES OF SUCH TARGETS ARE EXTREMELY UNCERTAIN. PROJECTIONS OF EMISSIONS ARE HEAVILY DEPENDENT ON EXPECTED GROWTH RATES. SHOULD ECONOMIC GROWTH PROVE TO BE FASTER THAN EXPECTED, EMISSIONS WILL PROBABLY ALSO GROW FASTER THAN EXPECTED AND MEETING A TARGET COULD PROVE TO BE PROHIBITIVELY EXPENSIVE, WITH POTENTIALLY SERIOUS CONSEQUENCES FOR THE WORLD ECONOMY, INCLUDING THE DEVELOPMENT ASPIRATIONS OF DEVELOPING COUNTRIES..

THE RESPONSE TO CLIMATE CHANGE MUST BE GLOBAL AND COMPREHENSIVE, DIRECTING ATTENTION TO ALL GREENHOUSE GASES, THEIR SOURCES AND SINKS. THE UNITED STATES IS TAKING THE LEAD IN ADVANCING THIS APPROACH.

**United States Department of State**

*Bureau of Oceans and International
Environmental and Scientific Affairs*

Washington, D.C. 20520

February 16, 1991

RAPIDFAX TRANSMISSION

22 Pages to Follow

TO: PCC Working Group on Climate Change
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FROM: OES/EGC - Jeff Miotke
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SUBJECT: Draft #4 of Testimony and Q&As

Draft #4 of Bob Reinstein's testimony and Q&As follows for the House Subcommittee on Health and the Environment hearing on February 21 and Senate Subcommittee on Environmental Protection hearing on March 5.

This will be circulated via OMB channels for final clearance as all testimony is. I am providing you with this copy because pages 9-11 of the testimony contain, at DOE's suggestion, material related to the NES, which were not in earlier drafts. The only other major change is that I have moved the details of the Action Agenda from a Q&A to the body of the testimony.

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Attn: **Joan Donoghue**

- 1 -

Thank you, Mr. Chairman. I am Robert A. Reinstein, the Deputy Assistant Secretary of State for Environment, Health and Natural Resources. I am also the United States negotiator for climate change. Appearing with me are Mark L. Kerrigan, Associate Deputy Under Secretary for Policy, Planning and Analysis at the Department of Energy, and Richard D. Morgenstern, Director of the Office of Policy Analysis of the Environmental Protection Agency.

It is a pleasure to appear before this subcommittee to discuss the negotiations on a framework convention on climate change. I would like to discuss briefly with you the results of the negotiating session that just ended, the timetable for future sessions and the overall U.S. position in these negotiations. I would also like to touch on the National Energy Strategy (NES) and the contribution that it can make to the addressing climate change.

Results of the First Session

At the President's invitation, the United States hosted the first session of these negotiations on February 4-14 just outside of Washington, DC. One hundred and one countries from every region of the world, representing both developing and industrialized nations, participated in this session.

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Consistent with the open process that we sought, 65 non-governmental organizations (NGOs) also participated and will be able to provide input throughout the negotiations.

Not content with merely hosting the first session, we entered these negotiations eager to move the discussion forward substantively. We had hoped to develop a draft negotiating text during this session, although we expected that such a draft text would have numerous brackets reflecting the differences in positions to be expected at the start of any negotiations. Compiling a bracketed text would have clarified the initial negotiating positions of the various parties and enabled them to consider those positions in the next few weeks, thus facilitating the discussions in subsequent sessions. Towards this end, we circulated draft sections of a framework convention and distributed a number of documents explaining the U.S. perspective on the contents of a framework convention. Unfortunately, however, resolution of procedural matters required the full two weeks of the first session and left no time for consideration of substantive proposals. The difficulty in resolving even procedural issues indicates the complexity of this subject and the importance many countries, including the United States, attach to it.

We are hopeful, nonetheless, that the organization and

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procedures on which we agreed in this session will pave the way for steady, substantive progress in the sessions to follow:

- We agreed, for instance, to organize two working groups, one which will consider all sources and sinks of all greenhouse gases, and one which will consider mechanisms of implementation of the convention. This structure will provide for a comprehensive discussion of the issue and will provide for full consideration of the concerns common to the negotiating parties.
- We reached agreement on Rules of Procedure which emphasize decision making by consensus and which will, as I have mentioned, allow NGOs to play a viable role in the negotiations. The United States was a forceful advocate of NGO participation.
- There was also a great deal of discussion on ways to improve the participation of developing countries. These negotiations and any long term response to climate change, will be effective only if the broadest spectrum of nations participate. The number of developing countries participating should increase in later sessions and they should now be able to send experts from their capitals. To this end, the United States was the first country to contribute to a voluntary trust fund established to support the participation of developing countries.
- Working with other nations, we produced an informal paper

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outlining the scientific, technical and economic research needs which the convention should address. This exchange of views should make it easier to conclude these sections of the convention at a later stage in the negotiations.

- We also reached agreement on the important role the Intergovernmental Panel on Climate Change (IPCC) will play in responding to the technical needs of the negotiations. With this mandate, the IPCC will be in a position to provide information and resolve questions of a technical nature during the negotiations.

Perhaps most importantly, we have laid the foundation of a cooperative relationship with other national delegations. Such relationships will help to move the process along and will facilitate positive consideration of our position.

Next Sessions

This session was the first of four or five sessions of the negotiations established under the auspices of the United Nations General Assembly by Resolution 45/212 on the "Protection of Global Climate for Present and Future Generations." The next session is tentatively scheduled for May or June. Following that session, we will meet in September and once or twice thereafter, as necessary. The

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goal, as articulated in 45/212, is to complete the negotiations so that the framework convention will be open for signature during the UN Conference on Environment and Development in June 1992.

The U.S. View on the Negotiations

The United States is approaching these negotiations with several principles in mind -- principles which are key to an effective convention and global response to climate change:

- First, we believe we must take a comprehensive approach to climate change, one which considers all aspects of this complex issue and which addresses all greenhouse gases and their sources and sinks;
- Second, we must not wait for all uncertainties to be resolved, but must pursue economically efficient and cost-effective actions - already justified on other grounds - which will limit net greenhouse gas emissions;
- Third, we must continue to pursue aggressively scientific and economic research; systematic observation; collection, archiving and distribution of information; and technology development in order to resolve uncertainties and build a solid foundation for innovative responses;
- Fourth, we must recognize the special needs of the developing countries and design mechanisms for assisting

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them in securing the scientific and technical tools necessary for their fullest participation in a truly global effort.

- Fifth, any response must be global. Emissions from developing countries are growing rapidly and action by industrialized nations alone would be ineffective at restraining emissions. We must also be sensitive to the fact that different forms of commitments and the extent to which appropriate commitments are applied unevenly will impact the competitive position of both developing and industrialized nations. An effective response will require that all nations participate and meet obligations that are appropriate to their circumstances.

The United States will seek to translate these principles into an innovative and effective framework convention that will engage all nations in a concerted international response to climate change.

A Comprehensive Approach to Climate Change

The United States strongly supports a comprehensive approach, one which considers all sources and sinks of all greenhouse gases, for a number of reasons. This approach provides the flexibility needed for each nation to address

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climate change in the context of its unique circumstances. A comprehensive approach also ensures that research and technology development address all facets of the problem. Further, a comprehensive approach will ensure that we take advantage of the most cost-effective opportunities to address climate change across the range of sources and sinks of all greenhouse gases. Finally, the comprehensive approach ensures accounting for all activities that emit or absorb greenhouse gases and avoids creating incentives that shift emissions from one type of gas or sector to another, as we know from experience can happen with narrowly focussed approaches. A comprehensive approach would allow each nation the flexibility to choose its best mix of response measures. Accordingly, we believe the framework convention, and any subsequent legal instruments, must be comprehensive and deal with the full array of greenhouse gases and their sources and sinks. In addition, the IPCC First Assessment Report notes that we must consider both limitation and adaptation as part of an integrated response.

During the first session, the United States distributed a booklet and led an informal discussion on the comprehensive approach. We will continue this effort to engage in open dialogue with the international community about the rationale and implications of this approach.

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Actions that are Justified in Their Own Right

The United States is already taking concrete measures that are justified in their own right, but also have climate change benefits. As outlined in the brochure "America's Climate Change Strategy: An Action Agenda" which we distributed at the first session, this strategy will result in U.S. greenhouse gas emissions in the year 2000 being equal to or below the 1987 level. These actions include:

- Phasing out chlorofluorocarbons (CFCs) and other ozone depleting compounds that are also greenhouse gases faster than required by the Montreal Protocol;
- Encouraging energy efficiency and reducing greenhouse gas emissions by capping sulfur dioxide emissions at substantially reduced levels while allowing utilities the flexibility to meet this cap in the most economically efficient manner possible;
- Reducing air pollutants which are greenhouse gases or greenhouse gas precursors, such as volatile organic compounds and methane;
- Initiating a program to plant a billion trees a year;
- Speeding the adoption of energy efficient technologies and practices in homes and businesses; and
- Promoting the use of, and research into, non-fossil fuel energy sources.

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Role of the National Energy Strategy

The National Energy Strategy, echoing the recommendations of the IPCC, includes a number of actions that, although taken principally for other energy or national security reasons, will have significant environmental benefits, including curbing the buildup of future U.S. emissions of greenhouse gases. The strategy includes actions that provide cost-effective alternatives to burning fossil fuels for generating electricity and more efficient and alternative-fueled vehicles that will reduce greenhouse gases produced from transportation emissions.

If no actions were taken, emissions from one important greenhouse gas, CO₂ would grow by 80 percent by the year 2030, according to one part of the NES scenario. Likewise, emissions of other greenhouse gases, such as methane, nitrous oxides and carbon monoxide, would grow as well. This growth would occur for the most part due to increased coal use for electricity generation and due to growth in auto emissions. While there is always uncertainty regarding future projections, without the NES, greenhouse gas emissions, as measured in terms of global warming potential, are likely to increase by over 2.82 billion tons of CO₂ equivalents. This would be a 38.4 percent increase over the 1990 levels by 2030.

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Collectively, the NES actions will not only reduce our dependency on foreign oil and increase our electricity supply options, but will also reduce the emissions of major greenhouse gases from what would otherwise occur. For most cases, these reductions will fully offset increases otherwise expected from growth in the economy and population:

- Based on the NES scenario, actions as a result of the strategy and current Administration programs will reduce the rate of growth of carbon dioxide and carbon monoxide emissions. These are key greenhouse gases related to energy use, in particular to combustion of fossil fuels. After 2015, these emissions should level off and remain stable through 2030, according to the projections in the NES.
- Increased use of alternative fuels, energy efficiency, renewable and nuclear energy, as well as EPA's regulations controlling methane from landfills, will reduce methane emissions below current levels through 2015. Further, after 2015 annual methane emissions from energy sources will continue to decline.
- Nitrogen oxide and volatile organic compounds, precursors to tropospheric ozone that could lead to potential warming, are held to levels that are about the same or below the 1990 levels and decline from 2015 to 2030.

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When all greenhouse gases are considered in terms of global warming potential, the National Energy Strategy, coupled with the existing Administration programs described in "America's Climate Change Strategy," will substantially curb the growth in these gases beyond the year 2000. The NES will allow us to hold emission levels within a range that is close to current levels well into the foreseeable future.

Consistent with our Climate Change Strategy and the NES, the framework convention could commit all nations to develop similar national strategies, emphasizing attention to actions that are warranted for other reasons and that also limit net greenhouse gas emissions. In light of the considerable uncertainties surrounding climate change, a global response of this nature will provide a realistic, prudent and cost-effective framework under which all countries can begin to implement measures with climate change benefits. At the same time, it recognizes that the appropriate measures available to different countries will vary depending on their social, environmental, and economic circumstances.

Research and Systematic Observation

Research and systematic observation are essential to improving our understanding of climate change and helping us

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to tailor responses that are appropriate, efficient, effective, and sustainable over the long term. Research can also provide the needed energy-efficient technologies that is both economic and environmentally beneficial. For our part, we are pursuing a \$2 billion program of global change research and energy technology development that will provide the tools for devising innovative, long-term responses. Consistent with our own actions, the United States put forward a specific proposal during the first session for a strong program of scientific and economic research and systematic observation as another cornerstone of the framework convention.

Implementation Issues

There are many other specific issues that must be addressed prominently in the framework convention. With regard to the developing countries, we recognize their desires and aspirations for economic growth. Thus we believe it is essential for developing countries to participate in any response to climate change in a manner that recognizes both their development needs and the greenhouse gas implications of such development. Thus, we believe the framework convention should include a general commitment to promote financial assistance to developing countries to study and address climate change. Existing bilateral and multilateral

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financial-assistance mechanisms and, in particular, the newly established Global Environmental Facility in the World Bank are the appropriate mechanisms for providing such assistance.

Technology transfer is essential to any effective global response and there are many existing low cost, effective technologies that can be transferred now. We stated in the first session our willingness to explore such ideas as energy efficiency centers and agricultural and forestry demonstration projects, as well as industry joint ventures with other countries to promote available technologies. Implementation of these concepts will need to be considered, of course, in the context of specific commitments to action. Special efforts will need to be made to match appropriate technologies to needs.

Over the long term, new technologies will play an increasingly important role in the response to climate change. Many of these technologies are still only ideas, or must undergo further development to become technologically and economically feasible. Therefore, the convention must provide the right incentives for continual research, development, and dissemination of appropriate technologies. Since the private sector researches, develops and disseminates new technology most effectively, the convention should seek to remove

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barriers to effective commercial development and transfer of technology and should ensure that intellectual property rights are fully protected so as to provide the incentive necessary for continual development of new technology.

We should also discuss ways to transfer the knowledge necessary to understand, plan for and address climate change. The United States has traditionally provided a great deal of technical assistance in dealing with specific environmental problems, developing environmental institutions, and conducting country studies. During the first session, therefore, we stated that we are prepared to undertake, in cooperation with other nations, specific country studies to define appropriate technologies to reduce greenhouse gases. The NGO community, including the business community, also has an important role to play in this regard.

Conclusion

Mr. Chairman, procedural matters prevented us from developing a draft negotiating text during this first session, as we had hoped. Nonetheless, we agreed on a negotiating process which will promote an expeditious, open and unbiased discussion of the issues surrounding climate change. In the sessions that follow, the United States will continue to seek

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an agreement that is comprehensive, that recognizes the value of actions which help to address climate change and are justified on other grounds, that provides for a strong scientific and economic research program, and that recognizes the special needs of the developing countries. Rest assured that the United States will make every effort to conclude such an agreement before the June 1992 deadline that we have set. Such a convention is the crucial first step in what the United States realizes must be a sustained and long-term effort to address climate change.

Mr. Chairman, let me thank you again for the opportunity to appear before this subcommittee. My colleagues and I would be happy to entertain any questions that you might have.

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Q: What is your view on the nature and severity of global climate change?

A: IN ITS FIRST ASSESSMENT REPORT, THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC) STATED THAT EMISSIONS RESULTING FROM HUMAN ACTIVITIES WILL RESULT, ON AVERAGE, IN AN ADDITIONAL WARMING OF THE EARTH'S SURFACE. ACCORDING TO ONE SCENARIO IN THE IPCC REPORT, THE AVERAGE SURFACE TEMPERATURE WILL LIKELY INCREASE FROM 2 TO 5 DEGREES CENTIGRADE AND THE AVERAGE SEA LEVEL WILL PROBABLY RISE FROM ONE TO THREE FEET BY THE END OF THE NEXT CENTURY. HOWEVER, THE IPCC NOTED THAT SIGNIFICANT UNCERTAINTY REMAINS REGARDING THE TIMING, MAGNITUDE AND REGIONAL DISTRIBUTION OF CLIMATE CHANGE.

ALTHOUGH THE IPCC NOTED THAT THESE CHANGES COULD HAVE SIGNIFICANT IMPACTS, PARTICULARLY ON AREAS ALREADY UNDER STRESS, OUR CONFIDENCE REGARDING THE IMPACTS OF CLIMATE CHANGE IS LOW. THIS LACK OF CONFIDENCE STEMS IN PART FROM THE UNCERTAINTIES REGARDING REGIONAL CLIMATE CHANGE BUT ALSO FROM OUR INCOMPLETE UNDERSTANDING OF THE COMBINED EFFECTS OF CLIMATE CHANGE AND CO₂ ON AGRICULTURE, VEGETATION GROWTH AND OTHER FACTORS.

- 2 -

Q: What is your view regarding the importance of international action to address the climate change problem?

A: INTERNATIONAL ACTION IS ABSOLUTELY ESSENTIAL IF WE ARE TO UNDERSTAND BETTER AND ADDRESS EFFECTIVELY CLIMATE CHANGE SINCE ACTIVITIES IN EVERY NATION IN THE WORLD CONTRIBUTE TO EMISSIONS OF GREENHOUSE GASES. NO ONE NATION, OR SMALL GROUP OF NATIONS, CAN HOPE TO ADDRESS THIS ISSUE EFFECTIVELY BY ACTING ALONE, PARTICULARLY OVER THE LONG TERM. FOR INSTANCE, SIGNALLING THAT THE INDUSTRIALIZED COUNTRIES CAN ADDRESS THIS ISSUE ALONE, AS IMPLIED IN PROPOSALS TO SET CO₂ TARGETS AND TIMETABLES, WOULD BE MISLEADING AND COULD DELAY THE CONCERTED GLOBAL RESPONSE THAT IS NEEDED. ACCORDINGLY, THE UNITED STATES FIRMLY BELIEVES THAT AN EFFECTIVE RESPONSE TO CLIMATE CHANGE MUST BE GLOBAL.

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Q: Summarize the commitments and policies that other nations have adopted, or are planning to adopt, to reduce emission of GHGs, CO₂ in particular.

A: MANY OTHER INDUSTRIALIZED NATIONS HAVE ANNOUNCED THEIR INTENTION TO STABILIZE CO₂ EMISSIONS BY THE TURN OF THE CENTURY. A FEW OF THESE, LIKE AUSTRIA, AUSTRALIA, DENMARK, GERMANY AND NEW ZEALAND, HAVE STATED FURTHER THAT THEY HOPE TO REDUCE CO₂ EMISSIONS BY THE YEAR 2005. THE BASELINE YEAR USED VARIES SOMEWHAT BETWEEN COUNTRIES AND SOME OF THESE NATIONS, SUCH AS FRANCE AND JAPAN, HAVE ADOPTED PER CAPITA TARGETS THAT ALLOW FOR CONTINUED GROWTH IN THEIR OVERALL EMISSIONS. ALL MAJOR CFC PRODUCERS HAVE ALSO COMMITTED UNDER THE MONTREAL PROTOCOL TO PHASE-OUT THEIR PRODUCTION OF OZONE DEPLETING SUBSTANCES, WHICH ALSO CONTRIBUTE TO CLIMATE CHANGE.

HOWEVER, WITH THE EXCEPTION OF AUSTRALIA, ICELAND AND CANADA, NONE OF THESE COUNTRIES HAVE SET QUANTIFIED EMISSION TARGETS FOR ANY OF THE OTHER GREENHOUSE GASES OR FOR TOTAL GLOBAL WARMING POTENTIAL, SUCH AS METHANE. MEETING THEIR CO₂ TARGETS COULD STILL ALLOW AN INCREASE IN EMISSIONS OF METHANE AND OTHER GREENHOUSE GASES MORE POTENT THAN CO₂. MOREOVER, NO DEVELOPING OR EASTERN EUROPEAN NATION, OTHER THAN POLAND, HAS SET ANY EMISSION TARGETS. THIS IS PARTICULARLY SIGNIFICANT IN THAT THESE COUNTRIES WILL PROBABLY ACCOUNT FOR OVER HALF OF THE GREENHOUSE GAS EMISSIONS BY EARLY IN THE NEXT CENTURY.

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Q: Summarize the actions and legal authorities adopted by the major industrialized nations to implement these targets and timetables.

A: ALTHOUGH A FEW NATIONS, LIKE THE NETHERLANDS, DENMARK, AND GERMANY, HAVE PREPARED PLANS FOR ACHIEVING THESE TARGETS, MOST ARE NOW CONSIDERING HOW THEY MIGHT BE ABLE TO REACH THESE GOALS. WE UNDERSTAND THAT HOW TO ACHIEVE THESE GOALS IS GENERATING SOME DEBATE IN A FEW OF THESE COUNTRIES. MOREOVER, MANY ARE STILL PERFORMING ECONOMIC ANALYSES OF THEIR TARGETS AND POSSIBLE MEASURES TO ACHIEVE THOSE TARGETS. FINALLY, A NUMBER HAVE QUALIFIED THEIR TARGETS, FOR EXAMPLE, BY STATING THAT THEIR ACTIONS DEPEND ON OTHER NATIONS ADOPTING SIMILAR TARGETS, THAT THEIR TARGETS ARE "INTERIM" OR FOR PLANNING PURPOSES, OR THAT THEIR EFFORTS WILL NOT BE ALLOWED TO INTERFERE WITH THEIR ECONOMIC GOALS.

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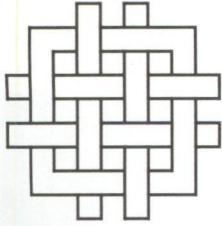
Q: If the United States will hold its emissions stable through the turn of the century, why are we reluctant to commit to a CO₂ target?

A: THERE ARE A NUMBER OF REASONS WHY A CO₂ TARGET IS INAPPROPRIATE:

- FIRST, ANY RESPONSE TO CLIMATE CHANGE MUST BE GLOBAL IF IT IS TO BE EFFECTIVE. MOST PROPOSALS REGARDING A CO₂ TARGET WOULD IMPOSE THE TARGET ON INDUSTRIALIZED COUNTRIES IMMEDIATELY BUT DELAY ITS APPLICATION TO DEVELOPING COUNTRIES TO GIVE THEM MORE TIME FOR INDUSTRIAL DEVELOPMENT. YET EMISSIONS ARE GROWING MUCH FASTER IN THE DEVELOPING WORLD. IMPOSING RESTRICTIONS ONLY ON INDUSTRIALIZED NATIONS IS LIKELY TO BE UNDERCUT BY TO THE RELOCATION OF EMISSIONS-INTENSIVE ACTIVITIES TO OTHER COUNTRIES.
- SECOND, WE BELIEVE A COMPREHENSIVE APPROACH IS A SOUNDER BASIS FOR INTERNATIONAL ACTION. CONCENTRATING JUST ON ONE GREENHOUSE GAS IGNORES THE POSSIBILITY OF OTHER, MORE COST-EFFECTIVE RESPONSES AIMED AT OTHER GREENHOUSE GASES. THE FOCUS OF ENVIRONMENTAL CONCERN SHOULD BE THE NET EFFECT ON RADIATIVE FORCING, NOT EMISSIONS OF ANY ONE GAS. IN FACT, CO₂ IS THE WEAKEST GREENHOUSE GAS PER KILOGRAM.

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- THIRD, FOCUSING NARROWLY ON CO₂ COULD UNINTENTIONALLY INCREASE EMISSIONS OF OTHER GREENHOUSE GASES. FOR EXAMPLE, AN EARLY RESPONSE TO A CO₂ TARGET WOULD BE FUEL-SWITCHING FROM COAL TO NATURAL GAS. THIS WOULD REDUCE CO₂ EMISSIONS BUT INCREASE METHANE EMISSIONS FROM DISTRIBUTION LEAKS OF NATURAL GAS. METHANE IS A ~~MUCH~~ MORE POTENT GREENHOUSE GAS THAN CO₂ AND EVEN SMALL METHANE LEAKS CAN OFFSET LARGE CO₂ REDUCTIONS. THIS PROBLEM COULD BE IMPORTANT IN MANY NATIONS.
 - FOURTH, IMPOSITION OF RESTRICTIONS TO A LIMITED NUMBER OF NATIONS COULD CAUSE SIGNIFICANT DISTORTIONS IN THE INTERNATIONAL COMPETITIVENESS OF THOSE NATIONS.
 - FIFTH, THE ECONOMIC CONSEQUENCES OF SUCH TARGETS ARE EXTREMELY UNCERTAIN. PROJECTIONS OF EMISSIONS ARE HEAVILY DEPENDENT ON EXPECTED GROWTH RATES. SHOULD ECONOMIC GROWTH PROVE TO BE FASTER THAN EXPECTED, EMISSIONS WILL PROBABLY ALSO GROW FASTER THAN EXPECTED AND MEETING A TARGET COULD PROVE TO BE PROHIBITIVELY EXPENSIVE, WITH POTENTIALLY SERIOUS CONSEQUENCES FOR THE WORLD ECONOMY, INCLUDING THE DEVELOPMENT ASPIRATIONS OF DEVELOPING COUNTRIES..
- THE RESPONSE TO CLIMATE CHANGE MUST BE GLOBAL AND COMPREHENSIVE, DIRECTING ATTENTION TO ALL GREENHOUSE GASES, THEIR SOURCES AND SINKS. THE UNITED STATES IS TAKING THE LEAD IN ADVANCING THIS APPROACH.



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January, 1991

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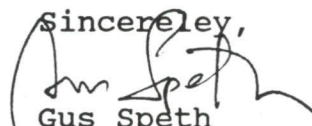
Dear Friend:

I am pleased to provide you with a copy of Minding the Carbon Store: Weighing U.S. Forestry Strategies to Slow Global Warming, a new World Resources Institute report by WRI Associate Mark C. Trexler.

As formal negotiations on international responses to the problem of global warming get underway in February, forestry is likely to be high on the agenda. International meetings over the last couple of years have referred repeatedly to the importance of slowing deforestation and increasing reforestation as ways to slow the buildup of carbon dioxide in the earth's atmosphere.

In Minding the Carbon Store, Dr. Trexler examines the most important opportunities facing the United States in the area of biotic carbon sequestration. He walks us through the science underlying each option, reviews the implementation pitfalls likely to be encountered, and assesses the cost-effectiveness and realistically achievable carbon benefit associated with each option. He concludes that biotic options can play a significant role in reducing net U.S. carbon emissions, but cautions that they are most appropriately used as just one part of a comprehensive transitional strategy intended to slow global warming and reduce our dependence on carbon-emitting fuels. Dr. Trexler also convincingly argues that biotic options as a class should not be expected to provide easy or cheap reductions in carbon dioxide emissions as compared to energy-based emissions reduction options.

Minding the Carbon Store is the second of three WRI studies examining forestry opportunities in a global warming context, and continues WRI's effort to clarify what is a complex and often misunderstood technical and policy issue. I hope it will help guide policy makers and international negotiators as domestic and multilateral responses to global warming policy are proposed and developed in coming years. Your comments and reactions would be most welcome.

Sincerely,

Gus Speth
President



PUBLICATIONS BRIEF

JANUARY 1991

MINDING THE CARBON STORE: WEIGHING U.S. FORESTRY STRATEGIES TO SLOW GLOBAL WARMING

by Mark C. Trexler

After decades of discovery and discussion, scientists are reaching consensus on how human activities are affecting the natural greenhouse effect. In near unison, they estimate that we have already committed the planet to significant warming that may not make itself manifest for some decades.

If we hope to slow global warming and eventually stabilize the atmosphere, we must control atmospheric concentrations of heat-trapping gases. Carbon dioxide, still the leading culprit, is a particular problem since its concentration is now rising by 0.5 percent each year.

At least two thirds of the carbon dioxide human activities produce comes from burning fossil fuels, and the rest from deforestation and other land-use changes. All told, these activities give rise to some 7 billion tons of carbon annually. That looks like a mere blip on the screen when Earth's carbon cycle moves 400 billion tons of carbon around each year, but it is enough to throw the natural cycle out of equilibrium, driving atmospheric carbon content steadily upward.

While there is little doubt that significantly slowing the atmospheric buildup of carbon dioxide would require major changes in energy use and consumption patterns, planting trees as a response to the threat of global warming is gaining more and more international support. The concept's most prominent endorsement to date is the 1989 Noordwijk Declaration, in which environmental ministers from 68 countries adopted a goal of yearly 30-million-acre net increases in forest cover by the year 2000—a reversal of the current annual loss of 30-50 million acres of forest. Because trees remove carbon dioxide from the atmosphere as they grow, achieving such a goal would dramatically reduce the net carbon emissions resulting from human activities.

Large-scale tropical reforestation is one way to ap-

proach this goal, but the United States and other developed countries could also pursue forestry options that would make a global difference. President Bush's "America the Beautiful" proposal to plant ten billion trees over the next decade is one of many ideas now percolating through scientific and policy-making circles about how the U.S. carbon cycle might be manipulated to slow carbon dioxide buildup, but there are many others as well.

RECOMMENDATIONS AND RATIONALES

In theory, the United States could pursue all available options to their biological limits. (See Table 1.) In practice, it's unlikely to mount such a vigorous all-fronts initiative since mitigating global warming must compete with many other pressing policy goals and land uses. However, as the following discussion suggests, many forestry and agricultural policy changes would advance several environmental policy goals at once, which should help to make such changes more politically palatable.

1. *Selectively convert southeastern pasture lands to tree cover.* One fourth of the one billion acres that are now cropland, pasture, or rangeland were forested when Europeans arrived in the New World. Many of these deforested acres are highly erodible or otherwise environmentally fragile, and would benefit from being returned to tree cover. The economic rationale for reforesting some 20 to 25 million acres of pasture in the southeastern United States is compelling since tree cover would return more profit to landowners than pasture does. Converting these acres should therefore entail little federal expense apart from educating landowners and providing extension services, making these pasture lands good candidates for the president's "America the Beautiful" program.

2. *Expand biomass-to-energy demonstration programs.*

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Table 1. U.S. Biotic Policy Opportunities and Costs

Option	Theoretical Carbon Benefit ^a (millions of tons/yr)	Practical Benefit to 2030 (millions of tons/yr) (\$/ton)	
Urban Forestry	15	3-5	\$0-25
Private Land Conversions	400-900 ^b	50-150	\$0-50
Public Land Conversions	(not known)	(not known)	(not known)
Forestry Management	100-400	35-75	\$0-100
Foregoing Old-Growth Harvests	10-20	5-10	\$0-100
Biomass Energy Production	400-1,000 ^b	20-150	\$20-75
Increase Wood Use	(not known)	(not known)	(not known)
Soil Carbon Buildup	50-150	10-25	\$0-10

a. The carbon benefit figure estimates carbon storage in biomass and in soils as well as fossil fuel carbon displaced through implementation of the biotic options. Figures represent an average annual carbon benefit and thus overstate the carbon benefits in the early years of a policy option's implementation.

b. These entries cannot be summed because they involve use of overlapping land bases.

During the 200,000 years between the discovery of fire and the Industrial Revolution, biomass was humankind's main energy source. Even today, more than half the wood taken from U.S. forests is used as firewood. Modern ways to use biomass—converting grassy and woody crops into liquid fuels as well as electricity—could help reduce fossil fuel use. In principle, any type of biomass can produce energy, but at present most biomass energy sources are more expensive than coal on a Btu-per-unit basis. However, if oil stays at \$30+ a barrel, a modest level of energy production from woody crops will become economically viable on its own. A biomass demonstration project on 10 million acres could displace almost 20 million tons of fossil fuel carbon emissions, more than 1 percent of total U.S. emissions. The short time needed to build a biomass-to-electricity capacity and its reliability as a fossil-fuel replacement justify greater effort to determine this option's technological, environmental, and economic feasibility.

3. *Improve future productivity on harvested timberlands.* Forest productivity on U.S. timberlands is far below its biological potential. Forest management measures including artificial regeneration and pre-commercial thinnings can significantly increase growth rates and carbon storage on some timberlands. Only 20 percent of the nation's 481 million acres of timberlands are federally owned, so increasing carbon storage on these lands will depend more on changing private incentives than on revamping federal land management.

4. *Increase tree cover on acreage enrolled in the Conservation Reserve Program.* Although some 34 million acres are enrolled in the Conservation Reserve Program (CRP), trees have been planted on only a little over 2 million acres. Restrictions on returning these highly erodible lands to agricultural production suggest that millions of additional acres could be converted to tree cover with only modest changes in CRP contract terms and lengths.

5. *Create a Forestry Reserve Program (FRP).* There are tens of millions of economically marginal crop and pasture lands in the United States besides those covered in Recommendation #1. A Forestry Reserve Program (FRP), loosely modeled on the CRP, could encourage converting some of these lands to tree cover. An FRP would rely on the same kind of cost sharing and rental payment provisions found in the CRP program, but by targetting less valuable cropland would cost less per acre than the CRP does.

The U.S. forestry community would likely push a new Forestry Reserve Program toward more of what it already does best—industrial plantation forestry—but this natural inclination should be resisted. Rather than focusing solely on environmentally robust lands, an FRP should target lands where tree planting would advance policy goals beyond carbon storage, i.e., reducing soil erosion and water pollution and enhancing riparian and other wildlife habitats.

6. *Promote urban tree planting.* By sheltering homes and businesses from summer sunshine and winter winds, urban trees can reduce energy demand and thereby energy-related carbon emissions. The natural cooling urban trees provide through evapotranspiration is an especially effective energy saver: city neighborhoods with mature tree cover record peak temperatures 3 to 5 degrees lower than those without trees.

Halting the ongoing decline in urban forests should be the first order of business: in 20 large cities, four trees are dead or dying for every one planted, a ratio that rises to eight to one in New York and Chicago. The \$500 million spent annually on municipal tree care is a far cry from the amount required to maintain our urban forests properly, much less expand them. Urban planning should be restructured to make cities more hospitable to trees, and a large-scale reforestation effort should be targeted at the urban areas where energy demand for heating and cooling is highest.

7. *Encourage farming strategies that enhance carbon storage in soils.* Globally, soils store two to three times as much carbon as above-ground vegetation does. Clearing forested lands for cropland reduces soil carbon by up to 40 percent, and conventional tillage and harvesting practices often allow or even invite wind or water erosion of topsoil. With modern sustainable agricultural practices that protect soil and water, however, it should be possible to rebuild the organic matter in these soils. Many such practices are already cost-effective, thanks to their ancillary benefits such as boosting harvests, slowing siltation of water reservoirs, and reducing the need for agricultural inputs.

8. *Assess existing disincentives to carbon-storing land uses.* It makes little sense to reforest millions of acres of pasture to slow the rate of global warming if nothing is done to slow the rate of carbon loss from existing forests and other lands. Diverse government programs—among them, federal commodity support programs, federal timber sale programs, federal tax and insurance policies, state real estate taxes, and local zoning regulations—influence land-use and land-management programs in the United States. Such programs and incentives should be reviewed with an eye to rooting out those that counteract carbon sequestration goals.

9. *Incorporate carbon storage goals in the mandates of U.S. land-management agencies.* Federal agencies must take considerable responsibility in coming years for protecting carbon reservoirs and preparing forest-management strategies for a warmer future. As a first step, carbon management and storage should be added to the Forest Service's multiple-use mandate. This would require the agency to consider both carbon storage and economic implications in setting logging timeframes and to set production targets on the basis of appropriate harvest levels, rather than vice versa.

Greater emphasis on carbon storage within the Forest Service and other agencies might increase protection of old-growth forest, reduce reforestation backlogs, and eliminate harvesting on land that regenerates poorly. It should also instigate research on adaptive management strategies that address the threat posed by global warming—knowledge that private timberland managers will need for developing their own adaptive strategies.

Analysis should be undertaken to assess the potential for increasing forest cover on public lands as well. Agencies such as the Forest Service and the Bureau of Land Management claim that few planting opportunities are available on public lands, but public agencies control so much land that this conclusion seems unduly pessimistic.

10. *Refine understanding of carbon dynamics.* Research is needed to improve understanding of carbon stocks and flows on all kinds of land and to refine forecasts of land productivities. Such data gathering and modeling is likely beyond the scope of any single agency and may well require an interagency approach. Making the model and its data base publicly available would facilitate public review of biotic policy options.

Table 2. Recommended Carbon Storage Options

Recommendation	Projected Carbon Benefit ^a (millions of tons/yr)	Projected Costs (annualized) (millions of \$)
1. Selectively Convert Southeastern Pasture Lands	15–20	\$75–95
2. Expand Biomass-to-Electricity Demonstration Programs	20–30	\$60–150
3. Improve Future Productivity of Harvested Timberlands	15–20	\$150–400
4. Increase Tree Cover on CRP-Enrolled Acres	1–2	\$10–25
5. Implement a Forestry Reserve Program	20–40	\$200–1,000
6. Promote Urban Tree Planting	3–5	\$30–75
7. Encourage Practices that Slow Carbon Loss and Build Soil Carbon	10–25	(not known)
8. Assess Existing Disincentives to Carbon-Storing Land Uses	NA	NA
9. Incorporate Carbon Storage Goals into the USFS Mandate	(not known)	(not known)
10. Improve Our Understanding of U.S. Carbon Stocks and Flows	NA	NA

NA = not applicable

a. The carbon benefit figure estimates carbon storage in biomass and in soils as well as fossil fuel carbon displaced through implementation of the biotic options.

PERSPECTIVES ON CARBON SEQUESTRATION IN THE UNITED STATES

Each of these so-called biotic options for increasing carbon storage has distinct advantages and disadvantages, but the difficulty of getting the numbers right is common to them all. How much carbon can be removed for how long by any particular policy measure? How reliable can any carbon-storage prediction be when it is grounded in the uncertainty that surrounds everything living? Indeed, precise conclusions about the biological and cost-benefit implications of biotic options are out of the question, so precisely sizing up their role in a comprehensive U.S. strategy to slow global warming must await further research. Nevertheless, several policy conclusions can be drawn:

- *Implementing biotic options cannot reduce net U.S. carbon dioxide emissions quickly or cheaply.* Most carbon storage benefits would take so many years to realize that it is unlikely they could stabilize—much less reduce—net carbon emissions, especially when industrial carbon emissions are on the rise again after fifteen years of relative stability.

- *Most biotic options are best used as part of a transitional energy strategy intended to combat global warming.* Tree planting is best viewed as a way to buy time while pursuing energy sector initiatives to reduce the amount of carbon being emitted and to promote development of sustainable bioenergy systems. While temperate forests are robust in today's climate, the eventual impact of global warming is hard to assess, which makes excessive reliance on biotic options risky.
- *How biotic options are implemented will determine the extent of their ancillary benefits.* Besides storing carbon, many biotic options can also halt soil erosion, conserve watersheds and aquifers, preserve wildlife habitat, and further U.S. energy security. It might be simplest, for instance, to plant millions of acres of plantations, but planting trees along a river's edge or planting mixed stands that simulate natural forest would do far more to promote multiple benefits.
- *Complex regulations and incentives must be taken into account in any attempt to further carbon sequestration goals by redirecting or predicting private behavior.* Any attempt to change the status quo must take hard reality into account: investment decisions about land use are very sensitive to market events and to existing policies and subsidies, which are complex and sometimes contradictory. Many industrial timberlands, for instance, are being broken up and sold to developers and other interests to fend off hostile takeovers or to pay off the debt that takeover attempts engender.
- *Reliably increasing the size of U.S. biotic carbon sinks requires major changes in public policy.* The decline of urban forests and rural forests in some regions, the urban sprawl that converts woodlands and croplands to housing and commercial use, the corporate need for fast cash, and the harvest of many old-growth forests at a loss to the public treasury are all trends that work against carbon sequestration goals. Only with coordinated policy changes in many sectors can the biotic carbon cycle help to mitigate global warming.
- *Problems are to be expected in determining what money spent on biotic policy buys.* Reliably accounting for all variables is impossible since some of them reflect inevitable uncertainty about the future. Careful "carbon accounting" should, however, assess as accurately as possible not only carbon stored but effects on timber and agricultural markets. Even though hedged about with uncertainties, such analyses should reveal much about the reliability and cost-effectiveness of various biotic options.
- *Implemented on a large scale, biotic policy options will not necessarily be more politically acceptable than alternative global warming mitigation strategies.* Tree planting and other biotic options are widely viewed as politically painless, but could be quite contentious if implemented on a large scale since important political and economic groups would be affected. Given the inevitable uncertainties in predicting how much biotic options can mitigate global warming, overcoming opposition from the forestry, agriculture, and energy sectors will be difficult indeed.

As these general conclusions suggest, it is important for policymakers to weigh each biotic option carefully, distinguishing between its theoretical benefits and the inevitably limited benefits that are politically and practically achievable. In principle, vigorous pursuit of all ten options could offset or displace almost all the carbon dioxide currently emitted by U.S. fossil fuel use. In practice, however, even storing or displacing from 9 to 25 percent of current emissions would require an aggressive and successful multipronged policy effort.

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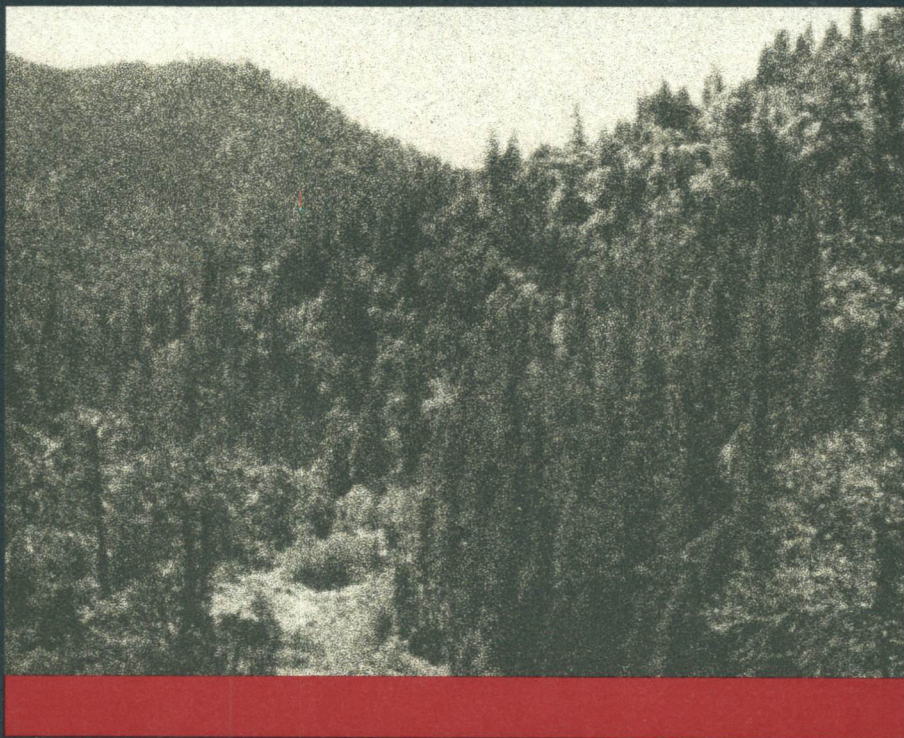
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MINDING THE

MINDING THE CARBON STORE: Weighing U.S. Forestry Strategies to Slow Global Warming

Mark C. Trexler



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M.C.T.

Foreword

After decades of discovery and discussion, scientists are reaching consensus on the ways that human activities are affecting the natural greenhouse effect. In near unison, they estimate that we have already committed the planet to significant warming that may not make itself manifest for some decades.

If we hope to slow—and eventually halt—global warming, the challenge is to control atmospheric concentrations of heat-trapping gases. Carbon dioxide, still the leading culprit, is a particular problem since its concentration is now growing by 0.5 percent per year. All told, human activities give rise to some seven billion tons of carbon in the form of carbon dioxide annually. That looks like a mere blip on the screen when Earth's carbon cycle moves 400 billion tons of carbon around each year, but it is enough to throw the natural cycle out of equilibrium, driving atmospheric carbon content steadily upward—by about 25 percent since preindustrial times. Capping the mercury's resulting climb will require staunching carbon emissions or expanding the so-called sinks that keep carbon out of the atmosphere, or both.

Tree planting, one of many ideas percolating through scientific and policymaking circles about how to store more carbon, is already being tried on a small scale. With WRI's advice, for instance, a U.S. electricity supplier is funding a forestry project in Guatemala to offset the lifetime carbon emissions of its new

coal-fired powerplant in Connecticut. President Bush's America the Beautiful proposal aims at planting 10 billion trees over the next decade, and the American Forestry Association's Global Releaf program aims at planting 100 million more trees in cities by 1992. Environmental ministers from 68 countries recently adopted an ambitious goal for the year 2000: to increase global forest cover by 30 million acres a year—a complete turnaround from today's annual *loss* of 30 to 50 million acres. A host of other ideas for storing and displacing carbon are making the rounds, too, from increasing the carbon content of soils, to making durable products out of wood rather than plastic, to substituting biomass for fossil fuels.

Some carbon-storing mechanisms promise many benefits *besides* mitigating climate change. Sustainable forestry and agriculture, for instance, not only protect carbon storage but also maintain such vital resources as soil and water. Such practices are often recommended for the tropics, but they are just as important for the industrial world. The United States and other developed countries could help balance the global carbon cycle if they stepped up existing conservation and reforestation programs and made carbon storage an explicit goal of their forestry and agricultural policies. Doing so might also lend them the moral standing needed to influence tropical countries, which face far tougher decisions in the struggle to meet human needs while controlling greenhouse gas emissions.

Storing more carbon is particularly important for the United States, the world's biggest fossil-fuel user. Many industrialized democracies have already set carbon stabilization or reduction goals. To meet these goals, they will have to cut carbon emissions by using less fossil fuel, but they may also be able to soak up more carbon by expanding carbon "sinks." Although the United States is now resisting the adoption of specific goals and timetables, the pressure to join the international alliance will grow as this country becomes ever more politically isolated among its industrial peers.

For all these reasons, carbon sequestration merits careful examination. In *Minding the Carbon Store: Weighing U.S. Forestry Strategies to Slow Global Warming*, Mark C. Trexler provides economic, political, and technical analyses for each of seven policy options that are feasible for the United States. Major trends and policies must be changed, he argues, and so must the complex incentive structures that currently guide the decisions of private landowners and public land managers. Dr. Trexler maintains that improving U.S. forestry and agricultural policies and practices offers significant potential for storing carbon and displacing fossil-fuel use, though these biotic options are neither as simple nor as inexpensive as commonly believed. Another caveat that emerges from his analysis is that while forestry can help moderate net carbon emissions, increased tree planting cannot compensate for the lack of a U.S. energy policy intended to address the problem of global warming.

Building on testimony submitted before the Senate Agriculture Committee in December

1988, Dr. Trexler assesses the political and economic ramifications of needed changes and the difficulties of bringing them about. He concludes that vigorous pursuit of sound biotic policies can help our leaders forge a transitional energy strategy to combat global warming. The policy recommendations spelled out in this report extend those of such other WRI studies as *A Matter of Degrees: The Potential for Limiting the Greenhouse Effect*, *Growing Power: Bioenergy for Development and Industry*, and *Energy for a Sustainable World*.

Minding the Carbon Store owes an intellectual debt to the leading experts in international relations, climatology, agriculture, energy, environment, law, trade, industry, and the developing world who serve on WRI's Policy Panel on Responses to the Greenhouse Effect and Global Climate Change. In several meetings over the past two years, the panel deliberated at length over climate change in general and reforestation in particular. Its members offered comments and recommendations crucial to the analysis contained in this report, and their assistance is highly valued.

We would like to thank the Ford Foundation, the Public Welfare Foundation, and the Rockefeller Brothers Fund for their generous support of WRI's research on energy and climate issues. To all these institutions, we owe a debt of gratitude.

James Gustave Speth
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I. Introduction

The composition of Earth's atmosphere is changing under human influence. Of major concern is the increase in concentrations of the so-called greenhouse gases. At natural levels, these gases keep Earth warm enough to support life, but increasing their concentrations is likely to warm the planet further and take global temperatures outside the relatively narrow band within which today's natural systems and human societies have evolved.

One way to slow and moderate global warming might be to manipulate the planet's biotic carbon cycle. One concept now being discussed is the fertilization of marine ecosystems in the hope that plankton populations would bloom and then sink to the ocean bottom, taking large quantities of carbon with them. Alternatively, deforestation could be slowed (thus slowing the release of carbon to the atmosphere), carbon could be drawn out of the atmosphere by increasing the storage capacity of terrestrial vegetation and soils, and biomass could be substituted for fossil fuels in producing needed energy. More generally, the management of forest, pasture, agricultural, and other lands can be modified around the world to slow the accumulation of carbon dioxide (CO₂) in the atmosphere and at the same time help meet such other policy objectives as sustainable economic development, watershed protection, energy efficiency, soil conservation, and the preservation of biological diversity.

The overall potential and cost-effectiveness of biotic policy options remain poorly understood, partly because what is appropriate in one country might not work as well in another.

The overall potential and cost-effectiveness of biotic policy options remain poorly understood, partly because what is appropriate in one country might not work as well in another. Tropical countries, where ongoing forest loss is most severe, often need to protect and increase forest cover if they want to safeguard watersheds and other natural resources as well as provide energy for their increasing populations. Large areas of marginal or degraded lands that are at least theoretically available for reforestation are also often present in tropical countries. In these same countries, however, competition for available land is often intense, and many still lack the governmental and private infrastructure needed to make large-scale reforestation work over the long run. In contrast, temperate industrialized countries, such as the United States, are not currently facing large-scale deforestation. Similarly, few have large areas of severely degraded or abandoned lands

that could support trees. Many temperate countries are better positioned, however, to employ market and management mechanisms to increase carbon storage on lands already being used.

A start in this direction is the president's America the Beautiful program announced in early 1990. Under this program, the Forest Service would coordinate and fund the planting of an additional one billion trees per year on private lands for at least the next 10 years. The program is also intended to endow U.S. cities with greater tree cover. According to various estimates, the program would offset the emission of from 16 to 65 million tons of carbon annually after 10 years of planting—roughly equivalent to one to four percent of current U.S. CO₂ emissions from fossil fuel combustion.

Why do these estimates of the potential carbon benefits of the America the Beautiful program range so widely? And how can forestry-based policy options' effect on global warming be evaluated? To find out, the first step is understanding how trees can help slow global warming and determining whether existing forestry policies are having this effect. The next is

reviewing the theoretical potential, the likely costs, and the probable advantages and disadvantages of various forestry-based policy options. Such options include slowing the conversion of forested land to alternative uses, accelerating the reforestation of suitable lands, adapting current forest-management practices to enhance carbon-storage goals, making cities more comfortable and energy efficient through tree planting, substituting biomass-based electricity and liquid fuels for fossil fuel consumption, and increasing the use of wood products.

As the following chapters show, each of these policy options has distinct advantages and disadvantages from a carbon-storage perspective, and no two have exactly the same overall potential for slowing global warming. Indeed, the uncertainties involved in projecting the specific implications and cost-effectiveness of the alternative options are so overwhelming that precise conclusions are out of the question. But one thing does emerge quite clearly from the following analysis: although forestry may be able to partially offset U.S. emissions of CO₂ from fossil fuel combustion, stepped-up tree planting cannot eliminate the need for policies intended to reduce the emissions of carbon dioxide in the first place.

II. The Carbon Cycle and Global Warming

Global warming is believed likely to result from a variety of human activities, with those that release carbon dioxide into the atmosphere topping the list. How fast CO₂ builds up in the atmosphere, however, depends on the workings of the carbon cycle, the largest and best quantified of the various natural cycles that sustain life on the planet. (See Box 1.)

The Global Carbon Cycle

When in equilibrium, carbon flows between the various reservoirs of the global carbon cycle roughly balance over the year: carbon emitted to the atmosphere through plant respiration and decay is offset by carbon drawn out through photosynthesis. Over the last 160,000 years (the extent of reliable CO₂ data), the carbon cycle has slowly moved in and out of balance a number of times, with atmospheric CO₂ concentrations ranging between 200 and 280 parts per million (ppm) over the millennia. High concentrations of atmospheric CO₂ characteristically have been associated with particularly warm climatic periods, and low concentrations of atmospheric CO₂ have been associated with cooler periods and the one ice age occurring during this 160,000-year period.

There is little doubt that the carbon cycle is now once again out of balance. In just two centuries, CO₂ concentrations have risen by over 25 percent from approximately 280 ppm in

1750 to more than 350 ppm in 1989. They are currently rising by about 1.4 ppm or 0.5 percent per year on average. Today, the atmosphere contains roughly 160 billion more tons of carbon than it did before industrialization began, reflecting an unprecedented rate of change.

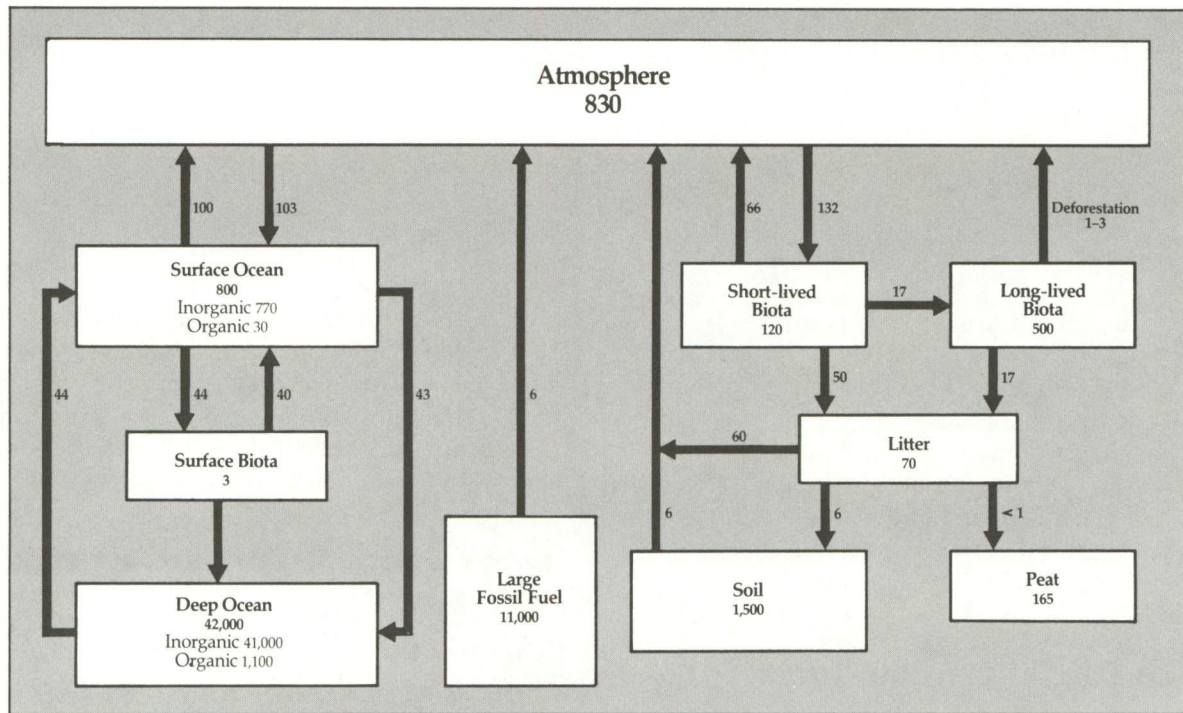
There is little doubt that the carbon cycle is now once again out of balance.

Human activities, including those dating back to well before the industrial revolution, are the primary force behind the carbon cycle's current instability. For centuries before the mid-1700s, for example, CO₂ was released into the atmosphere as people converted temperate forests and grasslands to farmland. Even today, owing mainly to deforestation in the tropics, these biotic releases are probably greater than ever. Estimates of the quantity of carbon released through land-use change in 1980, for example, range from 1.5 to 2.1 billion tons.¹ Even higher numbers are postulated for more recent years as tropical deforestation has accelerated.²

Cumulatively, an estimated 150 to 250 billion tons of carbon have been released to the atmosphere since 1860 through land-use change around the world.³ (See Figure 1.) The range of

Box 1. The Global Carbon Cycle

The Global Carbon Cycle (in Billions of Tons)



Human activities, including those dating back to well before the industrial revolution, are the primary force behind the carbon cycle's current instability.

estimates is wide because accurately quantifying carbon releases from land-use change is quite difficult. Nobody knows, for instance, exactly how many acres of forest are currently being converted or how much carbon is released per acre from vegetation and soils during conversion. (See Box 2.) Complicating

matters further is uncertainty about whether rising CO₂ concentrations are fertilizing remaining forests, particularly in temperate zones, thus offsetting some of the carbon emitted as trees are felled elsewhere in the world.⁴

Although biotic CO₂ emissions could rise to as high as 5.5 billion tons per year early in the next century if deforestation rates increase linearly with population growth,⁵ any such increase would be cut short quickly by the virtual disappearance of tropical forests from many countries. But there is nothing to limit growth in the other major source of human-caused CO₂ emissions—namely, the combustion of fossil fuels for energy production. Although cumulative biotic carbon emissions probably exceeded cumulative fossil fuel emissions until just a couple of decades ago, fossil fuel consumption is growing so rapidly that

The global carbon cycle is made up of large carbon flows and reservoirs. Hundreds of billions of tons of carbon as CO₂ are absorbed from or emitted to the atmosphere annually through natural processes. These flows include vegetational photosynthesis, respiration, and decay as well as the oceanic absorption and release of CO₂. But they are dwarfed by the various carbon reservoirs. Empirical measurements show that the atmosphere contains about 825 billion tons of carbon. An additional 800 billion tons are dissolved in the surface layers of the world's oceans. Because they are so heterogeneous, terrestrial carbon reservoirs are much more difficult to measure empirically. Some 1,650 billion tons of carbon are believed to have accumulated in ground litter and soils. Terrestrial organisms, primarily plants, account for an estimated 615 billion additional tons of carbon, though this number is the subject of considerable debate. (See Box 2.) By far, the largest carbon reservoirs are the deep oceans and fossil fuel deposits, which

account for some 42,000 and 11,000 billion tons of carbon, respectively.

Human activities released some 6.2 billion tons of fossil fuel carbon to the atmosphere in 1988. Deforestation, mostly in tropical countries, is estimated to have contributed more than two billion additional tons. Only about three billion tons, however, remained permanently in the atmosphere. Until recently, scientists believed that the bulk of the difference was absorbed by the surface layers of the oceans, but they are now increasingly contending that heightened CO₂ levels are "fertilizing" upper-latitude forests, potentially by as much as three billion tons of carbon annually.

Source: World Resources Institute in collaboration with the United Nations Environment Programme and the United Nations Development Programme, 1990. *World Resources Report 1990-91*. Oxford University Press.

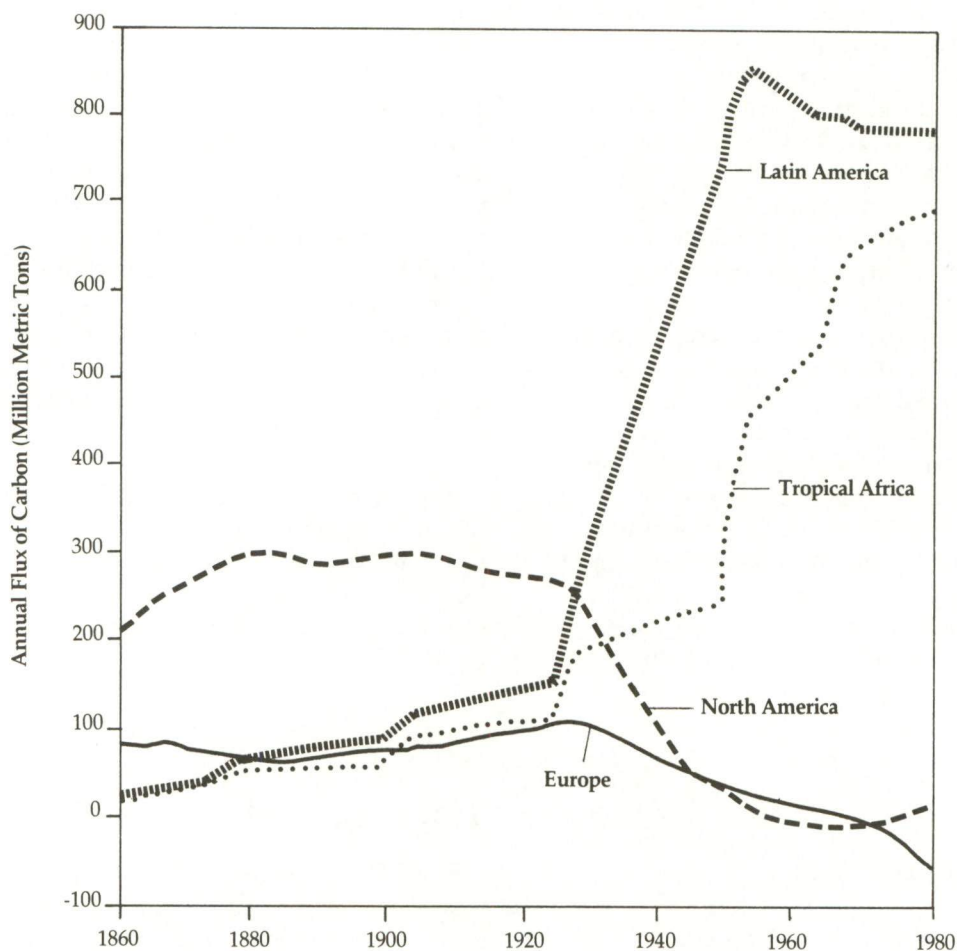
the reverse is now true. (See Figure 2.) CO₂ emissions from fossil fuels quadrupled between 1950 and 1980 alone. If nothing is done, says the Intergovernmental Panel on Climate Change, carbon emissions will probably increase by roughly two to three percent annually, going from some 6 billion tons today to more than 8 billion tons by 2000 and to more than 13 billion tons by 2025.⁶

Most countries release more carbon than they take in, but how much and how each contributes to the buildup of CO₂ in the atmosphere varies widely. In many tropical nations, for example, the dominant source of carbon emissions is land-use change. Although this used to be the case in most temperate countries as well, fossil fuel combustion is now the leading source. The United States is no exception to this general trend.

The U.S. Carbon Cycle

Fossil fuel consumption in the United States is well monitored. U.S. carbon emissions from fossil fuel combustion now total some 1.6 billion tons per year, and they are increasing. But although the fossil fuel portion of the U.S. carbon cycle is well quantified, the biotic side of the cycle is much less so. We do know how the 2.2 billion acres of surface area that make up the United States are distributed. (See Figure 3.) Land area and uses have been extensively studied and surveyed, but it is not known whether existing incentives and policies are already having the effect of offsetting some proportion of U.S. fossil fuel emissions by storing additional carbon or whether the reverse is occurring. (See Appendix.) Our inability to predict whether U.S. forest area will continue its 40-year decline illustrates the degree of our

Figure 1. CO₂ Released Through Regional Land Use Changes, 1860-1980



Source: R.A. Houghton, *et al.*, "Changes in the Carbon Content of Terrestrial Biota and Soils Between 1860 and 1980: A Net Release of CO₂ to the Atmosphere," *Ecological Monographs* 53, (1983): 235-62

ignorance. Figure 4 shows trends in U.S. forest area since 1920 and projects alternative scenarios of future forest area. The most optimistic reflects continuation of a short-term trend created by recent implementation of the Conservation Reserve Program, but that program is scheduled to end soon. The intermediate projection reflects the short-term trend without including the Conservation Reserve Program,

and the third projection simply extends long-term trends into the future. The United States Forest Service (USFS) does, in fact, project a continuing decline in at least the timberlands component of U.S. forest area.⁷ Timberlands are forests that are capable of producing more than 20 cubic feet of merchantable timber per year and that are not "reserved" for uses other than timber production.

Box 2. Estimating Global Biomass Levels

It is commonly assumed that the terrestrial biotic component of the carbon cycle makes up a carbon reservoir of more than 615 billion tons of carbon. Forests no doubt hold most of this total. Recently, however, some scientists have challenged prevailing biomass estimates, arguing that prevailing sampling methods significantly overstate average biomass concentrations, particularly for forests. They note that current estimates of tropical forest biomass, for example, are based on samples totalling less than 75 acres of forest, and that the chosen samples reflect forest ecosystems of above-average biomass density. Using timber volume estimates, which are based on much larger-scale sampling than biomass estimates, Brown and Lugo concluded that the total carbon stored in tropical forests is nearer 250 billion tons, only one-half the approximately 500 billion tons estimated by Whittaker and Likens a decade earlier.

New biome-specific research lends weight to the conclusion that global estimates have been overstated. Recent research on North American boreal forests suggests that the carbon content of above-ground biomass averages from 7 to 10 tons per acre, much less than the 25 to 35 tons-per-acre average in previous estimates. University of California researchers suggest that most older estimates were based on sampling undisturbed mature forest, thus overlooking the lower

carbon densities found in disturbed forests. In addition, past estimates used the southern range of the boreal forest, where biomass density is highest.

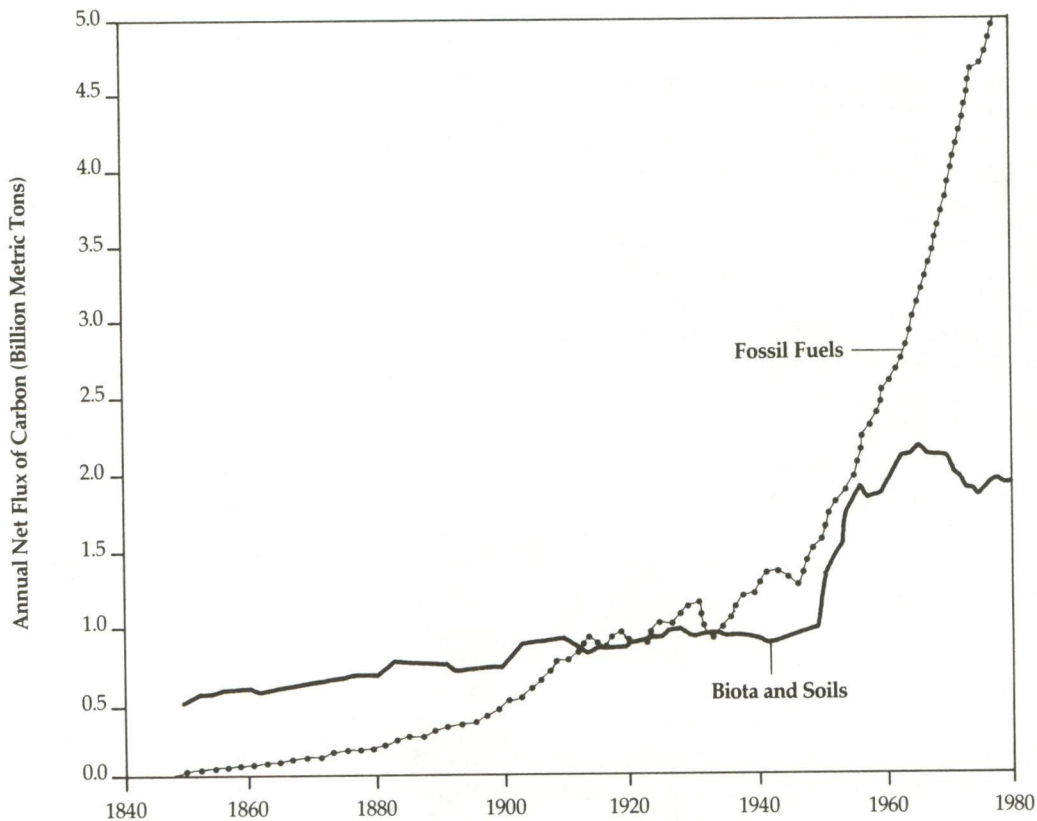
Significant revisions in global biomass estimates have important ramifications for understanding the carbon cycle and global warming. If the amount of biomass has been overestimated, for example, current deforestation would contribute less to global CO₂ emissions than is often assumed, and the potential role of CO₂ fertilization in moderating growth in atmospheric CO₂ concentrations would probably not be as significant as would otherwise be the case. Scenarios based on lower biomass estimates also suggest that slowing deforestation, and even increasing afforestation, would not have as beneficial an effect on global warming as might be projected under the high-biomass scenario.

Sources: Botkin, D.B., and Simpson, L.G., 1990. "Biomass of the North American Boreal Forest," *Biogeochemistry* 9:161-174; Brown, S., and Lugo, A.E., 1984. "Biomass of Tropical Forests: A New Estimate Based on Forest Volumes," *Science* 223:1290-93; Whittaker, R.H., and Likens, G.E., 1973. "Carbon in the Biota," in Woodwell, G.M., and Pecan, E.V., eds. *Carbon and the Biosphere*. U.S. Atomic Energy Commission. Symposium Series No. 30. National Technical Information Service.

Forests, especially timberlands, are almost certainly the nation's largest storehouses of biotic carbon. Although croplands, pasture, and rangelands cover more area, they store far less carbon than do forests,⁸ and urban and developed areas store even less. Domestic forest management practices will therefore significantly influence U.S. carbon stocks and flows in coming years. The role of U.S. forests as

carbon reservoirs—if the United States plays a role in international efforts to mitigate climate change—is likely soon to become much more prominent. Some U.S. forests, particularly Pacific Northwest old-growth forest, contain far more carbon per acre than the Brazilian tropical forests whose protection has repeatedly been called for by interest groups in the United States.⁹ (See Box 3.)

Figure 2. Biotic Versus Fossil Fuel Carbon Releases, 1860–1980



Source: R.A. Houghton, "The Contribution of Deforestation and Reforestation to Atmospheric Carbon Dioxide," in *Global Warming and Climate Change: Perspectives from Developing Countries*, S. Gupta and R.K. Pachauri, eds., Tata Energy Research Institute, Conference Proceedings, New Delhi, (1989)

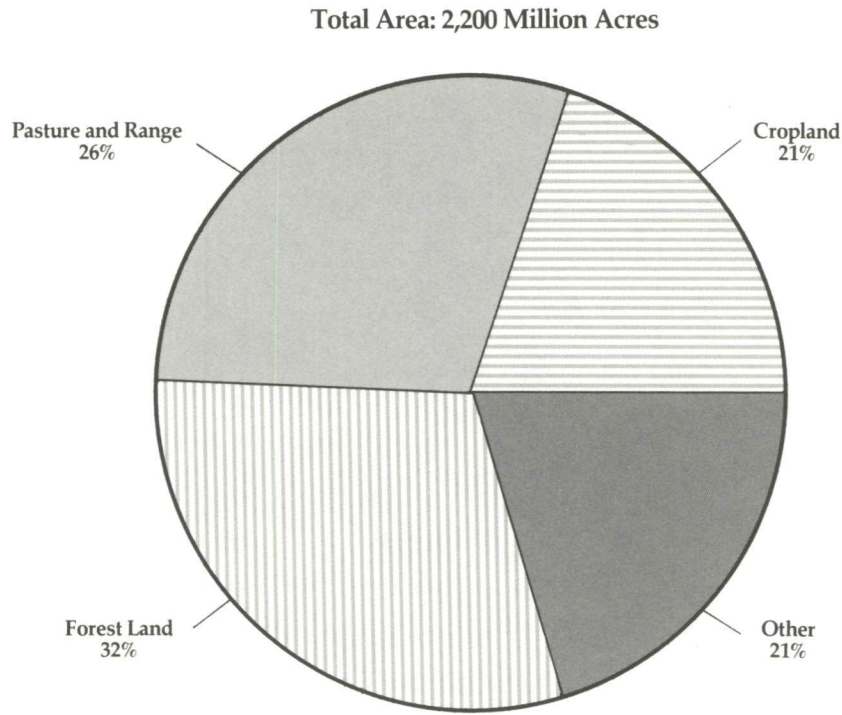
In assessing general carbon flows in the United States, policymakers do have available to them considerable information on land-use trends, but this information constitutes just a small part of a complex picture. (See Figure 5.) U.S. forests are currently estimated to store some 57 billion tons of carbon. (See Figure 6.) Several key questions need answers, however, before the size and direction of net carbon flows can be estimated:

- How large are stocks of noncommercial biomass on timberlands? And how much

carbon is stored in forested lands not classified as timberlands? What are the trends in each case?

- How much carbon is stored in wood products (both in use and disposed of)?
- How much carbon is stored in urban forests? How are trends in urban forestry affecting fossil fuel consumption?
- If the billions of tons of fossil fuel-emitted carbon previously thought to be disappearing

Figure 3. Distribution of United States Surface Area by Land Use



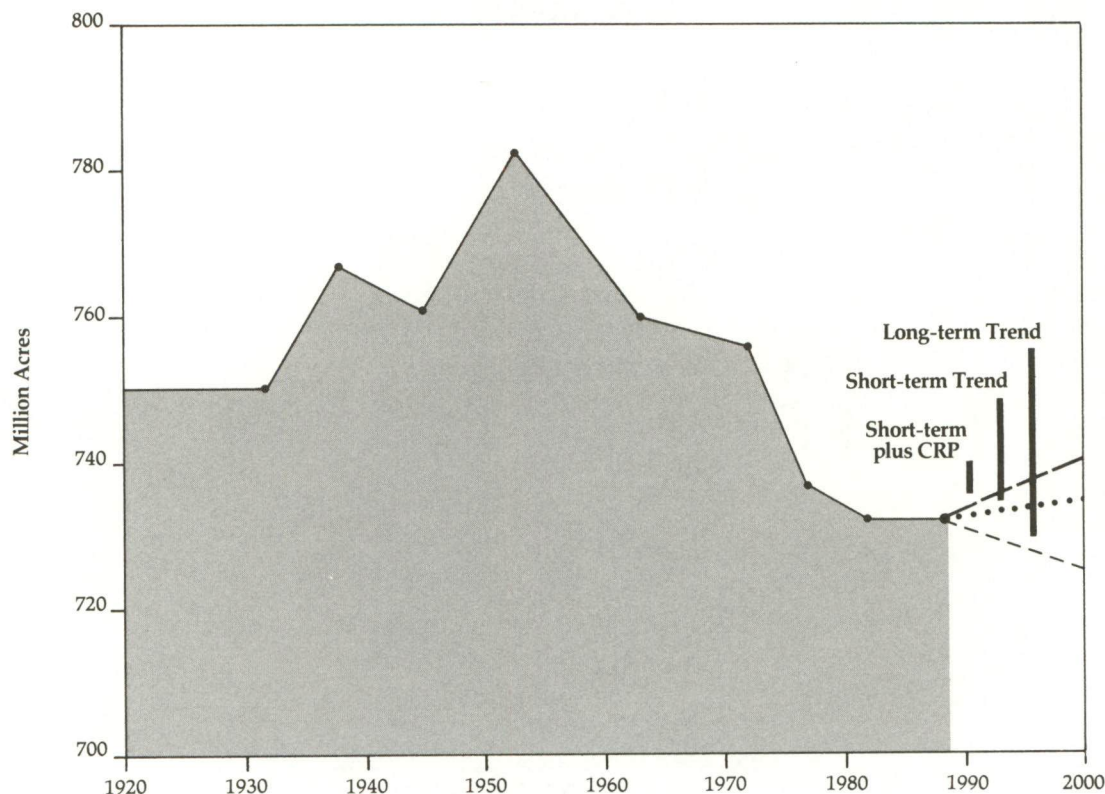
Source: H.T. Frey and R.W. Hexem, *Major Uses of Land in the United States: 1982*, Agricultural Economic Report No. 535, U.S. Department of Agriculture, Economic Research Service, (1985)

into the world's oceans every year are—as scientists now believe—instead fertilizing temperate biota around the world, what is the impact on domestic forests?¹⁰

These uncertainties notwithstanding, one key fact is incontrovertible. As hundreds of millions of acres of forests in what is now the United States were cut down over the last 200 years and converted to agriculture, pasture, and urban uses, and as virgin forests were replaced with younger forests and plantations, tens of billions of tons of carbon were added to the atmosphere. (For perspective, estimates of current annual global carbon releases through deforestation range between one and three billion tons.)

As hundreds of millions of acres of forests in what is now the United States were cut down over the last 200 years and converted to agriculture, pasture, and urban uses, and as virgin forests were replaced with younger forests and plantations, tens of billions of tons of carbon were added to the atmosphere.

Figure 4. United States Forest Area, 1920–2000



Source: U.S. Department of Agriculture, Forest Service, *Tree Planting and Forest Improvement to Reduce Global Warming*, (1989)

Biotic carbon levels in what is now the United States have steadily declined since Europeans settled the continent, but this trend cannot last. Agricultural production has been concentrated on fewer and fewer acres, thus allowing the reversion of lands to forest cover. According to some modelers, this change has already resulted in U.S. forests' becoming net sinks for atmospheric CO₂. Richard Birdsey of the USFS concludes that timber growth now exceeds harvest by more than 120 million tons of carbon annually,¹¹ and Edward Hansen, also of the USFS, concludes that the size of the forest carbon reservoir is increasing by some 80 million tons per year.¹²

Such estimates are far from definitive, however. If annual nonharvested tree mortality is subtracted from total tree growth,¹³ for instance, Birdsey's estimate of net carbon accumulation falls to just 11 million tons per year.¹⁴ In addition, a variety of warning signs suggest a need for concern about future U.S. carbon stocks. (See Box 4.) A comprehensive model of biotic carbon flows in the United States might well show that the United States continues to be a net contributor of biotic carbon to the atmosphere. (See Appendix.)

A wild card that has thus far been largely overlooked in this analysis is global warming

Box 3. Global Warming and the Harvesting of Old-Growth Forest

Logging old-growth forests in the Pacific Northwest and Alaska has for years been the subject of dispute between logging and conservation interests. Logging interests argue that logging is vital to the economic health of the region. Opponents argue that the interests of threatened species and biodiversity generally are left out in the U.S. Forest Service's (USFS) multiple-use calculus and that public subsidization of some of these sales cannot be justified. Because of its remote Alaskan location, for example, subsidies are necessary to make Tongass National Forest timber competitive with other Pacific Northwest national forests. The federal government is selling off 500-year-old spruce trees to loggers, and in some years has received just \$0.10 for every tax dollar invested.

The debate over old-growth harvesting, particularly in the Tongass National Forest, has recently been cast in terms of its global warming implications. Senator Murkowski of Alaska, for example, has argued that 48 trees grow back for every old-growth tree removed, concluding that replacing some of the old forest with young trees increases the amount of CO₂ removed from the atmosphere.

In a recently released study, however, scientists report that the amount of carbon stored in Pacific Northwest old-growth is huge and that harvesting old-growth forest results in a net release of carbon dioxide to the atmosphere for at least two centuries. Harmon, Ferrell, and Franklin calculate that converting one acre of old-growth forest to younger forest reduces net terrestrial carbon storage by 135 tons even after the new trees have had a chance to grow for 60 years and

even if 42 percent of the originally harvested timber is assumed to be used for long-term product. The logging of some 13 million acres of Northwest old-growth forest since 1890, they therefore conclude, has added an estimated 1.6 to 2.0 billion tons of carbon to the atmosphere. They also estimate that only five million acres of such forest remain.

Although Alaskan old growth forest is believed to hold somewhat less biomass than old growth in the Pacific Northwest, it still stores significant amounts of carbon. In a study of Alaska's old growth, Paul Alaback of the USFS states that not only is tree biomass drastically reduced in a second-growth forest, but understory vegetation is also much lower. He concludes that replacing old-growth, whether in Alaska or the Pacific Northwest, adds significant quantities of carbon to the atmosphere over both the short and long terms.

Sources: Alaback, P.B., 1989. "Logging of Temperate Rainforests and the Greenhouse Effect: Ecological Factors to Consider," in *Proceedings of Watershed '89: A Conference on the Stewardship of Soil, Air, and Water Resources*. U.S. Department of Agriculture, Forest Service; Harmon, M.E., Ferrell, W.K., and Franklin, J.F., 1990. "Effects on Carbon Storage of Conversion of Old-Growth Forests to Young Forests," *Science* 247:699-702; Murkowski, F.H., 1989. "The Tongass." *Christian Science Monitor*, March 14; Natural Resources Defense Council, 1989. *Cooling the Greenhouse: Vital First Steps to Combat Global Warming*; O'Toole, R., 1988. *Reforming the Forest Service*. Island Press; Rice, R.E., 1989. *National Forests: Policies for the Future*, vol. 5, *The Uncounted Costs of Logging*. Wilderness Society.

Figure 5. Important United States Biotic Carbon Flows

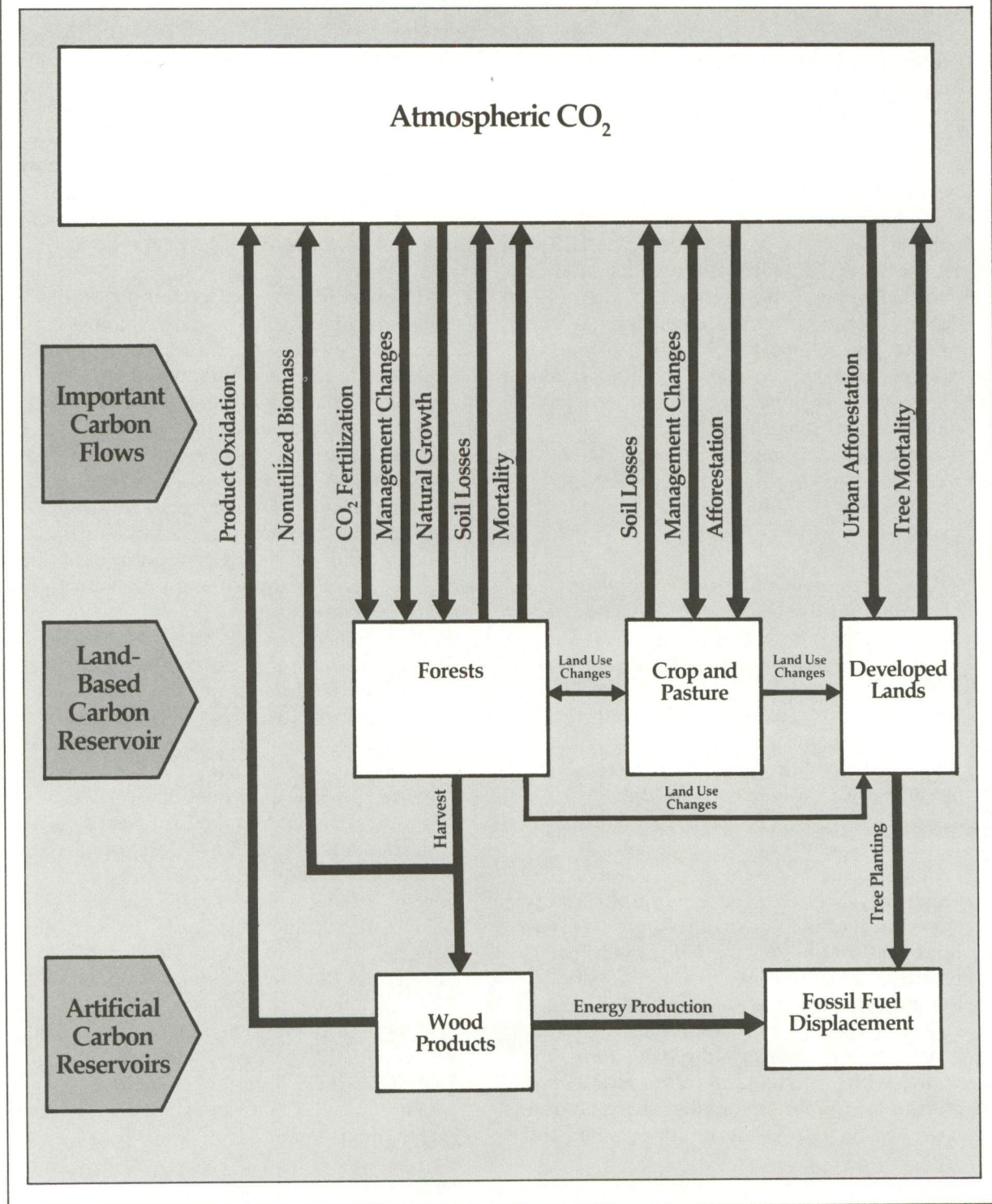
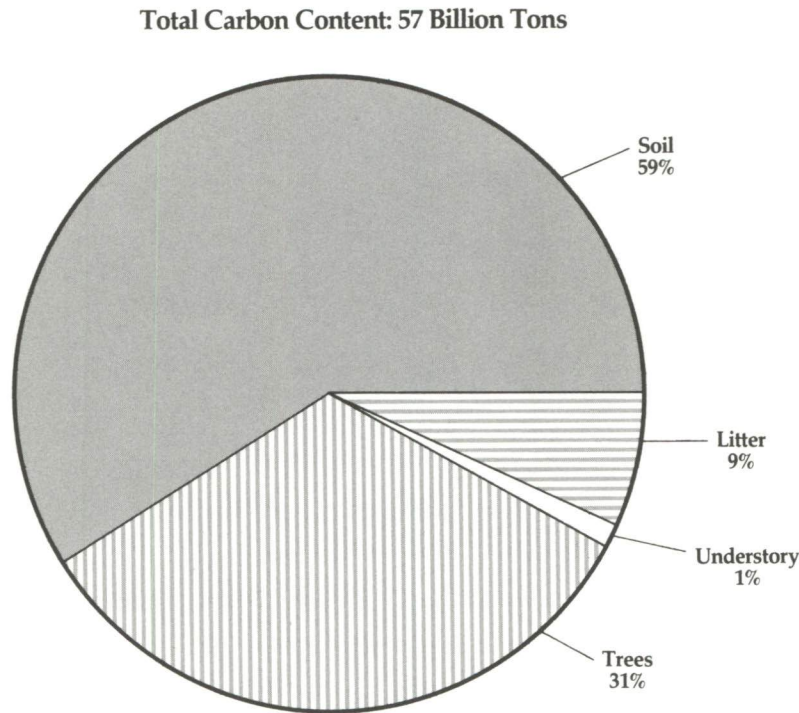


Figure 6. Carbon Content of United States Forest Ecosystems



Source: R.A. Birdsey, "Potential Changes in Carbon Storage Through Conversion of Lands to Plantation Forests," in *Proceeding, North American Conference on Forestry Responses to Climate Change*, Washington, D.C. Climate Institute, in press, (1990)

A comprehensive model of biotic carbon flows in the United States might well show that the United States continues to be a net contributor of biotic carbon to the atmosphere.

itself. If regional climates around the United States change significantly in coming decades, the impacts on forest resources could be considerable.¹⁵ Although climate models differ in

their projections of species-specific impacts, the equivalent of a doubling of atmospheric CO₂ levels could lead to climate change sufficient to shift the climatic ranges of tree species north by hundreds of miles, possibly leaving slowly maturing species behind to die out.¹⁶ For established forests in the southern parts of species' current ranges, physical and biological stresses would be aggravated.¹⁷ For some forests, water availability and soil moisture would decrease, intensifying natural fires.¹⁸ More generally, as temperatures change, seedlings may be unable to regenerate, so much larger-scale artificial regeneration than has been required thus far might be needed. Insect pests and other pathogens moving up from points south could

Box 4. Timberland Carbon Stocks—Signs of an Uncertain Future

Statistics purporting to reflect the status of U.S. timberlands from one perspective or another are both voluminous and readily available. The forest industry and the U.S. Forest Service (USFS) can provide statistics showing that timberlands are doing well in the sense that commercial timber stocks continue to increase even while timberland acreage falls. Critics of current forest management practices can provide statistics showing the destruction of old-growth forests and localized declines in forest growth. Both interest groups are just now collecting the types of information that will ultimately indicate where net carbon flows are headed in the nation's timberlands. A variety of illuminating statistics, however, at least suggest the need for concern about trends affecting biotic carbon storage and emissions.

- Despite ongoing reforestation efforts, timberland acreage is projected to decline from the present level of 483 million acres to 475 million acres by 2000 and to 462 million acres by 2040. Most of these losses will be from private timberlands, and they are real—not just reclassification casualties.
- Standing merchantable softwood timber volumes in national forests are projected to decline by almost 30 percent between 1986 and 2000, or some 60 billion cubic feet. As a result, total softwood carbon inventories on national forest lands will probably fall by more than one billion tons by the year 2000. If soil carbon

losses are added in, the figure will probably be higher.

- Although private timberland holdings account for most timber production in the United States, it is hard to predict how changing management practices on these lands might affect carbon stores. Anecdotal evidence suggests, for example, that timber companies nationwide are already stepping up the conversion of long-term timber stands. Pacific Lumber Co. is a former merger target that is now saddled with heavy debt. Since it was taken over in 1985 by financier Charles Hurwitz, the company has doubled or possibly even tripled its rate of logging in its redwood stands, which comprise three-fourths of the privately owned uncut redwoods in the United States. The company now estimates that these stands will disappear within 25 years; outside observers say 3 to 10 years.
- Growth rates in southern pine plantations are declining for still poorly understood reasons. If plantation growth in the southern United States ultimately falls by 5 to 10 percent, as evaluated in USFS scenarios, it would lead to a decline in timber inventories in the Southeast of more than 20 percent by 2040.
- USFS statistics suggest that harvesting areas containing old-growth forest will continue at high rates, bringing standing inventory down by 25 percent between

increase tree mortality significantly, and rising temperatures and more frequent drought could aggravate forest damage from pollutants such as ozone. Although U.S. forests would probably

reach a new equilibrium eventually if climate did so, the many transitional years would be stressful ones that would likely sap general forest health, alter growth rates, lower lumber

1986 and the year 2000. In some forests, harvest rates are more than double forest growth. As much as two billion tons of carbon have already been released on net through old-growth harvesting during the past century in the Pacific Northwest; hundreds of millions of additional tons will be released if these old-growth forests are ultimately eliminated.

- After already almost doubling between 1952 and 1986, the demand for commercial timber from U.S. forests is projected to increase by 50 percent between 1986 and 2040. Total timber consumption in the United States is projected to increase from 20.5 billion cubic feet in 1986 to 28.6 billion cubic feet by 2040. How much increasing timber consumption might increase the stocks of carbon stored in timber products remains quite uncertain.
- Annual harvest levels on U.S. timberlands are expected to rise over 25 percent to some 5.4 million acres by 2030. Remaining natural pine stands will decline in area by about 50 percent, or 20 million acres, and will be replaced with pine plantations. These changes could have either of two basic effects on carbon stocks. On the one hand, growth and stocking rates might increase, thus increasing carbon stores. On the other, the carbon stored in noncommercial timber and in soils could decrease.
- Natural disasters in recent years have destroyed considerable quantities of timber, and drought conditions in many

parts of the United States are a serious threat to timber resources. More than five million acres of U.S. forest were seriously damaged or destroyed by fire in 1988. In the same year, Midwest droughts raised the mortality rate of seedlings to between 60 and 80 percent, much higher than normal. About 250 million seedlings on 300,000 acres of forest plantations were lost nationally. In 1989, hurricane Hugo damaged or destroyed two to five million acres of trees in the Carolinas.

- Environmental concerns are challenging timber-management practices in ways that may reduce growth rates, particularly on public lands. It is estimated, for example, that 24 percent of the lands replanted by the Bureau of Land Management between spring 1986 and spring 1989 need planting again, primarily because of a court-imposed prohibition on herbicide use in the planted areas.

Sources: U.S. Department of Agriculture, Forest Service, 1990. *An Analysis of the Timber Situation in the United States: 1989-2040*. Editorial draft; Ryan, J.C., 1989. "Wall Street Goes Wild," *World Watch* 2(6):7; President's Interagency Drought Policy Committee, 1988. *The Drought of 1988, Final Report of the President's Interagency Drought Policy Committee*; Lewis, R., Bureau of Land Management, Medford District, pers. comm. to the Office of Technology Assessment, January 22, 1990; U.S. Department of Agriculture, Forest Service, 1989. *RPA Assessment of the Forest and Range Land Situation in the United States*, 1989.

quality, and undermine wildlife habitats. Major changes in carbon flows and reservoirs might result, almost certainly increasing net emissions of carbon, potentially seriously.

Conclusions

Carbon dioxide emissions from human activities account for just a small fraction of the

roughly 210 billion tons of carbon that cycle annually between the atmosphere and terrestrial biota.¹⁹ But because it is these activities that are responsible for the unwanted buildup of CO₂ in the atmosphere, modifying them should help moderate the rate and ultimate magnitude of global warming. Reducing fossil fuel CO₂ emissions in the first place is the most obvious place to start, but changing land-use practices and patterns can play a role as well. Five land-use-based approaches can be used to slow the buildup of CO₂ in the atmosphere:

- slowing or stopping the loss of existing forests, thus preserving current carbon reservoirs;
- adding to the planet's vegetative cover through reforestation or other means, thus enlarging living terrestrial carbon reservoirs;
- increasing the carbon stored in nonliving carbon reservoirs such as agricultural soils;
- increasing the carbon stored in artificial reservoirs, including timber products; and
- substituting sustainable biomass energy sources for fossil fuel consumption, thus reducing energy-related carbon emissions.

Because biotic policy options appear capable of contributing significantly to the mitigation of global warming while also furthering many other public policy objectives, their role deserves careful consideration on a country-by-country basis.

These approaches are all based on the same basic premise: adding to the planet's net carbon stores in vegetative cover or soil, or preventing any net loss, will help moderate global warming by keeping atmospheric CO₂ levels lower than they would otherwise be. Biotic carbon emissions are a significant part of total anthropogenic carbon emissions, exceeding fossil fuel emissions in many countries. Because biotic policy options appear capable of contributing significantly to the mitigation of global warming while also furthering many other public policy objectives, their role deserves careful consideration on a country-by-country basis.

III. Slowing Global Warming Biotically— Options for the United States

Whether deploying biotic options will slow the accumulation of CO₂ in the atmosphere depends on the type and quantity of vegetation being added to existing stocks or being protected from loss. It also depends on what eventually happens to the biomass thus added or protected. Planted on what would otherwise be bare land, even a vegetative cover that grows in summer and decomposes completely in winter will lower average annual CO₂ concentrations. Planting perennial vegetation on bare ground, however, lowers atmospheric CO₂ concentrations by the increment of carbon stored in the new perennial biomass and added to soils. Perennial vegetation normally accumulates much more carbon per acre over time than annual vegetation can, and thus it plays a far greater role in expanding terrestrial carbon reservoirs over the long term.

It makes no difference to atmospheric CO₂ concentrations whether a ton of carbon is added to the vegetation of a temperate or a tropical country. The applicability of the different biotic approaches, however, is likely to vary widely from country to country. Slowing deforestation, for example, would obviously prove most beneficial in tropical countries where significant deforestation is taking place. The best way to expand vegetative carbon reservoirs might be new plantations in one country and better management of existing forests in another. And although substituting biomass fuels for fossil fuels has significant

potential throughout the world, the technological infrastructure for taking advantage of the option in the short term is generally better developed in temperate countries.

It makes no difference to atmospheric CO₂ concentrations whether a ton of carbon is added to the vegetation of a temperate or a tropical country.

Each of the five biotic approaches introduced in Chapter II is applicable to some extent in the United States. Taking U.S. land-use characteristics into account, Table 1 presents a menu of policy options tailored to U.S. carbon storage opportunities. Several of the options are capable of significantly reducing net U.S. carbon emissions; several offer corollary benefits in areas other than global warming mitigation. The time frame and costs of the different options vary widely, although in most cases some level of implementation appears economically justified even without considering global warming. (See Box 5.) The approach, projected costs, and advantages of seven different policy options are profiled below.

Table 1. Options for Increasing the Uptake and Utilization of Biotic Carbon in the United States

- Planting Trees to Reduce Energy Use
- Converting Private Agricultural and Pasture Lands to Conventionally Managed Tree Cover
- Increasing Tree Cover on Nonforested Public Lands
- Stocking and Managing Already Forested Lands More Intensively
- Substituting Wood for Other Products
- Increasing the Commercial Use of Biomass Energy
- Improving Soil-Management Practices

1. Planting Trees to Reduce Urban Energy Use

Expanding and better managing our urban forests is commonly discussed as one of the most effective biotic ways to combat global warming in the United States. It is the primary focus of the American Forestry Association's (AFA) recently launched Global Releaf program, which calls for planting 100 million urban trees by 1992. It is also an important focus of the America the Beautiful initiative proposed in President Bush's 1991 budget, which calls for planting 30 million trees per year in U.S. communities. (See Box 6.)

Urban trees, and to some extent other types of vegetation, can slow the accumulation of CO₂ in the atmosphere by reducing urban energy demand. They can shade houses and small buildings from the sun and transpire large quantities of water,²⁰ thus lowering

ambient temperatures and reducing cooling loads. They can also increase the reflectivity of dark asphalt surfaces and other elements of urban environments, thus reducing the amount of solar radiation absorbed and reemitted as heat.²¹ And during winter, vegetation can help insulate structures from cold winds. For these reasons, an urban tree can be up to 15 times as effective at "reducing" atmospheric CO₂ as a rural tree.²²

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Researchers at Lawrence Berkeley Laboratory have done extensive modeling of the relative benefits of placing trees around residences and small buildings in climate zones where air conditioning is used.²³ Random placement of three trees around an otherwise unshaded house yielded reductions in annual cooling energy requirements of 11 to 42 percent; the strategic placement of the three trees on the southern and western exposures of the house reduced cooling energy requirements by 13 to 52 percent. Of the various energy impacts of urban trees, so-called evapotranspiration is the most important.²⁴ In this process, trees are natural air conditioners, alleviating some of the heat-island effect associated with human activities and the builtup environment in urban areas. In an urban setting, neighborhoods with mature tree cover record daytime peak temperatures 3° to 5° F lower than in newer areas with no trees.²⁵ In Washington, D.C., each 1°F temperature rise during hot summer days increases area cooling costs by \$10,000 per hour. Nationally, the urban heat-island effect costs an estimated \$1 million per degree per hour.²⁶

How much energy urban trees save during winter is less well investigated. It is known that trees help reduce outside air infiltration

Box 5. Quantifying the Costs of Mitigating Global Warming Biotically

Estimating the life-cycle costs (or savings) of purchasing a more efficient electrical appliance or a more efficient light bulb is quite straightforward. The up-front purchase price of new appliances or the light bulbs is compared, as is the present value of the stream of energy payments associated with their operation. If the life-cycle cost of the more efficient appliance or bulb is lower than that of the alternative, the cost of sequestering carbon through energy efficiency is virtually zero.

Unfortunately, assessing the life-cycle costs of implementing biotic policy options is far more difficult than determining the life-cycle costs of a light bulb. In the case of converting private lands, for example, the various opportunity costs confronting landowners are much more complex and difficult to estimate than those facing buyers of electric appliances. The National Research Council estimates that land-use decisions on over 60 percent of harvested croplands are heavily influenced by federal program rules and incentives and that such programs will continue to shape land-use decisions in the future. And even though total federal outlays for direct payments to farmers, export subsidies, storage costs, and loans have been declining since 1986, partially as a result of drought-related increases in many commodity prices, they still accounted for 40 percent of net farm income in 1987. Historically, the net effect of agricultural incentives has been to increase agricultural cultivation on lands ill suited to farming. Although the 1985 Farm Bill has alleviated this problem somewhat, farm programs continue to be complex and sometimes contradictory. Many

impose obstacles to adopting agricultural and land-use policies that would encourage the conservation and buildup of soil carbon, the reduction of energy inputs, and the withdrawal of unsuitable lands from agricultural production. Even though nearly 70 million acres were idled in set-asides in 1987, total agricultural capacity was still some 16 percent in excess of what prevailing market prices would justify.

Apart from the difficulties of assessing the true societal costs of changing land uses to mitigate global warming, other variables complicate the process further. The initial costs of forestry options can vary widely, as can the recurring costs of managing trees. The carbon benefits of tree planting are themselves subject to uncertainties that policy implementors cannot control—among them, long-term biomass growth rates and natural disasters. And further, the conventional economic payoff of planting trees is so far away, often 50 to 75 years, that it is often ignored in estimating the cost-effectiveness of biotic options. For these reasons, the costs of sequestering or displacing carbon through biotic options can vary so much that comparing the apparent cost-effectiveness of such options to each other and to other mitigation options (such as appliance efficiency) can be frustratingly difficult.

Sources: National Research Council, 1989. *Alternative Agriculture*. National Academy Press; U.S. General Accounting Office, 1990. *Alternative Agriculture: Federal Incentives and Farmers' Opinions*. Program Evaluation and Methodology Division.

Box 6. The America the Beautiful Initiative

As part of its proposed fiscal year 1991 budget, the Bush administration included an initiative known as America the Beautiful, an important element of which is the annual planting of one billion trees as part of a national reforestation program aimed at slowing global warming. Under this program, \$175 million was tentatively budgeted for the 1991 fiscal year to promote both rural and urban tree planting. Of this, \$110 million is for reforesting 1.5 million acres per year and initiating timber-stand improvement practices on an additional 180,000 acres. The remaining \$65 million is earmarked for the proposed urban forestry component of the program—planting 30 million trees annually in 40,000 communities around the country. Of the total set-aside for urban forestry, \$30 million is for coordination and technical assistance, and there is an additional one-time allocation of \$35 million for capitalizing a private nonprofit foundation to lend nongovernmental leadership to the effort and build further financial support. Overall leadership of the reforestation efforts would be shared by the Forest Service and the new community forestry foundation.

The carbon benefits of the rural reforestation component of the America the Beautiful program can be calculated quite easily if simplifying assumptions are made. If an additional 1.5 million acres of trees are actually planted per year as a result of the new program, if this move does not prompt other would-be tree farmers to forgo planting or reforesting their own lands, and if no natural or man-made problems (such as fire or pollution) keep the trees from surviving and growing, calculating the carbon benefit of the program is simply a matter of selecting a growth rate. Using the average productivity of all U.S. commercial forests, or about 0.6 tons of carbon per acre per year, the pro-

gram would draw about 900,000 tons of carbon per year from the atmosphere. If a higher growth rate is assumed to result from aggressive plantation management, perhaps as much as 2.5 tons of carbon per acre per year, annual carbon accumulation could reach 3.75 million tons. If the planting were continued for 10 years, the 15 million acres of trees planted could withdraw between 9.0 and 37.5 million tons of carbon from the atmosphere per year for several decades, roughly the equivalent of 0.5 to 2.3 percent of current U.S. fossil fuel emissions.

Calculating the carbon benefits of the urban forestry component of the America the Beautiful program is much more difficult, because some significant fraction of the trees is apparently intended for communities where cooling energy requirements are low. Planting trees in such cities would probably release more carbon than it would absorb or displace. Where space-cooling requirements are high, however, the carbon content of fossil fuel consumption eventually forgone through the program after 10 years of planting might be as high as 5 million tons per year, making the total program's carbon benefits the equivalent of 0.8 to 2.6 percent of current U.S. fossil fuel emissions.

The economics of the America the Beautiful program, however, are questionable. Even with optimistic assumptions, the \$110 million targeted for rural forestry allows a one-time payment of less than \$60 per acre to convince farmers to convert their unforested land to tree-crop cover. Although EPA and Department of Agriculture (USDA) analyses underlying the proposal suggested that this would likely prove insufficient, and indeed that rental payments of the sort seen in the CRP program would become necessary relatively rapidly, the Office of Management and Budget reportedly rejected their

conclusions. Similarly, the \$30 million budgeted for urban tree planting will cover only a small fraction of the total costs associated with planting 30 million new trees per year.

Although early reactions from the non-governmental forestry community to the America the Beautiful program have been positive, other line items in the overall forestry budget are controversial. Many proposals for reducing or eliminating existing programs in the forestry sector will negate some of the benefits being attributed to the America the Beautiful program. Problems that have been identified by forestry groups include:

- A reduction in other reforestation funding by more than \$4.5 million, notwithstanding an increase in area to be reforested.
- A reduction of spending on state and private forestry from almost \$100 to \$56.6 million.
- The elimination of funding for insect and disease suppression on cooperative state and private lands, which currently stands at \$10.6 million.
- A reduction in the firefighting budget for cooperative state and private lands from \$14 to \$4 million.
- A reduction by almost 50 percent in the forest management and utilization budget.
- The elimination of the federal forest stewardship and rural development initiative funding. These programs currently promote environmentally sound multiple uses of land, including timber production on nonindustrial private forest lands. The program is proposed for elimination just as states are completing

state stewardship plans intended to bring 25 million acres of nonindustrial private forest under stewardship management over the next five years.

- Reductions in the nursery and tree improvement program and urban forestry program funding.
- Elimination of the tropical forestry initiative, currently at \$4 million per year.
- The failure to repay the USFS's Knudsen Vandenberg account for some \$244 million in firefighting expenses beyond what was budgeted for in past years. The proposed budget for forest firefighting is \$118 million, though costs over the last three years have averaged more than \$300 million per year. The continued siphoning off of money to pay for firefighting may detract from the funding of other forestry activities in coming years.
- The likely closure of five additional USFS research stations, an increase in the interval between timber inventories from 10 to 13 years, the elimination of funding for remote sensing, and the reduction of funding for international trade research.

Many experts contend that many of these programs should be expanded, not reduced or eliminated. Expansion is needed, they say, to improve the health of U.S. forests as well as to help prepare those forests for the changes that may result from global warming and other environmental changes.

Sources: U.S. Department of Agriculture, Forest Service, 1990. *America the Beautiful: National Tree Planting Initiative*; Dinus, R.J., Francis, M.S., Sampson, N., and Mixon, J., 1990. Statements before the House Agricultural Committee, Forest, Family Farms, and Energy Subcommittee, February 6.

into buildings by making the city surface rougher and lowering wind speeds. According to one report, under certain conditions wind-breaks around homes and buildings can reduce heating energy use by 10 to 50 percent.²⁷

The Potential Magnitude of Urban Tree-Planting Benefits. The AFA estimates that the average urban area has a 30 percent canopy cover, which is only half of such areas' potential capacity. President Bush's America the Beautiful proposal to plant as many as 600 million new trees in urban areas over 20 years would virtually double this canopy. The AFA's more modest goal reflects its belief that there are 100 million sites for new trees around homes and small businesses that would yield particularly significant energy savings.²⁸

According to Lawrence Berkeley Laboratory, 100 million new trees could—if properly placed—prevent the emission through fossil fuel combustion of approximately 10 million tons of carbon by reducing national cooling energy requirements by 10 percent.²⁹ To realize such gains, the new urban trees would have to be planted around one-half the air-conditioned homes and small commercial buildings in the United States. If the reflectivity of these buildings were also increased—by, for instance, using more reflective roofing materials—the energy savings could be almost doubled, thus reducing carbon emissions by some 20 million tons. Total coverage of available planting opportunities would in principle result in even greater reductions, perhaps as high as 15 million tons.

From a carbon mitigation perspective, the maximum achievable benefits of urban tree-planting programs are modest. Only 2.7 quads of energy, or less than four percent of U.S. annual energy consumption, are used to cool residences and buildings (1.2 and 1.5 quads, respectively). Although producing this much energy emits some 50 million tons of carbon, much of it is consumed in large commercial buildings and other settings where trees do relatively little good. In addition, several

factors will affect the timing and realization of carbon savings projected for large-scale urban tree planting. First, trees need considerable time to grow large enough to shade buildings and transpire enough water to cool the local environment. They must also be properly placed around the house or building, and they must be kept healthy. Second, space-cooling technologies and buildings are themselves becoming more energy efficient over time: replacing an old residential air conditioner with one that is 50 percent more efficient will cut by about one-third the potential carbon benefits associated with planting trees around the house. Third, urban tree planting and maintenance consume energy in their own right. The energy used to grow, plant, water, fertilize, prune, spray, and otherwise maintain trees in urban areas where little or no air conditioning is used might well release more carbon than the trees take up or displace. Leaf collection and dead tree removal also consume significant amounts of energy.

From a carbon mitigation perspective, the maximum achievable benefits of urban tree-planting programs are modest.

The Costs of Urban Tree Planting as a Mitigation Strategy. Simply handing out tiny seedlings at fast-food chains or other establishments costs very little per tree, but a high percentage of these seedlings is likely to perish. Many more will not be planted where they will maximize energy savings. As a result, the "cheapest" trees are likely to be less reliable in mitigating CO₂ emissions, and they may prove less cost-effective than trees planted through sophisticated programs with much higher upfront costs. In one such scenario, with a one-time cost of trees of \$15 to \$75 per home (compared to a recurring expenditure of \$100 per

year for air conditioning), the estimated annualized cost per ton of carbon saved is \$6 to \$26.³⁰ However, providing needed extension services to ensure that trees are placed properly, finding the personnel and providing the infrastructures needed to maintain the trees, as well as countering the problems already facing urban forests of pollution and numerous other stresses, would all add to the estimated costs. So would relying on larger trees in the hope of speeding up the accrual of significant benefits, which would otherwise take well over a decade to discern.

The Pros and Cons of Urban Tree Planting. Compared to other types of forestry, urban tree planting has a number of advantages. It can, like the AFA's Global Releaf program, mobilize considerable citizen participation, thereby sensitizing the public to global warming and other environmental concerns. It can serve aesthetic needs and help advance such urban environmental goals as slowing the movement of storm water, thereby reducing erosion and combatting sewer overload. Even more important, this approach can decrease the need for expensive new powerplant capacity if urban air-conditioning demand at peak periods can be constrained—probably an even more significant benefit than its effect on slowing global warming.

These benefits notwithstanding, many barriers will impede the long-term success of an urban tree-planting program intended to mitigate global warming or reduce peak energy demand. More energy might well be consumed in maintaining improperly placed trees than is saved by them, especially if they reduce solar gain during the winter and thus increase heating costs. From policymakers to homeowners, the range of people who must be educated and mobilized to plant trees correctly, then maintain and protect them, can be surprisingly large. In addition, urban trees are already beleaguered by air pollution, compacted soils, inadequate growing pits and water, such irritants as salt, careless road and municipal repairs, and many other problems. Today, the

average downtown tree survives just seven years; even suburban trees last only an estimated 32 years. A 1986 survey of 20 larger cities found that four trees are dying or dead for every one tree being planted; in New York and Chicago, the ratio rises to eight to one.³¹ Ironically, trees themselves contribute to the production of volatile organic hydrocarbons, one of the precursors to the urban smog that poisons trees.³²

From policymakers to homeowners, the range of people who must be educated and mobilized to plant trees correctly, then maintain and protect them, can be surprisingly large.

Past efforts to increase the number of urban trees have met with varied success. One million seedlings were distributed for planting in Los Angeles before the 1984 Olympics; most apparently died. Whether the programs now starting up will turn the tide will take years to determine. Given the many barriers to overcome in expanding urban forests, however, it is unlikely that we can come close to reducing carbon emissions by the 15 million tons suggested as technically feasible. As a practical matter, even a broad-based policy initiative in the urban forestry sector appears unlikely to displace U.S. fossil fuel emissions by more than 20 to 30 percent of the technical potential. Indeed, just stopping the continuing deterioration of urban trees and the resulting intensification of the urban heat-island effect will take considerable effort. Urban forestry budgets and staffing have declined markedly over the last decade and the \$500 million currently spent annually on municipal tree care is a far cry from the amount required even to maintain our urban forests properly, much less to expand them.³³

Stopping the continuing deterioration of urban trees and the resulting intensification of the urban heat-island effect will take considerable effort.

As this brief analysis shows, there are many worthwhile reasons to plant and protect trees in urban areas. As a carbon storage and displacement option, tree planting could in principle provide a carbon benefit of some 15 million tons, although 3 to 5 million tons seems more likely even with an aggressive policy effort. In regions that have high cooling-energy demands and high energy costs and that face the construction of expensive additional electrical generating capacity, the cost of this policy option on a dollars-per-ton basis could be very low. Costs increase as cooling demand or capacity value falls, as extension and educational efforts become more sophisticated, and as larger trees are used to accelerate the accrual of benefits. After an increment of almost free carbon storage, most of the practically achievable carbon benefits might well cost \$10 to \$30 per ton. These costs could rise much higher in areas with modest space-cooling requirements or in communities with already relatively full tree canopies.

2. Converting Private Agricultural and Pasture Lands to Conventionally Managed Tree Cover

Some 250 million of the approximately 1 billion acres currently in agricultural, pasture, or rangeland uses were forested before Europeans settled the continent. Many of these once-forested acres are highly erodible or otherwise environmentally fragile, but they remain in agricultural production or related uses. The same can be said for millions of additional acres that could, in principle, support trees or

other crops for carbon storage or energy production.

One way to convert more private lands to tree cover is to expand existing programs such as the Agricultural Conservation Program (ACP) and Forestry Incentives Program (FIP). (See Box 7.) Alternatively, the acreage goals of the Conservation Reserve Program (CRP) could be expanded and its criteria loosened to encourage the conversion of additional acreage to tree cover; in addition, incentives could be adopted for converting to-tree-cover acreage already signed into the CRP. The goal of increasing forested acreage might also justify a new program, possibly termed the Forestry Reserve Program (FRP), that would function much as the CRP does but without the same eligibility criteria. Because the pool of eligible land could include agricultural land of considerably lower value than that now targeted for CRP inclusion, government payments could be kept lower with this approach.

A related land-conversion option is to encourage the construction of windbreaks around agricultural fields, on rural homesteads, and along rural roads. Such windbreaks can store carbon, reduce fossil fuel consumption, and provide ancillary economic and environmental benefits, such as reduced soil erosion.

Other opportunities also exist for converting agricultural land to further carbon-storage goals at least moderately. Promoting research, development, and market penetration for commodities such as kenaf—which yields a fiber that can be used to make paper—could free up land now used to produce wood pulp to produce wood for more long-lived products and could ultimately take some harvesting pressure off U.S. timber resources.³⁴

The Potential Magnitude of Carbon-Storage Benefits. Some 328 million acres were used to grow crops during 1988.³⁵ Another nearly 80 million acres were idled to reduce production or conserve land, an additional 65 million were used temporarily as pasture in cropland-

rotation schemes, and almost 600 million acres were in permanent pasture or rangeland.

How much land might reasonably be converted to tree cover? Estimates vary widely depending on the criteria used. For the nation as a whole, the U.S. Department of Agriculture (USDA) estimates that some 310 million nonforested acres are capable of supporting tree growth.³⁶ Estimates of the quantity of economically marginal or environmentally sensitive crop and pasture lands that could physically support tree cover range from about 120 million acres to almost 250 million acres.³⁷ In the eastern United States alone, some 40.4 million acres of cropland and 41.7 million acres of pasture land are estimated to fall into these two categories.³⁸ Some 26 million acres, most of them in the southeastern United States, would already be more profitable to their owners if planted in trees even without changes in governmental or private incentives.³⁹

The carbon-storage potential and cost-effectiveness of converting environmentally sensitive lands to tree cover depends to a large extent on how fast the trees grow. Current annual productivity in U.S. forests ranges widely, from 0.6 tons of carbon per acre for the average timberland to more than 2 tons of carbon per acre for intensive plantations.⁴⁰ Production targets for some species range as high as six to eight tons of carbon uptake per acre per year under particularly intensive management. But for the foreseeable future, an acre of land converted to a mid- to long-rotation tree-crop cover is more likely to incorporate from 1 to 2.5 tons of carbon per year into new biomass.⁴¹ Significant silvicultural advances would be needed to reach the 2.5-ton level; Richard Birdsey of the USFS believes a figure of 1.5 tons of carbon per acre (including soil carbon) is realistic.⁴² But keeping an upper limit of 2.5 tons per acre, to be optimistic, planting an additional acre of trees could result in 50 to 125 tons of carbon storage per acre over a 50-year growth cycle and for as long as the trees remain standing.

Unfortunately, the actual long-term carbon benefit of planting this acre of trees cannot be determined simply by extrapolating from

projected annual biomass growth rates. First, the fossil fuel energy inputs needed to plant and maintain the trees must be subtracted from net biomass accumulation. In general, more energy is needed the more intensively one manages a tree crop and the higher the growth rates achieved. Net carbon benefits per acre also depend on whether the timber is eventually harvested and on what happens to both the merchantable and nonmerchantable portions of the harvested biomass.⁴³ When an acre of trees is harvested, a significant proportion of the carbon accumulated in biomass and in the soils can be lost through oxidation to the atmosphere during or soon after harvest. The extent to which carbon-storage benefits extend past the point of harvesting depends on the proportion of harvested carbon that is added to product stocks, the amount of fossil fuel energy displaced by the combustion of nonmerchantable wood and wastes, the amount of soil carbon loss, and the extent and speed of replanting and regrowth on the acre. Given these factors, an acre of new trees evaluated on the basis of net carbon storage within a decade of harvesting could easily yield considerably less than the 50 to 125 tons of carbon benefit calculated for an unharvested acre.⁴⁴ Indeed, even 35 to 90 tons of carbon per acre is probably an optimistic estimate.

When an acre of trees is harvested, a significant proportion of the carbon accumulated in biomass and in the soils can be lost through oxidation to the atmosphere during or soon after harvest.

The technical potential of shelterbelt options to mitigate global warming is difficult to assess. The equivalent of more than 3 million acres of windbreaks would be required just to protect

Box 7. Past and Current U.S. Reforestation Programs

Although global warming has not been a motivating factor in promoting domestic forestry until recently, large-scale reforestation has been promoted for other policy reasons for decades. The five major initiatives have been:

Civilian Conservation Corps: Over nine years in the 1930s and early 1940s, the Civilian Conservation Corps (CCC) planted 2.3 million acres of trees. In addition, the CCC practiced conservation efforts to constrain soil erosion, protect against forest fire, and improve wildlife habitat. At the program's peak, there were 311 forestry camps in the South alone on both national forest and private land. With the onset of World War II, tree planting and fire-protection efforts declined because the workforce was needed elsewhere; the CCC was disbanded in 1942.

Soil Bank: Between 1956 and 1962, some 2.2 million acres of trees were planted as part of the Soil Bank program; 1.9 million acres of them were planted in the South, contributing significantly to that region's timber supplies. The program was enacted to conserve soil and to reduce surplus farm production. The program paid for tree-planting costs and made annual cash payments to the participating landowners for up to 10 years, much as the CRP does today. Follow-up studies have shown that most of the land planted in trees stayed out of crop production, even after cash payments were discontinued; according to one study, 86 percent of Soil Bank plantations in the South were still in trees in 1980.

Agricultural Conservation Program: Created as part of the Soil Conservation and Domestic Allotment Act of 1936, the Agricultural Conservation Program (ACP) has focused on promoting farm-conserving practices. Like other conservation programs, its work has

included tree planting, timber-stand improvement, and wildlife habitat enhancement. Federal cost sharing of tree-planting expenses under the program encouraged annual reforestation of 200,000 to 300,000 acres in the early 1960s, but that number has fallen to less than 100,000 acres per year in the last 15 years. Timber stands on an additional 200,000 to 250,000 acres per year were improved under the ACP in the early 1960s, but by 1986 that figure too had dropped—to some 27,000 acres per year. The government's share of costs has averaged \$60 to \$75 per acre (real 1988 dollars), with the total spent on reforestation and timber-stand improvement falling from approximately \$24 million in 1960 to \$7 million in 1986 (real 1988 dollars).

Forestry Incentives Program: Added as a rider to the Agriculture and Consumer Protection Act of 1973, the Forestry Incentives Program was created in response to the dwindling availability of ACP funding. In addition to cost-share payments for tree planting and stand improvement, the FIP also pays for site preparation for natural regeneration and for firebreak construction. Eligibility is restricted to nonindustrial private forest landowners who are not primarily involved with manufacturing forest products; in addition, land must be classed as commercial timberland and tracts of land must be between 10 and 10,000 acres. Since 1973, an average of 150,000 to 200,000 acres per year have been reforested under the program; timber-stand improvement has fallen from an average of 150,000 acres annually in the program's early years to approximately 40,000 acres during the past several years. Federal costs in 1988 dollars have fallen as well, from nearly \$23 million in 1974 to less than \$12 million in 1986.

The Conservation Reserve Program: Many acres of grasslands and wetlands were converted to agricultural use during the 1970s due to

high food prices and federal crop-price-support programs. Many of these acres have proven quite fragile, however, and erosion is severe. And at today's food and land prices, almost 100 million acres of U.S. cropland are in excess of demand. The CRP was established as part of the Food Security Act of 1985 to foster the withdrawal from agricultural production of between 40 and 45 million of these highly erodible acres by 1990. To be eligible for inclusion in the CRP, land must have an average erosion rate of at least 19.1 tons of soil per acre—nearly three times the national average. By this criterion, an estimated 24 percent of all U.S. cropland—mostly in the Corn Belt, northern and southern plains, and mountain regions—is potentially eligible. Without special dispensation, however, CRP sign-ups are limited to 25 percent of a county's cropland in an attempt to spare local economies significant damage. This limitation reduces eligible land by almost one-third, to just under 70 million acres. To encourage landowners to participate in the CRP, the government shares the cost of converting the land to an alternative use and provides rental payments throughout the 10-year CRP contracts.

The erosion-control element of the CRP appears successful. Erosion on acreage signed into the program fell from an annual estimated average of 20.9 tons per acre before enrollment to 1.6 tons per acre after enrollment and the implementation of conservation treatments. Overall, CRP implementation through 1989 is estimated to be reducing total erosion by more than 600 million tons per year. CRP's reforestation element, however, has proven less successful. Congress hoped that 5.6 million acres of CRP enrollments would be converted to tree cover. With 33.9 million acres of land enrolled in the CRP as of early 1990, only 2.2 million acres were contracted to go into tree cover. (Tree planting has been largely concentrated in Georgia, Mississippi,

Alabama, and South Carolina.) Some analysts believe, however, that some proportion—possibly as much as 650,000 acres—of CRP land currently in grasslands ultimately will be converted to tree cover by landowners.

In a recent survey of the obstacles to planting trees on CRP land, the reason farmers most often gave was the physical unsuitability of their land for growing trees, particularly owing to arid climate or sandy soils. Other common responses included beliefs that trees would interfere with the use of land after the 10-year CRP contract expired and that high maintenance costs and the long wait before trees could be harvested would make the switch unprofitable. The study also found, however, that farmers were more likely to plant trees if they had regular contact with the state forestry or agricultural extension agencies as well as prior commercial experience with planting or harvesting trees.

Sources: Cabbage, F.W., forthcoming. *Current Federal Land Conversion Programs: Accomplishments, Effectiveness, and Efficiency*. American Forestry Association; U.S. Department of Agriculture, Forest Service, 1988. *The South's Fourth Forest: Alternatives for the Future*; Esseks, J.D., Kraft, S.E., and Moulton, R.J., forthcoming. *A Survey Research Perspective on the Forestry Component of the Conservation Reserve Program*. American Forestry Association; Moulton, R.J., and Dicks, M.R., 1987. "Implications of the 1985 Farm Act for Forestry," in *Proceedings of the 1987 Joint Meeting of Southern Forest Economists and Midwest Forest Economists*. 1987, Asheville, North Carolina; U.S. Department of Agriculture, 1989. *Conservation Reserve Program: Progress Report and Preliminary Evaluation of the First Two Years*; U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, 1990. *Conservation Reserve Program "Logo Package."*

the almost 70 million acres of cropland seriously affected by wind erosion.⁴⁵ Nearly two million additional acres could be required to protect just 10 percent of other croplands, homes, and farms and to serve as living fences along rural roads. By one estimate, if this many trees were planted, almost 100 million tons of carbon could be stored over time directly in biomass and the emission of almost 165 million tons of fossil fuel carbon prevented over 50 years.⁴⁶ It is worth noting, however, that large numbers of windbreaks have been cut down in recent decades to make way for larger fields and irrigation systems.⁴⁷

Overall, the technical potential for land conversion runs into the tens and possibly even hundreds of millions of acres. If 50 million acres were converted, 50 to 125 million tons of carbon could be stored per year, up to a total of 2.5 to 6.3 billion tons over a 50-year growing cycle. Converting 100 million acres of land could lead to the storage of 100 to 250 million tons of carbon per year—a significant fraction of current U.S. fossil fuel emissions, some 1.6 billion tons. These figures dwarf the estimated potential of existing forestry-incentive programs to encourage additional tree planting. Only an estimated 300,000 additional acres could be planted annually under the ACP and the FIP. And according to USDA's Economic Research Service (ERS), paying all tree-establishment costs and extending CRP contracts for 10 years from the date of tree planting could encourage the afforestation of just 0.5 to 1.2 million acres of former cropland already enrolled in the CRP, a small fraction of the almost 40 million acres enrolled in the program.⁴⁸

The Costs of Converting Private Lands. The physical potential for reforesting pasture and agricultural lands is huge, but how much would it cost? One consideration is the various incentives that are encouraging the agricultural use of lands that might otherwise be forested or reforested. Almost 70 percent of U.S. cropland is currently enrolled in one federal commodity program or another.⁴⁹ Overall, the federal government spends more than \$10 billion

each year on farm programs, some proportion of which fosters the use of marginal and environmentally fragile lands.⁵⁰ Changing the terms or scope of these programs might encourage considerable tree planting while actually saving taxpayer money. In addition, most schemes proposed for reforesting private lands have focused on direct government payments to landowners. Many other approaches, including higher taxes on fertilizers and other inputs, might have different costs and impacts.

How much would it cost to impose a new layer of policies to encourage the conversion of certain categories of agricultural land to tree cover? Past experience with such programs should provide rough ideas. Some 4.1 million acres have been converted to tree cover through the ACP, FIP, and CRP over the last decade. If tomorrow's reforestation efforts take the same basic approach on the same land base, per-acre costs will no doubt continue to rise. Loosening eligibility criteria would lower program costs, though secondary environmental benefits would be lessened if the trees are planted on hardy, resilient lands. The choice between offering only cost-sharing payments (as the ACP and the FIP do) or making rental payments as well (as the CRP does) also significantly affects projected program costs. The average federal share of tree-planting costs on the 1.6 million acres enrolled under the CRP as of 1988, for example, was a one-time \$35 per acre, or \$56 million. In contrast, rental costs for those acres will average \$45 to \$50 per acre per year for 10 years, for a total cost of \$70 to \$80 million per year.⁵¹

A variety of estimates have been made of the cost of using government payments to expand reforestation. USDA's ERS believes that expanding the FIP and ACP by 300,000 acres per year would cost some \$25 to \$35 million annually if the government pays all planting costs.⁵² Another ERS analysis suggests that \$123 to \$239 million would be needed to convert 0.5 to 1.2 million acres of land already in the CRP to tree cover if the government pays all tree-planting costs and extends CRP contracts

for an additional 10 years.⁵³ Depending on how fast the newly planted trees grow, the annualized cost per ton of carbon stored is likely to range from \$5 to \$20 under these scenarios.

The ERS has considered even larger-scale efforts. A new Forest Reserve Program for converting 10 million acres would cost an estimated \$2.2 billion, and \$5.3 billion would be needed for 20 million acres—roughly \$10 to \$30 per ton of carbon stored.⁵⁴ More recently, economists Robert Moulton and Ken Richards of the USFS argued that up to 250 million acres of U.S. cropland and pasture could be forested to store more than 700 million tons of carbon per year at a top marginal cost per ton of carbon of only \$43 or so and a surprisingly low average cost of only \$24 per ton.⁵⁵ These first-order estimates do not, however, take into account the major timber and agricultural market impacts of a program of this scale.

The secondary market impacts of large-scale tree planting, including depressing wood prices, are likely to prove quite important to the long-term carbon benefit of such programs.

The secondary market impacts of large-scale tree planting, including depressing wood prices, are likely to prove quite important to the long-term carbon benefit of such programs. Unless the timber grown in large-scale projects is permanently kept out of the market, which would in itself raise the price demanded by farmers to convert their lands, such afforestation projects would probably push forestry investment down elsewhere in the country.⁵⁶ If one-half the carbon accumulation on the converted lands were negated by forgone tree growth on other lands in the United States or abroad, the real cost per incremental ton of carbon stored would double.

Despite the confusion engendered by varying estimates and the assumptions behind them, in principle it should be quite cheap to convert some 20 million acres to tree cover because landowners would make more money from planting timber on these lands than they now do grazing cattle on them. Additional tens of millions of acres could be included in a Forestry Reserve Program for only \$10 to \$30 per ton of carbon stored if the appropriate sites can be cost-effectively included. True costs might be even lower if the future financial returns from tree planting are positive and if savings result from reducing federal commodity price payments and curbing soil erosion. On the other hand, uncertainties about likely carbon accumulation rates, as well as the schemes' second- and third-order effects on timber and food markets, make it difficult to project reliably the net carbon storage or costs for these larger-scale conversions. In principle, however, the opportunities for private land conversions, ranging from windbreaks to plantations, are large.

The Pros and Cons of Converting Private Lands to Forest Cover. Besides carbon sequestration itself, the benefits of converting cropland or pasture vary considerably with the circumstances and the scale of the conversion. Reforesting highly erodible croplands and those that are major nonpoint sources of pollution from agricultural runoff, or planting trees in windbreaks and along riparian habitats, would be more environmentally beneficial than planting ecologically hardy lands—one reason to encourage additional tree planting on fragile lands. The land base originally eligible for inclusion in the CRP, for example, accounted for 60 percent of the total sheet, rill, and wind erosion from U.S. croplands.⁵⁷ Unfortunately, some of the more promising planting strategies have not been accorded much attention even under the CRP: today, windbreaks constitute only about 6,800 acres of more than 2 million converted to tree cover under the program.⁵⁸

An additional advantage of land conversions like these is that the return on public investment

has tended to be long lasting without continuing governmental oversight, partially because the farmers involved have realized net economic gains beyond the government payments received.⁵⁹ According to one assessment, 86 percent of the acreage planted under the Soil Bank program is still in tree cover after 15 to 20 years.⁶⁰ On forested ACP acreage, over 90 percent of the trees planted are still there after 10 years.⁶¹ Acreage forested under the CRP programs is likely to be even more permanent considering the constraints placed on returning highly erodible land to agricultural production under the 1985 Farm Act. Nevertheless, if long-term drought in the U.S. wheat belt persists, or if the United States fails to produce enough wheat or other staples to feed even itself, returning withdrawn lands to agricultural production might once again become politically irresistible. And if enough trees are planted to affect timber prices and financial returns to landowners significantly, landowners' incentive to keep converted lands forested once government payments expire may evaporate. Under such circumstances, longer-term contracts or easements could be required to preserve the carbon-storage benefits associated with large-scale tree planting.

An inherent risk with any large-scale rural tree-planting effort is its susceptibility to natural events.

An inherent risk with any large-scale rural tree-planting effort is its susceptibility to natural events. Droughts, hurricanes, disease outbreaks, or wildfires could all acutely affect how much carbon is stored on converted lands over a given time. As noted, for example, hurricane Hugo downed millions of acres of timber overnight. Although experience suggests that physical threats of this sort tend to damage seriously only a relatively small proportion of

forested land each year,⁶² global warming could make such events more frequent and severe.

Another potential disadvantage of adding new incentives to influence land-conversion and land-management practices is the potential problem of overlapping incentives. In such a case, landowners might receive more money by enrolling in a new program without planting more trees than they would have under an existing program. However, already existing incentives that could in principle overlap in this way—reforestation tax credits and cost sharing, for instance—have thus far had an additive effect on encouraging reforestation.⁶³

Large-scale land conversions could also take a toll on the health of rural economies and the industries they supply while also depressing timber markets. Covering 200 million acres of crop and pasture lands with highly productive plantations, for example, could almost double total commercial wood production from U.S. forests and produce more than 200 million tons of carbon in the form of merchantable timber per year. It could also produce tens of millions of tons of nonmerchantable wood that could be used to produce energy, just as wood wastes from current timber harvesting supply a large fraction of the processing industry's energy needs. Large-scale land conversions of even a fraction of this magnitude, however, would inevitably be offset to some extent by current timberland owners deciding not to reforest their own lands because of a perception that future timber prices would fall. According to one analysis of world timber supplies, planting 37 million additional acres of plantations in developing countries would yield 10 billion cubic feet of timber per year but would increase global timber production by only 2 billion cubic feet.⁶⁴ Under this scenario, as much as 80 percent of the mathematically calculated carbon benefit of the new plantations could be negated by reduced investment in forest regeneration elsewhere in the world.⁶⁵

Given the vast areas of private land that potentially could be converted to tree cover,

the barriers to large-scale forestry for global warming mitigation are more economic and social than physical. Some farmers and other landowners will no doubt resist becoming tree farmers. And the amount taxpayers would be willing to spend to induce landowners to convert millions of acres of economically valuable land to tree cover, or which agricultural policies that inflate the area of land in agricultural use could be eliminated, is unknown.

Given the vast areas of private land that potentially could be converted to tree cover, the barriers to large-scale forestry for global warming mitigation are more economic and social than physical.

Overall, tree planting on private lands could in principle sequester or offset more than 900 million tons of carbon per year. Even an aggressive land-conversion program, however, is unlikely to result in the net storage of more than a fraction of this technical potential. Indeed, the conversion of 30 to 50 million acres of land, resulting in the annual storage of an additional 30 to 125 million tons of carbon per year—an amount roughly the equivalent of two to eight percent of current fossil fuel emissions—could be seen as a significant success. Even at the upper end of this relatively modest range, commercial timber production might increase by as much as 7 billion cubic feet per year, a significant fraction of today's 18 billion cubic feet. This change could well cause market feedbacks such as higher land and lower timber prices that would partially negate the carbon-storage benefits.

3. Increasing Tree Cover on Nonforested Public Lands

Hundreds of millions of acres of nonforested land in the United States are managed by

government agencies. The Bureau of Land Management (BLM) alone controls 270 million acres of public lands, mostly pasture and rangelands. The Department of Defense (DOD) holds title to an additional 26 million acres. No doubt some public lands, including active and closed military bases, lands administered by the BLM, and highway and pipeline rights of way, would be hospitable to additional tree planting or other types of vegetation.

The Potential Magnitude of Afforestation on Public Lands. Relatively little information exists on the potential for increasing forest cover on public lands, and the recently announced America the Beautiful campaign makes no provision for such planting. Currently, less than 30 million acres of BLM lands are forested, and less than 10 million are considered productive timberland.⁶⁶ Some 11 to 12 million acres of DOD lands are forested.⁶⁷ Preliminary Environmental Protection Agency (EPA) analysis suggests that improving forest management or planting trees on one to three million acres of BLM lands would result in the storage of an additional 1.5 to 4 million tons of carbon per year.⁶⁸ In the same analysis, it was assumed that five percent of the Department of Defense's 26 million acres could be replanted or fully stocked, with a carbon benefit of one to three million tons of carbon per year. EPA has also estimated that 20 percent of the land area currently dedicated to rural highways (other than the roads themselves) in the north-east, north-central, and southern parts of the United States—some 4.5 million acres in all—might be suitable for reforestation.⁶⁹

Relatively little information exists on the potential for increasing forest cover on public lands.

The Costs of Public Land Conversions. Reliable cost figures for each ton of carbon stored

through land conversion on public lands are not available. Planting and managing trees on rights-of-way would probably entail high labor and energy costs. Although land purchase or rental payments would not be required to encourage tree planting on government lands, tree-establishment costs are likely to be higher than on private lands, many of which are more suitable for trees.

The Pros and Cons of Public Land Conversions. The primary advantage of converting public lands to forest or other tree cover is that no land purchase or rental payments would be required. But many unforested federal lands simply cannot support forest. Many of BLM's rangeland acres and many DOD acres, for instance, are too arid for tree planting. Some may also be degraded by past misuse or by military exercises. The BLM claims that no more than an additional 50,000 acres of its lands could be forested. The Forest Service also argues that it has no unforested acreage to plant, though in the past the Forest Service has administratively withdrawn logged-over lands from its reforestation backlog rather than replant them.⁷⁰ Physical limits to tree planting probably are not the primary barrier on federal lands, however; it is that government agencies do not currently see carbon storage as part of their missions.

Probably the least contentious way to increase carbon storage on unforested public lands at least marginally is to increase the number of trees found on rights of way, particularly along rural and interstate highways. Department of Transportation analysts, however, suggest that much less land is available than might be supposed.⁷¹ Once the land dedicated to driving lanes, shoulders, median strips, and clear zones is discounted and certain areas are eliminated for safety reasons, the gross total available for tree planting along U.S. rural interstate and primary highways may not exceed 1.1 million acres. Of this, some 30 percent is believed unsuitable for tree growing, and at least some significant fraction of the remaining 710,000 acres is already forested.⁷²

For safety, political, and economic reasons, proposals to harvest such timber commercially to defray costs also seem highly impractical.

Overall, the carbon-storage opportunities on unforested public lands appear quite modest—only enough to sequester perhaps three to five million tons of carbon per year. This policy option, however, remains considerably less well investigated than the conversion of privately held lands, and further research could well reveal further potential.

4. Stocking and Managing Already Forested Lands More Intensively

Yields on many of the 481 million acres of U.S. timberlands are well below physical potentials. To maintain or increase carbon-storage capacities, options range from forgoing the harvesting of some timberlands to clearing and replanting others.

Selectively forgoing timber harvesting to preserve existing carbon reservoirs can prolong the storage of carbon that would otherwise be released in the short term, particularly where the ratio of standing biomass to annual growth is unusually high—as it is, for example, in the old-growth forests of the Pacific Northwest and Alaska. Old-growth forests can contain hundreds of tons of carbon per acre in trees and soils.⁷³ For every acre of these lands left uncut, more than 220 tons of carbon can be kept out of the atmosphere in the short term. (*See Box 3.*)

Nationally, however, forest ecosystems store only about 80 tons of carbon per acre. Leaving lands with these lower carbon densities uncut for carbon storage is generally much less compelling, both because replanting the land can often restore the preexisting carbon stocks within a matter of decades and because forgoing the harvest could increase significantly the use of plastics and other alternative construction materials that require fossil fuel energy to manufacture. This statement does not suggest that restricting the harvest of forest

other than old-growth is never justified in the name of carbon storage. Below-cost timber sales, for example, provide an interesting example.⁷⁴ Although how such sales affect the long-term carbon cycle is likely to vary by forest,⁷⁵ many below-cost sales occur in relatively unproductive forests that will take decades to regenerate, if they successfully regenerate at all.⁷⁶ In such forests, soils are likely to release a greater proportion of their carbon to the atmosphere in the interim than is the case with more productive land. In addition, cutting these forests could be expected to release relatively more CO₂ through biomass oxidation than would occur in more productive forests (where a greater proportion of total biomass would likely be tied up in merchantable timber and where the collection and utilization of wood wastes might be more economically justified).

How below-cost timber sales affect the long-term carbon cycle is likely to vary by forest, since many below-cost sales occur in relatively unproductive forests that will take decades to regenerate, if they successfully regenerate at all.

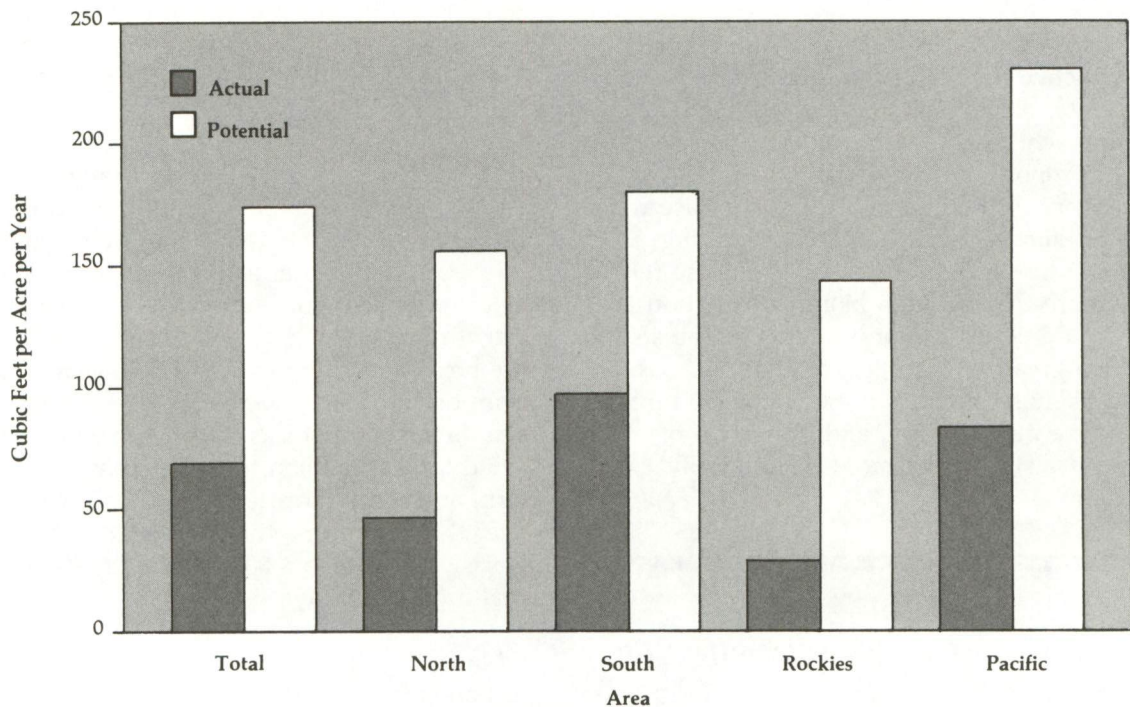
Making timberlands more productive is another approach to enhancing carbon storage both in the trees themselves and in wood products. Currently, the great majority of U.S. timberlands regenerate naturally once cut and are not intensively managed during the growth cycle. But they could be replanted, possibly with genetically improved seedlings, thinned during the growing cycle, or even fertilized. Timber stands can be intensively managed to protect against fire, insects, disease, and poor logging practices. Further reliance on the increasingly controversial even-aged stand management practices that have characterized

forest management in recent decades is not necessary to increase carbon storage.⁷⁷ What is needed instead is considerable site-specific research to determine how the goal of carbon storage can be integrated into existing multi-use forest management and to determine the capacity of U.S. timberland soils to sustain increased production.

The Potential Size of Carbon Benefit from Forest-Management Changes. Although the extent and even the definition of old-growth forest are in dispute, as much as four million acres of what is conventionally considered old-growth forest could be subject to harvest over the next several decades.⁷⁸ If a 50-year moratorium on harvesting were called to preserve standing carbon stocks, the net carbon benefit could total 20 million tons per year in the short term and more than 11 million tons per year over the long term—the equivalent of the CO₂ emissions of some 4,000 megawatts (MW) of coal-fired electricity.

Managing timberlands more intensively is a carbon-storage option that has received much more attention than that of putting some timberlands off limits altogether. Researchers have, for example, estimated that U.S. timberlands could theoretically produce more than twice as much merchantable timber as they do today.⁷⁹ (See Figure 7.) In most cases, the shift to more intensive management would be gradual and would begin with a new rotation cycle. Alternatively, particularly poorly stocked stands could be restocked without waiting for a future harvest. Estimates of how much timberland could practically be brought under intensive management within several decades vary from 45 to 150 million acres.⁸⁰ Such a program could be jump-started by reducing today's backlog of harvested acres waiting reforestation—about 1.2 million acres, nearly a three-year supply at current planting rates. Because federally owned timberlands constitute less than 20 percent of total U.S. timberlands, their likely contribution to strategies for increasing carbon storage in existing forests is modest compared to that of private lands.

Figure 7. Growth Potential on United States Timberlands



Source: U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States: 1952-2030*, Forest Resource Report No. 23, (1982)

The degree to which increases in commercial timber production might simply supplant the growth of noncommercially useful trees or species, thus failing to add to net carbon accumulation, cannot accurately be estimated.

Opportunities for intensifying forest management are abundant. The Forest Service estimates

that if only those management changes justified by current market economics were made, timber production on private timberlands would increase by almost four billion cubic feet per year—the equivalent of some 37 million tons of merchantable carbon, or an increase of some 30 percent over current commercial productivity on these lands. Because only three percent of the eight million private small-scale timberland owners in the United States have taken advantage of federal assistance to enhance timberland productivity, there is considerable room for improvement.⁸¹ The degree to which increases in commercial timber production might simply supplant the growth of noncommercially useful trees or species, thus failing to add to net carbon accumulation, cannot accurately be estimated.

Timelines are quite important in assessing the practical potential of intensifying forest management expressly to store carbon. If all harvested acres for the next 25 years were to be replanted under intensive management, the acreage under such management would increase by more than 75 million acres. If net carbon storage on these acres were to increase by 0.5 to 1 ton per acre per year,⁸² total carbon storage could increase by 35 to 75 million tons per year for several decades. Because intensive management will not be appropriate for all acres and because the time horizon for this analysis does not extend more than several decades into the future, it appears realistic to estimate the carbon benefit that might accrue from this policy option in the near- to midterm to be in the 15 to 20 million tons-per-year range. Roughly speaking, this 15 to 20 million tons could offset one percent of current carbon emissions from U.S. fossil fuel combustion.

The Costs of Intensifying Forest Management. Like the policy options already discussed, the costs of managing forests to increase overall carbon storage are hard to specify. Perhaps most difficult to gauge are the true costs of prohibiting logging on additional acres of federal (or even private) old-growth timberlands. One way to calculate the cost of this option—yielding a figure of \$100 to \$150 per ton of carbon “locked up”—is to base it on the current market value of an acre of high-quality old-growth timber.⁸³ It is this calculation that will convince many observers that the price is too high, especially when mill towns and logging communities are already suffering layoffs and shutdowns in the Pacific Northwest. On the other hand, other variables, including mechanization in the timber industry and the loss of processing jobs to the Japanese (who import raw logs from the United States and process them in Japan)—rather than preservation of old-growth forests for carbon storage or any other purpose—are also behind the economic crisis in timber-dependent communities in the Pacific Northwest.⁸⁴ In any case, the outcome of current economic and employment trends is likely to be a restructuring of the timber

harvesting and processing sectors in the relatively near future. Putting old-growth lands off limits may only accelerate the inevitable. In addition, biological and recreational values alone might economically justify logging bans in many old-growth forests. From this perspective, prohibiting logging in old-growth forests could offer a cheap approach to storing carbon.

After accounting for biological diversity, prohibiting logging in old-growth forests could offer a cheap approach to storing carbon.

Another cost consideration is the money required to intensify forest management. Basically, the more intensively timberland is managed, the more it costs. Enticing private landowners to intensify management on their lands has in the past involved governmental cost-sharing and, in some cases, rental payments as well. The costs of forest-stand improvement can run to \$450 per acre, although a more common range is \$100 to \$150.⁸⁵ Examples of management practices include site preparation and artificial regeneration, use of genetically improved seedlings, stand fertilization, precommercial thinning, and timber salvaging. If timber productivity were to increase by 0.5 to 1 ton of carbon per acre per year as a result, the cost per ton of additional carbon stored could be \$10 to \$100.⁸⁶ Fortuitously, intensifying forest management appears justified on many acres by existing market incentives, and it could presumably be achieved at a relatively low cost.

The Pros and Cons of Changing Forest Management Practices. Reducing the harvest of certain forest types serves multiple goals in areas where pressure to constrain timber harvests for biological, aesthetic, or recreational reasons is already mounting. Increasing timber growth on

other forested lands does not require changing land uses, and this approach conforms well to the mission of the USFS and other agencies likely to be involved. Expanding the extension services and the capabilities needed to encourage better management of private timberlands is also relatively easy.

Global warming itself may frustrate efforts to preserve large stores of carbon in old-growth forest.

From a carbon-storage perspective, however, legitimate questions can be raised about some of these options. First, just as the calculated carbon benefits of tree-planting on nonforested lands could be lost if forestry investment dropped elsewhere in the United States or abroad, the calculated benefits of forgoing harvesting could be dissipated if the harvest of old-growth forests increased elsewhere in the world as a result. Second, global warming itself may frustrate efforts to preserve large stores of carbon in old-growth forest. Indeed, forestry scientists expect to use old-growth forests as global warming laboratories precisely because they are so susceptible to damage from climate change.⁸⁷

Proposals to restock existing stands to promote timber growth must be evaluated with particular care. If these stands already contain considerable biomass, albeit noncommercial species or trees, restocking may be a wash from a carbon-sequestration standpoint or may even release carbon on net. Indeed, recent analysis suggests that restocking many poorly stocked U.S. forests might be commercially worthwhile but would yield little, if any, carbon benefit.⁸⁸

Forgoing harvesting and intensifying management of already forested lands have other drawbacks as well. Hopes of mitigating global

warming are unlikely to move local logging communities to accept reduced timber harvests. Imposing a carbon-storage mandate onto forest management agencies, whose performance has been measured previously largely in terms of board feet harvested, will also involve changing entrenched and sometimes complex decision-making processes. In addition, intensifying timber management to enhance growth may require environmental tradeoffs, and issues such as soil capabilities, preservation of wildlife habitat, and fulfillment of other multiple-use objectives have to be balanced carefully. Intensifying forest management could make timber management less sustainable than it is now or work against other policy objectives; balancing these interests may prove just as contentious as forgoing the harvesting of the much smaller numbers of acres for which this option would be appropriate.

Recent analysis suggests that restocking many poorly stocked U.S. forests might be commercially worthwhile but would yield little, if any, carbon benefit.

5. Substituting Wood for Other Products

Although relatively little is known about the life span and ultimate fates of various wood products, such products do constitute an artificial carbon sink. Storing harvested carbon in products can postpone the carbon's return to the atmosphere through oxidation, which happens relatively quickly when a dead tree is left to decompose in the forest. Increasing the use of wood products can also defray fossil fuel emissions to the extent that manufacturing nonwood substitutes like plastics and concrete requires comparatively more fossil fuel.

Although the average useful life of wood products can be reasonably well estimated, the

carbon storage of these products remains difficult to ascertain. It is known that a huge stock of worn-out wood products can now be found in U.S. landfills and that decomposition there is slow, but research on how much carbon is actually released in the use and disposal of wood products and the mechanisms through which it is released is just beginning.⁸⁹

Increasing the use of wood products can also defray fossil fuel emissions to the extent that manufacturing nonwood substitutes like plastics and concrete requires comparatively more fossil fuel.

Carbon sinks in long-lasting products can be expanded by increasing timber harvest levels, the percentage of harvested biomass that goes into long-term product, or the life spans of the products. Currently, considerably less than one-half of all harvested wood is used directly in long-lived wood products.⁹⁰ More efficient harvesting, milling, manufacturing, and building practices could increase this percentage. Reusing wood materials and extending their life spans through the use of preservatives and other means could increase the time it takes for products to reoxidize to the atmosphere. Using recycled materials to produce larger proportions of paper and paperboard could also make more lumber available for use in long-lived products by reducing demand for pulp. A drop in demand for virgin fiber, however, could just as easily decrease overall forestry investment and long-term carbon storage.

The Pros and Cons of Increasing Timber Utilization in Long-Lasting Products. Too little is known about the opportunities for using wood products as carbon sinks to draw any firm conclusions about the option's potential, side effects, or cost-effectiveness. There is a practical limit to the amount of wood that can

accumulate in product stocks (including in landfills) before annual oxidation equals or exceeds the annual addition of fresh product, and researchers do not know how far from this point the United States is now. Further complicating matters, as wood products decompose, they can also produce methane, which is a much more damaging greenhouse gas than CO₂. Little information is available, however, on the rates and patterns of wood fiber decomposition in landfills, where the anaerobic production of methane is common. For this reason, any estimates of either the technical or practical potential for this option are premature.

6. Increasing the Commercial Use of Biomass Energy

Biomass energy has been used for millennia. Ever since firewood was first burned for heating and cooking, human societies have relied on the energy embodied in vegetation and other organic matter. Until the relatively recent mass exploitation of fossil fuels, biomass was the world's chief energy source. Even today, more than one-half the wood removed from U.S. forests is used as firewood, though the total energy produced from wood accounts for only four percent of energy use in the United States.

Although our relative reliance on biomass has decreased markedly since industrialization began, the technological options available for converting biomass to useful energy have multiplied.⁹¹ Through techniques ranging from direct combustion to thermal gasification of feedstocks—be they annual grasses or whole trees—biomass can be converted into electricity, ethanol, methanol, biocrude gasoline, diesel fuel, or even synthetic natural gas. Given this versatility, biomass crops are not valuable primarily because they store carbon themselves but because they possess the potential to reduce the need for fossil fuels. The relatively high growth rates of biomass energy crops make them more suitable for energy generation than conventional tree cover in many cases,

and their relatively short rotations make it easier to adapt them to changing environmental and climatic conditions.

Substituting biomass for fossil fuels does at least as much to mitigate global warming as would conserving the displaced quantity of fossil fuel.⁹² And by raising the amount of carbon stored in the soils and vegetation of an average acre above what it is in conventional agricultural crop production, woody and perennial energy-cropping systems help expand natural carbon reservoirs and mitigate global warming even further.

Programs for the large-scale tapping of biomass energy, however, are not yet commercial for both economic and technological reasons. To help make biofuels more competitive with conventional fuels, researchers are striving to increase the production rates of new feedstock crops over a broad range of site types, reduce management and harvesting costs, and improve the quality of biomass so that it can be converted to fuel more efficiently. The U.S. Department of Energy's (DOE) work in energy crops emphasizes short-rotation woody crops (SRWC) and perennial herbaceous species—including switchgrass, with productivities of almost 2.5 tons per acre in a drought year with little fertilizer—and a tropical sugar cane hybrid that has yielded as much as six tons per acre per year.⁹³ Research on woody crops centers on poplar and sycamore species because they grow so rapidly and can regenerate from stumps and roots. To maximize biomass production, species such as poplars are planted at a density of 700 to 1,600 or more seedlings per acre, somewhat higher than in a conventional pulp or timber plantation, and harvested every four to eight years. Mean annual productivities of 2.8 to 3.5 tons of carbon per acre have been achieved with these trees in several locations, and a yield of 8.5 tons per acre per year was recorded in one field trial. DOE's target is to achieve five tons of carbon per acre per year over a wide variety of sites.

The Potential Magnitude of Future Biomass Energy Use. The amount of land that could in

principle be shifted over to biomass production and the amount of energy that could ultimately be produced are limited by economic and social factors, not physical constraints. Although more than 200 million acres of land not currently used for agricultural crop production appear suitable for short-rotation cropping, estimates of how much land could be practically committed to this use without cutting significantly into productive agricultural land range from 75 to around 100 million acres.⁹⁴ And if agricultural production continues to become more concentrated, more land would become potentially available for biomass energy production. Many of the determinants of land availability for converting cropland and pasture to conventional tree cover must also affect the availability of land for short-rotation wood or herbaceous energy-crop production because the available land base is essentially the same. One difference, however, is that over time energy crops would be more likely than conventional tree crops to compete for higher-quality cropland because they could offer farmers greater flexibility and faster returns on their investments.

Estimates of the technical potential of biomass fuels to offset fossil fuel emissions vary widely, largely because so many variables are involved. Biomass growth rates, land availability, energy inputs into the growing cycle, the energy requirements of converting biomass to alternative fuel types—all can significantly affect how much fossil fuel carbon is actually displaced when carbon is drawn out of the atmosphere by biomass energy crops. The production of ethanol from corn, for example, requires almost 50 percent more energy (excluding solar energy inputs) than is contained in the liquid fuel produced.⁹⁵ From a global warming perspective, ethanol from corn is thus undesirable.

A wiser tack is using less-energy-intensive crops and more efficient energy-conversion technologies. They can help reduce the amount of fossil fuel energy required to produce the crop in the first place as well as the proportion

of energy stored in the crop that is lost during the production of the final biofuel product. In the case of synthetic natural gas (SNG) production from herbaceous species, only 30 percent of the energy ultimately produced can actually count toward fossil fuel displacement.⁹⁶ In ethanol production from woody energy crops, this figure rises to 75 percent, and when such crops are directly converted to electricity, the figure can rise to 90 percent.⁹⁷

A 1975 analysis of SNG production from croplands estimated that converting some 75 to 100 million acres would yield 7 to 11 trillion cubic feet of synthetic natural gas—35 to 60 percent of current natural gas consumption in the United States.⁹⁸ More recently, the DOE has estimated biofuels' potential at about 17 quads per year, roughly 20 percent of total U.S. energy consumption. Nearly one-half this potential under the DOE scenario, however, would come from conventional wood and forest wastes.⁹⁹ According to another estimate, agricultural and municipal wastes, bioenergy crops, and other forms of biomass could eventually displace up to one-third of all U.S. fossil fuel use, including 30 to 90 percent of the gasoline and diesel fuel used for transportation.¹⁰⁰

With current technology, converting 35 million acres of land to SRWC (with a productivity of 2.7 tons of carbon per acre per year) would on net displace consumption of 67 million tons of fossil fuel carbon if the biomass were directly transformed into electricity.

The most comprehensive analysis of the fossil fuel displacement potential of woody short-rotation crops has been performed by Lynn Wright and her colleagues at Oak Ridge National Laboratory, a team that has also

developed scenarios of alternative biofuels futures.¹⁰¹ With current technology, they estimate, converting 35 million acres of land to SRWC (with a productivity of 2.7 tons of carbon per acre per year) would on net displace consumption of 67 million tons of fossil fuel carbon if the biomass were directly transformed into electricity (34 million tons if converted to ethanol). These figures work out to a fossil fuel displacement rate (taking into account energy inputs and conversion losses) of some 1.9 tons of carbon per acre per year for electricity production and almost 1 ton of carbon per acre per year for ethanol production. If assumptions regarding advanced conversion technologies are used and 5 tons of carbon can be fixed per acre per year, net fossil fuel displacement rates per acre increase by approximately 125 percent in each case. Considering a larger land base, 103 million acres, the Oak Ridge researchers conclude that (with advanced technologies and high growth rates) the emission of some 470 million tons of carbon from fossil fuels could be offset if the biomass is used to produce electricity and 272 million tons if converted to ethanol as a transportation fuel. This amount is the equivalent of more than 80 percent of the total CO₂ released by electric power production in the United States. The same amount of biomass converted to ethanol using advanced conversion technologies could satisfy 79 percent of current gasoline consumption—indeinitely if use rates remained stable. If the more than 250 million acres of private land discussed previously as potential candidates for conversion to tree cover were all considered eligible for conversion to biomass energy production, the carbon benefit figures could rise considerably higher.

The Costs of Increasing Biomass Energy Use. Whether sophisticated biofuels will be used more in the future depends substantially on comparative energy costs. Although biofuels' production costs have dropped significantly over the last two decades, it will probably be years before most biofuels can compete with fossil fuels in the absence of further policy encouragement or sharp fossil fuel price hikes.

Gasoline at \$1 and \$1.50 per gallon is the equivalent of \$8 and \$12 per million Btu (MMBtu), respectively. According to DOE estimates, the cost of converting wood to a liquid transportation fuel (biogasoline) could drop from \$2 to \$3 per gallon or \$16 to \$20 per MMBtu today to around \$0.85 per gallon or \$7 per MMBtu by 2007. With further research, the cost of wood-to-ethanol production is also expected to drop, from roughly \$25 per MMBtu today to under \$10 per MMBtu in the next decade.¹⁰²

More sophisticated biofuels are even more expensive, though prices are dropping fast. The estimated costs of a microalgae-conversion facility have fallen from \$149 per MMBtu in 1982 to \$58 in 1987, and they are expected to drop to \$13 by 2010.¹⁰³ The cost of oilseed diesel fuel is projected to drop from \$18 per MMBtu in 1987 to \$8 in 1995, the equivalent of dropping from \$2.75 to \$1.50 per gallon.¹⁰⁴

The direct conversion of short-rotation biomass to electricity presents the greatest short-term opportunity for substituting biomass energy for fossil fuels on a significant scale, though the relative costs of biomass production remain high. With yields of 2.5 to 3.5 tons of carbon as biomass per acre on a good site, the cost per dry ton of wood chips delivered to a powerplant would range from \$35 to \$50, the equivalent of \$2 to \$3 per MMBtu. Whole-tree handling (rather than chipping prior to combustion) might reduce feedstock costs from good sites to \$1.50 to \$2.00 per MMBtu.¹⁰⁵ Larger-scale woody biomass production on a broader range of site types, however, would raise the average delivered cost to approximately \$4 per MMBtu. For perspective, coal is currently being delivered to powerplants at an average national cost of \$1.25 per MMBtu, while natural gas is being delivered for about \$2 per MMBtu.¹⁰⁶

Subsidizing large-scale biomass energy production or, alternatively, taxing fossil fuels could make biomass competitive with fossil fuel feedstocks for electricity generation. At

current market prices, the cost differential between large-scale biomass production and coal is \$60 to \$90 per ton of carbon, roughly the equivalent of \$1.75 to \$2.75 per MMBtu. This sum does not reflect the cost of producing the biomass fuel but, rather, the net differential required to allow it to compete with coal—roughly the equivalent of a tax of two to three cents per Kwh of electricity consumed. Over the next decade, this differential should continue to fall, thus making large-scale biomass production more economically viable. Already, biomass production is nearly competitive on a few million acres of good sites where the required differential is much smaller, perhaps as low as \$10 to \$15 per ton of carbon.

Such a wide range of technologies can be used to convert biomass of various types into fuel that broad generalizations about the pros and cons of increasing commercial biomass utilization cannot be made.

The Pros and Cons of Increasing Biomass Energy Use. Such a wide range of technologies can be used to convert biomass of various types into fuel that broad generalizations about the pros and cons of increasing commercial biomass utilization cannot be made. Research on energy crops is too young to determine these crops' long-term ecological and land-use impacts, though available evidence suggests that energy cropping is more environmentally benign than conventional cropping systems. Perennial energy crops require less tillage (thus reducing erosion) and smaller amounts of chemical additives (thus reducing the risk of contaminating the soil, water, and farm workers) than most agricultural crops. On the other hand, biomass production is currently considerably more occupationally dangerous per unit of energy produced than is the production of fossil fuels.¹⁰⁷

Whatever the advantages of increasing biomass use, any large-scale expansion is still some years away. The practical potential of biomass fuels over the next decade or two is likely to be considerably smaller than the long-term potential calculated by Wright and colleagues, particularly for applications other than direct electricity production.¹⁰⁸ Although direct biomass-to-energy combustion techniques (primarily using chips and wood wastes) are in limited use, more research and development is needed on these and on more complex energy-conversion technologies. It will probably be quite a few years before large-scale liquid-fuel conversion plants are designed and built, but making direct-combustion technologies more efficient could yield benefits almost immediately.¹⁰⁹ One particularly promising concept is the whole-tree burner.¹¹⁰

Depending on how comprehensive our energy policy is and how big the subsidy or tax used to encourage biomass competitiveness, biofuels could displace annually the consumption of 20 to 150 million tons of carbon from fossil fuel combustion within 15 to 30 years.

Although the theoretical potential of biofuels to displace carbon emissions from fossil fuel combustion is likely to exceed one billion tons per year, the expectation of large increases in bioenergy production in the near term is unrealistic. It may be possible, however, to achieve 10 to 20 quads (or 12 to 25 percent of current U.S. energy consumption) within 30 to 40 years. Depending on how comprehensive our energy policy is and how big the subsidy or tax used to encourage biomass competitiveness, biofuels could displace annually the consumption of 20 to 150 million tons of carbon

from fossil fuel combustion within 15 to 30 years. For perspective, more conventional urban and rural forestry policies would also take about this long to deliver significant benefits. In fact, bioenergy production could begin to make at least a limited contribution to reducing U.S. CO₂ emissions before conventional trees would be large enough to begin to offset fossil fuel CO₂ emissions significantly. It may well be most cost-effective for now to develop energy-cropping programs only on the best sites and to grow trees conventionally on less-productive lands for timber production, some energy production, or purely carbon storage.

7. Improving Soil-Management Practices

Globally, two to three times more carbon is stored in soils than in above-ground biomass. (See Box 1.) Unfortunately, many land-use practices release soil carbon instead of retaining or augmenting it. Clearing and farming forested lands generally reduces soil carbon by up to 40 percent, and conventional monoculture tillage and harvesting practices work against the restoration of the lost soil carbon. Furthermore, conventional agricultural practices often allow or even invite wind or water erosion of fertile topsoil.

Changes in agricultural practice should make it possible to prevent continuing losses of soil carbon and to store additional carbon in soils by gradually rebuilding depleted soils. Rapidly reforesting logged lands, reforesting agricultural or pasture lands, and relying on resource-conserving tillage and crop rotations to reduce the need for such agricultural inputs as fertilizers and pesticides would all help to meet this goal.

The Potential for Storing Additional Carbon in Soils. More than 5 billion tons of topsoil were lost from farm and pasture acreage annually in the United States in the early 1980s—the equivalent of some 200 million tons of carbon. This figure is 10 to 50 times higher than the amount of soil formed during the same

period.¹¹¹ Exactly how much of this carbon ultimately oxidizes to the atmosphere is not known, but the potential for slowing this loss or for increasing the amount of carbon stored in remaining soils appears significant. Indeed, a modest beginning has already been made through such programs as the CRP and other provisions of the 1985 Farm Act. Researchers can only speculate on how much more can be accomplished through better land management, integrated pest management, enhanced nutrient conservation, and soil and water conservation.

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With modern sustainable agricultural practices, for example, it might be possible to build up organic matter in the soil by a small amount per year—say, 0.25 tons of carbon per acre.¹¹² On 300 million acres of agricultural lands, that increase could reach 75 million tons annually within the United States, in addition to whatever carbon oxidation is avoided by slowing erosion. Preventing wind and water erosion on these and other acres might double the net carbon benefit.

The Costs of Increasing Carbon Levels in Soils. It is estimated that soil erosion costs

farmers anywhere from \$1 billion to \$18 billion per year.¹¹³ Reducing erosion and otherwise enhancing the carbon content of soils could boost harvests, slow the siltation of water reservoirs, and reduce the need for fertilizer.¹¹⁴ If the true social costs of erosion are near the upper end of this dollar range, major programs to stabilize and increase soil carbon levels are already economically justified. Recent WRI research suggests, for example, that when the long-term productivity changes owing to the degradation or improvement of soil structure are considered, chemical-free farming systems based on soil-conserving practices and crop rotations become more profitable than conventional corn monocultures or corn-soybean rotations that rely heavily on chemical inputs. If the off-site benefits—reduced soil erosion and reduced chemical runoff, among them—are also considered, the relative advantage of this approach is even greater.¹¹⁵ On a cost-per-ton-of-carbon basis, the societal costs of this option likely range from negative to modest.

The Pros and Cons of Increasing Carbon Levels in Soils. Programs to enhance soil conservation traditionally have been adopted slowly and piecemeal, partly because federal incentives often discourage such practices. Significantly changing these incentives is almost certain to prove a political battle. An alternative would be new government programs that independently would foster soil conservation, but the potential benefits and costs of such programs remain to be determined. With these political and bureaucratic hurdles, it seems unrealistic to expect to increase biotic carbon storage by more than 10 to 25 million tons of carbon per year through this mechanism in the near term.

IV. Conclusions

In theory, the biotic policy options discussed here collectively could absorb huge quantities of carbon annually, thereby displacing or offsetting a large fraction of U.S. fossil fuel emissions. Conventional tree planting and forest management are by themselves estimated capable of increasing biotic carbon uptake in the United States by more than 800 million tons per year. (See Figures 8 and 9.) Yet, technical potential is often quite different from practical reality. Indeed, the average commercial productivity of U.S. timberlands is just 0.6 tons of carbon per acre per year, compared to a technical potential of more than 3 tons of carbon per acre per year on good temperate soils.

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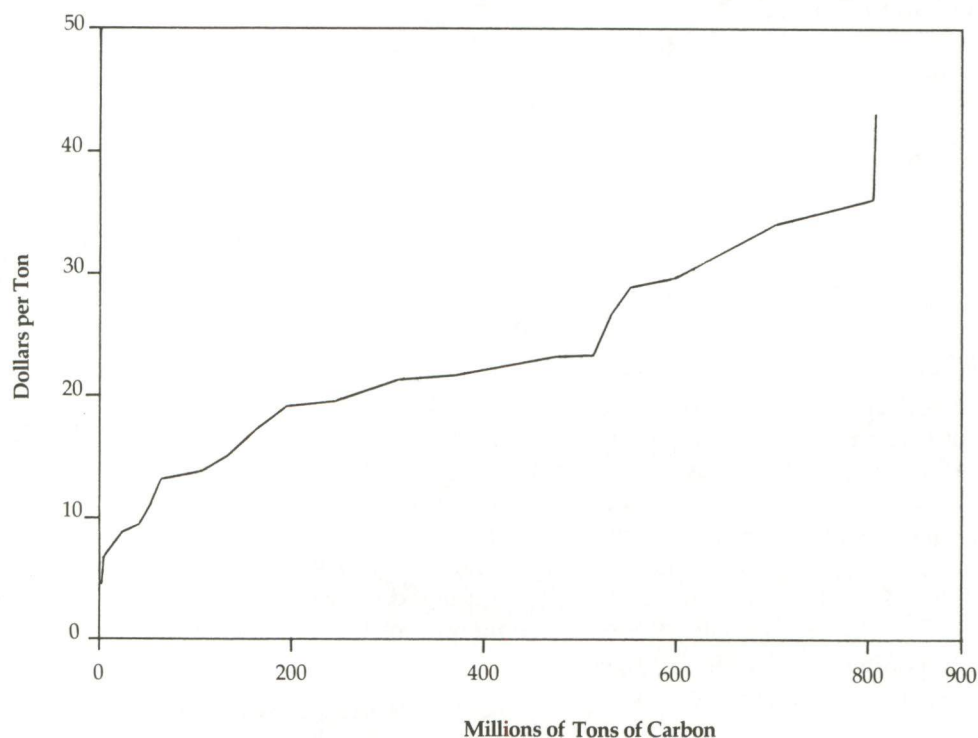
Projecting the practical is far harder than projecting the technically possible. (See Table 2.) Over the long term, the United States is likely to possess the land resources and technology needed to pursue any given policy option to the absolute limit of its potential, if in fact that were perceived as desirable. What that limit

may be remains uncertain in most cases, however, because of both physical and economic uncertainties. Nor is it likely that the United States would ever want to pursue any given option to the full extent of its theoretical potential; global warming mitigation is not the only operative policy goal. And none of the policy options discussed in Table 2 could be implemented in full instantaneously or even over the short term.

Projecting the practical is far harder than projecting the technically possible.

Arriving at what may be practically achievable by any given date, 2030 in the case of Table 2, therefore involves a significant element of subjectivity. The economics of various biotic policy options are not well understood and can change rapidly. Each policy option will face a rising marginal cost curve as more and more of the option's potential is used up. The perceived marginal cost curve for any individual option is dependent on whether the marginal costs reflected are private or societal, short term or long term. In addition, individual suboptions (e.g., biomass to electricity versus biomass to liquid fuel, harvesting planted trees versus leaving them standing indefinitely) all have their own marginal cost curves. The long-term

Figure 8. Estimated Marginal Costs of Biotic Carbon Sequestration



Source: R.J. Moulton and K.R. Richards, *Costs of Sequestering Carbon Through Tree Planting and Forest Management in the United States*, U.S. Department of Agriculture, Forest Service, (1990)

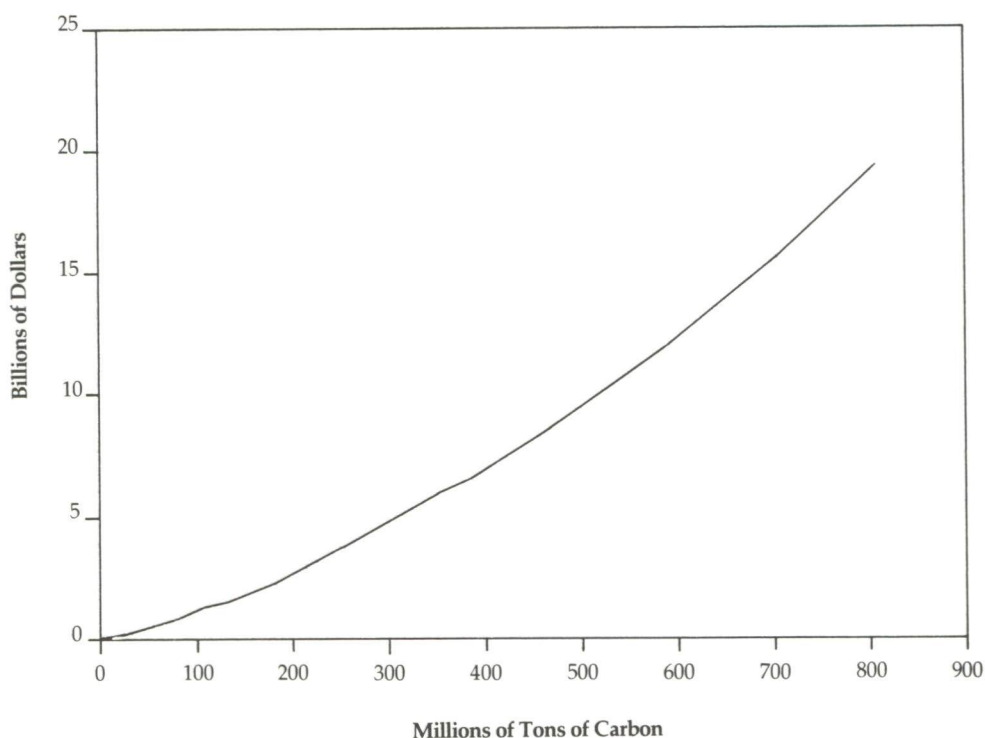
economic and environmental feedbacks of policy options have not yet been analyzed, and the existence of global markets for commodities such as timber will complicate such analysis. Market feedbacks from the large-scale implementation of biotic policy options anywhere in the world pose a potentially serious threat to the long-term effectiveness of carbon sequestration policies implemented unilaterally in the United States or any other country. Although energy policies pose some of the same problems—that is, any significant policy-inspired fall in global energy demand probably would be partially offset by falling prices and resulting upward pressure on consumption—these undesired market feedback effects are much easier to control in the energy sector; imposing

an energy tax that is neither too high nor too low can prevent the feedback altogether. In the forestry sector, however, imposing a guaranteed price floor for timber (the functional equivalent of the energy tax in this case) poses far more vexing problems.

Reliable answers to these questions will elude observers and experts alike until carbon models incorporating the entire U.S. carbon cycle as well as international timber markets are built and validated—a fairly distant prospect considering how poorly many aspects of the U.S. biotic resource base are understood.

Research problems notwithstanding, biotic policy options do have a role to play as part of

Figure 9. Estimated Total Costs of Biotic Carbon Sequestration



Source: R.J. Moulton and K.R. Richards, *Costs of Sequestering Carbon Through Tree Planting and Forest Management in the United States*, U.S. Department of Agriculture, Forest Service, (1990)

a comprehensive U.S. strategy to slow the buildup of CO₂ in the atmosphere. Although estimates of the size of this role must be treated cautiously, several important policy conclusions are not premature.

- 1. Although biotic options offer considerable opportunities for sequestering or displacing carbon, do not expect their implementation in the United States to reduce net CO₂ emissions quickly or cheaply.**

Although implementation of any of the biotic policy options discussed here should reduce net U.S. CO₂ emissions from what would otherwise be the case, most of the carbon benefits would take so many years to realize that it is unlikely that they could stabilize net

Most of the carbon benefits would take so many years to realize that it is unlikely that biotic options could stabilize U.S. CO₂ emissions, much less reduce them from today's levels.

U.S. CO₂ emissions, much less reduce them from today's levels. Indeed, after 15 years of relative stability, U.S. industrial CO₂ emissions are once again increasing. (See Figure 10.) If nothing is done to interrupt this trend, annual U.S. CO₂ emissions could rise to almost 2 billion

Table 2. U.S. Biotic Policy Opportunities and Costs

Option	Theoretical Carbon Benefit ^a (millions of tons/yr)	Practical Benefit to 2030 (millions of tons/yr)	(\$/ton)
Urban Forestry	15	3-5	\$0-25
Private Land Conversions	400-900 ^b	50-150	\$0-50
Public Land Conversions	(not known)	(not known)	(not known)
Forestry Management	100-400	35-75	\$0-100
Forgoing Old-Growth Harvests	10-20	5-10	\$0-100
Biomass Energy Production	400-1,000 ^b	20-150	\$20-75
Increase Wood Use	(not known)	(not known)	(not known)
Soil Carbon Buildup	50-150	10-25	\$0-10

a. The carbon benefit figure estimates carbon storage in biomass and in soils as well as fossil fuel carbon displaced through implementation of the biotic options. Figures represent an average annual carbon benefit and thus overstate the carbon benefits in the early years of a policy option's implementation.

b. These entries cannot be summed because they involve use of overlapping land bases.

tons within the next 20 years.¹¹⁶ Moreover, as emissions of CO₂ from fossil fuel combustion continue to rise, the relative role that could be played by biotic policy options in stabilizing or reducing net carbon emissions will inevitably shrink owing to a finite land availability.

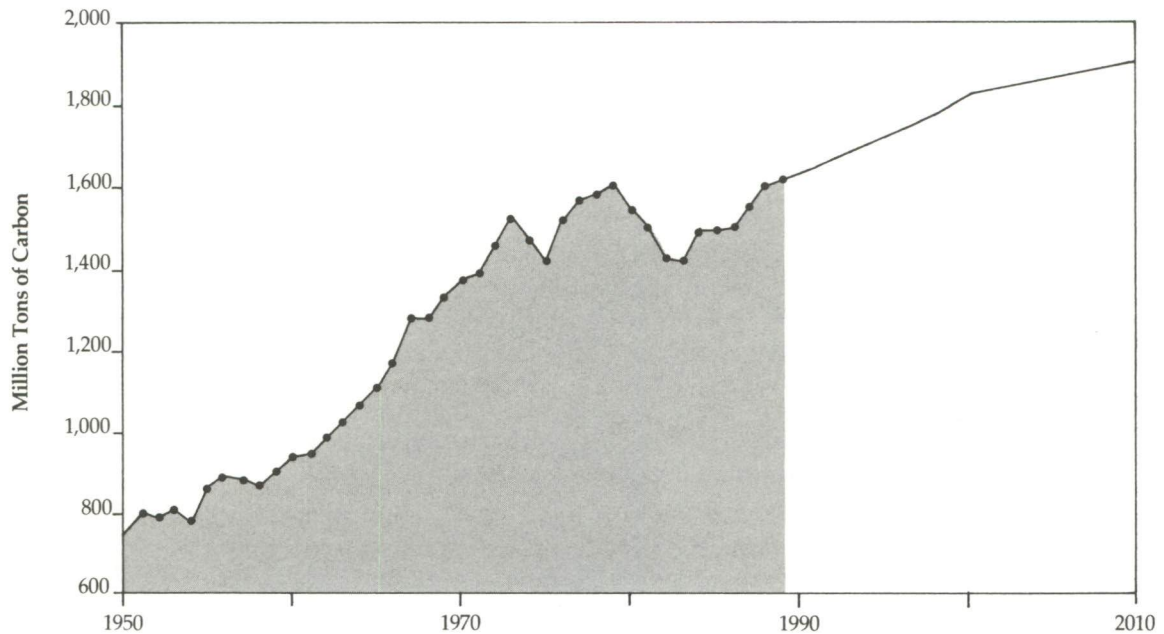
Biotic options as a class are unlikely to prove cheaper than alternative approaches.

From the standpoint of cost-effectiveness, implementing some biotic policy options in some places is likely to pay for itself. Indeed, if all the federal programs that create disincentives to carbon storage—ranging from some below-cost timber sales to commodity support programs—were abolished, a great deal of carbon storage would appear cost-effective from the outset. Once these obvious options have been exhausted, the cost-effectiveness of biotic policy options will have to be compared with

those from other sectors. Given the wide range of costs associated with these options and the similarly wide range often discussed in the context of energy policy options to reduce CO₂ emissions,¹¹⁷ biotic options as a class are unlikely to prove cheaper than alternative approaches.

As noted, the geographical location of carbon emissions or absorption is of no consequence. What really matters is how much CO₂ can be sequestered (or emissions avoided), and different regions of the world are likely to provide quite different opportunities and comparative advantages in this regard. In many tropical countries, where combined biotic emissions appear to dwarf fossil fuel emissions, biotic sector policy options aimed at slowing deforestation, making agricultural production sustainable, and spurring reforestation seem promising in the short to medium term for mitigating global warming—so promising, in fact, that the United States might consider supporting the implementation of biotic policy options abroad as well as in the United States. This is the principle underlying implementation of the only forestry project funded specifically

Figure 10. United States Fossil Fuel Emissions, 1950–2010



Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review*, DOE/EIA-0384, (1989), and *Annual Energy Outlook: Long-Term Projections*, DOE/EIA-0383, (1989)

as a carbon-emissions offset, a project that would have been prohibitively expensive in the United States. (See Box 8.)

2. Most biotic options are best used as part of a transitional energy strategy intended to combat global warming.

Biotic policy options are often seen as the flip side of emissions reductions. As a result, it is commonly assumed that a ton of carbon stored in trees is roughly comparable to a ton of carbon not emitted in the first place. But the complexities and uncertainties of biological systems argue against carrying this presumed equivalence too far.

First, trees withdraw large quantities of CO₂ from the air only as long as they are growing.

Consequently, physical and biological limits constrain the long-term value of large-scale conventional tree planting unless they can later be harvested and made into products without releasing a large pulse of carbon. Energy sector initiatives, in contrast, face no such constraint. Indeed, pursuing most biotic policy options today merely buys us time before energy sector initiatives have to be implemented anyway to eliminate permanently the emission of that quantity of carbon successfully being absorbed into biomass in the interim. Nevertheless, the value of buying 50 to 75 years to lessen the pain of switching to "smokeless" fuels that emit no CO₂ or to sustainable bioenergy systems that recycle CO₂ should not be underestimated.

Second, under most circumstances, years and even decades must pass before newly planted

Box 8. Offsetting U.S. Carbon Releases Abroad

Although planting trees to offset carbon emissions from fossil fuel consumption was first proposed in 1977, the idea was not acted upon until 1988, when Applied Energy Services (AES) began building a new 183-megawatt coal-fired powerplant in Connecticut.

AES, an independent power producer with a contract to sell power to Connecticut Power and Light, was concerned about how releasing approximately 15 million tons of carbon into the atmosphere, as the powerplant will over its 40-year life, would contribute to global warming. Approached for advice on how to neutralize the global warming impacts of the plant's CO₂ emissions, the World Resources Institute ultimately recommended that AES fund a sustainable agriculture and agroforestry project proposed for Guatemala by the relief organization CARE. Under the final terms of the agreement, AES contributed \$2 million to the project, making it possible for CARE to attract additional financial and in-kind support for the project valued at nearly \$15 million.

WRI analysis concluded that the project will more than offset the 15 million tons of carbon emitted over the plant's lifetime. In addition, significant benefits will accrue to local residents. Over 10 years, the project will bring private and community woodlots; agroforestry for food, fuel, and fodder; and alley-cropping, live-fencing, and soil-conservation practices to about 40,000 Guatemalan farm families. If the processes put into action by the project last 40 years, the life span of the power plant, well over 100 million trees will be planted. Nevertheless, the most important carbon-storage benefit lies in protecting the region's existing standing forest. This protection is to be achieved by increasing the productivity of agricultural lands, thus reducing the need to destroy neighboring forest to secure fuelwood and make way for agriculture.

Source: Trexler, M.C., Faeth, P.E., and Kramer, J.M., 1989. *Forestry as a Response to Global Warming: An Analysis of the Guatemala Agroforestry and Carbon Sequestration Project*. World Resources Institute.

trees grow large enough to achieve the predicted carbon-storage goals. It is impossible to predict the extent to which natural change, disasters, or human actions might reduce growth rates during this period or, for whatever reasons, tree mortality and decomposition might exceed growth. Although temperate forests are robust under current climate regimes, increased aridity owing to climate change could lead to lower regeneration and survival rates. Similarly, if tree mortality is heightened by increasingly severe fires, pest infestations, droughts, or weather, a significant fraction of the projected carbon storage benefits could simply fail to materialize. Overall, if significant climate change does occur within the United States, all of the forestry options

described above may be needed just to keep biotic CO₂ releases from rising dramatically.

If significant climate change does occur within the United States, all of the forestry options described above may be needed just to keep biotic CO₂ releases from rising dramatically.

Given these uncertainties and constraints, it is not prudent to assume that all available

policy options for mitigating global warming over the long term would be equally effective. Instead, biotic options might best be pursued as a transitional strategy to complement attempts to reduce fossil fuel emissions and not as a way to justify environmentally the combustion of fossil fuels in the long term. Yet, given the institutional, economic, and implementation barriers to rapidly reducing fossil fuel consumption, it makes sense to pursue the benefits of biotic policy options to the maximum extent feasible during the next several decades.

3. How biotic strategies are implemented will determine how significant ancillary benefits beyond global warming mitigation become.

Reducing the risk of global warming is not the only reason to plant trees. Tree planting in its various forms can protect fragile agricultural lands, conserve watersheds and aquifers, reduce erosion, preserve wildlife habitat, enhance recreation, make our cities more beautiful and comfortable, and further the nation's energy security. Because the carbon-sequestration benefits of many biotic options are by nature tentative and because the magnitude and rate of future global warming remain uncertain, there is every reason to maximize the ancillary benefits of whatever biotic policy initiatives are undertaken.

The type and quantity of ancillary benefits realized will depend on which biotic options are pursued and how. Although it might be simplest to plant millions of acres of new softwood plantations, there are other tree planting strategies that would promote worthy goals besides global warming mitigation. Planting trees along a river's edge, for example, can help control nonpoint source pollution and erosion while absorbing carbon. Planting mixed stands or even simulating natural forests can do far more to promote wildlife habitat than monoculture plantations can.

On the other hand, the ancillary benefits of tree planting should not be overstated. It has

recently been proposed, for example, that planting trees can reduce ozone, particulate, and sulfur dioxide pollution, thereby reducing the need for conventional pollution controls.¹¹⁸ But though trees can filter some pollutants out of the air, absorbing significant amounts of pollution is likely to kill the trees.

4. Complex regulations and incentives must be accounted for when attempting to further carbon sequestration goals by directing or predicting private behavior.

Some biotic policy options involve the fine-tuning of current land-use and land-management practices by either private landowners or government land managers. Some farmers would become tree farmers for the first time; others would have to manage their stands more intensively. In any case, the difficulty of changing individuals' and agencies' priorities and missions should not be underestimated. Any attempt to alter the U.S. biotic carbon cycle must take hard reality into account: investment decisions about land use are quite sensitive to market events as well as to existing policies and subsidies that affect a landowner's bottom line, and these incentives are complex and sometimes contradictory. (See Box 9.)

Some of these incentives are also changing. The ownership and management of industrial timberlands, which now account for some 25 percent of all private timberlands, is a case in point. Many timberlands are being broken up and sold to developers and other interests, sometimes to fend off hostile takeovers, sometimes to pay off the debt engendered by such takeovers.¹¹⁹ (See Box 4.)

5. Reliably increasing the size of U.S. biotic carbon sinks requires major changes in public policy.

The prognosis for increasing U.S. biotic carbon stores appears mixed. Programs such as the Conservation Reserve Program afford hope, but the decline of urban forests, the moribund state of rural forests in certain regions, the

Box 9. Private Decision-Making and Tree Planting

Various federal policies exist to foster reforestation, and federal, state, and private programs have been created to provide extension services, pest and fire control, and other types of support to tree growers. Although such government programs and policy decisions are not the only variables affecting the disposition of private lands, they can be quite important.

Federal land subsidies and price supports—major determinants of private land-use decisions—tend to shift as conditions change. Although the Soil Bank program of 1956 to 1962 was created to take fragile lands out of agricultural production and to reduce crop surpluses, for example, agricultural subsidies during the 1970s once again encouraged the conversion of fragile forest and wetlands to agricultural use. Today, many of these same acres are being withdrawn from agricultural use through such mechanisms as the Conservation Reserve Program. And by insuring up to 75 percent of normal crop yields even on lands commonly flooded, the USDA Federal Crop Insurance Corporation (FCIC) has implicitly encouraged the conversion of unsuitable lands to agricultural uses. The National Flood Insurance program also encourages the conversion of forested floodplains to agricultural and other uses.

Federal tax and insurance programs further complicate decision-making. Federal tax incentives—basically, expensing and amortizing the reforestation bills—cost the U.S. Treasury almost \$500 million per year. At the same time, deductions for expenses incurred in clearing land have encouraged the conversion of forest land to other uses. Tax breaks on timber sales, property tax abatements that require harvesting, and

capital gains benefits for harvesting timber lands all have similar effects. One timely example includes the extension in 1986 of favorable tax treatment to the losses amassed by native corporations in Alaska. Unintentionally, those tax breaks set the stage for potentially large-scale deforestation in Alaska's southeastern forests.

The 1985 Farm Act, on the other hand, took a big step toward impeding the conversion of unsuitable lands to agricultural use and encouraging the removal of fragile lands from agricultural production. Under the bill's "sodbuster" provisions, farmers with highly erodible lands must take conservation measures on them or face the loss of USDA farm-program benefits. Parallel "swampbuster" provisions deny eligibility for program benefits to farmers who produce crops on wetlands converted to agricultural use after 1985—in effect, eliminating a major source of market demand for converted wetlands. By one estimate, the various provisions of the 1985 Act will ultimately prevent the conversion of almost 12 million acres of forest to agricultural land.

How these policies are implemented or revised will help determine how much carbon is stored, absorbed, or released from private U.S. lands.

Sources: Moulton, R.J. and Dicks, M.R., 1987. "Implications of the 1985 Farm Act for Forestry," in *Proceedings of the 1987 Joint Meeting of Southern Forest Economists and Midwest Forest Economists*. 1987, Asheville, North Carolina; Wells, K., 1990. "Endangered Again," *Wall Street Journal*, March 30; U.S. General Accounting Office, 1990. *Forest Service: Timber Harvesting, Planting, Assistance Programs and Tax Provisions*.

continuing sacrifice of woodlands and agricultural lands to urban sprawl and corporate needs for fast cash, and the harvest of many old-growth forests at an economic loss to the public treasury warrant increased concern over net carbon flows. Indeed, these and possibly other losses spurred by public and private natural-resource management decisions in the United States may be contributing more CO₂ to the atmosphere than the CRP and similar programs can take out of it.

Altering the U.S. biotic carbon cycle to help mitigate global warming will require much more than simply creating yet another federal program. Reducing net biotic emissions to zero and offsetting fossil fuel-related emissions of CO₂ are likely to require coordinating policy changes in many sectors. Even with the inclusion of the America the Beautiful initiative in the administration's 1991 budget, for example, the budget's net effect on future carbon stocks in U.S. forests may be negligible. (See Box 6.)

6. Problems are to be expected in determining what money spent on biotic policy buys.

The net carbon benefit to be gained by pursuing most biotic options can at best be determined only roughly. Calculating just the first-order carbon balance effects is often tricky, while second- and third-order effects can be hard to identify, much less quantify. Without such calculations to support them, however, biotic policy proposals run the risk of aggravating global warming as, for example, the proposed harvesting of old-growth forest to promote new tree growth on those lands well might. Other proposals might yield short-term benefits that are undone at least partially by their own second- and third-order consequences, as the subsidized afforestation of large areas of agricultural land in the United States is likely to do. Still others might be counteracted by forestry policies being pursued in other countries to combat global warming or achieve other aims. Or the carbon benefits of proposals could be undercut by government actions taken to solve problems other than

global warming. The failure of the United States over the last two growing seasons to produce as much wheat as it consumed suggests that lands now idled could well be returned to agricultural production. But some proposals could work as planned and store additional carbon. At any rate, properly assessing the likely carbon storage implications of any new policy will require a detailed but comprehensive analysis.

Fully and reliably accounting for all of these variables, of course, is impossible, since some of them reflect an inevitable uncertainty about the future. Careful "carbon accounting" should, however, provide as accurate as possible an assessment of first-order carbon balances. (See Box 10.) In addition, as many second- and third-order effects as possible should be incorporated into the analysis, particularly for projects large enough to affect timber and agricultural commodity prices. Even without firm projections, such an analysis should reveal how reliable the projections of primary benefits and cost-effectiveness are.

7. Implemented on a large scale, biotic policy options will not necessarily be more politically acceptable than alternative global-warming-mitigation measures.

Although planting trees to mitigate global warming is widely perceived as politically painless, the widespread implementation of biotic policy options could, in fact, prove quite contentious. Withdrawal of millions of acres of old-growth timberlands from harvesting would be at least a short-term blow to the timber sector in the Pacific Northwest. Greatly intensifying timberland management on remaining public and private lands would likely heat up debate over forest management practices and the loss of wildlife habitat. Taking a significant fraction of agricultural lands out of crop production would engender significant political opposition from well-entrenched interest groups. A large-scale switch to biofuels would significantly alter the energy production sector. In each case, important political and economic

Box 10. Performing a Comprehensive Carbon Accounting

For a rough idea of how much carbon a particular forestry or other biotic policy will sequester, several steps must be taken.

- Project realistic biomass growth rates, accounting for the species to be planted, likely soil conditions, and water availability. Also account for the possible impacts of climate change itself on water availability and growth rates at project sites.
- Project the proportion of biomass accumulation likely to be lost to natural forces, including fires, droughts, and insect or disease outbreaks.
- Account for carbon released during project implementation, including that in vegetation cleared from project sites, soil carbon released when lands are cleared or planted, and fossil fuel energy consumed during the planting, maintenance, and possible eventual harvesting on project sites. The energy consumed in producing fertilizers and pesticides for the project as well as that consumed in converting the biomass to liquid fuels or other energy forms, must also be accounted for.
- Account for any carbon that would have accumulated on the project site in the absence of the project.
- Account for the ultimate disposition of accumulated carbon. Biomass growth estimates are often premised on whole-tree biomass rather than just merchantable timber. If harvesting or thinning takes place, a significant proportion of the total carbon can be released back to the atmosphere—as roots, parts of trees left behind, or lumber wastes decompose.
- Avoid any double counting of carbon benefits. Delaying harvest of a forest containing one million tons of carbon, for example, can “reduce” emissions over time by only one million tons, regardless of how many years the delay is in force.

interest groups will be affected by the change. Considering the great uncertainties in projecting the global warming mitigation benefits of such biotic policy options, overcoming opposition from these economic and policy interests will be difficult.

As these general conclusions regarding the implementation of biotic policy options in the United States suggest, it is important for policymakers to differentiate between the theoretically possible and practically feasible global warming mitigation benefit associated with each biotic policy option. In the case of almost every option, the practical potential is considerably smaller than the theoretical potential. As Table 2 suggests, biotic options within the United States could in principle offset or displace

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almost all current fossil fuel CO₂ emissions, the equivalent of more than 1.5 billion tons of carbon per year. In practice, however, storing or displacing just 150 to 400 million tons of carbon per year, or 9 to 25 percent of current U.S. fossil fuel emissions, would require an aggressive and successful multipronged policy effort.

V. Recommendations

As Table 2 illustrates, estimates of the cost-effectiveness of the various biotic policy options do not unambiguously determine which options should be pursued first. Yet, given the comparative analysis of the various biotic options, some recommendations—the projected costs and carbon benefits of which are summarized in Table 3—do emerge from the foregoing analysis. If implemented, these recommendations could improve net U.S. carbon balances by 75 to 115 million tons per year, the equivalent of five to seven percent of current emissions. The estimated cost of implementing these recommendations, \$525 million to more than \$1.5 billion per year, compares favorably to a \$1.1 to \$2.5 billion estimate for achieving the same level of reductions in CO₂ emissions within the energy sector.¹²⁰ (See Figure 11.)

1. Selectively Convert Southeastern Pasture Land to Tree Cover.

An estimated 20 to 25 million acres of pasture land in the southeastern United States would be more economically productive if used to grow timber, probably pine. Converting this acreage from its current use appears to present the most cost-effective opportunity for significantly increasing the area of timberland in the United States and would also help control erosion and increase wildlife habitat. Conversion of these acres should be pursued before promulgating any new large-scale tree-planting initiatives that might require significant cost

sharing and rental payments. Identifying the acres in question, providing the extension and technical assistance services required to educate landowners regarding alternative uses of their land, and possibly providing modest cost sharing or other mechanism to help plant the trees should result in the conversion of 15 million or more of the available acres at a relatively low cost. If it is assumed that an average allotment of \$50 per acre would cover the various costs involved, a cash outlay of \$750 million would be required to store 15 to 20 million tons of carbon annually. True societal costs, incorporating environmental benefits as well as future returns on planted timber, would be lower. Conversion of these areas should be a key aim of the president's America the Beautiful program, particularly given the modest sums currently budgeted for the program.

2. Expand Biomass-to-Electricity Demonstration Programs.

Any type of biomass can in principle be used to produce energy, and significant quantities of agricultural and woody wastes are already consumed for this purpose. But short-rotation woody and herbaceous crops represent the most cost-effective options for utilities and other large consumers of energy. Although biomass remains more expensive than coal on a MMBtu-delivered basis, if long-run world energy prices shift abruptly, so could these comparative costs. With oil at \$30 per barrel, for example, intensive biomass cultivation for

Table 3. Recommended Carbon Storage Options

Recommendation	Projected Carbon Benefit^a (millions of tons/yr)	Projected Costs (annualized) (millions of \$)
1. Selectively Convert Southeastern Pasture Lands	15-20	\$75-95
2. Expand Biomass-to-Electricity Demonstration Programs	20-30	\$60-150
3. Improve Future Productivity of Harvested Timberlands	15-20	\$150-400
4. Increase Tree Cover on CRP-Enrolled Acres	1-2	\$10-25
5. Implement a Forestry Reserve Program	20-40	\$200-1,000
6. Promote Urban Tree Planting	3-5	\$30-75
7. Encourage Practices that Slow Carbon Loss and Build Soil Carbon	10-25	(not known)
8. Assess Existing Disincentives to Carbon-Storing Land Uses	NA	NA
9. Incorporate Carbon Storage Goals into the USFS Mandate	(not known)	(not known)
10. Improve Our Understanding of U.S. Carbon Stocks and Flows	NA	NA
NA = not applicable		
a. The carbon benefit figure estimates carbon storage in biomass and in soils as well as fossil fuel carbon displaced through implementation of the biotic options.		

energy production becomes economically viable on good sites. A demonstration program of 10 million acres would include these as well as more average sites, and it could be expected to displace almost two tons of fossil fuel carbon per acre currently, and almost three tons per acre as technologies advance. The cost per ton of net fossil fuel carbon displacement might reasonably range from \$30 to \$50 per ton, although incorporation of environmental and energy security values as well as any savings from commodity support programs would considerably lower any estimate of true societal costs.

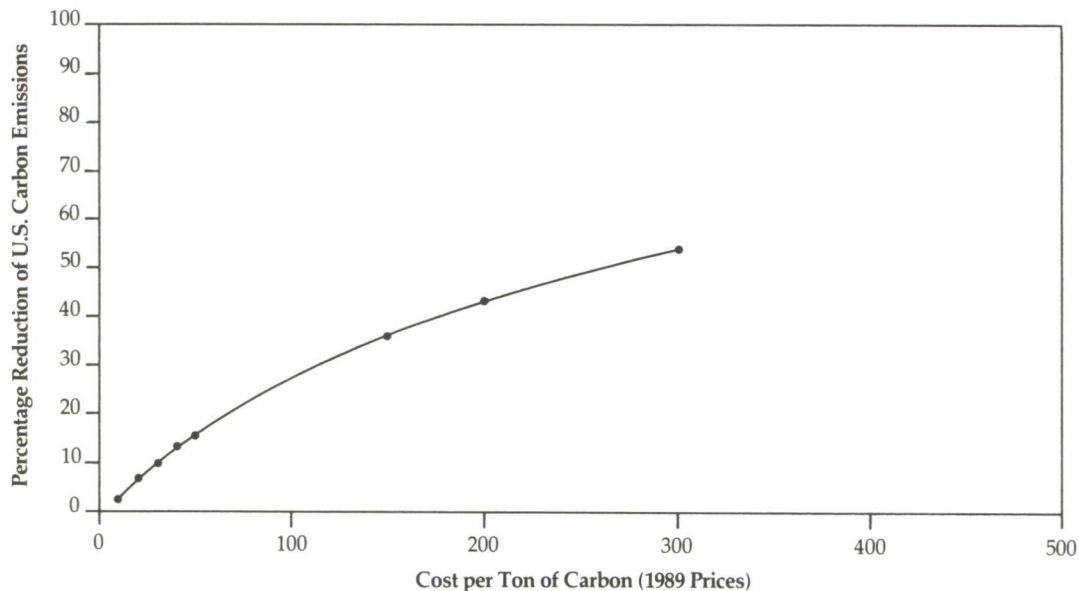
The relatively little time needed to expand the use of biomass in electricity production and

the relative reliability of the carbon displacement benefit of doing so justify a greater effort to determine this option's long-term technological, environmental, and economic feasibility. Demonstration efforts need to be directed not only at producing biomass (both woody and herbaceous) more efficiently but also at converting it more efficiently to electricity.

3. Improve Future Productivity of Harvested Timberlands.

A variety of forest management techniques can affect growth rates and other stand characteristics over the length of a growing cycle. The carbon-storage benefits of intensive management do not appear to justify the most costly

Figure 11. Estimated Marginal Costs of Non-Forestry Carbon Reductions



Source: W.D. Nordhaus, *A Survey of Estimates of the Cost of Reduction of Greenhouse Gas Emissions*, (Yale University, 1990)

and energy-intensive options—including forest fertilization and the use of genetically improved seedlings—and the restocking of growing stands. On some lands, however, modest silvicultural advancements could significantly increase growth rates and total carbon storage.

A great deal of intensification of timberland management, the equivalent of perhaps as much as 40 million tons of carbon per year, is already economically rational under existing market incentives. These acres, however, do not necessarily overlap with acres that will be harvested over the next couple of decades, and it is on these acres that intensive management is most appropriately begun. In addition, some of this intensification may result in simply favoring commercial over noncommercial biomass growth rather than actually increasing total carbon accumulation. Assuming that appropriate measures are taken on 30 to 40

million acres over the next couple of decades and an average incremental carbon storage of 0.5 tons per acre is achieved, 15 to 20 million tons of additional carbon might be stored annually. The average cost might well be \$10 to \$20 per ton, even if efforts are targeted at those forest acres where management intensification is judged already cost-effective. Long-term societal costs, once again, would likely prove lower.

4. Increase Tree Cover on CRP-Enrolled Acres.

Although some 34 million acres are currently enrolled in the Conservation Reserve Program, trees have been planted on only a little over 2 million acres. Because of restrictions on returning highly erodible lands to agricultural production, millions of additional and already enrolled acres could probably be converted to tree cover with relatively modest changes to the relevant CRP contract terms and lengths.

The USDA's Economic Research Service has estimated that over one million acres could be converted to tree cover at a cost of \$100 to \$200 million, although better outreach and extension services to affected farmers might well lower this cost estimate. The long-term nature of the tree cover would help prolong the environmental benefits of having removed this land from agricultural production, thus significantly cutting the societal cost of the option.

5. Implement a Forestry Reserve Program.

Based on the model provided by the Conservation Reserve Program, an FRP would offer the opportunity to identify less economically valuable land and encourage its conversion to tree cover. An FRP would rely on the same type of cost sharing and rental payment provisions found in the CRP, though it would involve lower per-acre costs. A target of creating an FRP of 20 million acres over the next decade (not counting the 15 million acres discussed in recommendation No. 1) would appear reasonable because many tens of millions of acres of economically or environmentally marginal crop and pasture lands are available. At a cost of \$10 to \$30 per ton of carbon stored, such a program would cost between \$200 million and \$1 billion per year. Because of uncertainties regarding future timber prices and the costs of future commodity support programs, this cost estimate does not account for financial returns or savings in either area.

In a new Forestry Reserve Program, however, the U.S. forestry community is likely to want to focus on what it already does best, which is pursue conventional industrial plantation forestry. This natural inclination should be resisted. If carried out on environmentally robust lands, land conversions under a Forestry Reserve Program might have few benefits besides carbon storage. If carried out on environmentally sensitive lands, however, the same magnitude of effort might significantly reduce erosion and nonpoint-source water pollution. If carried out in innovative ways even on nonsensitive lands, perhaps through the

construction of windbreaks and riparian corridors, such conversions would still promote a variety of environmental and policy goals in addition to carbon storage.

Before public funds are spent withdrawing lands from pasture or other alternative uses, the current policies that encourage these land uses should be reviewed and modified with global warming concerns in mind.

In any case, before public funds are spent withdrawing lands from pasture or other alternative uses, the current policies that encourage these land uses should be reviewed and modified with global warming concerns in mind.

6. Promote Urban Tree Planting Widely and Vigorously.

As noted, urban trees can both store carbon and reduce the cooling and heating requirements of homes and businesses, thus displacing sizable quantities of fossil fuels. Urban forestry initiatives should be directed primarily at urban areas where energy use for cooling is already significant or is likely to become significant soon. Through a combination of governmental and nongovernmental tree-planting and tree-protection initiatives (including changes in local zoning and development requirements), it should be possible to reverse the ongoing decline of urban forests and prepare cities for the potentially harsh effects of future global warming. Rising urban temperatures, for example, will aggravate the urban heat-island effect, favor the formation of such damaging pollutants as tropospheric ozone, and generally increase stress on trees. Although the total potential of urban tree-planting programs to mitigate global warming is limited, it combines the advantages of cost-effectiveness and multiple

ancillary benefits. It may also help reduce the need to increase utility capacity to handle peak summer loads, and it should benefit from considerable public goodwill and volunteer efforts.

If targeted at the appropriate areas of the United States, an expanded urban forestry program might store or displace three to five million tons of carbon annually at an average societal cost of \$10 to \$15 per ton. Implementation of a nontargeted program or incentive structure, however, would result in considerably fewer carbon displacement benefits and higher costs.

7. Encourage Agricultural Practices that Slow Rates of Soil Carbon Loss and Enhance Soil Carbon Buildup.

Many agricultural and other land-use practices favor the release of soil carbon rather than its retention or augmentation. Clearing and farming forested lands generally reduces soil carbon by up to 40 percent, and conventional monoculture tillage and harvesting practices work against the restoration of the lost soil carbon. More than 200 million tons of soil carbon were lost from farm and pasture acreage annually in the United States in the early 1980s, an unknown portion of which actually oxidized to the atmosphere as CO₂.

With modern sustainable agricultural practices that are often already economically profitable in their own right, it should be possible to build up organic matter in the soil by a small amount per year for a decade or more. On 300 million acres of agricultural lands, an increase of just 0.25 tons of carbon per acre per year could increase carbon storage by 75 million tons annually, in addition to whatever quantity of carbon oxidation is avoided by slowing erosion. If the true societal costs of erosion and the other environmental impacts often associated with conventional agricultural practices are as high as is often estimated, major programs to stabilize and increase soil carbon levels are already economically justified. On a cost-per-ton-of-carbon basis, the societal

costs of this option likely range from negative to modest. Considering the political and bureaucratic hurdles to its widespread adoption, however, it seems unrealistic to expect to increase biotic carbon storage by more than 10 to 25 million tons of carbon per year through this mechanism in the near term.

8. Assess Existing Disincentives to Carbon-Storing Land Uses.

Diverse governmental programs and rules and regulations influence land-use and land-management decisions in the United States—among them, federal commodity support programs, federal timber sale programs, federal tax and insurance policies, state real estate taxes, and local zoning regulations. Such programs and incentives should be reviewed with cost-effective ways to sequester or displace additional carbon in mind, and programs that counteract these goals should be rooted out. It makes little sense to reforest millions of acres of agricultural land to combat global warming at significant expense if nothing is done to slow the rate of loss of carbon from forests and other lands.

9. Incorporate Carbon Storage Goals in the Mandates of U.S. Land Management Agencies.

The United States Forest Service and other land management agencies must take considerable responsibility in coming years for helping protect U.S. carbon reservoirs and for preparing forest management strategies for a warmer future. As a first step, carbon management and storage should be added to the Forest Service's multiple-use mandate. More specifically, timber-rotation lengths should be selected on the basis of both carbon storage and economic returns, and the practice of determining economically appropriate harvest levels on the basis of production targets, rather than vice versa, should be ended.¹²¹ Greater emphasis on carbon management within the USFS and other agencies might also result in additional protection of old-growth forest, reduction in

the reforestation backlog, the elimination of harvesting (particularly if below-cost) in areas likely to regenerate poorly or slowly, and extensive research on adapting forest management strategies to the threat posed by global warming. Given the subtle nature of global warming, the Forest Service will probably also have to take primary responsibility for developing the knowledge base that private timberland managers need to adjust their own adaptive strategies.

As part of government agencies' review of their possible responses to global warming in the forestry sector, analysis should be undertaken to assess the potential for increasing forest cover on public lands. Although agencies such as the Forest Service and the Bureau of Land Management contend that few planting opportunities are available on public lands, so much land is under the control of these and other public agencies that this conclusion appears excessively pessimistic.

10. Improve Our Understanding of U.S. Carbon Stocks and Flows.

Considerable research is needed to improve the current understanding of U.S. carbon stocks and trends both on and off forested lands and to improve our ability to characterize the potential biomass productivity of non-forested lands. Available forestry data tend to be biased toward commercial biomass, and important elements of the carbon cycle are therefore overlooked in existing estimates. Such a data gathering and modeling effort is likely to be beyond the scope of any single natural resource management agency (such as the USFS) and may well require a broader inter-agency approach. Making the model and its underlying data base publicly available would make public consideration and review of biotic policy options much more practical.

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Notes

1. Houghton, R.A., 1990. "Emissions of Greenhouse Gases," in Myers, N., ed., *Deforestation Rates in Tropical Forests and Their Climatic Implications*. Friends of the Earth.
2. It has been estimated that deforestation in 1987 contributed more than 3 billion tons of carbon to the atmosphere, more than 1.3 billions tons of it from Brazil alone. World Resources Institute in collaboration with United Nations Environment Programme and United Nations Development Programme, 1990. *World Resources 1990-91*. Oxford University Press. A more recent estimate, however, argues that these estimates overstate Brazilian deforestation by as much as a factor of four. Fearnside, P.M., et al., 1990. *Deforestation Rate in Brazilian Amazonia*. Brazilian National Secretariat of Science and Technology.
3. Houghton, R.A., et al., 1983. "Changes in the Carbon Content of Terrestrial Biota and Soils Between 1860 and 1980: A Net Release of CO₂ to the Atmosphere," *Ecological Monographs* 53:235-62.
4. Opinion is deeply split among scientists as to whether such fertilization is already occurring. Foresters note their inability to observe rising growth rates in the world's forests. Some carbon modelers, however, believe that a CO₂ fertilization effect must be assumed in order to balance the global carbon cycle and that such an effect would not necessarily be measurable at the individual stand level. For a discussion of the science underlying the carbon fertilization debate, see Kramer, P.J., and Sionit, N., 1987. "Effects of Increasing Carbon Dioxide Concentration on the Physiology and Growth of Forest Trees," in Shands, W.E., and Hoffman, J.S., eds. *The Greenhouse Effect, Climate Change, and U.S. Forests*. Conservation Foundation.
5. Houghton, R.A., 1990. "The Future Role of Tropical Forests in Affecting the Carbon Dioxide Concentration of the Atmosphere," *Ambio* 19(4):204.
6. Intergovernmental Panel on Climate Change, 1990. *Policymakers Summary: The Formulation of Response Strategies*. World Meteorological Organization and United Nations Environment Programme.
7. U.S. Department of Agriculture, Forest Service, 1990a. *An Analysis of the Timber Situation in the United States: 1989-2040*. Editorial draft.
8. Houghton estimates the carbon content of temperate grasslands after disturbance for cultivation at about 42 tons per acre as soil carbon, with an additional couple of tons of carbon in vegetation. (Houghton, R.A., et al., 1983.) Using these figures, one could estimate the minimum carbon content of crop and pasture lands at 45 billion tons of

carbon. Birdsey, however, believes that U.S. forest soils average more than 46 tons of carbon per acre, for a total of some 35 billion tons. (Birdsey, R.A., in press. "Potential Changes in Carbon Storage Through Conversion of Lands to Plantation Forests," in *Proceedings, North American Conference on Forestry Responses to Climate Change*, 1990, Washington, D.C. Climate Institute.) Because the average carbon content of forest soils should be considerably higher than that of crop and pasture land soils, it seems likely that Houghton's number is significantly too high or Birdsey's is significantly too low. Birdsey, for example, estimates that grasslands probably hold some 25 tons per acre. (Birdsey, R.A., pers. comm.) In either case, forest ecosystems are likely by far to exceed agricultural lands as carbon repositories.

9. Estimates of the vegetational and soil carbon content of an acre of old-growth biomass in the Pacific Northwest range up to almost 300 tons per acre. Estimates of tropical forest biomass in Latin America are less than 100 tons per acre even for undisturbed productive forest. Harmon, M.E., Ferrell, W.K., and Franklin, J.F., 1990. "Effects in Carbon Storage of Conversion of Old-Growth Forests to Young Forests," *Science* 247:699-702; Brown, S., and Lugo, A.E., 1984. "Biomass of Tropical Forests: A New Estimate Based on Forest Volumes," *Science* 223:1290-93.
10. See note 4. Also see Tans, P.P., Fung, I.Y., and Takahashi, T., 1990. "Observational Constraints on the Global Atmospheric CO₂ Budget," *Science* 247:1431-38.
11. Birdsey, R.A., in press.
12. Hansen, E.A., in press. "Biological Opportunities to Increase Tree Biomass Accumulation and Yield from Timberland," in *Proceedings, North American Conference on Forestry Responses to Climate Change*, 1990, Washington, D.C. Climate Institute.
13. Because trees are unlikely to decompose and oxidize to CO₂ in the same year they die, it can be argued that they do not constitute a source of carbon for the year and that total mortality should not be subtracted from net growth in arriving at an overall carbon balance. On the other hand, some fraction of the biomass in trees that died in every previous year will oxidize during the year in question. Rather than attempt to calculate the fraction of mortality from each previous year oxidizing in the present year, it is much simpler for carbon accounting purposes simply to count total nonharvested mortality in a given year against total growth in that same year.
14. Birdsey, R.A., pers. comm.
15. Shands, W.E., and Hoffman, J.S., eds., 1987.
16. Davis, M.B., 1989. "Lags in Vegetation Response to Greenhouse Warming," *Climatic Change* 15(1-2):75-82; Smith, J.B., and Tirpak, D., eds., 1989. *The Potential Effects of Global Climate Change on the United States: Report to Congress*. U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation.
17. Leverenz, J.W., and Lev, D.J., 1987. "Effects of Carbon Dioxide-Induced Climate Changes on the Natural Ranges of Six Major Commercial Tree Species in the Western United States," in Shands, W.E., and Hoffman, J.S., eds.
18. Sandenburgh, R., Taylor, C., and Hoffman, J.S., 1987. "Rising Carbon Dioxide, Climate Change, and Forest Management: An Overview," in Shands, W.E., and Hoffman, J.S., eds.
19. This fact is sometimes cited to argue that human activities are responsible for just a small part of the accumulation of additional CO₂ in the atmosphere. The argument is highly misleading, however, for in the

- absence of human activities, natural systems normally would emit and absorb roughly equal amounts of CO₂, thus maintaining a planetary balance. It is the perturbation to the CO₂ cycle introduced by human activities that accounts for the rise in atmospheric CO₂ concentrations.
20. Trees pump water up from their roots to their leaves, where it evaporates into the air, moving up to 100 gallons of water per day. The evaporation of this water absorbs heat from the air and lowers surrounding air temperatures.
 21. An albedo of one refers to a surface that completely reflects all light, while a value of zero refers to one that completely absorbs the energy in light. Trees have an albedo of around 0.25. A practical upper-limit estimate of the albedo of a highly vegetated southern city with light-colored surfaces on its pavement and buildings is 0.40. Although trees can increase albedo under some circumstances, on average the addition of trees to the urban environment probably reduces rather than increases albedo, thus offsetting some of their global warming benefits. Akbari, H., et al., 1989. "Saving Energy and Reducing Atmospheric Pollution by Controlling Summer Heat Islands," in *Controlling Summer Heat Islands*. Proceedings of the Workshop on Saving Energy and Reducing Atmospheric Pollution by Controlling Summer Heat Islands, Lawrence Berkeley Laboratory, University of California, Berkeley.
 22. Akbari, H., et al., 1989.
 23. Representative cities where the effects of urban forestry have been modeled include Sacramento, California; Lake Charles, Louisiana; and Phoenix, Arizona.
 24. The three main effects measured in the computer model were reduced solar gain (shading), evapotranspiration (evaporation of water by vegetation), and reduced wind speed. Even when trees were strategically placed to maximize shading, evapotranspiration accounted for 65 to 90 percent of the energy savings; only 10 to 30 percent was attributable to shading itself. Akbari, H., et al., 1989; Huang, Y.J., et al., 1986. *The Potential of Vegetation in Reducing Summer Cooling Loads in Residential Buildings*. Lawrence Berkeley Laboratory, University of California.
 25. Huang, Y.J., et al., 1986.
 26. Moll, G., 1989. "The State of Our Urban Forest," *American Forests*, November/December:61-64.
 27. Robinette, G., 1977. *Landscape Planning for Energy Conservation*. Environmental Design Press, prepared by the American Society of Landscape Architecture Foundation.
 28. The AFA also estimates that an additional 60 million planting sites are available along streets and 160 million in parks and other open places in urban areas.
 29. Akbari, H., et al., 1989.
 30. Akbari, H., et al., 1989. This estimate does not separate out the costs of tree planting and increasing albedo.
 31. Moll, G., 1989.
 32. The other required precursors to smog, however, are oxides of nitrogen (NO_x), which are produced primarily through the combustion of fossil fuels. Chameides, W.L., et al., 1988. "The Role of Biogenic Hydrocarbons in Urban Photochemical Smog: Atlanta as a Case Study," *Science* 241:1473.
 33. *Weekly Bulletin*, June 5, 1989. Environmental and Energy Study Institute, Washington, D.C.
 34. Economic Incentives Committee, 1989. *Incentives for Tree Planting in the United*

States to Slow the Build-up of Atmospheric Carbon Dioxide. Report of the "Trees for U.S." Task Force, EIC.

35. U.S. Department of Agriculture, Economic Research Service, 1989. *Agricultural Resources: Cropland, Water and Conservation: Situation and Outlook Report*. USDA/ERS AR-16.
36. U.S. Department of Agriculture, Forest Service, 1990b. *America the Beautiful: National Tree Planting Initiative*.
37. Parks, P.J., in press. "Potential for Converting Marginal Crop and Pasture Lands to Forests," in *Proceedings, North American Conference on Forestry Responses to Climate Change*, 1990, Washington, D.C. Climate Institute; U.S. Department of Agriculture, Forest Service, 1990b.
38. These regions are defined as states east of the Mississippi River plus Minnesota, Missouri, Texas, Oklahoma, Arkansas, and Louisiana. Economic Incentives Committee, 1989.
39. Parks, P.J., in press; U.S. Department of Agriculture, Forest Service, 1988a. *The South's Fourth Forest: Alternatives for the Future*. Forest Resources Report No. 24.
40. Marland, G., 1988. *The Prospect of Solving the CO₂ Problem Through Global Reforestation*. DOE/NBB-0082, TRO39. U.S. Department of Energy, Office of Basic Energy.
41. These figures are based on total tree carbon productivity per acre rather than just the carbon content of merchantable timber. The multiplier for converting from merchantable timber to total tree biomass can vary from 1.5 to over 2.5 depending on the species. A conservative value of 1.6 was used in these estimates. This multiplier does not account for carbon that might accumulate over time in understory vegetation, in downed branches and other litter, and in soils.
42. Birdsey, R.A., pers. comm.
43. Wood removed during thinning must also be netted out if it is not incorporated into long-lasting wood products or compensated for by sufficiently better growth in the remaining trees.
44. The choice of a time line is of great importance to the estimation of the carbon benefits of planting trees that are to be harvested. If assessed in year 50 of a 50-year rotation, for example, carbon benefits will be at their peak. If assessed at year 51 just after harvest, carbon benefits could well be significantly less than what they were in year 50. If assessed at year 75, the carbon benefit (new growth + long-term product from the first rotation) may be approaching that seen prior to harvest. If assessed at year 99, the carbon benefit for the harvested acre could exceed that for a nonharvested acre.
45. Brandle, J.R., Wardle, T.D., and Bratton, G.F., forthcoming. *Shelterbelt Opportunities and the Potential Impacts on Global Warming*. American Forestry Association.
46. These savings would be realized by withdrawing the planted acres from intensive agricultural production, although total agricultural productivity is not projected to fall. They also accrue from reducing energy consumption in homes and farmsteads and from reducing snow-removal requirements. Brandle, J.R., Wardle, T.D., and Bratton, G.F., forthcoming.

47. Faeth, P., pers. comm.
48. Economic Incentives Committee, 1989.
49. National Research Council, 1989. *Alternative Agriculture*. National Academy Press.
50. Government expenditures on farm programs differ from year to year based on many variables and have ranged from \$10 to \$25 billion per year over the last decade. The total over the last five years was \$93 billion. U.S. Department of Agriculture, 1989a. *Agricultural Handbook #684*, Economic Research Service.
51. Cubbage, F.W., forthcoming. *Current Federal Land Conversion Programs: Accomplishments, Effectiveness, and Efficiency*. American Forestry Association.
52. Economics Incentives Committee, 1989.
53. Ibid.
54. Ibid. These cost estimates exceed those suggested for CRP land conversions because of the much larger scale of the program in the face of rising marginal costs. Convincing farmers with their land already enrolled in the CRP program to plant trees may well be cheaper than convincing those still using their land for commercial crop production.
55. These carbon storage figures incorporate high estimates of biomass accumulation other than actual carbon accumulation in wood. (See note 41.) Moulton, R.J., and Richards, K., 1990.
56. It is true that falling timber prices should increase the demand for timber products and possibly carbon storage in wood products, but one would still expect a net decline in investment on existing timberlands.
57. U.S. Department of Agriculture, 1989b. *Conservation Reserve Program: Progress Report and Preliminary Evaluation of the First Two Years*.
58. U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, 1990. *Conservation Reserve Program "Logo Package."*
59. Analysis of the FIP and the ACP has found that conversions to forest cover under those programs has proven cost-effective for the landowners, with internal rates of return varying from 10 to 15 percent over the last 15 years. Cubbage, F.W., forthcoming.
60. Alig, R.J., et al., 1980. "Most Soil Bank Plantings in the South Have Been Retained; Some Need Follow-Up Treatments," *Southern Journal of Applied Forestry* 4(1):60-64.
61. Kurtz, W.B., et al., 1980. "Retention and Condition of Agricultural Conservation Program Conifer Plantings," *Journal of Forestry* 78(5):273-76.
62. Vasievich, J.M., 1983. "Constraints and Risks: Physical Losses/Risks." *Proceedings of the American Forestry Association 108th Annual Meeting*, 1983, Washington D.C. American Forestry Association.
63. Royer, J.P., and Moulton, R.J., 1987. "Reforestation Incentives," *Journal of Forestry* 85:8.
64. Sedjo, R.A., and Lyon, K.S., 1990. *The Long-Term Adequacy of World Timber Supply. Resources for the Future*.
65. Because a significant fraction of global wood production is from natural forests, a reduction in commercial wood harvesting cannot be directly equated to a decrease in standing biomass. Some proportion of the forgone eight billion cubic feet in commercial wood production outside the new tropical plantations, for example, is likely to be the result of leaving standing forest alone (not a net carbon loss) rather than forgoing

plantations that otherwise would have been grown (a net carbon loss).

66. U.S. Department of the Interior, Bureau of Land Management, 1987. *Public Land Statistics 1946-1986*.
67. U.S. Department of Defense, 1990. *Our Nation's Defense and the Environment: A Department of Defense Initiative*.
68. U.S. Environmental Protection Agency, 1989a. *Reforest America: A Cost Effective Program to Reduce U.S. CO₂ Emissions by 10 Percent*.
69. U.S. Environmental Protection Agency, 1989b. *Policy Options for Stabilizing Global Climate. Report to Congress. Draft*.
70. Although the National Forest Management Act of 1976 mandated that the Forest Service eliminate its reforestation backlog by 1985, subsequent congressional investigations revealed that most of the backlog was eliminated through administrative means rather than by actual reforestation. A 1985 report to the Committee on Appropriations by its Surveys and Investigations Staff revealed that the Forest Service sometimes claims replanting of backlog acreage even when no tree planting is planned, before planned planting has occurred, or when only a part of an area is in fact treated. The report concluded that large portions of the backlog acres were removed from the rolls not by reforestation but by administrative fiat reclassifying the land out of the timberland system. Surveys and Investigation Staff, 1985. *10-Year Reforestation Backlog Elimination Program of the U.S. Forest Service. A Report to the Committee on Appropriations, U.S. House of Representatives; Carey, H.H., et al., 1989. National Forests: Policies for the Future, vol. 3, Reforestation Programs and Timberland Suitability. Wilderness Society*.
71. Wubbels, D., pers. comm.
72. This modest estimate of land availability is generally consistent with the AFA's estimate that an additional 60 million trees could be added along public roadways.
73. Harmon, M.E., Ferrell, W., and Franklin, J.F., 1990.
74. Timber sales are characterized as below cost when the Forest Service spends more on sale preparation and administration, mitigation, road construction, and reforestation than it receives for the sold timber. In the case of the Tongass National Forest in Alaska, for example, it is estimated that \$32 million was received in timber sales revenue but some \$287 million was spent on the sales. Below cost sales are estimated to occur in at least 76 national forests and to involve some 125 million acres of national forest lands. Wilderness Society, 1989. *New Directions for the Forest Service: Instructions from the President of the United States to the Chief of the Forest Service (Recommendations of the Wilderness Society)*; Repetto, R., and Gillis, M., eds., 1988. *Public Policies and the Misuse of Forest Resources*. Cambridge University Press.
75. Net carbon flows will depend on the biology of the forest, including the amount of standing timber and the likelihood and speed of its regeneration. It will also depend on the disposition of harvested biomass.
76. Wilderness Society, 1989.
77. For a discussion of the controversy over forest management practices, see Robinson, G., 1988. *The Forest and the Trees: A Guide to Excellent Forestry*. Island Press.
78. It is estimated that at least 80 percent of the old-growth forest in national forests remains potentially available for logging. (Wilderness Society, 1989). This situation may change in response to the listing of the northern spotted owl as a threatened species under the Endangered Species Act.

79. This estimate is not necessarily the equivalent of a doubling of total "carbon growth" on U.S. timberlands because an increase in merchantable timber growth might well imply a decrease in nonmerchantable species and growth.
80. U.S. Department of Agriculture, Forest Service, 1990b; U.S. Congress, Office of Technology Assessment, 1983. *Wood Use, U.S. Competitiveness and Technology*. OTE-E-210.
81. Wilderness Society, 1989.
82. Current commercial timber accumulation on an average acre of timberland totals less than 1 ton of carbon per year, so an increase of 0.5 to 1 ton per acre would represent a significant advance over current growth rates.
83. The lower end of the range assumes the interim loss to the atmosphere of roughly 200 tons of carbon from the cutting of one acre of old-growth forest, and the upper end of the range assumes the long-term loss of some 135 tons of carbon. (See Box 3.)
84. Judis, J.B., 1990. "Ancient Forests, Lost Jobs Ride Wings of Spotted Owl," *In These Times*, August 1-14, 1990. Institute for Public Affairs, Chicago, Illinois.
85. Winjum, J., pers. comm.
86. Some analysis suggests that 75 percent of the cost of timberland improvement that is not already prima facie economically justified will be made up for in the economic value of the harvested product, considerably reducing the projected net cost of the option. Without understanding the second-order effects of the increased management and planting on long-term timber supplies and markets, however, such an assumption is risky.
87. Because old-growth trees survive on a tight energy budget, shifts in climate may stress and weaken these trees more than younger specimens. Scientists have concluded that "[a]n increase in respiration leading to a loss of vigor in old growth stands could have devastating effects in some forest regions, particularly in the West and in parts of the East." U.S. Department of Agriculture, Forest Service, 1988b. *Forest Health and Productivity in a Changing Atmospheric Environment: A Priority Research Program*.
88. Birdsey, R.A., in press.
89. Row, C., and Phelps, R.B., in press. "Carbon Cycle Impacts of Improving Forest Products Utilization and Recycling," in *Proceedings, North American Conference on Forestry Responses to Climate Change*, 1990, Washington, D.C. Climate Institute.
90. Harmon, M.E., et al., 1990. Sedjo, however, suggests using a rate as low as 25 percent. Sedjo, R.A. and Solomon, R.A., 1989. *Climate and Forests*. Resources for the Future.
91. For a discussion of biomass utilization technologies, see U.S. Department of Energy, 1988. *Five Year Research Plan 1988-1992; Biofuels: Renewable Fuels for the Future*, DOE/CH10093-25. Biofuels and Municipal Waste Technology Program; Brower, M., 1990. *Cool Energy: The Renewable Solution to Global Warming*. Union of Concerned Scientists; Rader, N., 1989. *Power Surge: The Status and Near-Term Potential of Renewable Energy Technologies*. Public Citizen; Flavin, C., and Piltz, R. 1989. *Sustainable Energy*. Renew America.
92. Because it is projected that we will run out of liquid fossil fuels at some point in the future, displacing the production of a barrel of oil on the margin today does not mean the permanent sequestration of that amount of carbon. What it does do is delay the release of that carbon by the amount of time between the original substitution and

the ultimate depletion of supplies of that fossil fuel. Should depletion of that fossil fuel source be more than a century away, there is no conceptual difference between the global warming implications of burning one ton of carbon in the form of biocrude gasoline made from water hyacinths and storing the same amount of carbon in a long-lived Douglas fir tree.

93. Productivity figures are expressed in terms of tons of carbon per acre per year to maintain consistency with earlier discussion. These figures are derived by multiplying dry harvested biomass weights by 0.5. The conversion to carbon is not intended to suggest that no other sources of energy (e.g., hydrogen) are present in the biomass. Wright, L.L., Cushman, J.H., and Layton, P.A., 1989. "Expanding the Market by Improving the Resources." *Biologue* 6(3):12-19. National Wood Energy Association.
94. Wright, L.L., Graham, R.L., and Turhollow, A.F., in press. "Short-Rotation Wood Crop Opportunities to Mitigate Carbon Dioxide Buildup," in *Proceedings, North American Conference on Forestry Responses to Climate Change*, 1990, Washington, D.C. Climate Institute; InterTechnology Corporation, 1975. *The Estimated Availability of Resources for Large-Scale Production of SNG by Anaerobic Digestion of Specially Grown Plant Material: Final Report*. American Gas Association Project No. IU 114-1.
95. Estimates of the energy inputs and outputs involved in ethanol production from feedstocks such as corn can vary depending on the accounting method used and credits given for secondary products such as cattle and chicken feeds. Pimentel, D., et al., 1988. "Food Versus Biomass Fuel: Socioeconomic and Environmental Impacts in the United States, Brazil, India, and Kenya," in Chichester, C.O., and Schweigert, B.S., eds., *Advances in Food Research*, vol. 32. Academic Press, Inc.
96. For every 1.4 Btus of SNG produced, 1.0 Btu of conventional fuel would be required to grow the crop and run the conversion facility. InterTechnology, 1975.
97. Wright, L.L., Graham, R.L., and Turhollow, A.F., in press.
98. InterTechnology, 1975.
99. U.S. Department of Energy, 1988.
100. Brower, M., 1990.
101. Wright, L.L., Graham, R.L., and Turhollow, A.F., in press.
102. U.S. Department of Energy, 1988.
103. Current DOE research in plant-oil-derived diesel fuel includes the development of microalgae systems in the desert Southwest, where there is high incident solar radiation, plenty of land, and large reservoirs of saline water. To lower the cost of fuel production, DOE is looking for strains of microalgae that exhibit high oil accumulation and rapid growth. In fact, researchers have identified strains of microalgae that produce up to 65 percent of their body weight in oil. Genetic engineering will be used to maximize oil production because the species that have high lipid yields generally have low growth rates. The viability of large-scale production of oils is also being addressed as researchers verify the availability of saline waters and affordable supplies of CO₂. U.S. Department of Energy, 1988.
104. U.S. Department of Energy, 1988.
105. Ostlie, L.O., 1989. "The Whole Tree Burner: A New Technology for Power Generation," *Biologue* 5(3):79.
106. These prices precede any long-term impacts of Iraq's invasion of Kuwait in August 1990.

107. Various studies show higher injury and illness rates in the agricultural and forestry sectors than in the fossil fuels sector per unit of energy produced. U.S. Congress, Office of Technology Assessment, 1980. *Energy from Biological Processes*, vols. 1 and 2; Pimentel, D., et al., 1988.
108. Wright, L.L., Graham, R.L., and Turhollow, A.F., in press.
109. Biomass gasification is one alternative receiving considerable attention. Williams, R.H., 1989. Statement before the House Appropriations Committee, Subcommittee on Foreign Operations. February 21.
110. Ostlie, L.O., 1989.
111. U.S. Department of Agriculture, Soil Conservation Service, 1987. *Natural Resources Inventory*. Statistical Bulletin No. 756; Pimentel, D., et. al., 1988.
112. This reflects an increase in soil organic matter of 0.02 percent per year. Rader, N., 1989.
113. U.S. General Accounting Office, 1990. *Alternative Agriculture: Federal Incentives and Farmers' Opinions*. Program Evaluation and Methodology Division.
114. Soil losses in the southern United States during the past 100 to 200 years have reportedly caused crop-biomass reductions ranging from 25 to 50 percent for a variety of crops. Pimentel, D., et al., 1988.
115. Faeth, P., and Repetto, R., in press. *The Economics of Sustainable Agriculture*. World Resources Institute.
116. Edmonds, J.A., et al., 1989. *A Preliminary Analysis of U.S. CO₂ Emissions Reduction Potential from Energy Conservation and the Substitution of Natural Gas for Coal in the Period to 2010*. U.S. Department of Energy.
117. Congressional Budget Office, 1990. *Carbon Charges as a Response to Global Warming: the Effects of Taxing Fossil Fuels*.
118. Illinois Commerce Commission, 1989. *The Illinois Air Quality Enhancement Program Through Comprehensive Tree Planting: Program Prospectus*.
119. Porterfield, A., 1989. "Railroaded: The LBO Trend on Wall Street is Playing Havoc with that Nation's Forests," *Common Cause Magazine*, September/October: 21-23.
120. Derived from Nordhaus, W.D., 1990. *A Survey of Estimates of the Cost of Reduction of Greenhouse Gas Emissions*. Yale University.
121. Repetto, R., and Gillis, M., eds., 1988.

Appendix

Source or Sink? A Preliminary Analysis of Carbon Flows in the United States

The carbon cycle of the United States is poorly understood from a quantitative standpoint, partly because impacts on the carbon cycle have not figured heavily in natural resource management decisions. Indeed, swiftly changing and sometimes contradictory public policies, a basic lack of biological information on long-term resource trends, and the unknowns surrounding the potential impacts of such exogenous variables as global warming and acid rain suggest the need for great caution in estimating the effects and cost-effectiveness of alternative approaches to carbon storage. What scientists do know now is best summarized by land-use type.

Rural Forests

A key factor in the U.S. carbon cycle is the forest, a major land use in this country. (See text Figure 3.) In 1620, forests covered an estimated 45 percent or more of the land area of today's United States—more than 1 billion acres.¹ Soon thereafter, the wholesale clearing of forests for agriculture and pasture began.² Between 1700 and 1980, an estimated 1.7 million acres per year of forest were converted to agricultural land in North America.³ In the United States alone, estimates of forest losses from 1600 to 1980 range from 600,000 to 1 million acres per year.

By the early 1900s, U.S. forest cover had dipped to a low point of about 750 million

acres.⁴ By the 1950s, the reversion of abandoned crop and pasture lands to forest cover, together with planned reforestation, returned total forest cover to more than 780 million acres. Since then, however, forest cover has declined to just 730 million acres, or 32 percent of the surface area of the United States.⁵ Between 1977 and 1987, an average of almost 400,000 acres of forest was lost annually.⁶ These losses probably resulted in the release of some 20 million tons of carbon during each of those years.

Statistics reflecting changes in timberland acreage can say more about changes in classification than about changes in carbon stocks.

Of course, forest area tells only part of the story of carbon stocks. Often, statistics reflecting changes in timberland acreage say more about changes in use than they do about changes in carbon stocks. For example, when land classified as timberland is reclassified as wilderness, the resulting decrease in timberland acres is not matched by a decrease in forested acres or carbon.⁷ In other cases, timberland is redefined as "other" forest land when the site's productivity is reevaluated even

though the number and type of trees might not change at all. Alternatively, a real change in the resource might not show up in forest-acreage statistics. If one million acres of mature forest were converted to agricultural land and one million acres of agricultural land elsewhere were converted back to forest or tree-crop cover during the same year, no change would appear in forest area statistics; indeed, net growth estimates might even rise soon after the switch. Yet it would probably take decades, if not centuries, for the carbon accumulating on the newly forested acres to equal the quantity of carbon lost when the mature forest was cut. (See Box A-1.) The same principle applies to the replacement of virgin forest with managed forests, a consistent trend in the United States since Europeans settled the continent. Indeed, commercial timber volumes in U.S. forests have declined by an estimated two-thirds since 1630, while forest area has declined by less than one-third. (See Figure A-1.)

The first estimates of total U.S. forest ecosystem carbon stocks suggest that some 57 billion tons of carbon are currently tied up in those ecosystems.

The first estimates of total U.S. forest ecosystem carbon stocks suggest that some 57 billion tons of carbon are currently tied up in those ecosystems.⁸ The carbon loading of an acre of forest can vary widely, depending on species composition, age, geography, and soil type. On average, a forested acre in the United States is estimated to hold almost 80 tons of carbon in biomass and soils, a large proportion of which is lost when the land is cleared for alternative uses. Surprisingly, most of the

Box A-1. Changing Land Uses and Carbon Flows in the Southeastern United States

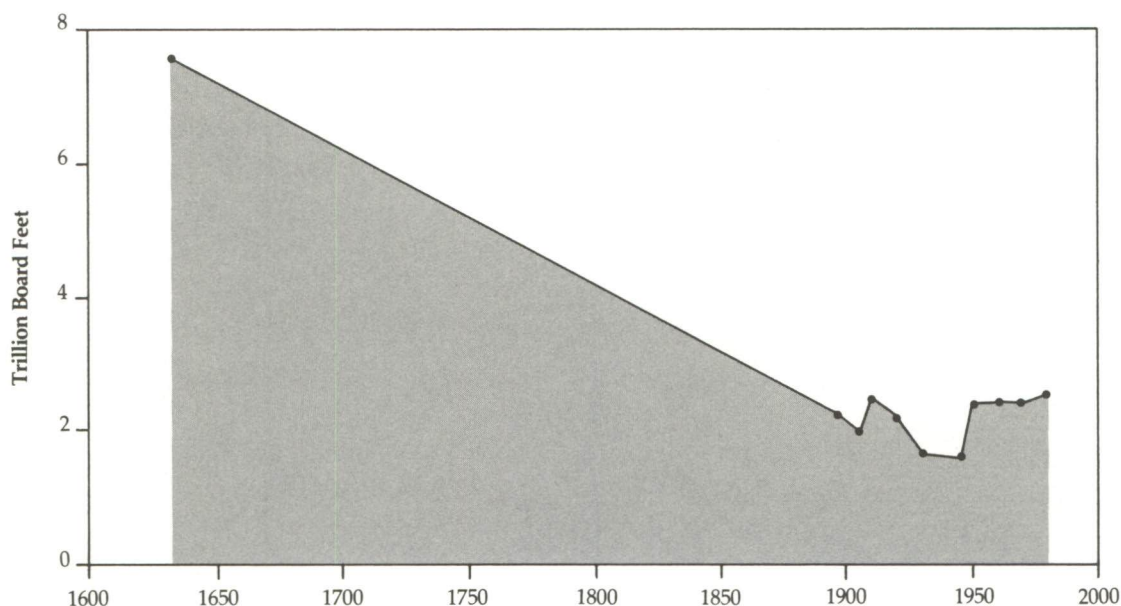
Few attempts have been made to track the impact of long-term land-use changes on carbon flows in a specific region. Delcourt and Harris, however, have done just that for the southeastern United States from 1750 to the present. They estimate that between 1750 and 1960 the total quantity of carbon in the soils and vegetation of the southeastern United States declined linearly from 47.6 to 16.6 billion tons as a result of converting forest and native prairie to agricultural uses. This change suggests an average annual net release of some 143 million tons of carbon per year, making the southeastern United States a major source of biotic carbon for most of the period since the industrial revolution.

Delcourt and Harris estimate that since 1960 the same region has become a net sink

for carbon as abandoned lands have reverted to forest and as forested lands have become more densely stocked and managed. They estimate, however, that only 77 million tons of carbon are being taken in on net every year, one-half as much as was lost for two centuries. Since 1960, therefore, only 3.1 percent of the carbon lost from between 1750 and 1960 has been restored. They conclude that because of the much higher biomass densities found in the original virgin forests, managed reforestation in the region will never fully offset losses incurred in previous years.

Source: Delcourt, H.R., and Harris, W.F., 1980. "Carbon Budget of the Southeastern U.S. Biota: Analysis of Historical Change in Trend from Source to Sink," *Science* 210:321-23.

Figure A-1. Decline in United States Commercial Timber Volume



Source: M. Clawson, "Forests in the Long Sweep of American History," *Science*, 204, (1979): 1168-74

carbon in U.S. forest ecosystems appears to reside in forest soils, not in the trees themselves. (See text Figure 6.) Considering these findings and that nearly all of today's forest cover has been disturbed over time and thus is likely to contain significantly less carbon than it once did, a plausible estimate of the amount of carbon present in the biota at the time of European settlement is well over 100 billion tons. Indeed, according to Richard Houghton of the Woods Hole Research Institute, North American land conversions released an estimated 22 billion tons of carbon between 1860 and 1980 alone.⁹

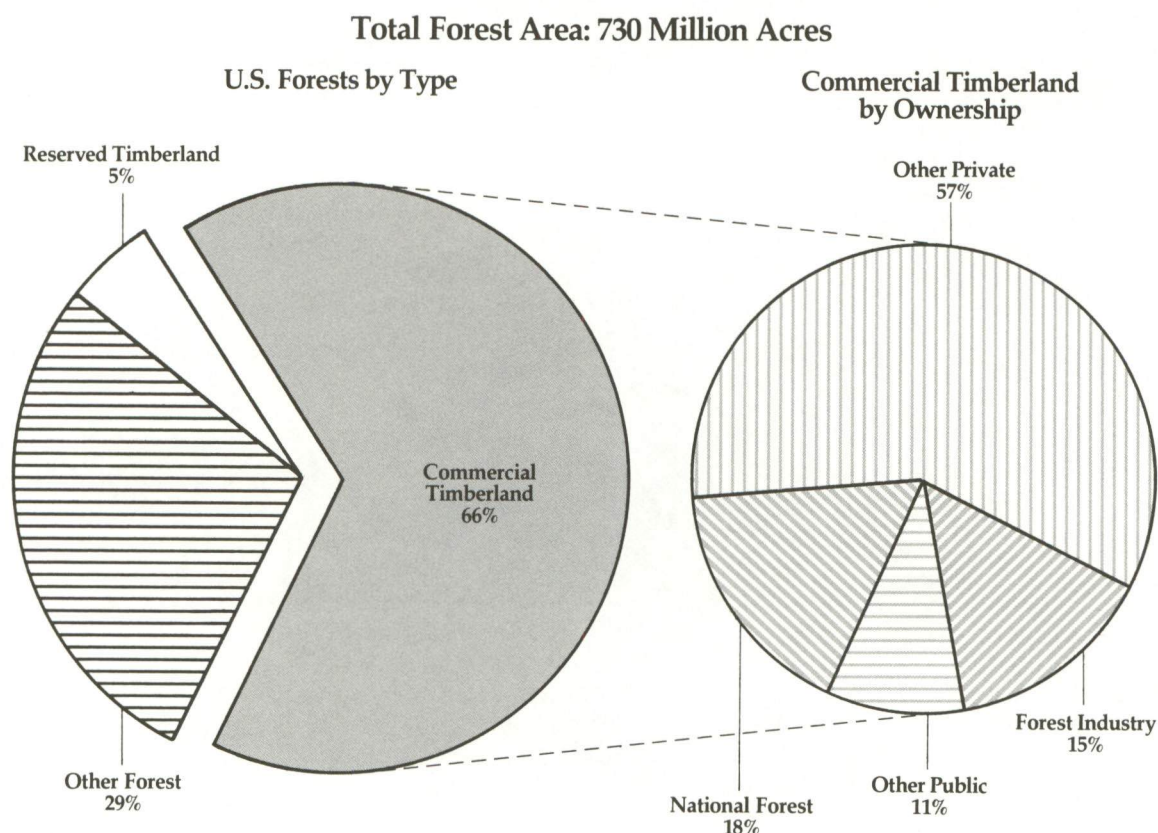
Timberlands

As with forest cover generally, timberland area declined from the time of European settlement to 1920, bottoming out at approximately 468 million acres. Timberlands are commonly defined as "unreserved" forests capable of

producing more than 20 cubic feet of merchantable timber per acre per year, or about 0.4 tons of carbon. By 1962, timberland area had rebounded to 516 million acres as cotton lands in the South and hilly clearings in other areas reverted to forest. But between 1962 and 1977, timberland area fell five percent to 491 million acres, and from 1977 to 1987, timberlands dropped further to some 483 million acres (about 66 percent of total U.S. forested land), where they remain today. Of these, approximately 278 million are controlled by small-scale landowners, and less than 70 million acres are in the hands of industrial timber interests. (See Figure A-2.)

Various factors have contributed to declining timberland area, including conversion to agricultural and developed uses. Since 1962, for example, some 6.1 million acres of timberland have been converted to urban and agricultural uses in the Southeast.¹⁰ An additional 35

Figure A-2. United States Forest Classifications and Ownership



Source: Based on U.S. Department of Agriculture, Forest Service, *An Analysis of the Timber Situation in the United States: 1989-2040, Part I: The Current Resource and Use Situation*, draft, (1988); and K.L. Waddell, et al., *Forest Statistics of the United States, 1987*, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, (1989)

million acres of forest that might meet the productivity requirement of timberlands are now included in reserves, including national parks and wilderness areas.

The United States Forest Service (USFS) projects that national timberland area will fall by an additional 20 million acres by 2040,¹¹ with most of this decline reflecting real changes in the resource rather than timberland withdrawals. Tree planting, however, has been on an upward trend for the last 50 years,

mainly because rates of artificial regeneration on harvested timberlands have been increasing. (See Figure A-3.) Some government programs are encouraging the afforestation of croplands too. (See text Box 7.) Reforestation programs tend to come and go, however, and land conversion under the Conservation Reserve Program (CRP) is scheduled to end soon as well. Although such programs could reverse the projected decline in timberland area, their long-term effect cannot yet be ascertained. (See text Figure 4.)

Figure A-3. Trees Planted in the United States, 1930-89



Source: U.S. Department of Agriculture, Forest Service, 1989 *U.S. Planting Report*, (1990)

Despite declining timberland area, timber volumes on the remaining lands are increasing, according to USFS statistics. U.S. timberlands contained an estimated 830 billion cubic feet or more of merchantable timber in 1987—up more than four percent from the previous decade.¹² Most of these productivity gains have been realized on private nonindustrial timberlands, particularly the 164 million acres located in the southeastern United States. Overall, commercial timber growth rates exceeded rates of harvest by an estimated 20 percent in 1989 (by 34 percent on national forests).¹³ As a result, some argue, U.S. timberlands can support significantly larger harvests, particularly on national forest lands.

Is it wise to increase harvest levels? Even on private timberlands, experts question the

long-term sustainability of existing growth rates and rotation times.¹⁴ Foresters are already concerned over unexplained decreases in growth rates on some timberlands. (See Box A-2.) As for the national forests, many analysts have argued that even logging at today's levels has often proven uneconomic, unsustainable over the long term, and too high in light of competing social priorities, including endangered species conservation and watershed protection. The Wilderness Society estimates, for example, that if a long-term sustainable yield criterion were integrated into multiple-use objectives, annual sales from the national forests would not exceed 5.0 to 6.5 billion board feet of timber, considerably less than the 10.5 billion board feet that the Forest Service originally expected to sell in fiscal year 1991.¹⁵

Box A-2. Declining Growth on Southern Pine Plantations

Southern pine forests provide fully one-third of all the growing stock harvested from the nation's timberlands each year. From the early 1950s to the mid-1970s, the net annual growth of softwood species in the South increased by 65 percent, partially as a result of the large-scale conversion of natural stands to more intensively managed plantations. During the last decade, however, annual growth rates fell 20 to 30 percent. The USDA expects southern pine productivity to continue to fall through the next decade. Mortality has doubled, now claiming up to 15 percent of gross annual growth.

Various causes for the pine's problems have been identified, including changes in density and stand age, drought or other weather factors, declining land fertility, increasing hardwood competition, insect invasion, and damage from atmospheric pollution. Some 30 to 40 percent of the mortality is attributed to insects and another 35 to 40 attributed to disease.

Recent research suggests that air pollution, particularly ozone deposition, is likely to be an increasing threat to many rural forests. Ozone damage has been found in more than 50 species in the Great Smoky Mountains. Seedling experiments suggest that ambient levels of ozone are stunting the growth of most, and possibly all, conifer and hardwood forests in the eastern United States. Although insects such as the balsam woody adelgid may deserve the blame for killing many trees, many scientists suspect that even these trees have been made vulnerable to the insect by acid deposition and other forms of air pollution.

Sources: MacKenzie, J.J., and El-Ashry, M.T., 1988. *Ill Winds: Airborne Pollution's Toll on Crops and Trees*. World Resources Institute; U.S. Department of Agriculture, Forest Service, 1988. *The South's Fourth Forest: Alternatives for the Future*; U.S. Department of Agriculture, Forest Service, 1988. *An Analysis of the Timber Situation in the United States: 1989-2040*. Draft.

Other Rural Forests

Of the 245 million acres of the United States now classified as unreserved forests but not as timberlands, almost 60 percent are accounted for by the fir-spruce forests of interior Alaska and the pinyon-juniper forests of the Rockies.¹⁶ Relatively little is known about how these economically less important forests have changed over time, much less about trends in their carbon flows. Their potential role in U.S. biotic carbon balances is therefore hard to assess.

Crop, Pasture, and Rangelands

Agricultural, pasture, and rangelands account for just over one billion acres, or 47 percent of

the land area of the United States.¹⁷ This figure, down by approximately 50 million acres since 1949, is falling gradually.¹⁸ Significant quantities of agricultural land continue to be converted to urban and other developed uses, and many of the acres currently dedicated to agriculture and range were once far more richly laden with biomass than they are today. An estimated 250 million acres of forest land have been converted to agricultural and pasture use since North America was settled. In the process, most standing biomass on those acres was eliminated, resulting in the release of enormous quantities of carbon to the atmosphere.

Conversion of land from one use to another continues to this day in the United States,

though not on the scale seen in past years. More than one-half of the 12 million acres of wetlands drained for agricultural uses from the mid-1950s to the 1970s were forested.¹⁹ When such lands are stripped of tree cover to make way for agriculture, loss of standing biomass is not the only source of carbon released into the atmosphere. Soil carbon levels fall by an estimated 40 percent or more.²⁰ Erosion compounds this problem: an estimated 44 percent of all U.S. cropland, or some 170 million acres, is eroding at rates sufficient to destroy its long-term productivity, and fully one-quarter is losing more than 19 tons of topsoil per acre per year.²¹ In 1982, total soil losses from U.S. croplands exceeded 3 billion tons per year. Total soil losses from all nonfederal rural lands, primarily through water and wind erosion, approached 5.5 billion tons in the same year. Although not all this carbon will oxidize to CO₂, some eventually will. In addition, the depletion of soil productivity owing to topsoil loss often requires an increase in the application of nitrogen fertilizers, which require great amounts of energy to manufacture—a process that emits CO₂—and which can trigger emissions of other greenhouse gases, such as nitrous oxide (N₂O).

Urban Forests and Developed Lands

Historically, the need for agricultural land has driven most conversion of forest land. Recently, however, land conversion to urban and other developed uses such as highways has become more and more important. Unfortunately, though, discrepancies in how different government agencies measure and define urban areas make it difficult to arrive at a clear picture of the situation.²² The Department of Agriculture estimates that the average annual conversion of rural land to developed uses increased from 0.9 million acres per year in the 1960s to 1.3 million acres per year by 1980 and that land committed to urban areas, highways, airports, and other such uses now totals over two percent of the U.S. land area.²³ (See Figure A-4.)

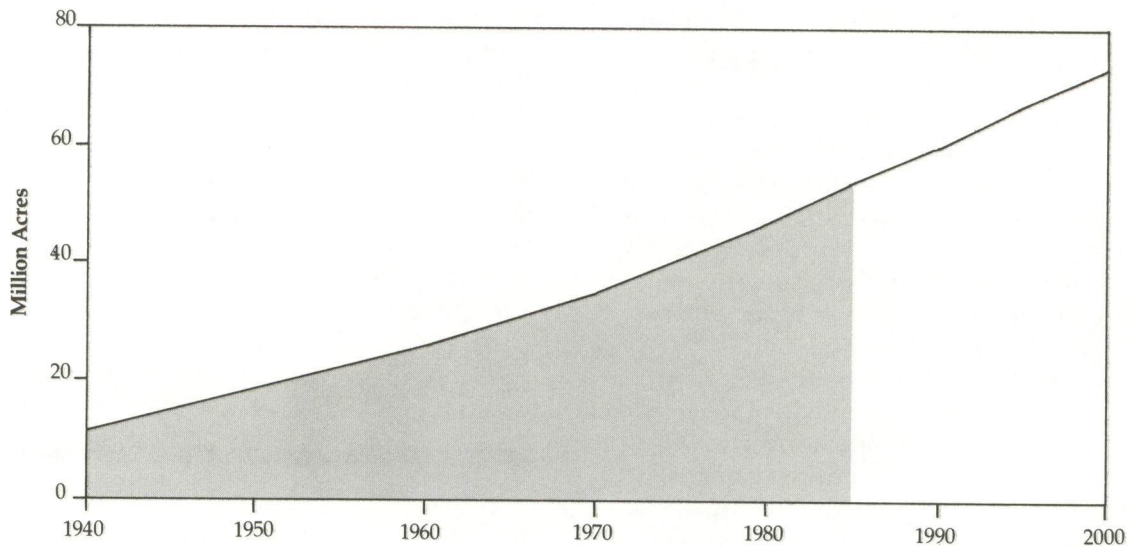
The expansion of developed land uses is usually at the expense of woodlands or croplands. About one-half million acres of each are lost to development annually.²⁴ In the Southeast alone, 170,000 acres of timberland are converted to urban use each year.²⁵ In Fulton County outside Atlanta, forest cover has decreased by 50,000 acres in the past 15 years; in 1988 alone, an estimated 50 acres of forest and cropland were lost there every day. Similar losses are occurring outside Washington, D.C., where 80,000 acres of forest have been eliminated in Fairfax County, Virginia, in the past 35 years.²⁶ As we move into the 1990s, the USFS projects, forest conversion will stem primarily from expanding needs for reservoirs, urban areas, highways, airports, and mining.²⁷

As we move into the 1990s, forest conversion will stem primarily from expanding needs for reservoirs, urban areas, highways, airports, and mining.

The loss of forested land, whether directly or indirectly the result of urban development, reduces U.S. carbon reservoirs. Significant quantities of biomass and soil carbon are lost each year, even when some trees remain or are replanted in cities. In fact, the American Forestry Association estimates that 61 million trees line urban streets and another 550 million trees grow elsewhere in urban or builtup areas.²⁸ Comprehensive surveys of our urban forests are not available, but it is known that a large fraction of these trees are relatively small (less than 12 inches in diameter) and that the habitat for urban trees often is poorly planned and maintained. Urban trees are also under assault from various airborne pollutants. A common rule of thumb is that four urban trees are dying for every new tree planted around the nation.

The decline of our urban forest may soon be reversed, at least temporarily. Billed as something

Figure A-4. Growth in Urban and Other Developed Land Area, 1940–2000



Source: Based on H.T. Frey and R.W. Hexem, *Major Uses of Land in the United States: 1982*, Agricultural Economic Report No. 535, U.S. Department of Agriculture, Economic Research Service, (1985); and L.A. Reuss, *et al.*, *Inventory of Major Land Uses: United States*, Miscellaneous Publication No. 663, U.S. Department of Agriculture, Bureau of Agricultural Economics, (1948)

individuals can do to combat global warming while making the local environment more comfortable and attractive, urban tree planting has attracted a large following recently. Global Relief programs have been initiated by the American Forestry Association in 11 states and more than 100 communities. Other programs and organizations—among them, Trees Atlanta, Tree People (Los Angeles), and Philadelphia Green—are seeking similar ends, and the president's America the Beautiful program is likely to spur federal involvement in urban forestry. (See text Box 6.)

Consumption of Wood Products

An estimated 42 billion cubic feet of wood, the equivalent of 390 million tons of carbon, are removed from U.S. forests annually.²⁹ Of this quantity, only a fraction is used for durable

wood products.³⁰ Production of roundwood products from U.S. forests was estimated at 18 billion cubic feet for 1986,³¹ the equivalent of some 165 million tons of carbon. The disposition of all this carbon is a potentially important element of the biotic carbon cycle because wood products can serve as an artificial carbon sink by keeping the harvested carbon out of the atmosphere for months (in the case of disposable products) to many decades (in the case of construction materials and other long-lived items).

Although the average useful life of wood products can be reasonably well estimated, the carbon storage of these products remains difficult to ascertain. It is known that a huge stock of worn-out wood products can now be found in U.S. landfills and that decomposition there is slow, but research on how much carbon is released in the utilization and disposal of wood

products and the mechanisms through which it is released is just beginning.³² It remains unclear, therefore, what the size of this artificial carbon reservoir is and whether it is now a net sink or source of carbon. As the quantity of stored carbon builds up, for example, even gradual decomposition will eventually release more carbon than can be stored in the form of new wood products. In landfills, decomposition can also release methane, a much more potent greenhouse gas than carbon dioxide.

Wood products are by no means the only product of U.S. forests that figure into global warming. By at least one estimate, more than one-half the wood removed from U.S. forests in the early 1980s was burned for energy,³³ and fuelwood offtake from forest lands is expected to increase significantly in coming years.³⁴ Residential fuelwood consumption, for example, is expected to increase by 64 percent between 1986 and 2020.³⁵ Right now, direct combustion of wood and wood wastes currently accounts for almost 90 percent of all biomass energy used in the United States but only 4 percent of total energy consumption and 8 percent of industry's energy use.³⁶ Most of this energy is consumed in the paper-and-pulp industry, where it supplies 70 percent of all energy requirements. This use is likely to grow three- to fourfold over the next several decades.³⁷

Conclusions

Although land uses in the United States are relatively well tracked, major uncertainties remain with respect to the net carbon flows associated with the changes that continue to take place. It is virtually certain that forests, especially timberlands, are the nation's largest storehouses of biotic carbon, but a variety of

questions need answers before the size and direction of net carbon flows can be estimated:

- How large are stocks of noncommercial biomass on timberlands? And how much carbon is stored in forested lands not classified as timberlands? What are the trends in each area?
- Are net changes occurring in the stresses facing existing forests and timberlands? Are rising fire frequencies resulting in net releases of forest carbon? Will air pollution continue to slow the growth of large areas of U.S. forest?
- How much carbon is stored in urban forests? How are trends in urban forestry affecting fossil fuel consumption?
- How much carbon is stored in wood products (both in use and disposed of)? Have we already exceeded the point at which annual oxidation of a small proportion of these products equals annual additions to product stocks?
- If the billions of tons of carbon previously thought to be disappearing into the world's oceans are instead fertilizing temperate forests around the world, what are the impacts on domestic forests?

These and other uncertainties notwithstanding, one key fact is incontrovertible. As hundreds of millions of acres of forests in what is now the United States were cut down over the last 200 years and converted to agriculture, pasture, and urban uses and as virgin forests were replaced with younger forests and plantations, tens of billions of tons of carbon were added to the atmosphere.

Notes

1. Forest area in the United States has been specifically tracked since 1952, and there is general agreement on the current expanse of U.S. forests. Estimates of forest cover earlier in the century and in prior centuries in what is now the United States, however, vary significantly. Sedjo, for example, estimates original forest cover at 950 million acres, but the Forest Service's estimate is 1.1 billion acres. Sedjo, R.A., 1990. *The Nation's Forest Resources*. Discussion Paper No. ENR90-07. Resources for the Future; U.S. Department of Agriculture, Forest Service, 1989. *Tree Planting and Forest Improvement to Reduce Global Warming*.
2. For a discussion of the history of U.S. forests, see Williams, M., 1988. "Death and Rebirth of the American Forest: Clearing and Reversion in the United States 1900-1980," in Richards, J.F., and Tucker, R.P., eds. *World Deforestation in the Twentieth Century*. Duke University Press.
3. Houghton, R.A., et al., 1983. "Changes in the Carbon Content of Terrestrial Biota and Soils Between 1860 and 1980: A Net Release of CO₂ to the Atmosphere," *Ecological Monographs* 53:235-62.
4. U.S. Department of Agriculture, Forest Service, 1989.
5. U.S. Department of Agriculture, Forest Service, 1990a. *America the Beautiful: National Tree Planting Initiative*.
6. Available statistics invite different interpretations of trends in forest acreage. Some USFS data, for example, suggest that the United States lost, on net, 700,000 acres of forested land per year during the last decade. This is the figure used in the president's 1991 budget proposal. Most foresters, however, consider the figure too high, preferring an average rate of loss of approximately 400,000 acres per year. Birdsey, R.A., pers. comm.
7. Between 1977 and 1987, for example, eight million acres of timberland were apparently lost in the United States. Further analysis, however, shows that much of the recorded loss of timberland was due to redefinition of land use (i.e., from national forest to national wilderness area) rather than an actual reduction in forested lands. In Alaska alone, nearly four million acres were placed in reserved status as national parks and wilderness from 1977 to 1987.
8. The estimate is based on the extrapolation from timber inventory statistics to total tree biomass, the modeling of forest soil carbon on the basis of temperature, precipitation, and forest-stand age, and empirical data on biomass in understory vegetation and litter for selected ecosystems. Nevertheless, it represents only the first attempt to quantify these variables and may be subject to significant change as research progresses. Birdsey, R.A., in press. "Potential Changes in Carbon Storage Through Conversion of Lands

to Plantation Forests," in *Proceedings, North American Conference on Forestry Responses to Climate Change*, 1990, Washington, D.C. Climate Institute.

9. Houghton, R.A., et al., 1983.
10. U.S. Department of Agriculture, Forest Service, 1988a. *The South's Fourth Forest: Alternatives for the Future*. Forest Resources Report No. 24.
11. U.S. Department of Agriculture, Forest Service, 1990b. *An Analysis of the Timber Situation in the United States: 1989-2040*. Editorial draft.
12. Because timber statistics focus almost exclusively on merchantable timber, it remains unclear to what degree these increases reflect actual increases in biomass as opposed to a reallocation of biomass among commercial and noncommercial species.
13. Mickey, R.S., 1990. Statement before the House Agricultural Committee, Forests, Family Farms, and Energy Subcommittee. February 6.
14. Robinson, G., 1988. *The Forest and the Trees: A Guide to Excellent Forestry*. Island Press.
15. Wilderness Society, 1989. *New Directions for the Forest Service: Instructions from the President of the United States to the Chief of the Forest Service (Recommendations of the Wilderness Society)*.
16. U.S. Department of Agriculture, Forest Service, 1988b. *An Analysis of the Timber Situation in the United States: 1989-2040. Part I: The Current Resource and Use Situation*. Draft.
17. All land-use estimates presented here are approximate. Although several government agencies are charged with periodically reviewing nationwide land uses, differing organizational goals as well as inconsistencies in definition and measurement methods often result in land-use estimates that are difficult to compare. Even within the same agency, estimates made from one decade to the next are often not easily comparable.
18. Frey, H.T., and Hexem, R.W., 1985. *Major Uses of Land in the United States: 1982*. Agricultural Economic Report No. 535. U.S. Department of Agriculture, Economic Research Service, Natural Resource Economics Division.
19. U.S. Department of Agriculture, 1986. *Environmental Assessment for the Regulations Implementing the Wetland Conservation Provisions of the Food Security Act of 1985*.
20. Delcourt, H.R., and Harris, W.F., 1980. "Carbon Budget of the Southeastern U.S. Biota: Analysis of Historical Change in Trend from Source to Sink," *Science* 210:321-23; Covington, W., 1981. "Changes in Forest Floor Organic Matter and Nutrient Content Following Clearcutting in Northern Hardwoods," *Ecology* 62(1):41-49.
21. U.S. Department of Agriculture, 1989. *Conservation Reserve Program: Progress Report and Preliminary Evaluation of the First Two Years*.
22. Even within the same agency, changing methodologies can add to the confusion. The 1977 Soil Conservation Service (SCS) National Resources Inventory, for instance, used two sampling methods to estimate urban land use. The first, which used county maps to measure urban and builtup areas larger than 40 acres, was later determined to have overestimated builtup areas by several million acres. To correct this sampling error, the 1982 National Resources Inventory (NRI) changed measuring procedures and calculated urban area entirely from sample data. As a result, the NRI statistics now show acreage devoted to urban and transportation uses increasing from 51 million acres in 1958 to 90 million acres in 1977 and then falling to 73 million acres in 1982.

23. Conservation Foundation, 1987. *State of the Environment: A View Toward the Nineties*.
24. Bowen, G., 1989. Statement before the House Committee on Agriculture, Subcommittee on Forests, Family Farms, and Energy. June 7.
25. U.S. Department of Agriculture, Forest Service, 1988a.
26. Moll, G., 1989. "The State of Our Urban Forest," *American Forests*, November/December:61-64.
27. U.S. Department of Agriculture, Forest Service, 1988c. *An Analysis of the Timber Situation in the United States: 1989-2040. Part II: The Future Resource Situation*. Draft.
28. Moll, G., 1989.
29. Birdsey, R.A., in press.
30. For example, Harmon et al. estimate that 42 percent of timber currently harvested in the Pacific Northwest is converted to long-term products, compared with 20 percent in the 1950s. An even smaller proportion of smaller trees would be likely to end up in long-lived products. Harmon, M.E., Ferrell, W.K., and Franklin, J.F., 1990. "Effects in Carbon Storage of Conversion of Old-Growth Forests to Young Forests," *Science* 247:699-702.
31. U.S. Department of Agriculture, Forest Service, 1988b.
32. Row, C., and Phelps, R.B., in press. "Carbon Cycle Impacts of Improving Forest Products Utilization and Recycling," in *Proceedings, North American Conference on Forestry Response to Climate Change*, 1990, Washington, D.C. Climate Institute.
33. U.S. Congress, Office of Technology Assessment, 1983. *Wood Use, U.S. Competitiveness and Technology*. OTE-E-210 U.S. Government Printing Office.
34. U.S. Department of Agriculture, Forest Service, 1990b.
35. High, C., and Skog, K., 1989. "Current and Projected Wood Energy Consumption in the United States." Paper Presented at the Energy from Biomass and Wastes XIII Conference, New Orleans, 1989.
36. U.S. Department of Energy, Energy Information Administration, 1989. *Annual Energy Review*. DOE/EIA-0384(89); Rader, N., 1989. *Power Surge: The Status and Near-Term Potential of Renewable Energy Technologies*. Public Citizen.
37. High, C., and Skog, K., 1989.

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United States Department of State

*Bureau of Oceans and International
Environmental and Scientific Affairs*

Washington, D.C. 20520

March 11, 1991

TO: PCC Working Group on Climate Change

FROM: OES/EGC - Daniel A. Reifsnyder

SUBJECT: UNCED Position Paper

Attached for your information is a copy of the revised United States position paper on climate change for the UNCED Prepcom. This document incorporates all changes received by COB Friday, March 8.

Preparatory Committee for the 1992 U.N.
Conference on Environment and Development

Climate Change
Agenda Item ____

ISSUE:

What role should UNCED play with respect to climate change, particularly with respect to the Intergovernmental Negotiating Committee (INC) and the Intergovernmental Panel on Climate Change (IPCC)?

RELATIVE IMPORTANCE OF THE ISSUE TO THE UNITED STATES:

The UNCED and the negotiating process on climate change are both very important to the United States. However, the UNCED will culminate in June 1992; the negotiating process may continue well beyond June 1992, even if a framework convention is completed prior to UNCED and opened for signature at the Conference.

As currently envisioned, the UNCED seeks to embrace virtually every aspect of environmental concern, including issues dealt with or being dealt with in established fora dedicated to those issues (e.g., depletion of the ozone layer, climate change, bio-diversity) and issues for which an agreed forum is now being considered (e.g., forests).

Given the limited time available prior to the UNCED and the broad scope of the Conference, care must be taken to set reasonable, achievable goals. The United States has thus advocated that the UNCED monitor developments in existing, established fora without seeking to duplicate ongoing efforts. In addition, the United States considers that more progress on specific issues is likely to be achieved (and sustained) in existing, established fora than by the UNCED, which must work against a tight deadline and seek to cover a vast spectrum of environment and development concerns.

These considerations attach in particular to the issue of climate change. While UNGA Resolution 44/228 (TAB A), which set the UNCED in motion, encompasses this issue in its broad mandate, a more recent UNGA resolution (45/212) (TAB B) establishes a single negotiating process under the auspices of the General Assembly in which the climate change issue is now being actively considered. In addition, following adoption of its First Assessment Report in August 1990, the IPCC is now preparing to provide scientific and technical advice on climate change to the negotiating process.

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Consequently, the role of the UNCED with respect to climate change requires careful scrutiny to ensure the integrity of the single negotiating process established by the General Assembly, to avoid duplication of efforts underway in existing, established fora, and to enable the UNCED effectively to allocate its scarce resources to issues and problems that may not be adequately addressed elsewhere.

BACKGROUND:

The UNCED Secretariat has prepared two documents specifically related to the climate change issue for the Second PrepCom (Geneva, March 18-April 5). They are:

- 1) PROTECTION OF THE ATMOSPHERE - CLIMATE CHANGE:
Synthesis Report on Ongoing Processes and
Recommendations: Report of the Secretary General
(A/CONF.151/PC/22) (Tab C)
- 2) PROTECTION OF THE ATMOSPHERE - CLIMATE CHANGE -
Progress Report on the Costing Exercise: Report of
the Secretary General (A/CONF.151/PC/23) (TAB D)

In addition, the Report of the UNCED Secretary General also contains a number of statements with respect to climate change. This document is:

PREPARATIONS FOR THE UNITED NATIONS CONFERENCE ON
ENVIRONMENT AND DEVELOPMENT ON THE BASIS OF GENERAL
ASSEMBLY RESOLUTION 44/228 AND TAKING INTO ACCOUNT
OTHER RELEVANT GENERAL ASSEMBLY RESOLUTIONS: Report
of the Secretary General (A/CONF.151/PC/14) (TAB E)

Essential background with respect to each of these Second PrepCom documents is provided below.

Synthesis Report

This report was prepared in response to decision 1/11 (a) of the UNCED First PrepCom (Nairobi, August 1990) which called for a report by the UNCED Secretary General analyzing and synthesizing results of ongoing climate change activities and making recommendations concerning UNCED's contribution to the negotiating process for a framework convention on climate change. The report was prepared by the UNCED Working Party on Atmosphere and relies heavily on the IPCC's First Assessment Report and the reports of the Second World Climate Conference (SWCC) (Geneva, October/November 1990).

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Section I introduces the Synthesis Report, providing general background. Section II provides background to the SWCC. Section III provides background to the IPCC.

Section IV of the Synthesis Report summarizes the Scientific and Technical Statement of the SWCC (21 paragraphs) as well as the SWCC Ministerial Declaration (14 paragraphs).

Section V summarizes UNGA Resolution 45/212 ("Protection of Global Climate for Present and Future Generations of Mankind") (5 paragraphs), which established the INC.

Section VI identifies major environment development issues for consideration by the Second UNCED PrepCom (17 paragraphs).

Section VII contains recommendations on the negotiating process (6 paragraphs).

Costing Report

This report was prepared in response to decision 1/11 (c) of the UNCED First PrepCom, which called for a report by the UNCED Secretary General initiating appropriate work to estimate the cost, in particular to developing countries, of adopting measures to limit possible climate change and mitigate its adverse effects. The report was prepared by the UNCED Working Party on Atmosphere based on a technical paper prepared for UNCED by the staff of the Stockholm Environment Institute.

Section II discusses the difficulty in defining the costs of responding to climate change.

Section III surveys costing studies undertaken in recent years, dividing them into three categories: 1) assessments of climate impacts; 2) analyses of the costs of adapting to the impacts of global warming; and 3) studies of the costs of reducing greenhouse gas emissions. This section also discusses methodological problems associated with the various types of costing studies.

Section IV lists institutions involved in costing studies, including regional institutions, intergovernmental agencies, national governments and non-governmental organizations.

Section V identifies potential areas for action, citing five specific activities that need to be strengthened or accelerated, including:

- a) a more complete and thorough review of costing studies and their methodologies;

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- b) the preparation of a compendium of impact assessments and adaptation studies, focused specifically on the cost implications of climate change for developing countries if no action is taken;
- c) support of ongoing projects and encouragement of new ones, especially in the developing countries to assess the costs of climate change;
- d) a comparison of a "business as usual" scenario with a "no regrets" strategy using one or more of the major modelling tools now available;
- e) a study to identify the geographic and industrial activities of greatest potential vulnerability to rapid climate change.

Report of the UNCED SecGen

This report provides a broad overview of work in progress by the UNCED. Page 16 begins a discussion of potential outputs of the Conference. In particular, the report notes:

"Global Conventions will enshrine certain basic legal principles. However, international action on many of these issues will neither begin nor end with the enunciation of legal principles. Specific programmes and actions need to be developed to address these issues, their underlying causes and their effects. While many of these programmes and actions will ultimately be mandated and carried out pursuant to the provisions of conventions when they come into force, the process of developing and implementing them on a voluntary basis should proceed in parallel with the negotiating processes."

In addition, the report notes:

"Another major contribution which the UNCED preparations can make to the processes of negotiating the relevant conventions is through examining and pointing out the policy directions that emerge from its consideration of the inter-action of environment and development in respect of the issues being addressed in the negotiations.... Thus the Preparatory Committee's role can be seen as one of providing broad and complementary support to these negotiating processes. In particular, the Preparatory Committee may wish to consider these issues in the context of the negotiations on the Climate Convention."

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UNITED STATES POSITION:

It is widely agreed that the UNCED and the climate change negotiations are two separate processes, which will go forward on separate tracks. In fact, the UNCED SecGen took this view publicly as recently as last month. Still, this distinction is blurred by the documents prepared for the UNCED Second PrepCom, and could be lost, depending on the decisions taken at the PrepCom. As previously noted, the United States believes that there are compelling reasons to maintain it.

U.S. concerns with each of the documents are discussed separately below. The position that should be taken by the U.S. Del to the Second PrepCom is set forth after this discussion.

Synthesis Report

Section IV - The report attempts to summarize at length both the SWCC Conference Statement and the SWCC Ministerial Declaration. Such an effort in this document is unnecessary and unwise. It is unnecessary because both the Conference Statement and the Ministerial Declaration have been made widely available. If necessary, they could be attached to the report as appendices. It is unwise because both documents were hotly contested at the SWCC and the final language represents a delicate compromise of the interests involved.

Summarizing either document risks deleting important items. For example, paragraph 44 of the Synthesis Report notes that "The potentially serious consequences of climate change give sufficient reasons to begin by adopting response strategies even in the face of significant uncertainties." It deletes that portion of the Declaration which immediately followed this statement and made it acceptable to the United States, namely:

"Such response strategies include phasing out the production and use of CFC's, efficiency improvements and conservation in energy supply and use, appropriate measures in the transport sector, sustainable forest management, afforestation schemes, developing contingency plans for dealing with climate-related emergencies, proper land use planning, adequate coastal zone management, review of intensive agricultural practices and the use of safe and cleaner energy sources with lower or no emissions of carbon dioxide, methane, nitrous oxide and other greenhouse gases and ozone precursors, paying special attention to new and renewable sources."

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Only because this list of "measures justified on other grounds" followed the statement cited in the Synthesis Report did the United States agree at the SWCC to include the statement without a specific qualification. The United States had previously proposed to insert "which are justified on other grounds" at the end of the sentence. This is but one example of the concerns that arise with respect to summaries of such documents.

The Synthesis Report makes no distinction between the SWCC Ministerial Declaration, which was adopted by 137 governments, and the SWCC Conference Statement, which was developed by experts in their personal capacities and which does not have the imprimatur of governments. At the SWCC, sensitivities concerning the Conference Statement ran so high that governments would not agree even to note the Conference Statement in the Ministerial Declaration. The UNCED Synthesis Report ignores these sensitivities and elevates the Conference Statement to a status equal to that of the Ministerial Declaration.

Section VI - The section contains the most troublesome portions of the Synthesis Report. Paragraph 62, in particular, blurs the distinction between the INC and the UNCED in its statement of UNCED's mandate.

The IPCC's Working Group III identified "response strategies" without seeking to propose specific strategies or courses of action. At the time, participants agreed that decisions with regard to specific strategies would need to be considered in the context of the negotiations that were to follow. Those negotiations have now begun, and yet the Synthesis Report contends that it is the mandate of the UNCED PrepCom "to propose appropriate response strategies for the world community."

The Synthesis Report misapplies UNCED's mandate with respect to climate change. While it is UNCED's mandate to take into consideration cross-sectoral linkages (e.g., technology transfer and financial assistance) generally, across all environmental issues, the application of this mandate must vary depending on the specific issue involved. With respect to climate change, the INC established working groups at its first session in February 1991. The INC's Working Group I is specifically charged with preparing a text related to:

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- "(a) Appropriate commitments, beyond those required by existing agreements, for limiting and reducing net emissions of carbon dioxide and other greenhouse gases, on the protection, enhancement and increase of sinks and reservoirs, and in support of measures to counter the adverse effects of climate change, taking into account that contributions should be equitably differentiated according to countries' responsibilities and their level of development;
- "(b) Appropriate commitments on adequate and additional financial resources to enable developing countries to meet incremental costs required to fulfill the commitments referred to above and to facilitate the transfer of technology expeditiously on a fair and most favourable basis;"
- "(c) Commitments addressing the special situation of developing countries, taking into account their development needs, including, inter alia, areas threatened by erosion, flooding, desertification and high urban atmospheric pollution, and also taking into account the problems of economies in transition."

(See at TAB F the draft decision submitted by the Chairman concerning the "Establishment of subsidiary organs and organization of work" of 14 February 1991, A/AC.237/L.5. The draft decision was adopted by the INC, although the final version has not yet been distributed).

At the time the Synthesis Report was prepared, the INC had not yet met or adopted the decision referred to above. Now that the INC has done so, and now that it is clear that the INC will be the forum in which appropriate commitments are negotiated, the UNCED does not need to "formulate a set of actions and programmes as part of the proposed Agenda-21 in response to the problem of climate change." For UNCED to do so would duplicate efforts now underway in the INC.

The Synthesis Report in paragraph 68 calls for development of a comprehensive global energy strategy by the time of the 1992 Conference "to support a potential protocol on energy-related issues to the framework convention on climate change." Paragraph 69 mentions transportation issues. Paragraph 70 notes that the Preparatory Committee may wish to

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consider a variety of potential actions related to biomass sinks. Paragraphs 71-74 discuss adaptation issues. Paragraph 75 discusses technology and paragraphs 76 and 77 discuss finance.

It is not clear exactly what the UNCED proposes to do with respect to each of these areas, but all of these areas were considered by the IPCC and are subjects for continuing scientific and technical assessment by the IPCC. Moreover, all of these areas will be considered in the negotiations taking place within the INC. Finally, the approach contemplated in the Synthesis Report (sector by sector), runs counter to the U.S. position which strongly supports a comprehensive approach to the climate issue. As explained in our Report, "A Comprehensive Approach to Addressing Potential Climate Change" (February 1991), piecemeal treatment of these topics would be economically wasteful and environmentally ineffective.

Section VII - This section contains recommendations on the negotiating process. It notes that "the actions and programs developed as part of the UNCED preparatory process will provide for cooperative actions on a voluntary basis in many of the same areas that will ultimately be covered by mandatory provisions of a convention and/or its protocols." The section further provides that "Development of an agenda for such programmes and activities and their implementation on a voluntary basis will therefore make an important contribution to the negotiating process and help to establish the framework and basis for implementation of measures included in the convention/protocols when they come into force."

In essence, the Synthesis Paper proposes that the UNCED be the forum for consideration of "voluntary" measures to address climate change, whereas the INC would serve as the forum for consideration of "mandatory" measures. It is difficult to see how this approach could be implemented without undermining the "single negotiating process" called for in General Assembly Resolution 45/212. Measures to address climate change under a framework convention may or may not be "mandatory" in the sense that they are binding on all governments. Given that the global effort to address climate change must be phased and flexible, initial measures under the convention may consist largely of the voluntary measures that governments are willing to adopt now, recognizing the large uncertainties involved. Placing "voluntary measures" in the UNCED would engender resistance to any "mandatory measures" in the INC, further slowing its efforts.

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In another sense, UNCED efforts to develop actions and programmes on a voluntary basis may not differ significantly from efforts undertaken at environment ministerials during the IPCC process (e.g., Noordwijk, Bergen) to 'add political impetus to the process of addressing climate change.' Since the IPCC's was an analytical exercise, the rationale for adding political impetus was perhaps clearer then. The INC effort is political, however, and the rationale for "political impetus" as it may have existed in the past is no longer so clear.

Costing Report

This report could be quite useful to the IPCC, which will hold its 5th Plenary Meeting in Geneva from March 13-15, immediately prior to the UNCED Second PrepCom. At the 5th Plenary, the IPCC specifically will turn its attention to economic aspects of climate change and response options. Since the IPCC will provide scientific and technical assessment to the INC, as well as continue its longer term efforts, the recommendations contained in the Costing Report should be directed to the IPCC for consideration and possible future work.

Further work along the lines of the Costing Report within the UNCED would, however, likely duplicate efforts that will be undertaken by the IPCC, and the United States should urge that such efforts not be initiated.

Report of the UNCED SecGen

Like the Synthesis Report, the SecGen's Report proposes that the UNCED develop and implement specific programmes and actions on a voluntary basis, and that such efforts proceed in parallel with the negotiating process. The SecGen's Report cites three bases for its proposal:

- 1) Governments will be prepared, and even prefer, to proceed with such programmes and actions on a voluntary basis before they become mandatory under a legal agreement;
- 2) Developing and initiating such programmes and actions will facilitate the negotiations and provide the basis for their expeditious and effective implementation when the relevant instrument comes into force; and
- 3) The UNCED process will clarify the linkages between the issues being addressed in each of the individual negotiations.

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Again, it is not clear how the UNCED will be able to proceed with such an approach without undermining the "single negotiating process" established by the General Assembly in Resolution 45/212. The distinction between "mandatory" and "voluntary" may in fact be a distinction without a difference, particularly since governments have yet to decide on "appropriate commitments" under the framework convention. To encourage UNCED to proceed to develop and implement specific programmes and actions on a voluntary basis would be, potentially, to deliver a large portion of the climate negotiations to the UNCED.

The SecGen's Report also suggests that UNCED could make a major contribution to the "processes of negotiating the relevant conventions" through examining and pointing out the policy directions that emerge from its consideration of the inter-action of environment and development in respect of the issues being addressed in the negotiations. The Report notes, in particular, that the Second PrepCom may wish to consider these issues in the context of the negotiations on the climate convention. While the United States supports UNCED's efforts to consider the inter-action of environment and development in most areas, these issues are being addressed with respect to climate by the INC. In fact, the agreed Working Group structure of the INC was devised specifically to ensure complete consideration of the development and other needs of developing countries. UNCED should assist that process with respect to the climate negotiations only by providing information to the INC on how such issues are being dealt with elsewhere.

LANGUAGE TO BE SOUGHT:

- o The UNCED climate documents prepared for the Second Prepcom are described as "final." Thus, it may not be possible to modify them at the Second PrepCom. However, if possible to revise them, the U.S. Del should seek to achieve the following objectives:
 - a) delete section IV, which summarizes the SWCC Conference Statement and Ministerial Declaration; attach these documents, if necessary, as appendices to the Synthesis Report distinguishing clearly between the Ministerial Declaration, which has the imprimatur of governments, and the Conference Statement, which does not.
 - b) in section VI, paragraph 61, substitute "related instruments" for "possible protocols" to track the language of UNGA Resolution 45/212.

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- c) in section VI, paragraph 62, delete "and to propose appropriate response strategies for the world community."
- d) in section VI, delete paragraphs 63-77, especially paragraphs 68-77.
- e) in section VII, delete paragraph 78
- f) in section VII, paragraph 79, delete "therefore".
- o The U.S. Del should seek to have the recommendations contained in the Costing Paper referred to the IPCC for further consideration and analysis, where the United States seeks to ensure that economic analysis is undertaken.

LANGUAGE TO BE AVOIDED:

- o The U.S. Del should oppose any suggestion that UNCED implement and develop specific actions and programs with respect to climate change or response strategies that would be implemented on a voluntary basis, since such an effort would undermine the single negotiating process on climate change established by the General Assembly.
- o The U.S. Del should oppose any suggestion of a piecemeal, sector-by-sector or gas-by-gas approach to the climate issue.

TALKING POINTS:

- o As currently envisioned, the UNCED will embrace virtually every aspect of environmental concern, including issues dealt with or being dealt with in established fora dedicated to those issues (e.g., depletion of the ozone layer, climate change, bio-diversity) and issues for which an agreed forum is being considered (e.g., forests).
- o Given the limited time available prior to the UNCED and the broad scope of the Conference, care must be taken to set reasonable, achievable goals.
- o The United States has thus advocated that the UNCED monitor developments in existing fora without seeking to duplicate ongoing efforts.

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- o We believe that more progress on specific issues is likely to be achieved and sustained in these existing fora since the UNCED must work against a tight deadline and seek to cover a vast spectrum of environment and development concerns.
- o With particular reference to climate change, we acknowledge that UNGA Resolution 44/228 encompasses this issue in its broad mandate, but we note that the more recent UNGA Resolution 45/212 established a single negotiating process under the auspices of the General Assembly in which the climate change issue is now being actively considered.
- o Subsequent to the drafting of these reports, the INC set up a negotiating process that will consider the issues outlined in the UNCED documents; this process mitigates the need for UNCED involvement in considering these issues.
- o In addition, following adoption of its First Assessment Report in August 1990, the IPCC is now preparing to provide continuing scientific and technical advice on climate change to the negotiating process.
- o Consequently, the role of the UNCED with respect to climate change requires careful scrutiny to ensure the integrity of the single negotiating process established by the General Assembly, to avoid duplication of efforts underway in existing fora, and to enable the UNCED effectively to allocate its scarce resources to issues and problems that may not have been or may not now be adequately addressed elsewhere.
- o In this regard, we are concerned that the Synthesis Report proposes that the PrepCom develop and implement specific actions and programs to respond to climate change that could be adopted by governments on a voluntary basis.
- o We do not understand how this effort could be launched without undermining the single negotiating process underway in the Intergovernmental Negotiating Committee.

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- o We question the suggestion that the UNCED could pursue "voluntary" measures whereas the INC is seeking to negotiate "mandatory" measures; it is not yet clear to us what commitments will be agreed in the negotiations and whether they will be "voluntary" or "mandatory."
- o The Synthesis Report's division of climate issues by sector (energy, transport, etc.) is incomplete (omitting agriculture and forestry) and is at odds both with the Working Group structure of the INC and agreement within the INC on the need for an integrated or comprehensive approach.
- o For these reasons, we believe that UNCED's role with respect to climate change is necessarily more limited and should be more carefully defined than the role proposed in the Synthesis Report, and should be focussed on informing the INC about the inter-action of environment and development in other areas.

Attachments:

- Tab A - UNGA Resolution 44/228
- Tab B - UNGA Resolution 45/212
- Tab C - UNCED Synthesis Report
- Tab D - UNCED Costing Report
- Tab E - UNCED SecGen's Report
- Tab F - INC Decision on Subsidiary Organs

-14-

Drafted:OES/EGC:JPershing&DAREifsnyder:647-4069:3/5/91:
revised:3/11/91

SEEGC Doc #1896

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AND OES PCC WORKING GROUP ON CLIMATE



EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

SPECIAL

February 26, 1991

LEGISLATIVE REFERRAL MEMORANDUM

TO: Legislative Liaison Officer -

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SUBJECT: *Energy* draft response to
questions from Congressman Waxman concerning Global
Climate

The Office of Management and Budget requests the views of your agency on the above subject before advising on its relationship to the program of the President, in accordance with OMB Circular A-19.

A response to this request for your views is needed no later than
2:00 P.M. WEDNESDAY, FEBRUARY 27, 1991.

Questions should be referred to Norm Hartness (395-6840).

Ronald K. Peterson

RONALD K. PETERSON FOR
Assistant Director for
Legislative Reference

Enclosures

cc: J. Hezir
H. Williamson

J. Holmstead
A. Fraas

A. Card

7 pages

Department of Energy
Response to

Congressman Henry A. Waxman

National Energy Strategy -- Global Climate Change

1. What are the Department of Energy's (DOE) views on the nature and severity of global climate change expected as a result of the release of manmade greenhouse gases? What is DOE's evaluation of the potential health and environmental impacts from climate change induced by manmade emissions?

Answer

Regarding the magnitude of global climate change and possible health and environmental consequences, a useful starting point for discussing these issues is the First Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), which was issued in September 1990.

With regard to the state of our knowledge, the report concludes that greenhouse gas emissions from human sources are increasing atmospheric concentrations of the gases and that on average additional warming will result. Relying on various current model results, the report indicates that the global mean temperature could increase by 0.1 to 0.3 degrees C per decade during the next century, depending on which of a variety of hypothetical scenarios you select. The report notes that there are many uncertainties in those predictions, particularly with regard to timing, magnitude and regional patterns of climate change. These uncertainties are a product of our incomplete understanding of sources and sinks of greenhouse gases, and of the responses of clouds, oceans and polar ice sheets to a change of radiative forcing.

Concerning the impacts that global climate change could have on various systems, the report estimates that climate change could have an important impact on agriculture, but the experts were unable to determine whether global agricultural potential will increase or decrease. Estimates of impacts from global climate change are also handicapped by substantial uncertainties. Estimates of physical and biological effects at the regional level are difficult to make, and they have a low level of confidence.

In addition, humans and their institutions take many adaptative actions for reasons other than climate change and these actions must also be factored into an evaluation of future impacts of climate change. In most impact analyses that have been done to date, the probable impact of such adaptations has not been factored into the analysis.

2. How are global warming concerns taken into account in the National Energy Strategy (NES)?

Answer

The National Energy Strategy, echoing the recommendations of the IPCC, includes a number of actions that although taken principally for energy-related reasons, will have significant environmental benefits, including curbing the buildup of future U.S. emissions of greenhouse gases. The Strategy includes actions that provide cost-effective alternatives to burning fossil fuels for generating electricity and more efficient and alternative-fuel vehicles that will reduce greenhouse gases produced from transportation emissions.

If no actions were taken, emissions in the United States, from one important greenhouse gas, CO₂, are projected to grow by 80 percent by the year 2030, according to one part of the NES scenario. Likewise, emissions of other greenhouse gases, such as methane, nitrous oxides and carbon monoxide, are projected to grow as well. This growth would occur for the most part due to increased coal use for electricity generation and due to growth in auto emissions. While there is always uncertainty regarding future projections, without the NES, greenhouse gas emissions, as measured in terms of global warming potential, are likely to increase by over 2.82 billion tons of CO₂ equivalents. This would be a 38.4 percent increase over the 1990 levels by 2030.

Collectively, the NES actions will not only reduce our oil vulnerability, make the United States more energy efficient and increase our electricity supply options, but will also reduce the emissions of our major greenhouse gases from what would otherwise occur:

- o Based on the NES scenario, actions as a result of the Strategy, and current Administration programs, will reduce the rate of growth of carbon dioxide and carbon monoxide emissions. These are key greenhouse gases related to energy use, in particular to combustion of fossil fuels. After 2015, increased use of alternative fuels, energy efficiency, renewable and nuclear energy will result in these emissions leveling off and remaining stable through 2030.
- o NES actions, as well as EPA's regulations controlling methane from landfills, will reduce methane emissions below current levels through 2015. Further, after 2015 annual methane emissions from energy sources will continue to decline.

- o Nitrogen oxide and volatile organic compounds, precursors to tropospheric ozone that could lead to potential warming, are held to levels that are about the same or below the 1990 levels and decline from 2015 to 2030.

When all greenhouse gases are considered in terms of global warming potential, the National Energy Strategy, coupled with the existing Administration programs described in "America's Climate Change Strategy," will substantially curb the growth in these gases beyond the year 2000. The NES will allow us to hold emission levels within a range that is close to current levels well into the foreseeable future.

The key NES options that will reduce greenhouse gases include actions that relate to increasing energy efficiency in all sectors of the American economy. The NES actions will improve energy efficiency through:

- o Increased transportation fuel efficiency by accelerated scrappage of older cars, policies to stimulate mass transit and ride sharing, and development of alternative fuel vehicle fleets. In particular, we will be implementing a series of measures that will increase the use of car pools, van pools and mass transit. These measures would encourage the broader use of tax-free transit subsidies, increased high occupancy vehicle right-of-way, and improved public transportation service. To promote alternative fuel vehicles, we are proposing to (1) remove the caps on corporate average fuel economy (CAFE) credits for manufacturers of vehicles capable of operating on alternative fuels; (2) accelerate the purchase of alternative-fueled vehicles for the Federal fleet; and (3) require that by the year 2000, 90 percent of new vehicle purchases for private centrally fueled fleets must use alternative fuels. These measures, coupled with an enhanced R&D program to improve the technology for the producing and distributing alternative fuels will provide significant reduction in greenhouse gas emissions.
- o Federal support for integrated resource planning in electricity markets will also reduce the demand for electricity and the need for powerplants that emit greenhouse gases. Through a number of financial, regulatory, and technical assistance mechanisms, such as eliminating Federal taxation of utility efficiency rebates to consumers, significant progress can be made in encouraging utilities to increase their commitment to energy efficiency and creating new market opportunities for improved end-use energy technologies.

- o Improved building efficiency through initiatives addressing low-income housing energy efficiency, public housing energy efficiency, and building energy efficiency. The Strategy includes measures to expand the use of mortgage financing incentives for residential energy efficiency, and measures for greater energy efficiency improvements in Federal facilities. Also, more funds will be committed to enhanced research and development for improving industrial energy efficiency.

In addition, in FY 1992, we are requesting a 27 percent in our funding for energy efficiency R&D over the 1991 level and 60 percent from our last year's request. In fact, President Bush has nearly doubled the funding committed for energy efficiency research since taking office in 1989. We will be setting new, more stringent appliance and equipment energy efficiency standards. These measures will improve our overall economic efficiency and reduce the demand for additional powerplants.

- o Enhanced transportation research and development, including the development of electric vehicles and high-speed rail systems. We have committed to a major research initiative with Chrysler, Ford and General Motors to develop the electric vehicle. The National Energy Strategy also includes enhanced research and development of new aviation technology to improve the fuel economy of aircraft.

The NES will increase the availability of energy supply technologies with low or minimal net greenhouse gas emissions. The actions range across the spectrum and include natural gas, hydroelectric, nuclear, alternative fuels, and clean coal technologies. The NES actions will:

- o Remove regulatory constraints to natural gas production, transmission, and use. This will be done through deregulating natural gas pipeline rates, allowing gas pipeline construction without Federal certification and encouraging the use of natural gas as an alternative transportation fuel. The Strategy will greatly expand the market potential for natural gas and as a result, concomitantly reduce greenhouse gases.
- o Reduce constraints to obtaining additional hydroelectric power from existing dams, and extend investment tax incentives for certain renewable electric energy technologies. Continue research and development efforts to develop photovoltaic, wind, solar thermal, biomass, and geothermal technologies for electric power applications. Also, increase research and promote expanded use of waste to energy facilities.

We project that with these types of incentives, renewable energy that produced little or no greenhouse gases could significantly increase its market share by early in the next century,

- o Facilitate nuclear power development through improved licensing, development of standardized advanced light water reactor plant designs with improved safety and economic features, public communication programs, and comprehensive solutions to the high-level nuclear waste management problem. Although nuclear power will not make a major contribution to reducing greenhouse gases until after 2000, a number of impediments must be removed in the near future to allow for this option to play a major role.
- o Develop accelerated research and development on biomass-based alcohol and alternative fuels and renewable energy-based feedstocks.
- o Provide incentives for the deployment of clean coal technology that will be more efficient than current coal-fired powerplants. A more efficient plant will emit less CO₂.

3. What are DOE's views regarding the importance of international efforts to address global climate change?

Answer

DOE recognizes the importance of international efforts to address global climate change and fully supports the U.S. approach to the negotiations on the framework convention for global climate change. That approach is based on several principles, which include:

First, we believe we must take a comprehensive approach to climate change, one which considers all aspects of this complex issue and which addresses all greenhouse gases and their sources and sinks.

Second, we must not wait for all uncertainties to be resolved, but must pursue economically efficient and cost-effective actions -- already justified on other grounds -- which will limit net greenhouse gas emissions.

Third, we must continue to pursue aggressively scientific and economic research; systematic observation; collection, archiving and distribution of information; and technology development in order to resolve uncertainties and build a solid foundation for innovative responses.

Fourth, we must recognize the special needs of the developing countries and design mechanisms for assisting them in securing the scientific and technical tools necessary for their fullest participation in a truly global effort.

Fifth, any response must be global. Emissions from developing countries are growing rapidly. Action by industrialized nations alone would be ineffective at restraining emissions. We must also be sensitive to the ways in which different commitment could affect the competitive position of both developing and industrialized nations. An effective response will require that all nations participate and meet obligations that are appropriate to their circumstances.

DOE strongly supports a comprehensive approach, one which considers all sources and sinks of all greenhouse gases, for a number of reasons. This approach provides the flexibility needed for each nation to address climate change in the context of its unique circumstances. A comprehensive approach also ensures that research and technology development address all facets of the problem. Further, a comprehensive approach will ensure that we take advantage of the most cost-effective opportunities to address climate change across the range of sources and sinks for all greenhouse gases. The comprehensive approach accounts for

6

all activities that emit or absorb greenhouse gases and avoids creating incentives that shift emissions from one type of gas or sector to another, as we know from experience can happen with narrowly focused approaches. A comprehensive approach would allow each nation the flexibility to choose its best mix of response measures. Accordingly, the framework convention, and any subsequent legal instruments, must be comprehensive and deal with the full array of greenhouse gases and their sources and sinks. In addition, the IPCC First Assessment Report notes that both limitation and adaptation must be considered as part of an integrated response.



EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

SPECIAL

February 26, 1991

LEGISLATIVE REFERRAL MEMORANDUM

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Additional
SUBJECT: EPA draft response to
questions from Congressman Waxman concerning Global
Climate

The Office of Management and Budget requests the views of your agency on the above subject before advising on its relationship to the program of the President, in accordance with OMB Circular A-19.

A response to this request for your views is needed no later than
10:00 A.M., WEDNESDAY, FEBRUARY 27, 1991.

Questions should be referred to Norm Hartness (395-6840).

Ronald K. Peterson

RONALD K. PETERSON FOR
Assistant Director for
Legislative Reference

Enclosures

cc: J. Hezir
H. Williamson

J. Holmstead
A. Fraas

A. Card

**Questions and Answers Submitted for the Record
by the United States Department of State
to the
Subcommittee on Health and the Environment,
Committee on Energy and Commerce,
United States House of Representatives**

Q: What is your Agency's view on the nature and severity of global climate change?

A: There appears to be a scientific consensus that a serious, long-term problem exists. Given that every natural system has its limits, continued emissions of GHGs at current levels will eventually disrupt the global climate system. However, it is not clear when this disruption will occur, nor what the specific impacts will be.

On the other hand, there does not appear to be a scientific consensus that climate change is already occurring. The warming that has occurred over the last 100 years is consistent both with the enhanced greenhouse effect and with natural variability.

Thus, climate change presents a long-term problem but the science does not warrant taking drastic, short-term actions that are not already justified for other reasons.

Q: What is your view regarding the importance of international action to address the climate change problem?

A: International action is absolutely essential if we are to better understand and effectively address climate change. No one nation, or small group of nations, can hope to address this issue effectively by acting alone.

Q: Provide a brief description of the developments at the recent Framework Convention on Climate Change in Washington, D.C. Please describe the U.S. role at the Framework Convention. Please provide your Agency's views of the likely next steps in the effort to reach an international agreement to address the climate problem.

A: For answers to these questions, see the testimony provided by Robert A. Reinstein, Deputy Assistant Secretary for Environment, Health and Natural Resources, on February 21.

02/25/91

11:53

202 647 0191

STATE OES/EGC

--- OMB

004/005

Q: Summarize the commitments and policies that other nations have adopted, or are planning to adopt, to reduce emission of greenhouse gases, CO₂ in particular. Include in this summary details of the actions and legal authorities adopted by each of the major industrialized nations.

A: A number of industrialized nations have made statements regarding targets and timetables for the stabilization or reduction of their emissions of CO₂. A description of these targets and timetables is attached.

These targets and timetables vary somewhat and, in some cases, appear to be evolving. Several countries have conditioned their targets on adoption of similar targets by other countries, determination of technological or economic feasibility, or achievement of other national goals, such as economic growth. A few targets will actually allow for continued growth in overall CO₂ emissions.

It appears that only a small minority of these nations have begun to identify specific actions for implementation of these targets. The implementing legislation and regulations that will be adopted to achieve these targets are also still not clear. Many of these nations are still conducting economic analyses of their targets and possible measures to achieve those targets.

All major CFC producers have also committed under the Montreal Protocol to phase-out production of ozone depleting substances, which also contribute to climate change. However, only three countries have set targets for any of the other greenhouse gases, such as methane. Moreover, no developing country, and only one Eastern European country, have set any emission targets. This is particularly significant in that these nations will account for over half of the greenhouse gas emissions by early in the next century.

02/25/91 11:53

202 647 0191

STATE OES/EGC

+++ OMB

005/005

Q: Please compare the actions and commitments of other nations with those of the United States.

A: The United States is already taking concrete measures that are justified in their own right which will result in net U.S. greenhouse gas emissions in the year 2000 being equal to or below the 1987 level. We believe that the U.S. approach has several strong advantages over the target and timetable approach adopted by other countries. First, the U.S. approach is based on concrete measures, not broad and qualified goals. In this sense, we have already begun to act whereas others are still considering what specific actions they might take. Second, the U.S. approach is comprehensive. If we truly desire to address the environmental challenges posed by climate change, we must look at all sources and sinks of all greenhouse gases, not just emissions of CO₂. Third, the U.S. approach is far-sighted and flexible. Rather than focus just on the next decade, we must develop the knowledge and technology necessary to devise responses that are appropriate, effective and sustainable over the long-term.

Q: Describe leading proposals for multilateral action to address the climate change problem, and please indicate nations supporting and nations opposing such proposals. Please indicate the U.S. position on each proposal.

A: While a number of suggestions have been made in various fora, no proposals have yet been officially made for inclusion in a framework convention on climate change. As pointed out in Mr. Reinstein's testimony given before the Subcommittee on February 21, discussions during the first negotiating session did not proceed past organizational and procedural issues, despite U.S. efforts. Since no proposals have been officially tabled, the negotiating parties have not officially indicated what specific proposals they would support or oppose.

The overall U.S. position is described in Mr. Reinstein's testimony. The position that the United States takes on specific proposals made in the context of the negotiations will have to be developed in light of the overall U.S. negotiating strategy.



United States Department of State

*Bureau of Oceans and International
Environmental and Scientific Affairs*

Washington, D.C. 20520

February 25, 1991

RAPIDFAX TRANSMISSION

4 Page to Follow

TO: PCC Working Group on Climate Change
(See following Distribution List)

FROM: OES/EGC - Jeff Miotke
Phone: (202)647-4069
Fax: (202)647-0191

SUBJECT: Q&A's for Waxman

During the February 21 hearing of the House Subcommittee on Health and Environment, Congressman Waxman asked for written answers to the questions raised in his letter calling for the hearing. He has asked for these answers by COB, Wednesday, so I must once again ask for your comments and clearance by COB today.

Thanks.

URGENT

PCC Working Group on Climate Change

AID, tel: 647--1827 fax: 647-3028,
Attn: **Jeff Schweitzer**

AID, tel: 875-4205, fax: 875-4394,
Attn: **Jack Vanderryn**

CEA, tel: 395-6982, fax: 395-6947,
Attn: **Howard Gruenspecht**

DOJ, tel: 514-2744, fax: 514-0557,
Attn: **Jonathan Wiener**

OMB, tel: 395-6840, fax: 395-6899,
Attn: **Norm Hartness**

DOE, tel: 586-2061, fax: 586-2062,
Attn: **Rick Bradley, Ted Williams**

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Attn: **Manny Barrera, Geoff Wolfe**

EPA, tel: 382-4034, fax: 252-0780,
Attn: **Richard Morgenstern, Alan
Hecht, Jack Fitzgerald**

NOAA, tel: 377-2151, fax: 377-8203,
Attn: **J.R. Spradley**

CEQ, tel: 395-5750, fax: 395-3744,
Attn: **John Elkind**

DOC/ITA, tel: 377-1466, fax: 377-8836,
Attn: **William Sugg, Ed Leviton**

NWS, tel: 427-7645, fax: 587-4524,
Attn: **Joseph Friday**

NOAA, tel: 673-5360, fax: 673-5355,
Attn: **Tom Magginis, Martin Yerg**

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Attn: **Tom Ballentine**

DOD, tel: 695-1370, fax: 697-3366,
Attn: **Morgan Rees**

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Attn: **Richard Williamson**

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Attn: **Denise Dwyer**

DOE, tel: 586-4259, fax: 586-5313,
Attn: **Mark Kerrigan**

DOI, tel: 208-4951, fax: 208-4867,
Attn: **Indur Glokany, John Scheffter**

EPA, tel: 475-8825, fax: 382-5605,
Attn: **Dennis Tirpak**

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Attn: **Truman Goins**

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Attn: **Beverly Fleischer**

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Attn: **Frances Li**

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Attn: **Eugene Bierly, Bob Corell**

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Attn: **Bob Watson, John Theon**

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Attn: **Michael Springer**

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Attn: **Courtney Tucker, Catherine Hung**

Treasury, tel: 566-2487, fax: 566-8066,
Attn: **Nelson Coar**

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Attn: **Gary Evans**

USDA, tel: 447-9805, fax: 472-5805,
Attn: **Norton Strommen**

USIA, tel: 619-4760, fax: 619-6520,
Attn: **Wendy Beaver**

USTR, tel: 395-6864, fax: 395-3911,
Attn: **William Bartley**

OSTP, tel: 456-6202, fax: 395-3719,
Attn: **Nancy Maynard, Vicki Sutton**

OSTP, tel: 456-6272, fax: 395-3261,
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Attn: **Jeff Holmsted**

White House, tel: 456-2533, fax:
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Attn: **Jack Schick, John Weiss**

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647-1106,
Attn: **Doroty Bergamaschi**

DOS/IO/SCT/T, tel: 647-2753, fax:
647-6510,
Attn: **Judith Buncher**

DOS/L/OES, tel: 647-2282, fax: 647-1037,
Attn: **Joan Donoghue**

**Questions and Answers Submitted for the Record
by the United States Department of State
to the
Subcommittee on Health and the Environment,
Committee on Energy and Commerce,
United States House of Representatives**

Q: What is your Agency's view on the nature and severity of global climate change?

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**United States Department of State**

*Bureau of Oceans and International
Environmental and Scientific Affairs*

Washington, D.C. 20520

February 20, 1991

RAPIDFAX TRANSMISSION

10 Page to Follow

TO: PCC Working Group on Climate Change
(See following Distribution List)

FROM: OES/EGC - Jeff Miotke
Phone: (202)647-4069
Fax: (202)647-0191

SUBJECT: Agenda for IPCC V Plenary

I am forwarding the annotated provisional agenda for the fifth plenary session of the Intergovernmental Panel on Climate Change, March 13-15 in Geneva. I am also forwarding a copy of Chairman Bolin's "Overview of the Next Tasks for the IPCC".



World Meteorological Organization
Organisation météorologique mondiale

Case postale N° 2300
1211 - GENEVA 2
SWITZERLAND

United Nations
Environment Programme

Programme des Nations Unies
pour l'Environnement

P.O.Box 30552 - Nairobi, Kenya



INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

INTERGOVERNMENTAL PANEL
ON CLIMATE CHANGE
FIFTH SESSION

GENEVA, 13-15 MARCH 1991

IPCC-V/Doc. 1

(25.I.1991)

Original: ENGLISH

ANNOTATED PROVISIONAL AGENDA

Delegates can register on Tuesday, 12 March 1991, between 15.00 and 17.00 hours at the reception desk of the WMO Secretariat Building, 41, avenue Giuseppe Motta, and on Wednesday, 13 March 1991, at 08.00 hours, outside Salle XVI at the Palais des Nations.

It is requested that written summaries of all presentations and remarks at the session be given to the IPCC Secretary immediately after such interventions. While such summaries may not be included as part of the report of the session, they would be of immense help in the timely production of the report.

IPCC-V/Doc. 1, p. 2

1. OPENING OF THE SESSION

The IPCC Chairman, Prof. B. Bolin, will open the session at 09.30 hours on Wednesday, 13 March 1991, in Salle XVI of the Palais Nations, Geneva.

- 1.1 Opening remarks by Prof. Bolin
- 1.2 Opening remarks by Prof. G.O.P. Obasi, the Secretary-General of the World Meteorological Organization (WMO)
- 1.3 Opening remarks by Dr. M.K. Tolba, the Executive Director of the United Nations Environment Programme (UNEP).

1.4 Approval of the annotated provisional agenda

The annotated provisional agenda will be submitted for approval; it may be amended at any time during the session. Delegations may wish to take the opportunity to introduce other items for consideration, under agenda item 4 (OTHER BUSINESS) or otherwise.

1.5 Programme of work of the session

Under this item, the Panel may wish to examine the following questions relating to the organization of the session.

a) Working hours of the session.

It is suggested that the hours be from 09.30 to 12.30 hours for the morning, and from 14.30 to 17.30 hours for the afternoon meetings respectively, with appropriate tea/coffee breaks.

b) Tentative programme of work for the session.

It may be noted that simultaneous interpretation in English, French, Russian and Spanish will be provided during the plenary meetings, but not at other times. All documentation prepared before and during the session, other than the annotated provisional agenda, will be in, and available only in, English. The report of the session will be available in French, Russian and Spanish at a later date.

It is suggested that decisions of the Panel be arrived at by consensus following the practice of past IPCC sessions.

2. IPCC WORK PROGRAMME FOR 1991 AND BEYOND

The Chairman will summarize the relevant WMO and UNEP decisions and the implications for IPCC of the results of the first session of the Intergovernmental Negotiating Committee on the Framework Convention on Climate Change (Washington D.C., 4-14 February 1991).

IPCC-V/Doc. 1, p. 3

He will introduce the following 5 topic areas for the consideration of the Panel:

- 2.1 How to assess national greenhouse gases emissions?
- 2.2 Predictions of the regional distributions of climate change and associated impact studies.
- 2.3 Energy-related issues, including the Noordwijk remits.
- 2.4 Forestry-related issues, including the Noordwijk remits.
- 2.5 Selected studies of the economic implications of climate change.

The Panel may wish to propose other topic areas.

It may be recalled that the Noordwijk Declaration had, inter alia, referred these remits to IPCC:

- (i) the necessity and efficiency of the concept of CO₂ equivalence (para 10),
- (ii) investigation of quantitative targets to limit or reduce greenhouse gases emissions (paras 15 and 16),
- (iii) feasibility of achieving a world net forest growth of 12 million hectares a year by the beginning of the next century (para 21).

The Chairman will invite the following Organizations to comment on their activities in relation to agenda items 2.1 through 2.5. Please note the list is not an all-inclusive list, nor will the presentations be invited in the order mentioned below:

FAO, IAEA, IEA, IIASA, ITTO, OECD, SEI, TERI, WEC, WRI.

The Chairman will invite the Panel to discuss its work programme and implementation plan in light of the above.

3. IPCC BUDGET AND OTHER SUPPORT

The Chairman may call upon the IPCC Secretary to present the budget request for 1991 and 1992 for the consideration of the Panel.

4. OTHER BUSINESS

5. ADOPTION OF THE REPORT OF THE SESSION

The Panel may wish to authorize the Chairman to finalize and approve the report on its behalf before distribution.

6. CLOSURE OF THE SESSION

The fifth session of the IPCC is expected to close in the afternoon of Friday, 15 March 1991.

The Chairman's Overview
of the Next Tasks for the IPCC

To be discussed at the IPCC Plenary Meeting

13-15 March 1991

The fifth IPCC plenary session will take place in Geneva on 13-15 March 1991. The objective of the meeting was tentatively discussed in October last year at an ad hoc meeting between those members of the Bureau that participated in the Second World Climate Conference. I outlined on that occasion in general terms my view on this matter and a preliminary agenda was sketched, which in principle found the approval of those that took part in the meeting. Since then I have on several occasions been in contact with the chairmen of the three Working Groups and also with other members of the IPCC. As a basis and starting point for the deliberations at the next IPCC session I will outline below in some more detail my view with regard to the present tasks of the IPCC and its continued work.

The IPCC report is available and has been extensively discussed at the Second World Climate Conference. A series of recommendations were agreed upon on this occasion.

The full reports of the three working groups have also become commercially available through the initiatives of IPCC supporting national secretariats to the three Working Groups, i.e. the UK, Australia and the US respectively. It is hoped that a printed booklet containing the IPCC overview, the policy-makers summaries of the three Working Group reports and the report by the Special Committee on the Participation of Developing Countries will also appear soon.

The report was the subject for lengthy discussions at the United Nations in November and December 1990 and a resolution on the status of the negotiations and the role of the UN was adopted, a copy of which is appended to this circular letter. It is clear that the IPCC report will serve as the basis for the negotiations that begin February 4, 1991 in Washington DC.

The three Working Group reports and particularly the policymakers summaries were prepared with great care. For example, the full report of Working Group I was reviewed by a large number of external reviewers from all over the world and the comments received were largely included in the final version. During the 8-10 months that have passed since the three working groups met for adoption of their respective reports, research and analyses of the subject matter has continued and as a matter of fact attracted an increasing number of researchers. New findings have been reported. It should be emphasized however, that care should be exercised before the IPCC conclusions are modified.

The IPCC should of course assist the negotiators as far as is possible and central issues that arise in the course of the negotiations should be referred back to the Working Groups for consideration. If such issues arise already at the first session in February this year the IPCC should attempt to take steps at the IPCC meeting in March and respond. Hopefully some small task group, particularly if Working Groups I and/or II is concerned, could be created to do the necessary analyses, but generally it will be difficult to complete more extensive studies that could serve in the context of the present round of negotiations being aimed at an agreement on a convention at the UNCED in Brazil, June 1992. Also, statements in the policymakers summaries might in some cases call for further interpretation. I propose that the IPCC Chairman and the three Working Group Chairmen and the Chairman of the Special Committee be given the responsibility to handle such matters. In some cases the issue may be delegated to a small group in one or the other of the Working Groups under its Chairmen or some of the Vice Chairmen that he wishes to call on.

It is clear that the first round of negotiations that will be conducted during the period until the UNCED in 1992 can only be the first steps towards resolving the climate change issue. We must be looking forward to a process which will evolve during decades. It is important that the fact-finding task that has been given to IPCC continues after the 1992 conference. The IPCC should now plan accordingly.

In my judgement, it does not seem desirable to attempt now another major assessment of the kind that was concluded in 1990. I can imagine that this maybe required in a few years time for example to be completed in 1994 or 1995, i.e. four to five years after the adoption of the first IPCC report. I do not think, however, that the three Working Groups should be dissolved, but rather be requested to follow the ongoing developments in respective fields and initiate assessments of specific issues as judged to be required. As a matter of fact the different groups have submitted proposals of this kind to the fourth IPCC plenary meeting but no time was available to discuss these tasks at Sundsvall. I propose that the IPCC discuss this matter and adopt a policy accordingly.

It is, however, obvious that there are several specific issues that soon are going to be important in the negotiating process, perhaps before June 1992, certainly soon thereafter. Further, several of these concern more than one of the working groups. The IPCC must accordingly foster closest possible collaboration between the Working Groups. Of course all countries are free to take part in the work of all the Working Groups, but it is important that also the scientists and experts from the various fields of relevance will be collaborating closely. I propose that the IPCC discuss this matter and adopt a clear policy.

On the basis of the IPCC deliberations so far and the ad hoc meeting of members of the Bureau in October last year I consider the following tasks to be of particular importance at present.

1. The establishment of a procedure aimed at reaching agreement of the magnitude of present annual emission of greenhouse gases from the countries of the world. The issue requires experts from all three working group areas of responsibility.

Many attempts to assess regional and national man-induced emissions have been made during the last few years. The figures that have appeared in the literature on CO₂ emissions due to fossil fuel burning and emissions of the different CFC-gases show reasonable agreement. This is, however, not the case with regard to CO₂ emissions from deforestation and changing land use, methane and nitrous oxide emission and the possible changes of ozone concentrations due to increased air pollution. I think that emissions of the latter group of gases at present hardly can serve as a basis for a more conclusive discussion because of the controversies that almost certainly would arise in the absence of sufficiently plentiful and accurate data. There is further a need to reach agreement on a precise terminology and to develop a satisfactory methodology for the required assessments in order to make national data truly comparable. The OECD has taken an initiative to analyse the problem more thoroughly and has called for an expert meeting in February 1991. I propose that IPCC discuss this matter and agree on a procedure to be followed.

2. The need for improved regional climate predictions and impact assessments.

It became very clear in the assessment process during the last two years that it is difficult to arrive at quantitative regional and even more so local impact assessment. The results are very uncertain due to uncertain regional predictions of climate change. This will certainly also be so for several years to come. It should first of all be made clear that regional climate changes to some degree are unpredictable. First of all climate has varied during past centuries in spite of the fact that the greenhouse gas concentrations in the atmosphere have remained approximately constant. An example is the Little Ice Age that began in late medieval times and ended a couple of hundred years ago. Further, climate variations have not been the same in different parts of the globe. For example, the temperature in North Polar regions declined from about 1940 well into the 1970's, while some increase simultaneously was observed in other parts of the world. The global average temperature remained about unchanged during this period of time.

We do not know the reason for these variations, nor the extent to which they may be stochastic (due to random variations of the weather on smaller time and space scales). It should be possible to obtain a better understanding of the predictability of climate. Some, even rather general analyses of this problem would obviously be of great political importance.

Still, the pursuit of developing better climate models should obviously be given increased attention and more resources. Some predictability most likely can be developed if we can understand better how the features of the land surface and the oceans influence climate conditions on earth. Finally special attention should of course be given to the problem of how prediction can be validated before changes actually will occur.

There is a need for climate impact analysts to appreciate better the characteristics and reliability of climate predictions on a regional scale as well as their statistical interpretation, and vice versa for climate modellers to understand the kind of climate data that are needed by people in agriculture and forestry.

It is important to develop the prediction capability to the extent possible and to validate climate models with the aid of observed changes of climate as they presumably gradually will become noticeable.

I propose that this matter be discussed by the IPCC and that some action programme be agreed upon.

3. The acquisition of better data and improved knowledge about the role of forestry for greenhouse gas emissions and for the development of an international forest policy.

Much work has been done, particularly by FAO and ITTO (International Tropical Timber Organization), to find ways and means to establish sustainable forest management practices both in order to maintain the forests as a source base and to preserve biodiversity. Because of the similar needs for IPCC and these two organizations (and perhaps for other governmental as well as non-governmental organizations), more joint efforts are desirable in the future. Work is going on to prepare this issue for the UNCED.

Further, recent analyses of the carbon cycle reveal that middle and high northern latitude forests may have been a significant carbon sink during the last half century. It is not understood in which way this could have been brought about. The role of the forest soils may, for example, not have been adequately accounted for. Further there will be a number of issues that need attention in coming years.

I propose that IPCC discuss this matter and decide on proper actions. The FAO and ITTO are being invited to present their views on these issues and to prepare short written summaries on the present state of their work. The issue concerns all three Working Groups.

4. Energy policy and greenhouse gases

The EIS subgroup of Working Group III has been extensively concerned with the problem of the future energy supply in the world. This issue is undoubtedly a most central one for the development of a policy for reduced CO₂ emission. There are many other international organizations and also non-governmental organizations that have engaged themselves for analysis of this problem. With the central role that the IPCC has been asked to play in this context, i.e. to provide a factual basis for the negotiation process, it is important that IPCC can bring together the different views that have been put forward in as clear a way as possible. The role of nuclear energy as a possible alternative energy source is obvious, but some advocate that renewable sources of energy, above all solar energy in the long term must be considered as a likely major source to be more efficiently exploited for continuous use. The further consideration of this issue requires a more penetrative analysis of the very different possibilities that different countries have in their development of sustainable energy supply systems.

The following international organizations have been asked to contribute: The International Energy Agency (IAE), the World Bank, the Asian Development Bank (ADB), the OECD and also the non-governmental organizations: the World Energy Council, the World Resources Institute, the Stockholm Environmental Institute and a few more are being considered.

I propose that IPCC discuss and decide how the further analysis of this problem should be dealt with to take advantage of ongoing work by these and possible other organizations. The task is one that primarily falls within the field of responsibility of Working Group III. It is, however, important to collaborate with scientists of Working Group I with regard to the possible development of alternative scenarios. Also the analysis of the exploration of biomass and biogas means calling on expertise outside the traditional energy sector. Clearly the development of energy policies requires analysis of the potential costs for alternative sources of energy and their likely change with time (see item 5 below) and particularly with consideration of the marked differences between nations. It is proposed that technical matters as sketched above first be subject for a discussion.

5. Costs and benefits for alternative energy strategies:
economic analysis of global change.

This subject matter is again primarily in the purview of Working Group III. In the light of the increasing emphasis that is being given to this aspect of the global warming issue, it is, however, important to bring it up in the IPCC plenary session at this time for consideration of a broad pursuit of its further analysis. It has also been the subject for analysis by several other international governmental as well as non-governmental organizations. Although it is important to consider the role of the market forces for the optimization of possible necessary changes in for example the energy systems in different countries, the relatively easy access to fossil fuels implies that also other means for achieving the changes that are desirable from an environmental point of view will have to be used. Thorough analyses of different options are required and the IPCC should consider ways and means to achieve this in collaboration with other appropriate international bodies and experts. Those listed under item 4 are invited to contribute also to this item of the IPCC agenda.

* * *

There may be other issues that at present deserve the special attention of the IPCC. National delegates are of course free to propose such issues to be dealt with by IPCC or by one or the other of the working groups. The Working Group Chairmen are particularly asked to consider such items on the lists of proposed activities within the working groups that possibly should be discussed in the IPCC plenary session.

It is further proposed that a period of 12 to 18 months be devoted to such analysis in order for them to be presented to IPCC in late 1992 or early 1993. Together with other studies by the working groups these could possibly serve as a starting point for renewed policy discussions in IPCC. The special efforts that would be initiated in this way could be viewed as the formation of special task groups of limited duration that could be dissolved at the time of completion of their tasks. The method of work might be viewed as similar to the one employed by Working Group I during 1989-90 but given more time than was available during the first IPCC assessment.

I hope that this overview can serve as a basis for national delegations to the IPCC to prepare themselves for the next plenary meeting of the IPCC.

Bert Bolin
Chairman of IPCC
Stockholm, 31 January 1991



United States Department of State

*Bureau of Oceans and International
Environmental and Scientific Affairs*

Washington, D.C. 20520

*conducted at 3:20 p.m.
2/20/91*

February 20, 1991

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TO: PCC Working Group on Climate Change
(See following Distribution List)

FROM: OES/EGC - Jeff Miotke
Phone: (202) 647-4069,
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SUBJECT: Q&As for hearings on climate change

I am forwarding you the latest version of Q&As for Bob's appearances on the Hill. Please note that the first and fifth Q&As have been changed significantly and that the last two Q&As are new.

I need your comments and clearance by COB today, since the hearing is tomorrow. Thanks.

PCC Working Group on Climate Change

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- 1 -

**Q&As for
ROBERT A. REINSTEIN
before the
Subcommittee on Health and the Environment,
Committee on Energy and Commerce,
United States House of Representatives
February 21, 1991
and the
Subcommittee on Environmental Protection,
Committee on Environment and Public Works,
United States Senate
March 5, 1991**

Q: What is your view on the nature and severity of global climate change?

A: A NUMBER OF SCIENTIFIC STUDIES HAVE BEEN CONDUCTED ON POSSIBLE CHANGES IN THE GLOBAL CLIMATE. ONE OF THE MOST COMPREHENSIVE ASSESSMENTS WAS DONE BY THE UN-MANDATED INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE. IN ITS FIRST ASSESSMENT REPORT, THE IPCC STATED THAT EMISSIONS RESULTING FROM HUMAN ACTIVITIES WILL RESULT, ON AVERAGE, IN AN ADDITIONAL WARMING OF THE EARTH'S SURFACE. THE IPCC ALSO NOTED THAT SIGNIFICANT UNCERTAINTY REMAINS REGARDING THE TIMING, MAGNITUDE AND REGIONAL DISTRIBUTION OF CLIMATE CHANGE.

ALTHOUGH THE IPCC INDICATED THAT THESE CHANGES COULD HAVE SIGNIFICANT IMPACTS, PARTICULARLY ON AREAS ALREADY UNDER STRESS, OUR CONFIDENCE REGARDING THE IMPACTS OF CLIMATE CHANGE IS LOW. THIS LACK OF CONFIDENCE STEMS IN PART FROM THE UNCERTAINTIES REGARDING REGIONAL CLIMATE CHANGE BUT ALSO FROM OUR INCOMPLETE UNDERSTANDING OF THE COMBINED EFFECTS OF CLIMATE CHANGE AND CO₂ ON AGRICULTURE, VEGETATION GROWTH AND OTHER FACTORS.

Q: What is your view regarding the importance of international action to address the climate change problem?

A: INTERNATIONAL ACTION IS ABSOLUTELY ESSENTIAL IF WE ARE TO BETTER UNDERSTAND AND EFFECTIVELY ADDRESS CLIMATE CHANGE. NO ONE NATION, OR SMALL GROUP OF NATIONS, CAN HOPE TO ADDRESS THIS ISSUE EFFECTIVELY BY ACTING ALONE, PARTICULARLY OVER THE LONG TERM. FOR INSTANCE, SIGNALLING THAT THE INDUSTRIALIZED COUNTRIES CAN ADDRESS THIS ISSUE ALONE, AS IMPLIED IN PROPOSALS TO SET CO₂ TARGETS AND TIMETABLES, WOULD BE MISLEADING AND COULD DELAY THE CONCERTED GLOBAL RESPONSE THAT IS NEEDED. ACCORDINGLY, THE UNITED STATES FIRMLY BELIEVES THAT AN EFFECTIVE RESPONSE TO CLIMATE CHANGE MUST BE GLOBAL.

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Q: Summarize the commitments and policies that other nations have adopted, or are planning to adopt, to reduce emission of GHGs, CO₂ in particular.

A: MANY OTHER INDUSTRIALIZED NATIONS HAVE ANNOUNCED THEIR INTENTION TO STABILIZE CO₂ EMISSIONS BY THE TURN OF THE CENTURY. A FEW OF THESE, LIKE AUSTRIA, AUSTRALIA, DENMARK, GERMANY AND NEW ZEALAND, HAVE STATED FURTHER THAT THEY HOPE TO REDUCE CO₂ EMISSIONS BY THE YEAR 2005. THE BASELINE YEAR USED VARIES SOMEWHAT BETWEEN COUNTRIES. SOME OF THESE NATIONS, SUCH AS FRANCE AND JAPAN, HAVE ADOPTED PER CAPITA TARGETS THAT ALLOW FOR CONTINUED GROWTH IN THEIR OVERALL EMISSIONS. ALL MAJOR CFC PRODUCERS HAVE ALSO COMMITTED UNDER THE MONTREAL PROTOCOL TO PHASE-OUT THEIR PRODUCTION OF OZONE DEPLETING SUBSTANCES, WHICH ALSO CONTRIBUTE TO CLIMATE CHANGE.

HOWEVER, WITH THE EXCEPTION OF AUSTRALIA, ICELAND AND CANADA, NONE OF THESE COUNTRIES HAS SET QUANTIFIED EMISSION TARGETS FOR ANY OF THE OTHER GREENHOUSE GASES, SUCH AS METHANE, OR FOR TOTAL GLOBAL WARMING POTENTIAL. MEETING THEIR CO₂ TARGETS COULD STILL ALLOW AN INCREASE IN EMISSIONS OF METHANE AND OTHER GREENHOUSE GASES MORE POTENT THAN CO₂. MOREOVER, NO DEVELOPING OR EASTERN EUROPEAN NATION, OTHER THAN POLAND, HAS SET ANY EMISSION TARGETS. THIS IS PARTICULARLY SIGNIFICANT IN THAT THESE COUNTRIES WILL PROBABLY ACCOUNT FOR OVER HALF OF THE GREENHOUSE GAS EMISSIONS BY EARLY IN THE NEXT CENTURY.

Q: Summarize the actions and legal authorities adopted by the major industrialized nations to implement these targets and timetables.

A: ALTHOUGH A FEW NATIONS, LIKE THE NETHERLANDS, DENMARK, AND GERMANY, HAVE PREPARED PLANS FOR ACHIEVING THESE TARGETS, MOST ARE NOW CONSIDERING HOW THEY MIGHT BE ABLE TO REACH THESE GOALS. WE UNDERSTAND THAT IMPLEMENTING THESE GOALS IS GENERATING SOME DEBATE IN A FEW OF THESE COUNTRIES. MANY ARE STILL PERFORMING ECONOMIC ANALYSES OF THEIR TARGETS AND POSSIBLE MEASURES TO ACHIEVE THOSE TARGETS. FINALLY, A NUMBER HAVE QUALIFIED THEIR TARGETS, FOR EXAMPLE, BY STATING THAT THEIR ACTIONS DEPEND ON OTHER NATIONS ADOPTING SIMILAR TARGETS, THAT THEIR TARGETS ARE "INTERIM" OR FOR PLANNING PURPOSES, OR THAT THEIR EFFORTS WILL NOT BE ALLOWED TO INTERFERE WITH THEIR ECONOMIC GOALS.

- 3 -

Q: If the United States will hold its emissions stable through the turn of the century, why are we reluctant to commit to a CO2 target?

A: THERE ARE A NUMBER OF REASONS WHY A CO2 TARGET IS INAPPROPRIATE:

- FIRST, WE BELIEVE A COMPREHENSIVE APPROACH, ADDRESSING THE SOURCES AND SINKS OF ALL GREENHOUSE GASES, PROVIDES THE SOUNDEST BASIS FOR INTERNATIONAL ACTIONS. CONCENTRATING ON JUST ONE GREENHOUSE GAS IGNORES THE POSSIBILITY OF OTHER, MORE COST-EFFECTIVE RESPONSES AIMED AT OTHER GREENHOUSE GASES. THE FOCUS OF ENVIRONMENTAL CONCERN SHOULD BE THE NET EFFECT ON RADIATIVE FORCING, NOT EMISSIONS OF ANY ONE GAS. IN FACT, CO₂ IS THE WEAKEST GREENHOUSE GAS PER KILOGRAM.
- SECOND, FOCUSING NARROWLY ON CO2 COULD UNINTENTIONALLY INCREASE EMISSIONS OF OTHER GREENHOUSE GASES. FOR EXAMPLE, AN EARLY RESPONSE TO A CO₂ TARGET WOULD BE FUEL-SWITCHING FROM COAL TO NATURAL GAS. THIS WOULD REDUCE CO₂ EMISSIONS BUT INCREASE METHANE EMISSIONS FROM DISTRIBUTION LEAKS OF NATURAL GAS. METHANE IS A MUCH MORE POTENT GREENHOUSE GAS THAN CO₂ AND EVEN SMALL METHANE LEAKS CAN OFFSET LARGE CO₂ REDUCTIONS. THIS PROBLEM COULD BE IMPORTANT IN MANY NATIONS.
- THIRD, ANY RESPONSE TO CLIMATE CHANGE MUST BE GLOBAL IF IT IS TO BE EFFECTIVE. MOST PROPOSALS REGARDING A CO₂ TARGET WOULD IMPOSE THE TARGET ON INDUSTRIALIZED COUNTRIES IMMEDIATELY BUT DELAY ITS APPLICATION TO DEVELOPING COUNTRIES. YET EMISSIONS ARE GROWING MUCH FASTER IN THE DEVELOPING WORLD. IMPOSING RESTRICTIONS ONLY ON INDUSTRIALIZED NATIONS IS LIKELY TO BE UNDERCUT BY THE RELOCATION OF EMISSIONS-INTENSIVE ACTIVITIES TO OTHER COUNTRIES.
- FOURTH, IMPOSITION OF RESTRICTIONS ON A FEW NATIONS COULD CAUSE SIGNIFICANT DISTORTIONS IN THE INTERNATIONAL COMPETITIVENESS OF THOSE NATIONS.
- FIFTH, THE ECONOMIC CONSEQUENCES OF SUCH TARGETS ARE EXTREMELY UNCERTAIN. PROJECTIONS OF EMISSIONS ARE HEAVILY DEPENDENT ON EXPECTED GROWTH RATES. SHOULD ECONOMIC GROWTH PROVE TO BE FASTER THAN EXPECTED, EMISSIONS WILL PROBABLY ALSO GROW FASTER THAN EXPECTED AND MEETING A TARGET COULD PROVE TO BE PROHIBITIVELY EXPENSIVE, WITH POTENTIALLY SERIOUS CONSEQUENCES FOR THE WORLD ECONOMY, INCLUDING THE DEVELOPMENT ASPIRATIONS OF DEVELOPING COUNTRIES.
- SIXTH, CLIMATE CHANGE WILL OCCUR OVER THE LONG TERM. ANY RESPONSE MUST BE SUSTAINABLE OVER THE LONG TERM AND ENCOURAGE ALL NATIONS TO DEVELOP PLANS OF ACTION THAT WILL CARRY US BEYOND THE TURN OF THE CENTURY. MOST TARGETS AND TIMETABLES, HOWEVER, FOCUS ONLY ON THE NEXT TEN TO FIFTEEN YEARS.

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- SEVENTH, THE ENVIRONMENTAL BENEFITS OF SUCH TARGETS ARE UNKNOWN BECAUSE OF SCIENTIFIC UNCERTAINTIES ABOUT THE STRENGTH, RATE, AND TIMING OF CLIMATE CHANGE FROM A GIVEN CHANGE IN GREENHOUSE GAS EMISSIONS. GIVEN SUCH UNCERTAINTIES, WE BELIEVE A FLEXIBLE APPROACH WHICH FOCUSES INITIALLY ON ACTIONS JUSTIFIED FOR OTHER REASONS IS PRUDENT.
- FINALLY, RIGIDLY IMPOSING IDENTICAL OBLIGATIONS DOES NOT ADEQUATELY RECOGNIZE THE DIVERSITY OF NATIONAL CIRCUMSTANCES. WE MUST INSTEAD SEEK WAYS TO BUILD ON THE UNIQUE STRENGTHS OF INDIVIDUAL NATIONS IN DEVISING THE INTERNATIONAL RESPONSE TO CLIMATE CHANGE.

Q: You mentioned that the United States had hoped to develop a draft negotiating text during the first session. Has the Administration developed or circulated its own draft convention?

A: NO. PRIOR TO THE FIRST SESSION, HOWEVER, THE BRITISH DEVELOPED A STRAW-MAN DRAFT CONVENTION. HAD THE DISCUSSIONS PROCEEDED PAST PROCEDURAL MATTERS, WE WERE PREPARED TO PROVIDE DETAILED COMMENTS ON THE UK DRAFT. OUR COMMENTS WOULD HAVE CLEARLY INDICATED THE TYPE OF CONVENTION WHICH WE ARE SEEKING.

Q: Do you plan to circulate a draft convention prior to or during the next round of negotiations?

A: AT THE END OF THE FIRST SESSION, THE CHAIRMAN OF THE NEGOTIATIONS SOLICITED NON-PAPERS FROM THE NEGOTIATING PARTIES REGARDING POSSIBLE CONTENTS OF THE CONVENTION. THE NEGOTIATIONS SECRETARIAT WILL COPY AND CIRCULATE THESE NON-PAPERS FOR CONSIDERATION BY THE PARTIES PRIOR TO THE NEXT SESSION. WHILE WE DO NOT PLAN TO CIRCULATE A DRAFT TEXT, WE WILL TAKE ADVANTAGE OF THIS OPPORTUNITY TO PROVIDE FURTHER DESCRIPTION OF THE KEY ELEMENTS WHICH WE WOULD WANT INCLUDED IN THE FRAMEWORK CONVENTION.

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London Economic Summit 1991

ECONOMIC DECLARATION

BUILDING WORLD PARTNERSHIP

1. We, the Heads of State and Government of the seven major industrial democracies and the representatives of the European Community, met in London for our seventeenth annual Summit.

2. The spread of freedom and democracy which we celebrated at Houston has gathered pace over the last year. Together the international community has overcome a major threat to world peace in the Gulf. But new challenges and new opportunities confront us.

3. We seek to build world partnership, based on common values, and to strengthen the international order. Our aim is to underpin democracy, human rights, the rule of law and sound economic management, which together provide the key to prosperity. To achieve this aim, we will promote a truly multilateral system, which is secure and adaptable and in which responsibility is shared widely and equitably. Central to our aim is the need for a stronger, more effective UN system, and for greater attention to the proliferation and transfer of weapons.

Economic policy

4. Over the last year, some of our economies have maintained good growth, while most have slowed down and some gone into recession. But a global recession has been avoided. The uncertainty created by the Gulf crisis is behind us. We welcome the fact that there are now increasing signs of economic recovery. Progress has been made too in reducing the largest trade and current account imbalances.

5. Our shared objectives are a sustained recovery and price stability. To this end, we are determined to maintain, including through our economic policy coordination process, the medium-term strategy endorsed by earlier Summits. This strategy has contained inflationary expectations and created the conditions for sustainable growth and new jobs.

6. We therefore commit ourselves to implement fiscal and monetary policies, which, while reflecting the different situations in our countries, provide the basis for lower real interest rates. In this connection, continued progress in reducing budget deficits is essential. This, together with the efforts being made to reduce impediments to private saving, will help generate the increase in global savings needed to meet demands for investment. We also welcome the close cooperation on exchange markets and the work to improve the functioning of the international monetary system.

7. We will also, with the help of the Organisation for Economic Co-operation and Development (OECD) and other institutions, pursue reforms to improve economic efficiency and thus the potential for growth. These include:-

a) greater competition in our economies, including regulatory reform. This can enhance consumer choice, reduce prices and ease burdens on business.

b) greater transparency, elimination or enhanced discipline in subsidies that have distorting effects, since such subsidies lead to inefficient allocation of resources and inflate public expenditure.

c) improved education and training, to enhance the skills and improve the opportunities of those both in and out of employment, as well as policies contributing to greater flexibility in the employment system.

d) a more efficient public sector, for example through higher standards of management and including possibilities for privatisation and contracting out.

e) the wide and rapid diffusion of advances in science and technology.

f) essential investment, both private and public, in infrastructure.

8. We will encourage work nationally and internationally to develop cost-effective economic instruments for protecting the environment, such as taxes, charges and tradeable permits.

International trade

9. No issue has more far-reaching implications for the future prospects of the world economy than the successful conclusion of the Uruguay Round. It will stimulate non-inflationary growth by bolstering confidence, reversing protectionism and increasing trade flows. It will be essential to encourage the integration of developing countries and Central and East European nations into the multilateral trading system. All these benefits will be lost if we cannot conclude the Round.

10. We therefore commit ourselves to an ambitious, global and balanced package of results from the Round, with the widest possible participation by both developed and developing countries. The aim of all contracting parties should be to complete the Round before the end of 1991. We shall each remain personally involved in this process, ready to intervene with one another if differences can only be resolved at the highest level.

11. To achieve our objectives, sustained progress will be needed in the negotiations at Geneva in all areas over the rest of this year. The principal requirement is to move forward urgently in the following areas taken together:-

a) market access, where it is necessary, in particular, to cut tariff peaks for some products while moving to zero tariffs for others, as part of a substantial reduction of tariffs and parallel action against non-tariff barriers.

b) agriculture, where a framework must be decided upon to provide for specific binding commitments in domestic support, market access and export competition, so that substantial progressive reductions of support and protection may be agreed in each area, taking into account non-trade concerns.

c) services, where accord on a general agreement on trade in services should be reinforced by substantial and binding initial commitments to reduce or remove existing restrictions on services trade and not to impose new ones.

(d) intellectual property, where clear and enforceable rules and obligations to protect all property rights are necessary to encourage investment and the spread of technology.

12. Progress on these issues will encourage final agreement in areas already close to conclusion, such as textiles, tropical products, safeguards and dispute settlement. Agreement to an improved dispute settlement mechanism should lead to a commitment to operate only under the multilateral rules. Taken all together, these and the other elements of the negotiations, including GATT rule-making, should amount to the substantial, wide-ranging package which we seek.

13. We will seek to ensure that regional integration is compatible with the multilateral trading system.

14. As we noted at Houston, a successful outcome of the Uruguay Round will also call for the institutional reinforcement of the multilateral trading system. The concept of an international trade organisation should be addressed in

this context.

15. Open markets help to create the resources needed to protect the environment. We therefore commend the OECD's pioneering work in ensuring that trade and environment policies are mutually supporting. We look to the General Agreement on Tariffs and Trade (GATT) to define how trade measures can properly be used for environmental purposes.

16. We are convinced that OECD members must overcome in the near future and, in any case, by the end of the year, remaining obstacles to an agreement on reducing the distortions that result from the use of subsidised export credits and of tied aid credits. We welcome the initiative of the OECD in studying export credit premium systems and structures and look forward to an early report.

Energy

17. As the Gulf crisis showed, the supply and price of oil remain vulnerable to political shocks, which disturb the world economy. But these shocks have been contained by the effective operation of the market, by the welcome increase in supplies by certain oil-exporting countries and by the actions co-ordinated by the International Energy Agency (IEA), particularly the use of stocks. We are committed to strengthen the IEA's emergency preparedness and its supporting measures. Since the crisis has led to improved relations between producers and consumers, contacts among all market participants could be further developed to promote communication, transparency and the efficient working of market forces.

18. We will work to secure stable worldwide energy supplies, to remove barriers to energy trade and investment, to encourage high environmental and safety standards and to promote international cooperation on research and development in all these areas. We will also seek to improve energy efficiency and to price energy from all sources so as to reflect costs fully, including environmental costs.

19. In this context, nuclear power generation contributes to diversifying energy sources and reducing greenhouse gas emissions. In developing nuclear power as an economic energy source, it is essential to achieve and maintain the highest available standards of safety, including in waste management, and to encourage co-operation to this end throughout the world. The safety situation in Central and Eastern Europe and the Soviet Union deserves particular attention. This is an urgent problem and we call upon the international community to develop an effective means of coordinating its response.

20. The commercial development of renewable energy sources and their integration with general energy systems should also be encouraged, because of the advantages these sources offer for environmental protection and energy security.

21. We all intend to take a full part in the initiative of the European Community for the establishment of a European Energy Charter on the basis of equal rights and obligations of signatory countries. The aim is to promote free and undistorted energy trade, to enhance security of supply, to protect the environment and to assist economic reform in Central and East European countries and the Soviet Union, especially by creating an open, non-discriminatory regime for commercial energy investment.

Central and Eastern Europe

22. We salute the courage and determination of the countries of Central and Eastern Europe in building democracy and moving to market economies, despite formidable obstacles. We welcome the spread of political and economic reform throughout the region. These changes are of great historical importance. Bulgaria and Romania are now following the pioneering advances of Poland, Hungary and Czechoslovakia. Albania is emerging from its long isolation.

23. Recognising that successful reform depends principally on the continuing efforts of the countries concerned, we renew our own firm commitment to support their reform efforts, to forge closer ties with them and to encourage their integration into the international economic system. Regional initiatives reinforce our ability to co-operate.

24. All the Central and East European countries except Albania are now members of the International Monetary Fund (IMF) and the World Bank. We welcome the steps being taken by those countries that are implementing IMF-supported programmes of macro-economic stabilisation. It is crucial that these programmes are complemented by structural reforms, such as privatising and restructuring state-owned enterprises, increasing competition and strengthening property rights. We welcome the establishment of the European Bank for Reconstruction and Development (EBRD), which has a mandate to foster the transition to open, market-oriented economies and to promote private initiative in Central and East European countries committed to democracy.

25. A favourable environment for private investment, both foreign and domestic, is crucial for sustained growth and for avoiding dependence on external assistance from governments. In this respect, technical assistance from our private sectors and governments, the European Community and international institutions should concentrate on helping this essential market-based transformation. In this context, we emphasise the importance of integrating environmental considerations into the economic restructuring process in Central and Eastern Europe.

26. Expanding markets for their exports are vital for the Central and East European countries. We welcome the

substantial increases already made in exports to market economies and we undertake to improve further their access to our markets for their products and services, including in areas such as steel, textiles and agricultural produce. In this context, we welcome the progress made in negotiating Association Agreements between the European Community and Poland, Hungary and Czechoslovakia, as well as the Presidential Trade Enhancement Initiative announced by the United States, all of which will be in accordance with GATT principles. We will support the work of the OECD to identify restrictions to East/West trade and to facilitate their removal.

27. The Group of Twenty-four (G24) process, inaugurated by the Arch Summit and chaired by the European Commission, has mobilised \$31 billion in bilateral support for these countries, including balance of payments finance to underpin IMF-supported programmes. Such programmes are in place for Poland, Hungary and Czechoslovakia. We welcome the contributions already made for Bulgaria and Romania. We are intensifying the G24 coordination process and we reaffirm our shared willingness to play our fair part in the global assistance effort.

The Soviet Union

28. We support the moves towards political and economic transformation in the Soviet Union and are ready to assist the integration of the Soviet Union into the world economy.

29. Reform to develop the market economy is essential to create incentives for change and enable the Soviet people to mobilise their own substantial natural and human resources. A clear and agreed framework within which the centre and the republics exercise their respective responsibilities is fundamental for the success of political and economic reform.

30. We have invited President Gorbachev to meet us for a discussion of reform policies and their implementation, as well as ways in which we can encourage this process.

31. We commend the IMF, World Bank, OECD and EBRD for their study of the Soviet economy produced, in close consultation with the European Commission, in response to the request we made at Houston. This study sets out many of the elements necessary for successful economic reform, which include fiscal and monetary discipline and creating the framework of a market economy.

32. We are sensitive to the overall political context in which reforms are being conducted, including the "New Thinking" in Soviet foreign policy around the world. We are sensitive also to the importance of shifting resources from military to civilian use.

33. We are concerned about the deterioration of the Soviet economy, which creates severe hardship not only within the

Soviet Union but also for the countries of Central and Eastern Europe.

The Middle East

34. Many countries have suffered economically as a result of the Gulf crisis. We welcome the success of the Gulf Crisis Financial Co-ordination Group in mobilising nearly \$16 billion of assistance for those countries suffering the most direct economic impact of the Gulf crisis and urge all donors to complete disbursements rapidly. Extensive assistance is being provided by Summit participants for the Mediterranean and the Middle East, as well as by the IMF and World Bank.

35. We believe that enhanced economic co-operation in this area, on the basis of the principles of non-discrimination and open trade, could help repair the damage and reinforce political stability. We welcome the plans of major oil exporting countries for providing financial assistance to others in the region and their decision to establish a Gulf Development Fund. We support closer links between the international financial institutions and Arab and other donors. We believe this would encourage necessary economic reforms, promote efficient use of financial flows, foster private sector investment, stimulate trade liberalisation and facilitate joint projects e.g. in water management, which would draw on our technical skills and expertise.

Developing Countries and Debt

36. Developing countries are playing an increasingly constructive role in the international economic system, including the Uruguay Round. Many have introduced radical policy reforms and are adopting the following principles:

- (a) respect for human rights and for the law, which encourages individuals to contribute to development;
- (b) democratic pluralism and open systems of administration, accountable to the public;
- (c) sound, market-based economic policies to sustain development and bring people out of poverty;

We commend these countries and urge others to follow their example. Good governance not only promotes development at home, but helps to attract external finance and investment from all sources.

37. Our steadfast commitment to helping developing countries, in conjunction with a durable non-inflationary recovery of our economies and the opening of our markets, will be the most effective way we have of enhancing prosperity in the developing world.

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38. Many of these countries, especially the poorest, need our financial and technical assistance to buttress their own development endeavours. Additional aid efforts are required, to enhance both the quantity and the quality of our support for priority development issues. These include alleviating poverty, improving health, education and training and enhancing the environmental quality of our aid. We endorse the increasing attention being given to population issues in devising strategies for sustainable progress.

39. Africa deserves our special attention. Progress by African governments towards sound economic policies, democracy and accountability is improving their prospects for growth. This is being helped by our continued support, focused on stimulating development of the private sector, encouraging regional integration, providing concessional flows and reducing debt burdens. The Special Programme of Assistance for Africa, co-ordinated by the World Bank and providing support for economic reform in over 20 African countries, is proving its worth. We will provide humanitarian assistance to those parts of Africa facing severe famine and encourage the reform of United Nations structures in order to make this assistance more effective. We will also work to help the countries concerned remove the underlying causes of famine and other emergencies, whether these are natural or provoked by civil strife.

40. In the Asia-Pacific region, many economies, including members of the Association of South-East Asian Nations (ASEAN) and the Asia-Pacific Economic Co-operation (APEC), continue to achieve dynamic growth. We welcome the efforts by those economies of the region which are assuming new international responsibilities. Other Asian countries, which are strengthening their reform efforts, continue to need external assistance.

41. In Latin America we are encouraged by the progress being made in carrying out genuine economic reforms and by developments in regional integration. We welcome the continuing discussions on the Multilateral Investment Fund, under the Enterprise for the Americas Initiative which, together with other efforts, is helping to create the right climate for direct investment, freer trade and a reversal of capital flight.

42. We recognise with satisfaction the progress being made under the strengthened debt strategy. Some countries have already benefited from the combination of strong adjustment with commercial bank debt reduction or equivalent measures. We encourage other countries with heavy debts to banks to negotiate similar packages.

43. We note:

(a) the agreement reached by the Paris Club on debt reduction or equivalent measures for Poland and Egypt,

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which should be treated as exceptional cases;

(b) the Paris Club's continued examination of the special situation of some lower middle-income countries on a case by case basis.

44. The poorest, most indebted countries need terms. We agree on the need for additional debt measures, on a case by case basis, for these countries well beyond the relief already granted under Tors therefore call on the Paris Club to continue its how these measures can best be implemented promptly

45. We recognise the need for appropriate new to developing countries. We believe the appropriate avoid unsustainable levels of debt is for developed to adopt strengthened policies to attract direct the return of flight capital.

46. We note the key role of the IMF, whose resources strengthened by the early implementation of the under the Ninth General Review and the associated Amendment to the Articles of Agreement.

Environment

47. The international community will face formidable environmental challenges in the coming decade. Managing the environment continues to be a priority issue for us. Our economic policies should ensure that the use of this planet's resources is sustainable and safeguards the interests of both present and future generations. Growing market economies can best mobilise the means for protecting the environment, while democratic systems ensure proper accountability.

48. Environmental considerations should be integrated into the full range of government policies, in a way which reflects their economic costs. We support the valuable work in this field being undertaken by the OECD. This includes the systematic review of member countries' environmental performance and the development of environmental indicators for use in decision-making.

49. Internationally, we must develop a co-operative approach for tackling environmental issues. Industrial countries should set an example and thus encourage developing countries and Central and East European nations to play their part. Co-operation is also required on regional problems. In this context, we welcome the consensus reached on the Environmental Protocol of the Antarctic Treaty, aimed at reinforcing the environmental preservation of this continent. We note the good progress of the Sahara and Sahel Observatory as well as the Budapest Environmental Centre.

50. The UN Conference on Environment and Development (UNCED)

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in June 1992 will be a landmark event. It will mark the climax of many international environmental negotiations. We commit ourselves to work for a successful Conference and to give the necessary political impetus to its preparation.

51. We aim to achieve the following by the time of UNCED:-

a) an effective framework convention on climate change, containing appropriate commitments and addressing all sources and sinks for greenhouse gases. We will seek to expedite work on implementing protocols to reinforce the convention. All participants should be committed to design and implement concrete strategies to limit net emissions of greenhouse gases, with measures to facilitate adaptation. Significant actions by industrial countries will encourage the participation of developing and East European countries, which is essential to the negotiations.

b) agreement on principles for the management, conservation and sustainable development of all types of forest, leading to a framework convention. This should be in a form both acceptable to the developing countries where tropical forests grow and consistent with the objective of a global forest convention or agreement which we set at Houston.

52. We will seek to promote, in the context of UNCED:

a) mobilisation of financial resources to help developing countries tackle environmental problems. We support the use of existing mechanisms for this purpose, in particular the Global Environment Facility (GEF). The GEF could become the comprehensive funding mechanism to help developing countries meet their obligations under the new environmental conventions.

b) encouragement of an improved flow of beneficial technology to developing countries, making use of commercial mechanisms.

c) a comprehensive approach to the oceans, including regional seas. The environmental and economic importance of oceans and seas means that they must be protected and sustainably managed.

d) further development of international law of the environment, drawing inter alia on the results of the Siena Forum.

e) the reinforcement of international institutions concerned with the environment, including the United Nations Environment Programme (UNEP), for the decade ahead.

53. We support the negotiation, under the auspices of UNEP, of an acceptable framework convention on biodiversity, if possible to be concluded next year. It should concentrate on protecting ecosystems, particularly in species-rich areas, without impeding positive developments in biotechnology.

54. We remain concerned about the destruction of tropical forests. We welcome the progress made in developing the pilot programme for the conservation of the Brazilian tropical forest, which has been prepared by the Government of Brazil in consultation with the World Bank and the European Commission, in response to the offer of co-operation extended following the Houston Summit. We call for further urgent work under the auspices of the World Bank, in co-operation with the European Commission, in the framework of appropriate policies and with careful attention to economic, technical and social issues. We will financially support the implementation of the preliminary stage of the pilot programme utilising all potential sources, including the private sector, non-governmental organisations, the multilateral development banks, and the Global Environmental Facility. When details of the programme have been resolved, we will consider supplementing these resources with bilateral assistance, so that progress can be made on the ground. We believe that good progress with this project will have a beneficial impact on the treatment of forests at UNCED. We also welcome the spread of debt for nature exchanges, with an emphasis on forests.

55. The burning oil wells and polluted seas in the Gulf have shown that we need greater international capacity to prevent and respond to environmental disasters. All international and regional agreements for this purpose, including those of the International Maritime Organisation (IMO), should be fully implemented. We welcome the decision by UNEP to establish an experimental centre for urgent environmental assistance. In the light of the recent storm damage in Bangladesh, we encourage the work on flood alleviation under the auspices of the World Bank, which we called for at the Arch Summit.

56. Living marine resources threatened by over-fishing and other harmful practices should be protected by the implementation of measures in accordance with international law. We urge control of marine pollution and compliance with the regimes established by regional fisheries organisations through effective monitoring and enforcement measures.

57. We call for greater efforts in co-operation in environmental science and technology, in particular:-

a) scientific research into the global climate, including satellite monitoring and ocean observation. All countries, including developing countries, should be involved in this research effort. We welcome the development of information services for users of earth observation data since the Houston Summit.

b) the development and diffusion of energy and environment technologies, including proposals for innovative technology programmes.

Drugs

58. We note with satisfaction progress made in this field since our Houston meeting, notably the entry into force of the 1988 United Nations Convention Against Illicit Traffic in Narcotic Drugs and Psychiatric Substances. We welcome the formation of the United Nations International Drugs Control Programme (UNDCP).

59. We will increase our efforts to reduce the demand for drugs as a part of overall anti-drug action programmes. We maintain our efforts to combat the scourge of cocaine and will match these by increased attention to heroin, still the principal hard drug in Europe and Asia. Enhanced co-operation is needed both to reduce production of heroin in Asia and to check its flow into Europe. Political changes in Central and Eastern Europe and the opening of frontiers there have increased the threat of drug misuse and facilitated illicit trafficking, but have also given greater scope for concerted Europe-wide action against drugs.

60. We applaud the efforts of the "Dublin Group" of European, North American and Asian governments to focus attention and resources on the problems of narcotics production and trafficking.

61. We commend the achievements of the task-forces initiated by previous Summits and supported by an increasing number of countries:-

a) We urge all countries to take part in the international fight against money laundering and to cooperate with the activities of the Financial Action Task Force (FATF). We strongly support the agreement on a mutual evaluation process of each participating country's progress in implementing the FATF recommendations on money laundering. We endorse the recommendation of the FATF that it should operate on a continuing basis with a secretariat supplied by the OECD.

b) We welcome the report of the Chemical Action Task Force (CATF) and endorse the measures it recommends for countering chemical diversion, building on the 1988 UN Convention against drug trafficking. We look forward to the special meeting in Asia, concentrating on heroin, and the CATF meeting due in March 1992, which should consider the institutional future of this work.

62. We are concerned to improve the capacity of law

enforcement agencies to target illicit drug movements without hindering the legitimate circulation of persons and goods. We invite the Customs Cooperation Council to strengthen its cooperation with associations of international traders and carriers for this purpose and to produce a report before our next Summit.

Migration

63. Migration has made and can make a valuable contribution to economic and social development, under appropriate conditions, although there is a growing concern about worldwide migratory pressures, which are due to a variety of political, social and economic factors. We welcome the increased attention being given these issues by the OECD and may wish to return to them at a future Summit.

Next meeting

64. We have accepted an invitation from Chancellor Kohl to hold our next Summit in Munich, Germany in July 1992.

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