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To: Katie McGinty, Gene Sperling, Jim Steinberg, Todd Stern, Dan Tarullo

From: Fred Krupp

Date: November 19, 1997

Re: US Acid Rain Program's Lessons for Climate Policy

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Fred Krupp
Executive Director

Last week EDF released a report on the U.S. experience to date with the acid rain emissions trading program established under the 1990 Clean Air Act Amendments. I thought that you would be interested in seeing the report, especially now that the Kyoto climate negotiations are so close in time.

The Report attempts to distill the environmental, economic, and policy performance of the acid rain trading program in 1995 and 1996. The results are striking and should serve to remind decision-makers here and abroad of what a powerful model the acid rain program can be in guiding the design of the structure of a global climate treaty. The Report's analysis of the ingredients of the acid rain program's success underscores both the fundamental soundness of the U.S. proposal on the structure of a climate protocol and the need to incorporate the critical elements of that proposal.

Specifically, the acid rain program's resounding success to date demonstrates that the essential elements of the Administration's climate plan

- a legally binding emissions target
- the "when" and "where" flexibility of emissions budgets, emissions trading and joint implementation, including the use of "banking" as a powerful tool to stimulate early reductions and create the foundation for a robust market over time
- transparent reporting and accounting systems with double-entry book-keeping; mandatory "true-up" of accounts; and an enforcement system that uses the "stuff" of the trading program to foster compliance through real, credible and automatic consequences for non-compliance

all work together to deliver the kind of superior environmental performance at least cost that will be key to the success of a Kyoto Protocol. The Report also highlights the importance of steering clear of pitfalls such as imposing cost-caps or sanctioning transaction monopolies in the design of an international or domestic climate regime.

I would appreciate the opportunity to meet with you prior to December 1 to review the relevance of this report for the Kyoto Protocol.

I thank you in advance for your careful review of the Report and I look forward to meeting with you soon.

Thank you for your consideration in this matter.

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**MORE CLEAN AIR
FOR THE BUCK:
LESSONS FROM THE
U.S. ACID RAIN
EMISSIONS TRADING
PROGRAM**

Daniel J. Dudek, Joseph Goffman,
Deborah Salon, and Sarah Wade



November 1997

MORE CLEAN AIR FOR THE BUCK: LESSONS FROM THE U.S. ACID RAIN EMISSIONS TRADING PROGRAM¹

Executive Summary

In 1990, then President George Bush and the U.S. Congress launched what many have described as the largest-ever "experiment" with the use of emissions trading for reducing and managing pollution. To reduce sulfur dioxide (SO₂) emissions, the major precursor of "acid rain," the Clean Air Act Amendments of 1990 require all electric power plants to reduce and cap their SO₂ emissions. At the same time, the program allows those power plants to trade any SO₂ emissions reductions they make below their required SO₂ "cap" or emissions limit.

The first phase of the acid rain/SO₂ trading program began in 1995 and has yielded two years – 1995 and 1996 – of impressive environmental and economic results. Figure i summarizes the most dramatic ones: Not only have Phase I utilities reduced their SO₂ emissions as much as the law requires, but they also have made more reductions than required in response to the incentives created by the SO₂ emissions trading market.

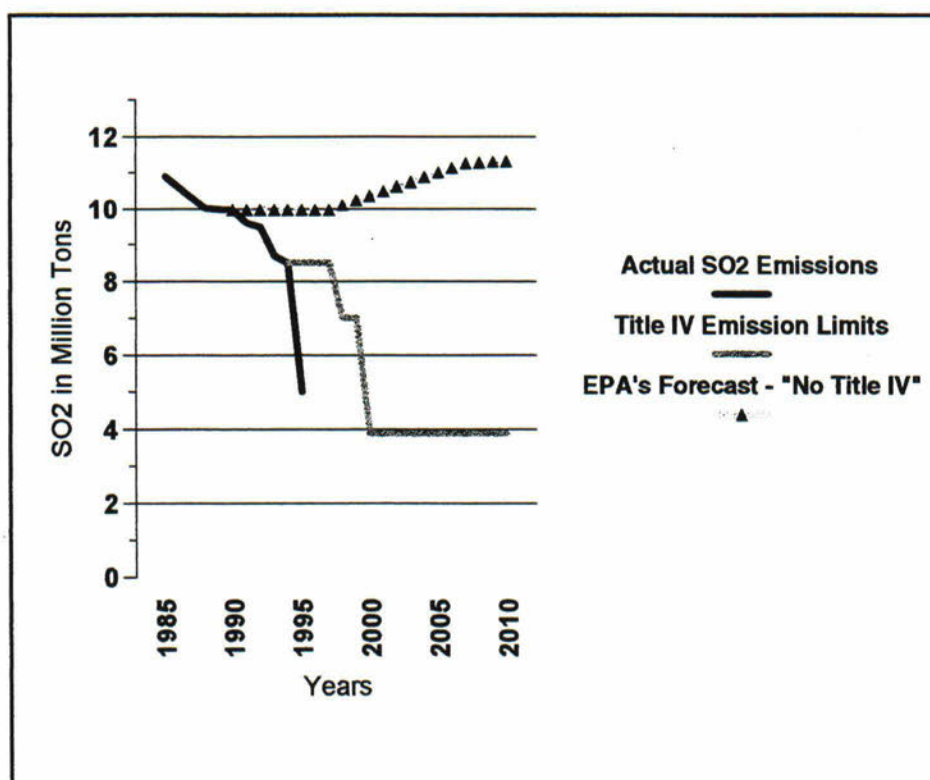


Figure i: Emissions Performance

¹ This report was prepared by the following staff members in the Global and Regional Atmosphere Program at EDF: senior economist Daniel J. Dudek, senior attorney Joseph Goffman, science intern Deborah Salon, economic analyst Sarah Wade, and with the assistance of senior scientist Michael Oppenheimer.

At the same time, the SO₂ emissions trading market has done what markets do best: drive down costs.

Largely through a series of graphs and illustrations, this report details these remarkable results in the hope of helping to inform three critical, ongoing policy debates: (1) how to manage the emissions of greenhouse gases (GHGs) both domestically and internationally (including the achievement of early GHG reductions, on which President Clinton focused in the climate change initiative he unveiled on October 22, 1997); (2) how to control pollutants, like oxides of nitrogen (NO_x), whose long-range transport across the eastern United States interferes with attainment of the health-based standard of the Clean Air Act for ground-level ozone; and (3) how to finish the job, apparently only just started by the current acid rain program, of protecting sensitive ecosystems from acid deposition. In each case, the use of emissions trading is at, or near, the focus of the debate.

The U.S. EPA has recently proposed a new mandate under which 22 states would be required to implement reductions in NO_x as a precursor of ozone. As part of this proposal, the EPA has promised to help the states develop emissions trading programs for NO_x that could resemble the one that Congress created for SO₂. The debate that has the greatest urgency at the moment, however, is the one set to culminate in December 1997 as the nations of the world convene in Kyoto, Japan, in hopes of adopting a protocol for the reduction of emissions of GHGs. Because the United States made international GHG emissions trading the centerpiece of its proposal, the entire international community has turned its attention to this innovative policy tool.

With the challenges of combating the growth of GHG emissions and of curbing the transport of NO_x emissions still to be met, this report lays out the following environmental and economic successes of the first two years of acid rain emissions trading:

- SO₂ emissions have not only been reduced to required levels, but utilities have achieved greater than 35% more SO₂ reductions than required.
- These extra reductions are distributed across the 24 states whose utilities had to make reductions during 1995 and 1996.
- The highest-emitting sources and/or states have tended to make the greatest number of extra reductions.
- The cost of SO₂ reductions, as reflected in the trading price of extra SO₂ reductions, or "allowances" as the Clean Air Act calls them, is far below predicted levels.
- Notwithstanding the rapid fall in SO₂ emissions, both electricity generation and the U.S. economy as a whole were up during 1995 and 1996.
- Although the acid rain program is too new to sustain firm conclusions about the ecological effects of the SO₂ reductions achieved, there is evidence that the emissions reductions have already reduced sulfate deposition in many areas.

To be sure, changes in the coal industry, notably dramatic efficiency improvements in the mining and transportation of low-sulfur coal in the West, have done much to facilitate the utility industry's response to the new SO₂ emissions limits. Nevertheless, the consistent overcontrol of SO₂ emissions during 1995 and 1996 and the low cost of traded SO₂ emissions allowances bear the distinct imprint of an emissions trading market. The robustness of the emissions reduction and the economic results of the acid rain program's first two years suggests that these results are precisely what would be expected of a program that, through the creation of a market, turned extra pollution reductions into money.

For its first two years, at least, the acid rain emissions trading program has turned in superior environmental performance at startlingly low cost. Such an outcome is essential if the United States and the global community are to solve other pressing air pollution problems like that posed by the continued rise of GHG emissions.

MORE CLEAN AIR FOR THE BUCK: LESSONS FROM THE U.S. ACID RAIN EMISSIONS TRADING PROGRAM¹

Part I - Introduction

The U.S. experience with its acid rain emissions trading program has been strikingly positive. Throughout the 1970's both lay and scientific observers noted the occurrence of acidified lakes and streams across large areas of the eastern United States, many of which were devoid of animal life. Anecdotal and scientific evidence also pointed to declines in some forests in roughly the same areas. Dr. Gene Likens, the first scientist in the United States to identify the cause as related to air pollutants, coined the term "acid rain" to describe the phenomenon. In 1980 the National Academy of Sciences issued a report supporting the view that the emissions of sulfur dioxide (SO₂) into the atmosphere resulted in acidic deposition (rain, snow, and fog) that, in turn, caused these environmental damages. The academy's report also suggested that a 50% reduction in total SO₂ emissions would alleviate the problem of lake water acidification.

The ensuing scientific debate about the link between air pollution, acid deposition, and adverse effects on ecosystems consumed the rest of the decade. It was fueled by the bitter political and economic controversy, among participants from different sections of the United States and different industries, over the total cost of reducing SO₂ emissions and the perceived inequitable distribution of those costs and the claimed benefits. Specifically, the vast bulk of U.S. SO₂ emissions were, and are, from coal-burning utilities in the Midwest and Southeast. These companies and regions would bear the cost of the reductions, as would that part of the coal industry that produced higher sulfur coal.

Finally, in 1990, Congress enacted legislation that imposed a little less than 50% reduction on total U.S. utility SO₂ emissions. The reduction is being implemented as an annual SO₂ emissions budget for utilities. Each power plant is issued a fixed number of SO₂ emissions allowances, which it may trade with any other power plant, provided that at the end of the year it holds emissions allowances in an amount equal to its emissions for that year. Allowances that are not used to cover emissions in one year may be saved for use in later years.

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The ability to trade and save unused allowances offers utilities a direct financial incentive to achieve more reductions in emissions than required, as well as the ability to find the lowest-cost means of achieving compliance. An additional environmental benefit is realized by

¹ This report was prepared by the following staff members in the Global and Regional Atmosphere Program at EDF: senior economist Daniel J. Dudek, senior attorney Joseph Goffman, science intern Deborah Salon, economic analyst Sarah Wade, and with the assistance of senior scientist Michael Oppenheimer.

virtue of the fact that many regulated sources choose to maintain some compliance margin flexibility by permanently maintaining an account of "banked" allowances. Under this program, each power plant can choose between various compliance alternatives – for example, using lower sulfur fuel, investing in energy efficiency, chemically removing sulfur from smokestack emissions – or can elect to acquire allowances from other utilities. As a result, the different compliance alternatives have been forced to compete intensively with each other. The expected result has occurred: Compliance costs have been driven steadily downward.

The program, which began in 1995, and continued through 1996, is still underway. The results of these first two years are eye-opening both for those who promised that this domestic emissions budget and trading system would deliver superior environmental performance at lower cost and for those who questioned such optimism. For the first two years, at least, even the optimists' expectations have been exceeded. This report explains the results of the program in terms of both its economic and environmental performance.

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Once emitted, SO₂ reacts with other pollutants in the atmosphere, particularly the various components of smog, to form acidic particles and droplets that eventually compose acid deposition. Various components of this "soup" of pollutants have been traced over long distances. For example, ground level ozone is a major component of smog that is created as the byproduct of the atmospheric mixing of ozone precursors in the presence of sunlight. The sources of ozone precursors are not necessarily located in the same area where ozone is formed; also, once ozone is formed, it can travel great distances and persist for days. In attempting to develop a program to control ozone, policymakers needed to study general transport patterns. Figure 1 depicts the prevailing wind patterns on days with high local and regional ozone readings; it is representative of a series of maps that describe identifiable wind patterns.

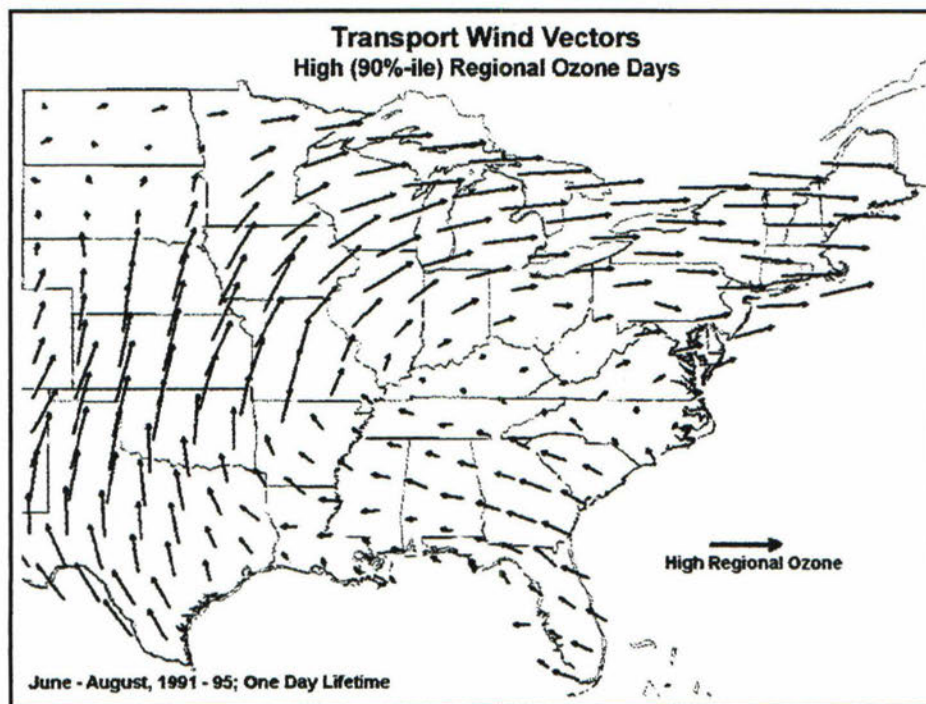


Figure 1: Local Transport Wind Vectors on High Local Ozone Days

One common wind pattern shows a general trend in air movement from the Midwest to the Northeast and from the south-central to north-central regions of the country. These same winds also mix and carry the other pollutants involved in the formation of acid deposition, including SO₂ and sulfate particles. In fact, we now suspect that atmospheric mixing and transport play a key role in both the ozone and the acid rain problem.

Figure 2 shows the location and magnitude of the major sources of SO₂ covered in the first phase of the acid rain program. These sources are considered to be the major source of sulfur in acid rain.

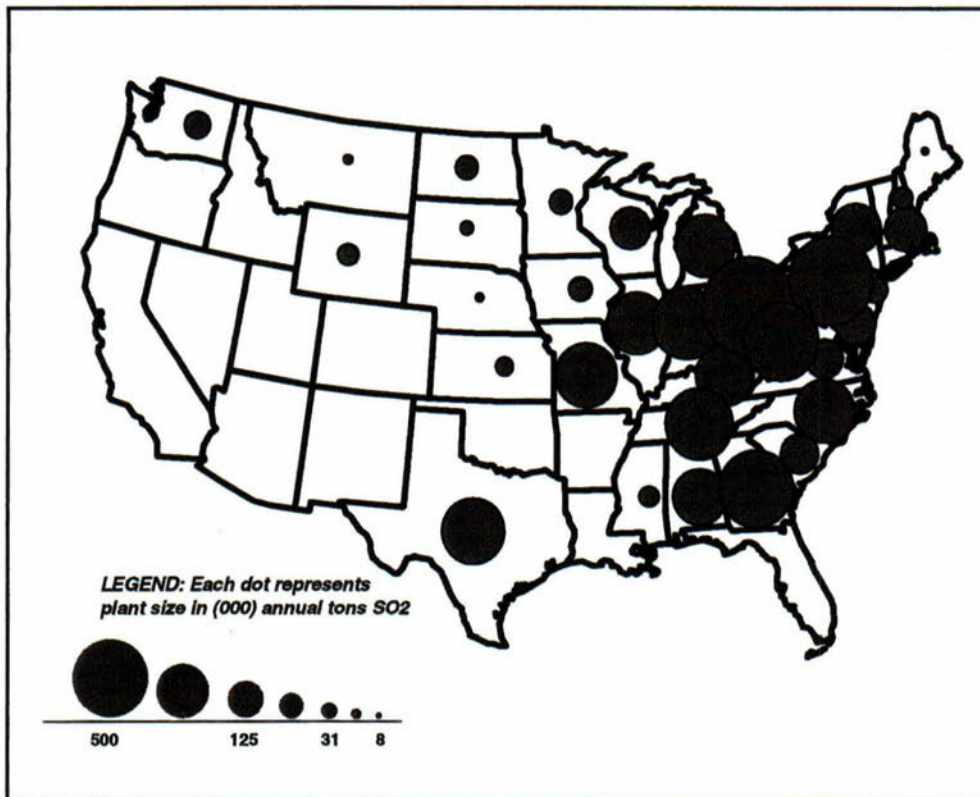


Figure 2: SO₂ Emissions from the Largest Sources

When Figure 2 is coupled with Figure 1, it becomes easy to see the logic of Congress' decision to cap *overall* SO₂ emissions and permit unrestricted emissions trading under that cap or budget. The general wind patterns that prevail over the eastern half of the country capture the large amount of SO₂ emissions in the Midwest and South and disburse them widely over those parts of the country as well as over the Mid-Atlantic and the Northeast. Thus, the quantity of total SO₂ emissions and the size and timing of their reduction appeared to be the critical variables in determining the effect of the program. Of course, local sources of SO₂ also play a role.

[Wind] captures SO₂ emissions in the Midwest and South and disburse them widely over those parts of the country as well as over the Mid-Atlantic and the Northeast.

Two things are worth noting. First, at the time the program was proposed and adopted, the very large quantity of uncontrolled SO₂ emissions in the Midwest and parts of the South suggested to EDF and others that those regions and their sources would enjoy economies of scale in making SO₂ reductions². The resulting lower marginal cost of an incremental ton of reduction would make it possible for those sources to be sellers in a SO₂ emissions trading market, if they chose to overcontrol their emissions.

Second, in the context of acid deposition control, SO₂ emissions are somewhat analogous to those of global greenhouse gas (GHG) emissions. It is their total accumulation in the atmosphere that, for the most part, determines their effect on the environment, rather than emissions from any one source. SO₂ emissions and GHG emissions share an additional characteristic in their respective environmental contexts: There is a benefit to removing them from the atmosphere sooner rather than later. In the case of SO₂, the earlier the reductions, the sooner ecosystems affected by acid deposition can begin to recover their acid-neutralizing capacity. In the case of GHG emissions, slowing the increase in emissions early can slow the rate at which the climate will change in the future. This is critical because it is not just the levels to which temperature may rise, but the speed at which that rise takes place, that ecologists believe will determine the fate of sensitive ecosystems in a greenhouse-intensified world. Of course, the slower the build-up of GHG, the slower the resulting temperature change, and the more time and latitude decision-makers have to respond to changing information and experience.

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Part II - Market Development and the Achievement of Extra Emissions Reductions

Early critics suggested that markets for allowances would not develop or that they would not function like conventional markets. These claims have been proven wrong. Although the SO₂ market experienced many of the same characteristics of any startup market, it is blossoming into a full-fledged commodities market. Figure 3 shows the steady increase in the number of allowance transfers that have occurred in the past three and a half years, including the first half of 1997, whose annual total is expected to exceed that of previous years.

It is notable that the vast bulk of these transfers have involved transfers between and among individual boiler units (the level at which the emission source is defined under the program) within single operating systems, although many such systems cross several state borders. This type of transaction is sometimes referred to as internal optimization. In other words, it indicates that a company, when given the flexibility to determine the best means of reducing total emissions, will review the operations of its entire physical plant and phase in control measures at the location and of a size that makes economic sense, within the constraints of the environmental program.

² See "Emissions Trading: Environmental Perestroika or Flimflam?," full reference can be found at end of report.

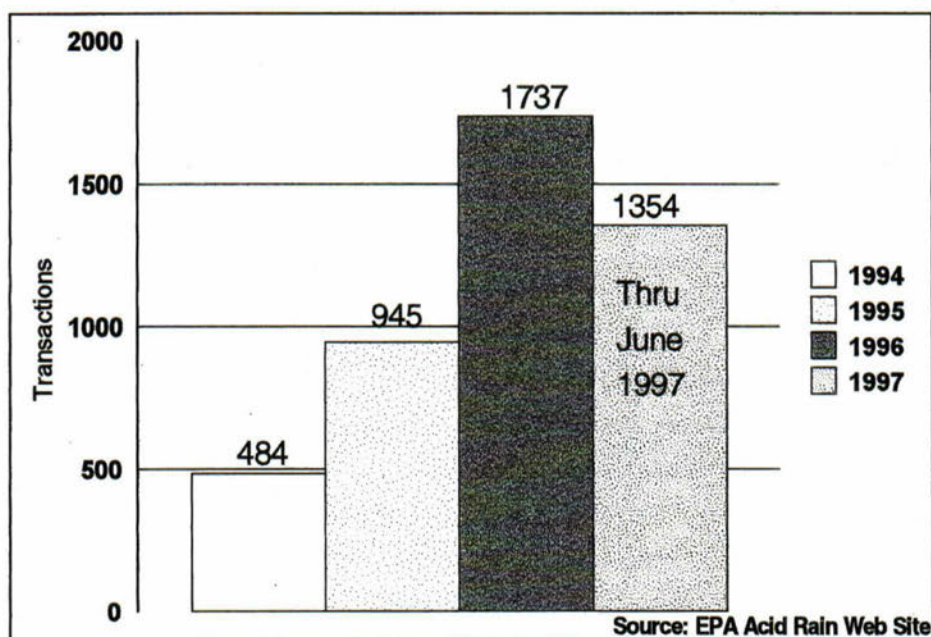
Figure 3: SO₂ Allowance Transactions

Figure 4 indicates, in terms of the total quantity of allowances, the variety and distribution of the types of allowance transactions that have occurred thus far. As the market further matures, we can expect to see a growth in the relative proportion of transactions that are between, rather than within, companies. Simply comparing 1995 and 1996 suggests that this shift is already occurring: the cumulative reallocation of allowances between units within utilities was largely completed in 1995, and the number of utility-to-broker trades grew in 1996.³

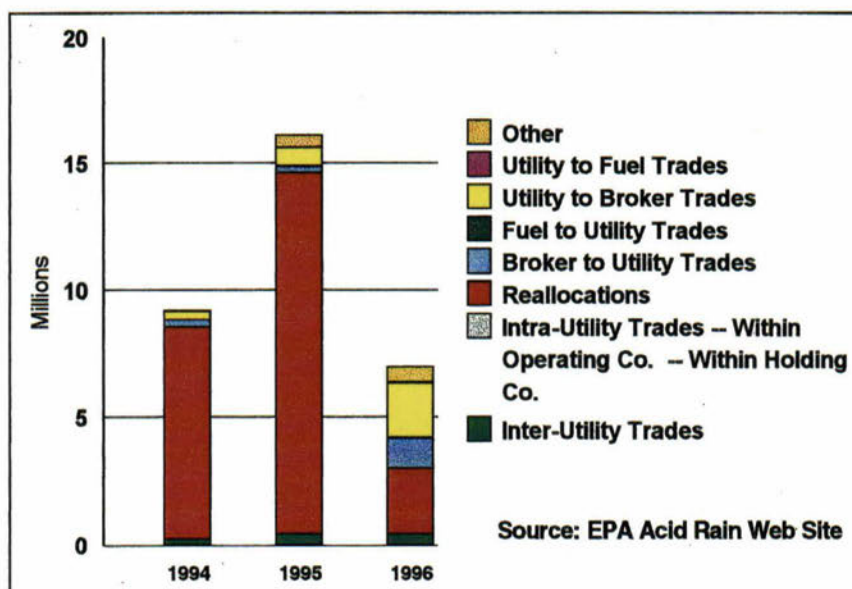


Figure 4: Trading Activity Summary

³ See "The Clean Air Act Acid Rain Program: Lessons for Success in Creating a New Paradigm," full reference can be found at end of report.

In retrospect, the results of this trading activity were predictable. The monetization of the SO₂ allowances resulting from a market in which unused allowances can be sold or saved for future use forced sources to treat emissions in effect as a variable operating cost. As a result, sources had to do what is sometimes called a “make or buy” analysis about their costs of emissions reductions. Many sources decided to “make” emissions reductions rather than buy them. Figure 5 demonstrates that in 23 of 24 states, power plants are emitting less SO₂ than the number of allowances initially allotted to them. Because of the monetization of SO₂ emissions, utilities’ “make or buy” analyses led overwhelmingly to direct and indirect investment in overcontrol. Figure 5 compares actual emissions to allowed emissions, by state, in 1995 and 1996.

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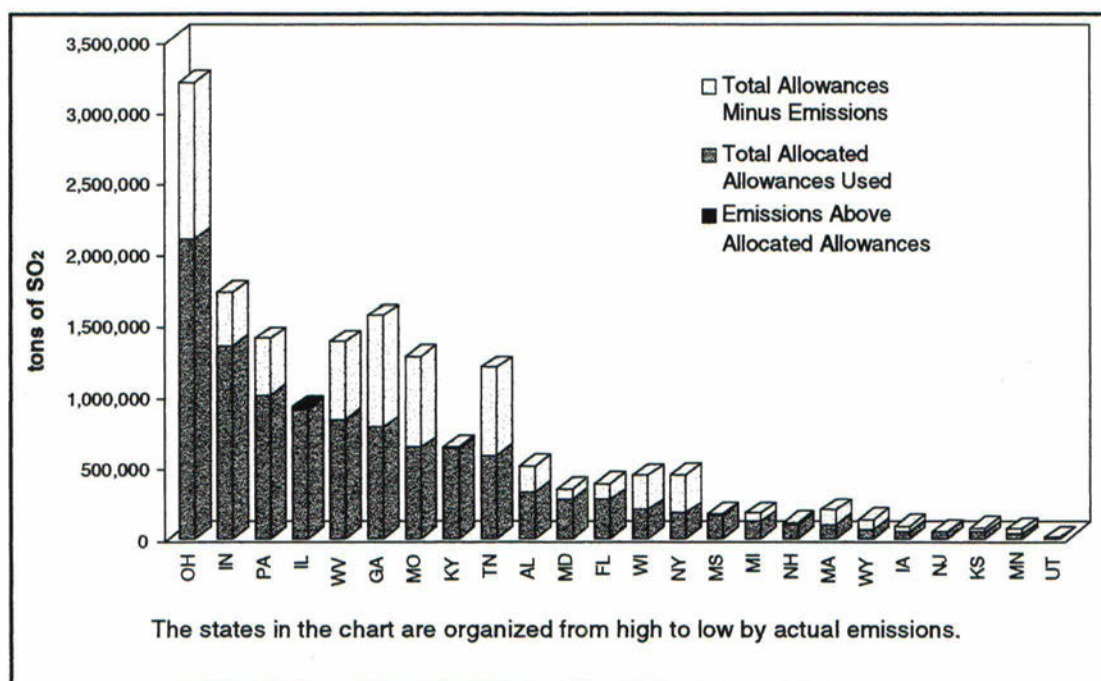


Figure 5: 1995 and 1996 Emissions from 24 Power Plants

Note that only 24 states are represented because the SO₂ reduction program is phased in. The first phase, between the years 1995 and 2000, requires only the largest-emitting plants to make reductions and to make those reductions to an interim level. It is only in 2000 that all power plants will be affected by the program and will be required, collectively, to achieve the full reduction of SO₂ emissions. In the first phase, however, power plants that had no requirements prior to 2000 but that are owned by the same companies that own Phase I plants may elect to participate in the program and provide alternative emissions reductions. Additional provisions ensure that together these mandatory and elective Phase I plants operate under what amounts to a Phase I “cap” or budget for their total SO₂ emissions. In addition, emissions allowances held but not used by these Phase I plants may be saved and carried forward for use in Phase II as well as Phase I.

The state-by-state representation of net sales and acquisitions (Figure 5) appear to suggest that, as predicted by EDF at the time it proposed the use of SO₂ emissions trading, the highest-emitting states/sources are achieving the greatest overcontrol. Figure 5 reinforces the view that the financial incentive created by the opportunity to carry into the future unused allowances, and the extra emissions reductions they represent, is prompting widespread direct and indirect investment in overcontrol of SO₂ emissions.

As predicted by EDF at the time it proposed the use of SO₂ emissions trading, the highest-emitting states /sources are achieving the greatest overcontrol.

Figures 6, 7, and 8 distill and represent, in the form of both bar graphs and geography, power plant SO₂ emissions in the 24 Phase I states as well as the ratio of such emissions to the total number of allowances held by the power plants in each state.

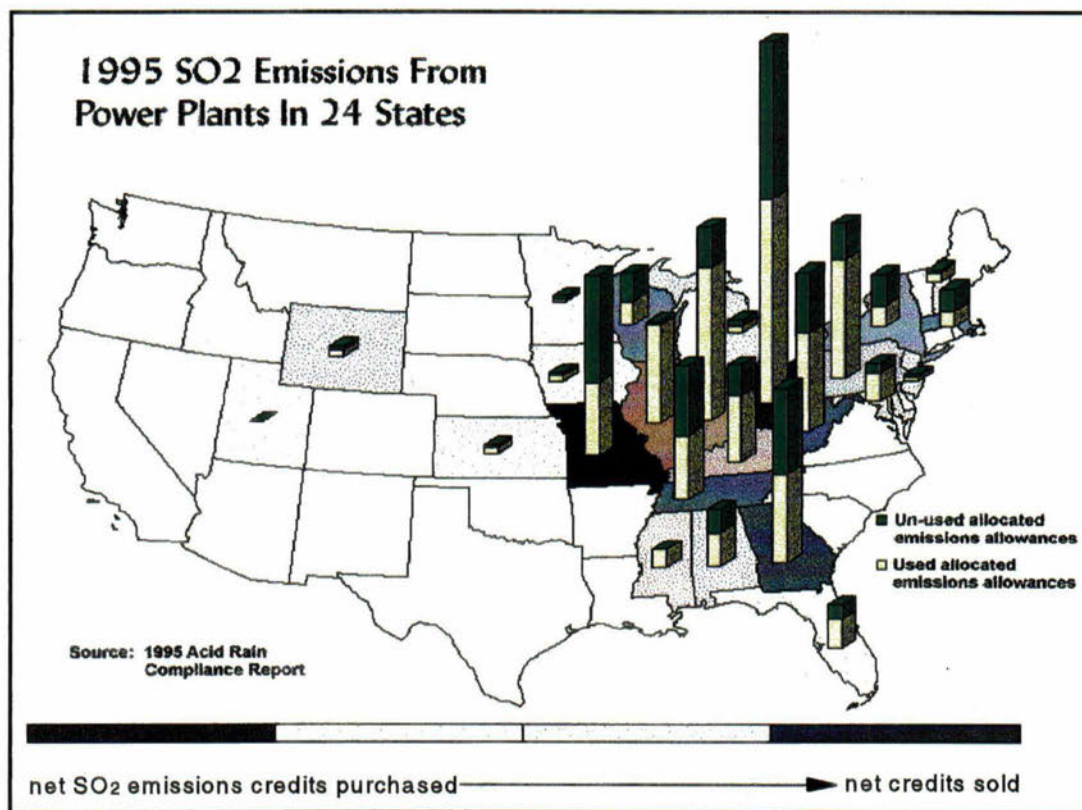


Figure 6: 1995 SO₂ Emissions from Power Plants in 24 States

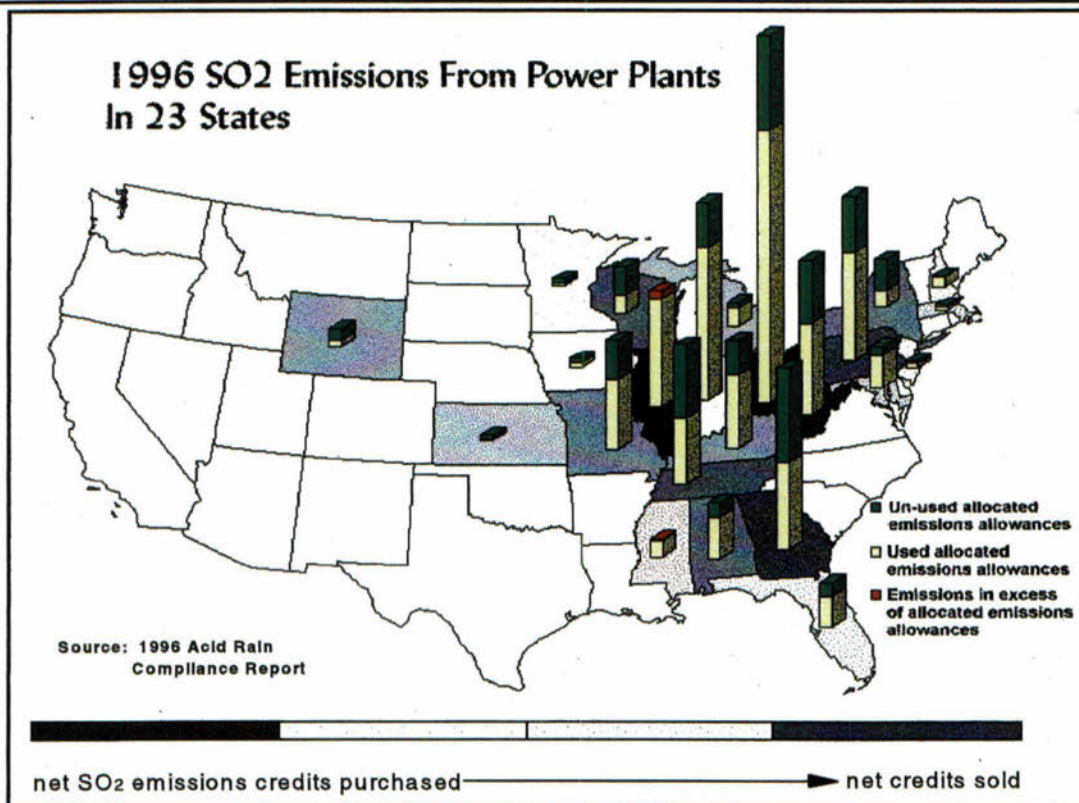


Figure 7: 1996 SO₂ Emissions from Power Plants in 23 States

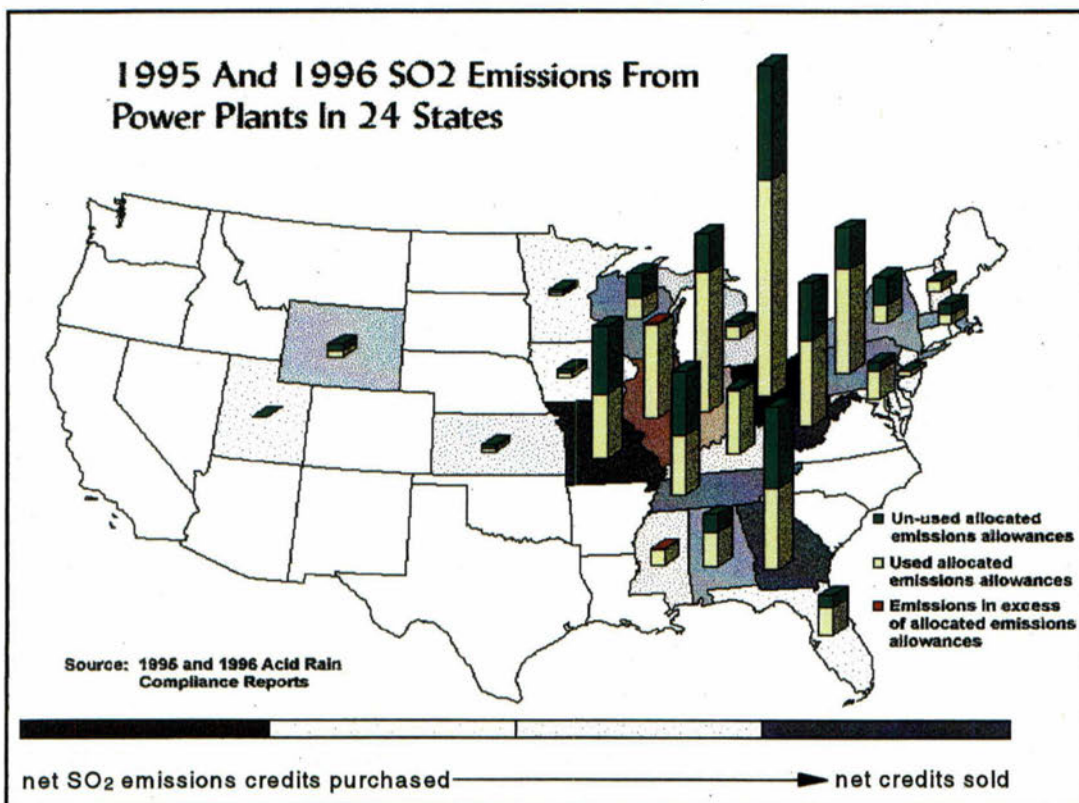


Figure 8: 1995 and 1996 SO₂ Emissions from Power Plants in 24 States

Superimposing Figures 6, 7, and 8 on the wind patterns shown in Figure 1 shows just how important the extra SO₂ emissions reductions are in removing SO₂ from the atmospheric transport system.

[T]he best way to spur innovation is to create competition among that markets...that can help industry meet environmental targets...[T]he SO₂ program put them into direct competition for meeting the needs of utilities and their customers.

The major benefit of the SO₂ program thus stems not from allowance trading, but from a structural reform in environmental legislation that removes government from direct involvement in the decision of business. At the same time, the SO₂ program firmly reinforces the role of government in determining and enforcing social goals about the desirable level of environmental quality.

*- Dallas Burtraw, Fellow at Resources For the Future,
Washington Post Commentary, March 31, 1996*

Part III - Economic Performance

General economic performance during the years 1995 and 1996 was excellent throughout the United States. Notwithstanding the investment in the reduction and overcontrol of SO₂ emissions, overall U.S. electric power generation continued to increase during the first two years of the program, as did electricity generation in the regions specifically affected by the requirements of the SO₂ program in these two years - a result that flatly refutes the claims made by opponents of acid rain legislation throughout the 1980's. Figure 9 indicates that total electricity generation in the United States increased over the period 1985 to 1996.

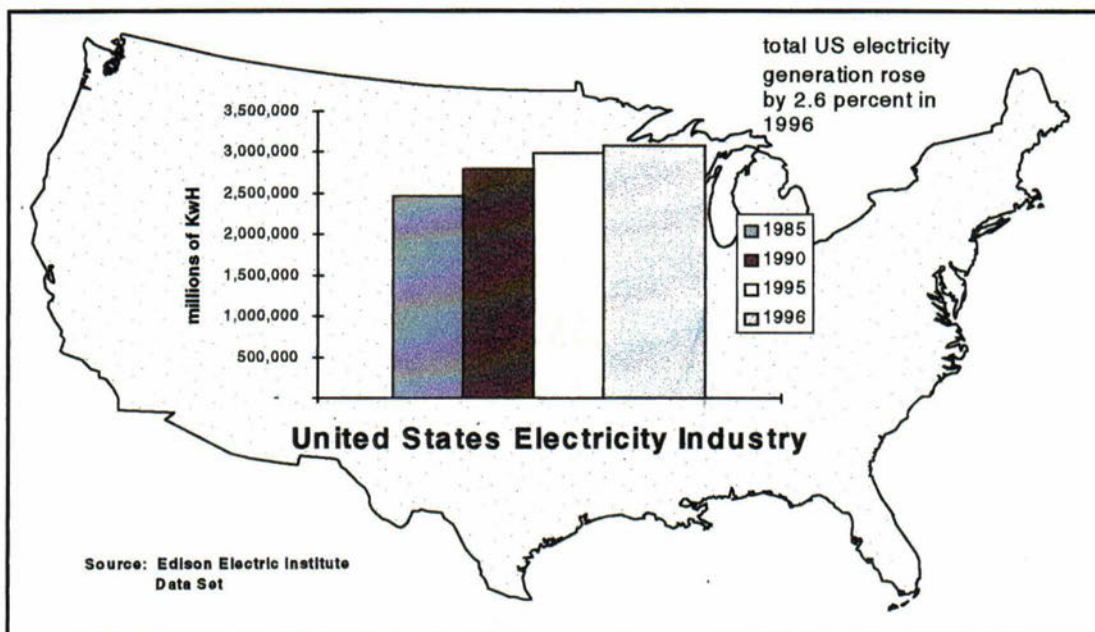


Figure 9: United States Electricity Industry

Figure 10 indicates the regional breakdown of electricity generation in 1995 and 1996. It is important to note that specific provisions of the acid rain allowance trading program prevent Phase I power plants from simply *appearing* to achieve SO₂ emissions reductions as a result of shifting generation to non-Phase I plants. As a result, the expedient of generation-shifting that avoids the achievement of real emissions reductions cannot explain the continued growth of generation while SO₂ reductions are being achieved.

Provisions of the acid rain allowance trading program prevent Phase I power plants from simply appearing to achieve SO₂ emissions reductions as a result of shifting generation.

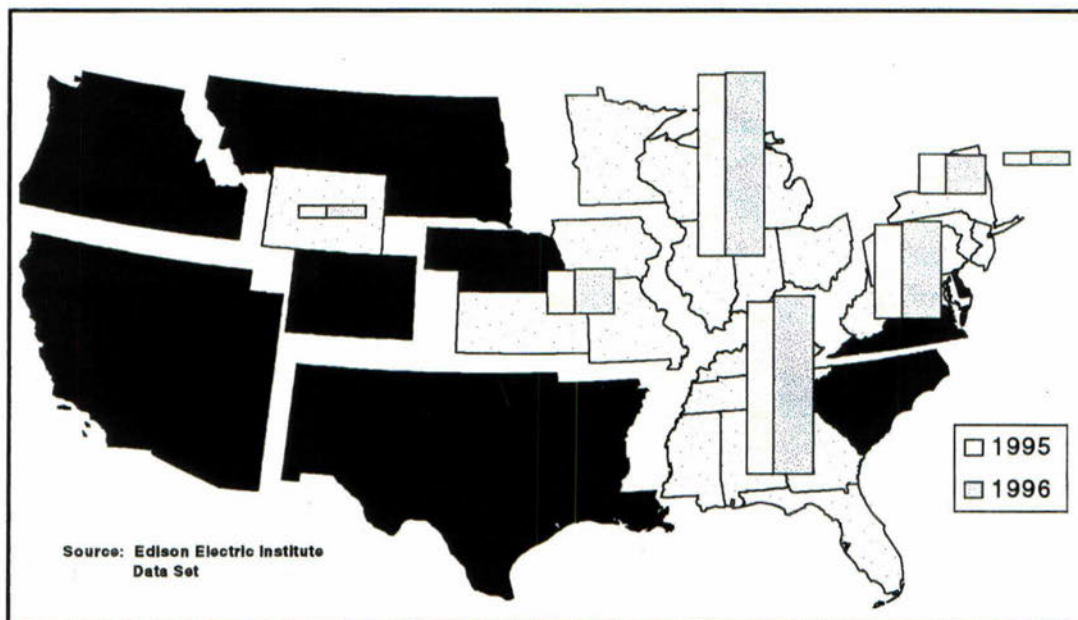


Figure 10: Regional Electric Power Generation: 1995-1996

At the same time that overall generation increased, so too did the amount of generation fueled by coal. Figure 11 indicates this trend.

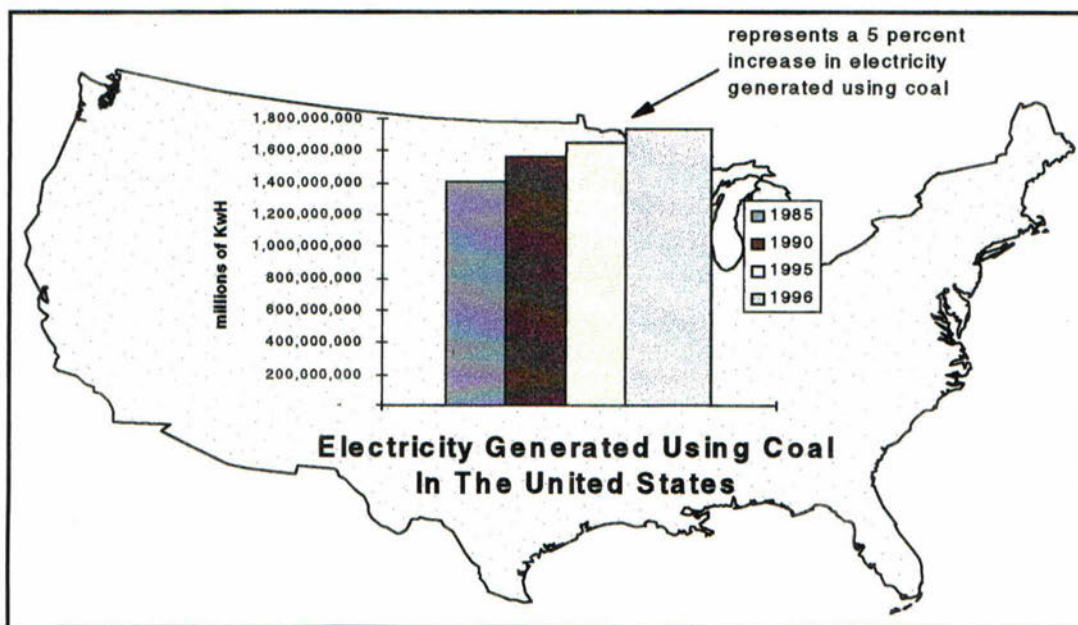


Figure 11: Electricity Generated Using Coal in The United States

As the following quote indicates, coal use also continued to rise even during the first two years of the program.

The electric power industry consumed a record 814.4 metric tons of coal, up by 5.6% from 1995.

The robust growth in coal use for electricity generation was attributable primarily to:

- *Significant growth in electricity usage due to strong economic growth and colder-than-normal weather in the early part of the year.*
- *Substantially reduced levels of gas-fired electricity generation caused by higher natural gas prices.*
- *Negligible growth in nuclear-powered generation.*

Source: "Annual Review 1996: Coal," Mining Engineering, Vol. 49, No.5, pp. 43-50, May 1997.

To the extent that the 1996 increase in SO₂ compared to 1995 emissions is linked both to increases in electricity use and to increases in natural gas prices, utilities were able to find ways to integrate compliance with their SO₂ control obligations with the response to overall economic demands.⁴ This conclusion is demonstrated further, and certainly dramatized, by the juxtaposition of the following two figures.

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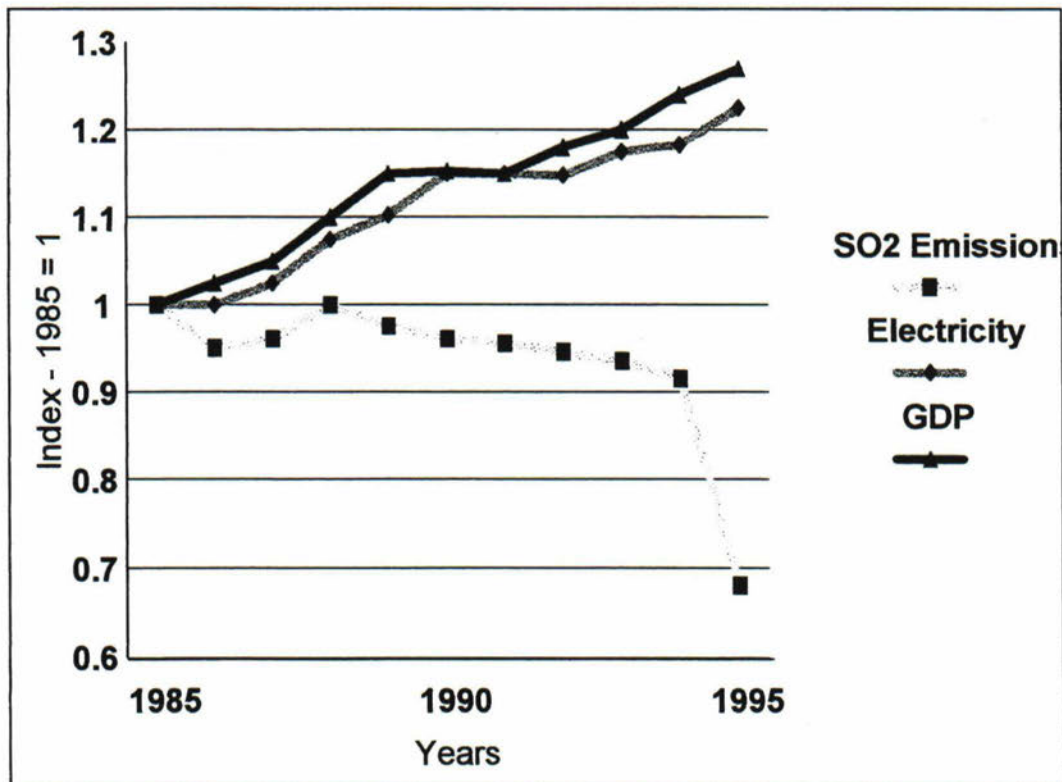


Figure 12: Growth Indicators and Emissions

⁴ See "Emissions Trading: Practical Lessons From Experience," full reference can be found in the back of the report.

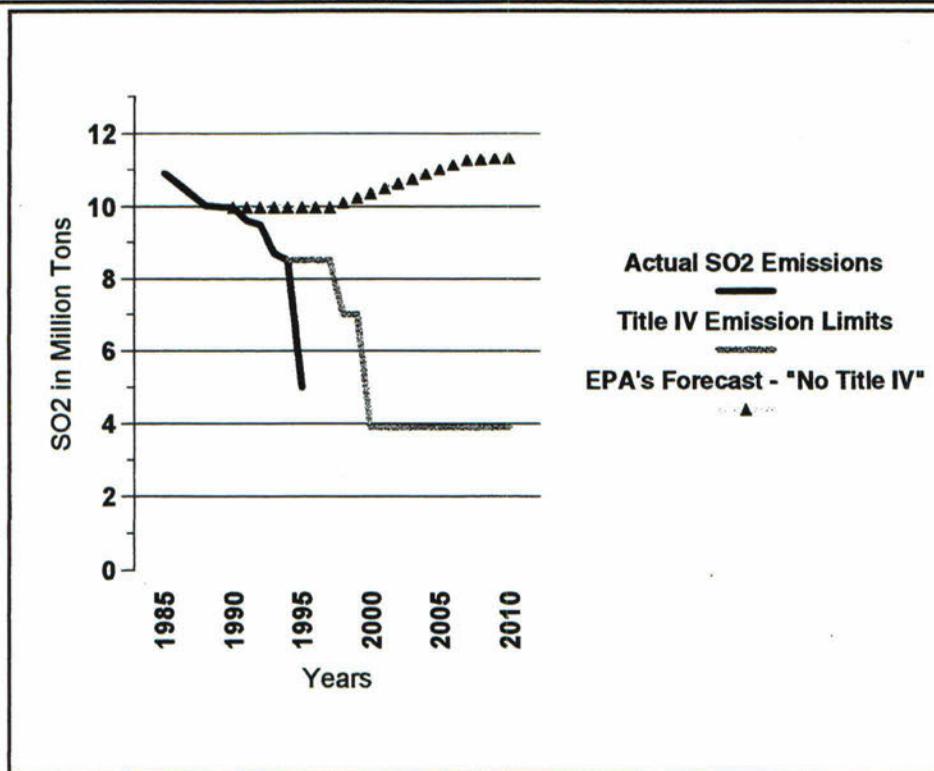


Figure 13: SO₂ Emissions Caps and Forecasts - Phase I Units

Together these graphs belie the initial claims of opponents of SO₂ emissions budgets or caps that such limits would preclude economic growth. The area between EPA's forecast under a "no Title IV" scenario (the triangles line) and the Title IV Emissions Limit (medium dark gray line) of Figure 13 depicts the sharp cuts in SO₂ required, as a matter of legal mandate, by the acid rain program. The actual emissions line (black line) shows the achievement of cuts that were greater than required in SO₂ emissions. According to the Massachusetts Institute of Technology's Energy Laboratory, the "decline in emissions between 1990 and 1994 was largely due to cheaper low-sulfur coal from the West. However, the dramatic drop in 1995 [could] be attributed mostly to the new market-based" program that went into effect that year (source: Newsletter, January-March, 1997). In Figure 12, the two darkest lines chart continued growth in U.S. electricity generation and gross domestic product against the reductions in SO₂ emissions charted by the lightest line. Again, through emissions trading, electric utilities and the overall economy seem to be able to integrate emissions reduction compliance with economic activity and growth.

Through emissions trading, electric utilities and the overall economy seem to be able to integrate emissions reduction compliance with economic activity and growth.

Wisconsin Electric's own experience with the trading provisions of the Acid Rain Program has been very positive. Compliance planning done immediately following passage of the CAAA showed that Wisconsin Electric expected to have a Phase I allocation that exceeded expected emissions by 200,000 to 250,000 allowances over the five years of Phase I (from 1995 through 1999). During Phase II (year 2000 and beyond), the company expects a shortage of approximately 30,000 allowances per year if no action is taken to reduce emissions.

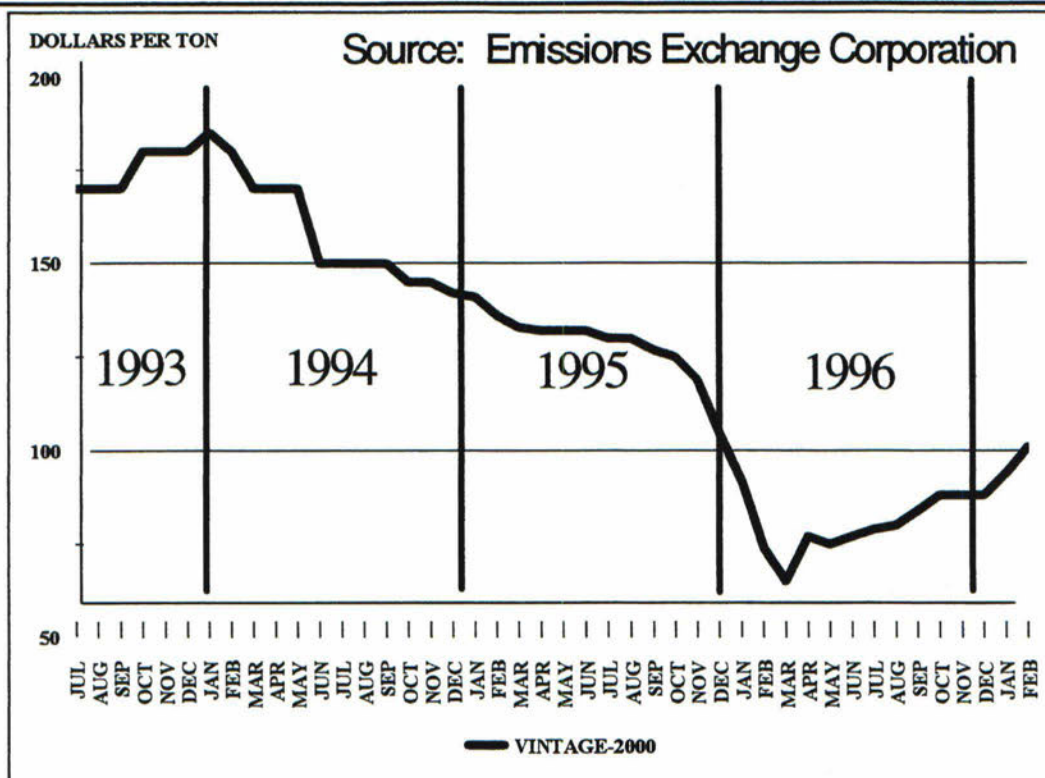
After careful study of emission reduction strategies it was determined that the least-cost compliance methodology for Phase II would be to switch to lower sulfur fuels at several facilities, achieving 10,000- 20,000 tons of total reductions. The balance of the required reduction would be purchased from the market.

In order to achieve the total 30,000 ton SO₂ reduction on the Wisconsin Electric system alone, absent the market, would have meant the installation of scrubbers on at least two units. Comparing the capital and O&M cost to scrub the two units, to the cost of purchasing the same emissions reduction on the market, there was over a \$100 million (in 1995 \$'s) savings by pursuing the purchase allowances option.

With such dramatic cost savings available through the market, Wisconsin Electric gradually entered the market as early as 1992 to begin contracting for the sale of the excess Phase I allowances and the purchase of the needed Phase II allowances. Analysis of the market based on projected future allowance costs and internal economic factors (such as the cost of capital and inflation factors), showed that the simultaneous sale and purchase of allowances was the most beneficial to Wisconsin Electric. Other companies with excess Phase I allowances have concluded, using different economic data, that simply banking Phase I allowances for use in later years was the most economically advantageous route to follow. If Wisconsin Electric had chosen to only bank allowances, and not make any other changes, scrubbers would have been required within 5-7 years of the start of Phase I. This made fuel switching and allowance purchase the most viable option when compared to simply banking allowances.

In summary, by choosing the compliance path of fuel switching and allowance purchases for Phase II, Wisconsin Electric has saved its customers over \$100 million and deferred the installation of scrubbers for the foreseeable future.

-Daniel L. Chartier, Manager - Emissions Trading, Wisconsin Electric Power Company, before the Joint Economic Committee, United States Congress, July 9, 1997

Figure 14: SO₂ Allowance Values

That emissions trading is instrumental in this economic response is suggested by the path that allowance prices have followed since active trading began, first in anticipation of the program and then continuing into the present. The price information recorded in Figure 14 was compiled by a variety of private brokers and intermediaries active in the SO₂ emissions trading market. At the time the legislation was enacted, predictions of marginal compliance costs and allowance prices ranged from \$350 to \$1000 per ton; however, allowances have traded at much lower levels, with prices ranging from \$62 to \$170 per ton. There is a striking correlation between these dramatically low prices and the intensification of competition between and among the various compliance options (in addition to trading) available to power plants, competition that is uniquely created through the emissions trading market.

Predictions of compliance costs and allowance prices ranged from \$350 to \$1000, allowances have traded at... prices ranging from \$62 to \$170 per ton.

Part IV - Environmental Performance

The first two years of experience with the SO₂ program amply demonstrate the spectacular success of an emissions budget and trading program in delivering substantial and early emissions reductions and substantial cost-savings. Equally striking is the suggested effect these emissions reductions are having on the physical environment they are intended to protect.

Figure 15 demonstrates the sharp cut in SO₂ emissions achieved in the last two years in each of the several multi-state regions whose power plants are affected by Phase I of the program.

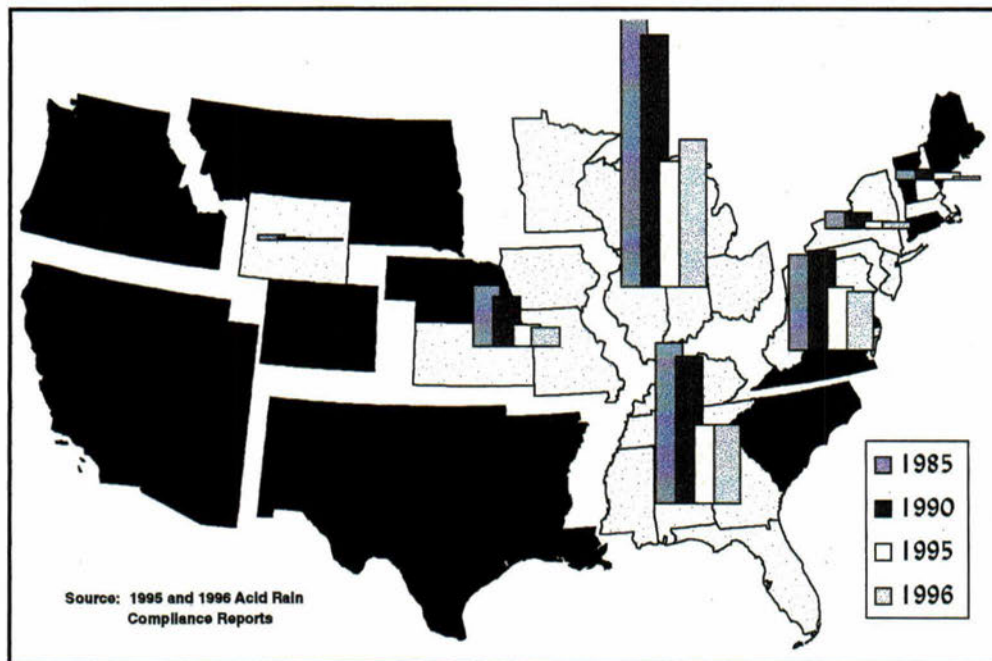


Figure 15: Regional SO₂ Emissions: 1985-1996

Figure 16 depicts the state-by-state trend in emissions over an even longer period. In all but one of the 24 states with Phase I sources, there is a noticeable - and, in the majority of states, significant - drop in SO₂ emissions in 1995 compared with 1980-1990 levels.

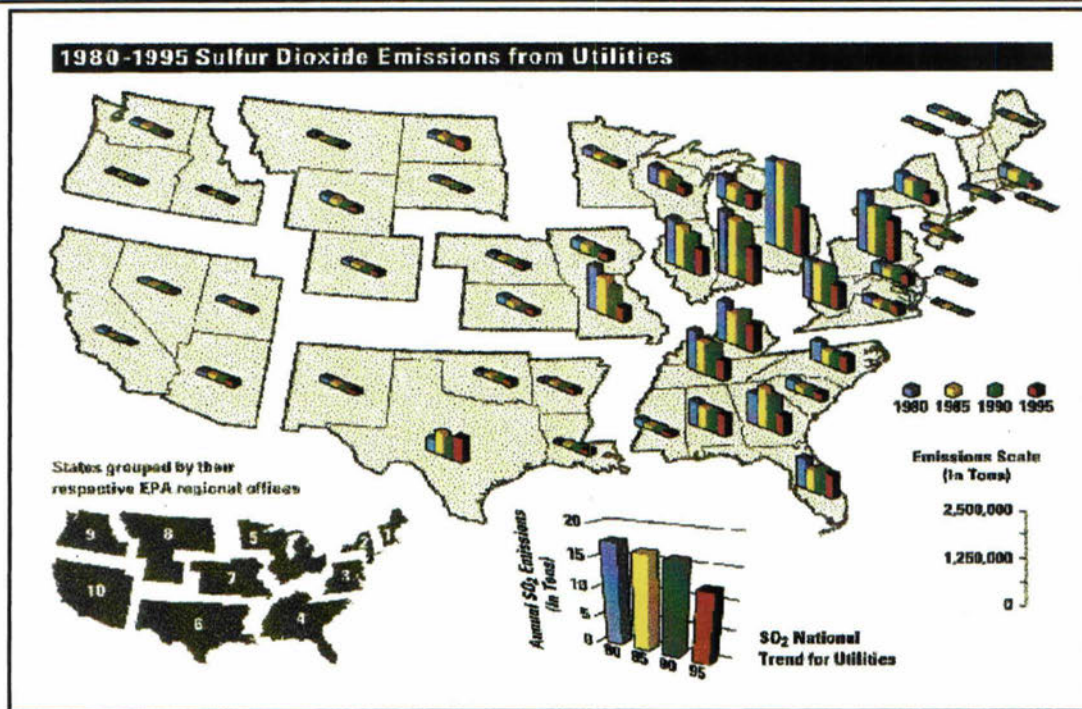


Figure 16: 1980-1995 SO₂ Emissions from Utilities

The EPA's conclusions, cited below, speak to the environmental benefits of these reductions, including the suggestion that their earlier-than-required occurrence is of particular value.

One factor mitigating the benefit of the overcompliance in the SO₂ program, of course, is the ability to use banked allowances in the future. The 40 percent of 1995 allowances and 35 percent of 1996 allowances that were not retired for compliance purposes can be used to cover emissions in a later year. However, immediate health and environmental benefits are arguably more valuable than a benefit several years from now.

Source: 1996 Acid Rain Compliance Report

Perhaps most satisfying is the recent information reported by the U.S. Geological Survey (USGS) that rainfall in the Eastern U.S. is significantly less acidic as a result of the first year of implementation of the Acid Rain Program. The June 27, 1996 study reports a significant reduction in 1995 sulfate concentrations relative to the historical trend (1983-1994). These results are derived from data collected at monitoring sites across the country. The change in sulfate concentrations shows a 10-25 percent drop in rainfall acidity, particularly at some sites located in the Midwest, Northeast, and Mid-Atlantic regions. These geographical areas coincide with areas downwind of affected utility units which have significantly reduced their emissions."

Source: 1995 Acid Rain Trading Program Compliance Report

Figure 17 shows the drop (referred to by the EPA, above) below predicted levels during 1995 in sulfate ion concentrations throughout much of the overall Phase I area, including sensitive "downwind" areas. Although one-year data does not provide a sufficient basis for definitive conclusions, this figure does suggest that SO₂ emissions reductions already may be providing benefit to many ecosystems in terms of reduced deposition.

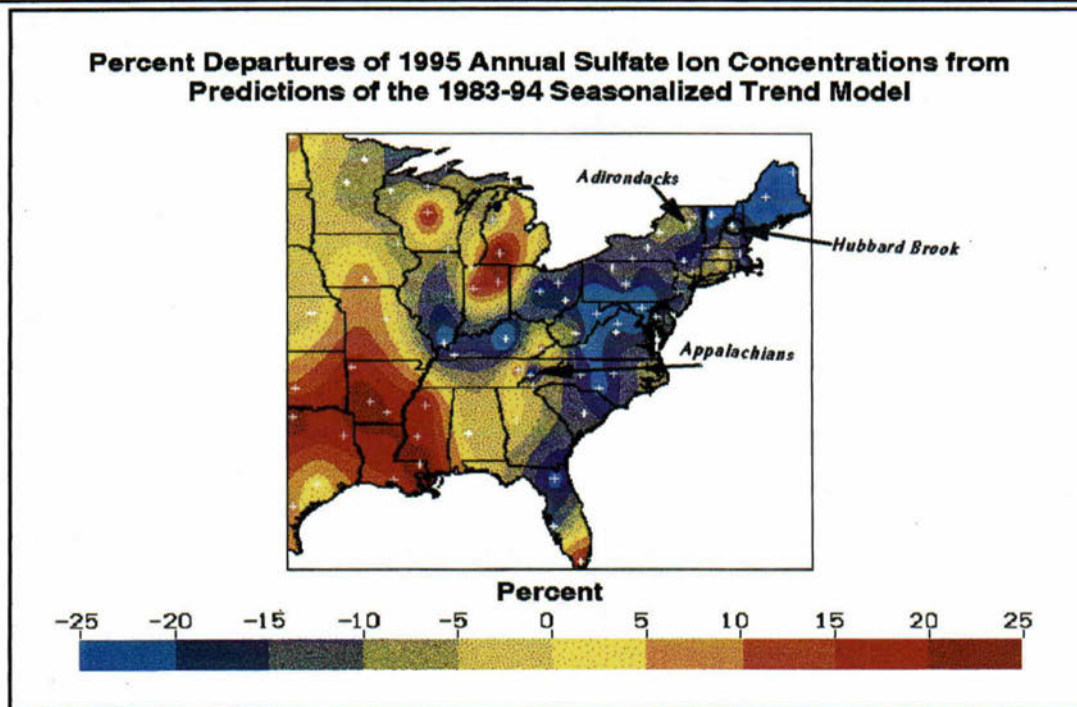


Figure 17: Percent Departure of Sulfate Ion

The significance of this correlation is strengthened when it is contrasted with Figure 19, which shows changes in nitrate ion concentrations. While the acid rain program demanded aggressive reductions in SO_2 emissions, the same program's provisions for emissions of oxides of nitrogen (NO_x), also a critical set of acid deposition precursors, call for only minor NO_x reductions, as suggested by Figure 19. As Figures 17 and 18 together show, while sulfate ion concentrations dropped in 1995, nitrate ion concentrations stayed approximately constant or rose in much of the Phase I and downwind regions.

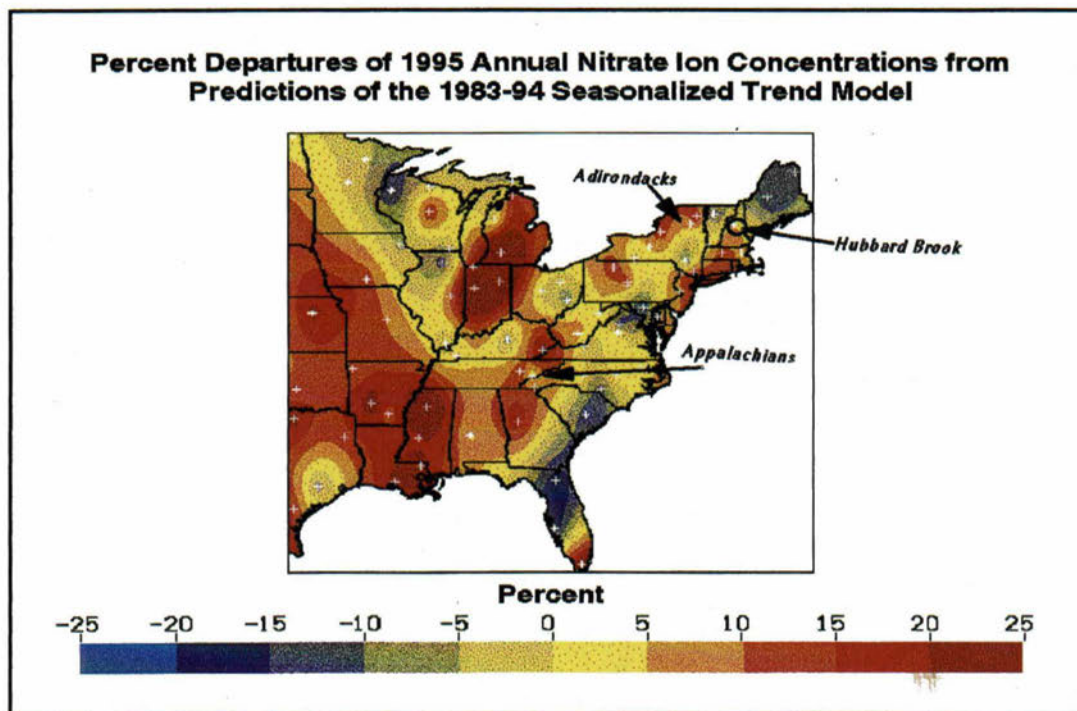


Figure 18: Percent Departure of Nitrate Ion

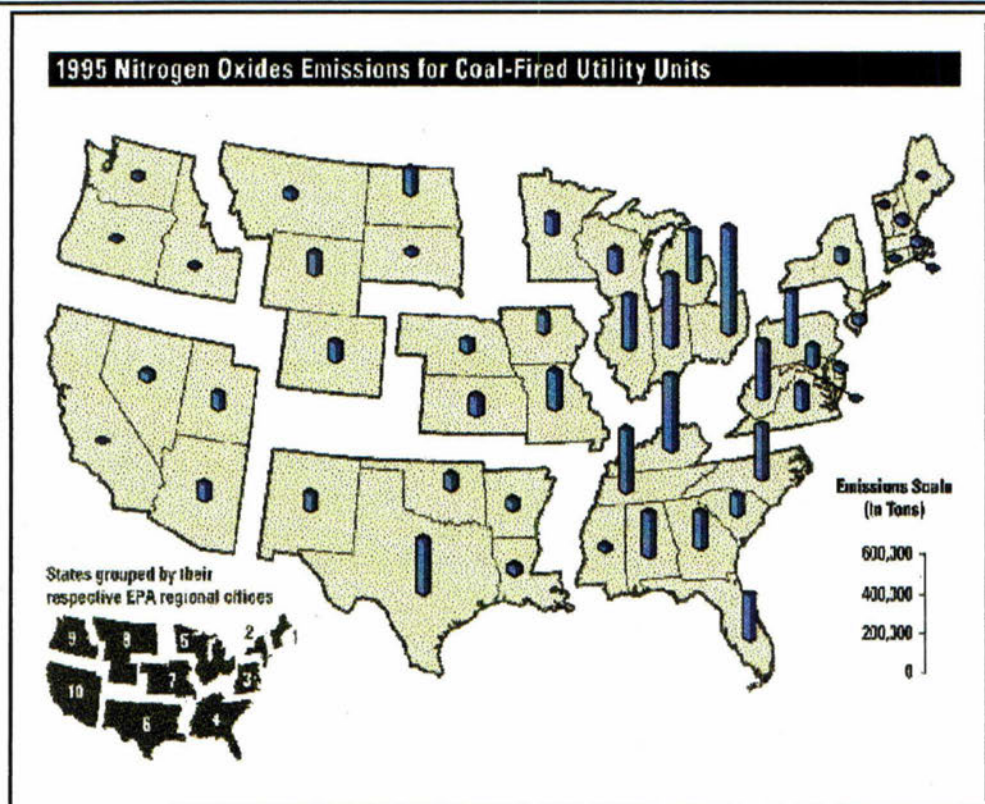


Figure 19: 1995 NOx Emissions from Coal-Fired Utility Units

In 1995, ... we saw the largest one-year drop in SO₂ emissions since 1970. The 110 power plants required to be in this first phase of the program reduced emissions by more than 50% below their levels in 1980 and 40% below the levels required by law. In 1996, these impressive results were nearly repeated with emissions 35% below required levels. These emissions reductions resulted in a decrease of 10 to 25% in wet sulfur deposition over large areas of the eastern U.S. in 1995. Ambient concentrations of sulfur dioxide also declined by 17% between 1994 and 1995. By the year 2010, the reduction in fine sulfate particulate matter is expected to provide health benefits of \$12 to 40 billion per year and visibility benefits of \$3.5 billion per year.

Data from the SO₂ Allowance Tracking System (ATS) is showing that utilities are taking advantage of the market flexibilities and cost saving opportunities afforded by the program. More than 2,400 allowance transfers moving approximately 38 million allowances were recorded by EPA between early 1994 and the end of the first quarter of 1997. More than 50% of Phase I affected utilities have engaged in trades with others outside of their company such as other utilities and brokers...From 1995 to 1996, the flow of allowances from brokers/traders to utilities increased six-fold and the stream from utilities to brokers increased three-fold. The price of allowances has fallen from early estimates of \$400 - \$1000 to less than \$100 for an allowance. These results prove that a legitimate trading market in SO₂ emission allowances exists and is thriving."

-Mary Nichols, Assistant Administrator, Air and Radiation, U.S. EPA, before the Joint Economic Committee, U.S. Congress. July 9, 1997

Part V - Lessons for Policy-Makers

When enacted, the acid rain program was but one of several titles of the Clean Air Act Amendments of 1990, whose scope encompassed urban smog, air toxics, mobile sources, and stratospheric ozone. At the time of enactment and since, however, the program has commanded a disproportionate amount of attention, not only because of the environmental problem of acid deposition but also because of the innovative design and use of the emissions budget and trading template. For these same reasons, it is not too early for decision-makers to try to draw lessons from the program's record so far.

"Learning from [the acid rain program] shows there is significant opportunity to apply them to address other vexing environmental problems. The Title IV emissions cap and allowance trading approach could be applied on a regional basis to abatement of urban ozone precursors, nitrous oxides, and volatile organic compounds. This could improve attainment and save billions of dollars annually..."

A second area of application is in the current debate about greenhouse gases...The global climatic effects of these gases appear to make an emissions cap and allowance-trading trading approach ideally suited to their abatement...

Indeed, the Acid Rain Program shows that the conversion of technology-based...standards to overall performance-based standards may be the simplest way forward to least-cost environmental regulation."

*- Byron Swift, Environmental Law Institute,
"The Acid Rain Test"*

On the most general level, the first two years of the program bear out the claims of even the most ardent proponents of emissions budget and trading programs. The program is achieving even greater emissions reductions than required and doing so at even lower costs than predicted. For current decision-makers both in the United States and worldwide settings, several specific lessons have particular urgency:

1. **Restricting emissions trading, even in the supposed interest of increasing environmental protection, is likely to be self-defeating.** The economic dynamic of the emissions trading market itself drives not only cost-reduction but the kinds of investment in emissions overcontrol seen in the first two years of the program. Trading restrictions can weaken or even destroy that dynamic and, as a result, sacrifice the additional (and early) reductions achieved by overcontrol investments.

2. **Acid deposition is not the only environmental problem in the U.S. to which the long-distance transport of pollution is critical.** The EPA and states throughout the Eastern U.S. are grappling with the effect of NO_x transport on ozone smog formation in urban areas. In the SO₂ program they can find the exact template for solving this problem.

3. Acid deposition continues to plague sensitive ecosystems. The contrasting treatment of SO₂ and NO_x under the acid rain program and the resulting contrasting effects of their emissions on the physical environment point to the urgency of making substantial additional NO_x reductions.

4. Both the economic and environmental challenges of climate change demand the use in any international agreement on climate change and greenhouse gas emissions of an emissions budget and trading approach. Nowhere are the need for cost-effectiveness and the benefit of early reductions more critical. The economic dynamic of a GHG emissions budget implemented through a competitive global market for GHG emissions reductions could produce the kind of cost-savings and investment in early emissions control already seen in the U.S. SO₂ emissions budget and trading program.

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EDF paper

Argument 1: The ceiling price would prevent the GHG emissions trading market from achieving the full measure of potential cost-savings.

Response: This argument is valid only to the extent that firms expect a high permit price without the safety valve (i.e., they expect a price exceeding the ceiling). *In other words, it is internally inconsistent for the environmental groups to be arguing that 1990 by 2010 will be cheap -- and that the ceiling will cause a problem.* Their argument that firms will invest a lot thinking that the price would be high, and that investment would drive the price down, assumes that firms make systematic forecast errors -- that they invest thinking the price will be high, and then are surprised when the price is low.

Argument 2: The ceiling price transforms the emissions trading program into a tax.

Response: We don't expect that it will be necessary to trigger the safety valve. Even if we do, the emissions handled under the safety valve would be small and any funds raised could be used to cut other taxes. More importantly, there's no reason that the additional permits would necessarily have to be sold -- they could also be grandfathered to firms, perhaps based on some performance criteria.

Argument 3: The ceiling price would defeat an early action program

Response: The ceiling price would only reduce incentives for early action if prices were expected to be above the ceiling without the safety valve. So once again, there is tension between assuming that it would be easy to meet the target and assuming that a ceiling price would interfere with incentives.

Argument 4: The ceiling price does not follow the SO2 design

Response: A carbon trading program will be substantially larger than the SO2 program, and there will undoubtedly be many differences between the two programs.

Argument 5: Ceiling price may save costs, but only at the cost of the environment

Response: *This argument contradicts the earlier assertion that the ceiling price would raise the cost of the program.* Furthermore, we don't expect that the safety valve would be invoked -- so that we could achieve our environmental goal while protecting the economy against excessive costs.



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10/09/97 05:29:00 PM

202

Record Type: Record

To: William J. Antholis, Peter R. Orszag, Gene B. Sperling

cc:

Subject: Why the GHG "Ceiling Price" Will Increase Costs

MIME-Version: 1.0

Content-type: text/plain; charset=US-ASCII MEMORANDUM

Re: Failure of "Ceiling Price" on Emissions Permits as a Climate Change Policy Tool

Introduction. In January, 1997, the U.S. government formally proposed that any international protocol to control the emissions of greenhouse gases (GHG) be structured in a way that imposed total GHG emissions "budgets", covering multi-year periods, on each participating nation. Nations could meet their budgets by trading surplus GHG emissions reductions with each other, and, presumably, permit their affected firms to do the same in private GHG emissions trading markets. There are a wide range of decisive environmental and economic advantages to this approach. Chief among these is that the global GHG emissions trading market that such a structure would unleash could be expected to do what markets do best: lower costs and spur (cost-saving) innovation. By defining nations' obligations as meeting actual budget limits for their total GHG emissions, the U.S. proposal is the single most effective way of ensuring the achievement of the "binding commitments" which many world leaders, including President Clinton, have pledged to make.

Unfortunately, despite the U.S. experience with its own market economy and with highly successful pollution markets, such as the sulfur dioxide emissions allowance trading system used to curb acid rain, some in the Clinton Administration have proposed the inclusion of a "ceiling price" in the U.S. proposal. Under this approach, the U.S. government would specify a cost-per-ton ceiling price for GHG emissions reductions. If the cost of making GHG reductions, or, presumably, the market price, rose above that level, then, the U.S. would be excused from making additional GHG emissions reductions even if that resulted in U.S. failure to meet the national GHG emissions budget. This approach would apply as well to individual firms, which would be required to pay the "ceiling price" for each ton of GHG emissions in lieu of making GHG emissions reductions.

The ostensible purpose of this proposal is to protect the U.S. economy from excessive costs in implementing its national GHG budget obligation. Ironically, the inclusion of a "ceiling price" in a GHG emissions trading program could have the perverse effect of impeding the capacity of an otherwise unfettered emissions trading market to maximize cost-savings. If that were the case, then the "ceiling price" proposal would actually make the cost to the U.S. economy of meeting its GHG emissions obligations more,

1 2

rather than less, expensive. (X)

Key to the success of an emissions trading market is the ability of competition to drive costs down. Two critical elements of competition are risk and reward. Firms take risks (e.g. developing new technologies, banking early reductions) because in their calculation they perceive the value of a specific business decision to be positive. Under the ?ceiling-price? proposal both risks and rewards are capped at the level of the ceiling price. As a result there is only limited competition. Worse still, since the risk/reward calculation is based on estimating a variety of unknown variables, the presence of a known ceiling price will tend to encourage firms to estimate an even higher risk premium when evaluating new technologies with unknown costs or other near-term emissions reduction action with uncertain future returns. This distortion of the risk/reward calculation is therefore likely to preclude much initial investment in the development of cost-saving reductions, even at the start of the program. At the same time, the costs added by this approach would not even enhance the environmental performance of the program. On the contrary, since the payment of the ceiling price would result in emissions increases, the proposal would all but ensure that the U.S. would not meet its GHG emissions budget.

1. The "Ceiling Price" Would Prevent the GHG Emissions Trading Market from Achieving the Full Measure of Potential Cost-Savings. The ability of firms to make and "bank" emissions reduction credits in the early years of a trading program for use in later years is almost universally regarded as critical to the success of trading programs (assuming that such treatment is compatible with environmental effects of the pollutant being managed). One of the reasons for this is that banking is instrumental to market formation ? and to the process of achieving cost-reductions. If firms know that at least eventually there will be a market in which surplus reductions will be in demand, then they will be able to identify a financial incentive to find and make such reductions, even if the firms are "banking" surplus reductions simply for their own future use. The reductions they make, especially early on, tend to be relatively inexpensive; as a result, investment in such reductions begins the market dynamic of limiting the cost of compliance. Thanks to these near-term low-cost surplus reductions, the compliance program can "start off" with low-cost compliance options readily available. As the market becomes more active, firms find themselves subject to continuous signals favoring ongoing investment in cost-effective reductions, particularly reductions that can be achieved below whatever the market price is, or is anticipated to be.

Part of the confidence that banking instills in investors in surplus reductions comes from the knowledge that all affected sources have no compliance option other than to achieve emissions reductions themselves or to purchase surplus emission reductions from others who can make them at less expense. As a result, all expenditures made in connection with program compliance will either be made on the demand side to purchase reductions, or on a competitive supply side to achieve the most cost-effective reductions. The "ceiling price" approach undermines confidence in banking because it gives all affected sources an ?out?, and in so doing, unravels the dynamic of cost-reduction that a soundly designed

emissions trading market can create.

Specifically, a "ceiling price", not connected in any way to the purchase of additional surplus reductions, is a vicious competitor to early reduction investment strategies. With a ceiling price present as an alternative to participation in an emissions reduction market, potential investors in early reductions, no matter how low cost, must alter their calculus radically. They cannot simply weigh, as they would in a sound emissions trading market, the cost of current investment in low-cost emissions reductions against the value (admittedly discounted) of a future return on that investment. Such return would take the form either of sales of their reductions or of the use of their reductions to avoid future higher compliance costs or of the overall flexibility for the firm's operations afforded by an available bank of surplus reductions ? all outcomes whose current value is increased by a premium created by firms' uncertainties about future cost and changing economic conditions. Because these uncertainties are amply justified, the ability to pin down costs as well as increase flexibility through the creation of a supply of low-cost reductions is especially valuable. In contrast, in the presence of a "ceiling price" escape path, firms contemplating near-term reduction options must compare the cost, including opportunity costs, of near-term investment in emissions reductions, against the discounted value of avoided future costs, but they must do so in a context where the "ceiling price" creates an artificial certainty as to future costs.

In theory, obviously, the ceiling price could be set high enough so as to preserve and ensure the value of the investment in early reductions. Unfortunately, the "ceiling price" proposal is, almost by definition, a political artifact, designed to ease the adverse pressure on decision-makers sensitive to claims that a GHG emissions budget would damage the U.S. economy. Consequently, as an administration of official has already acknowledged ? unaware, apparently of the internal contradiction ? proponents of the ceiling price approach anticipate that the price would be set at a relatively modest level, precisely for the purpose of creating the needed economic assurance and thus relieving the political pressures decision-makers are now facing.

At best, then, the introduction of a ceiling price "escape valve" complicates and creates grave uncertainties as to the outcome of firms' near-term reduction investment calculus. At the very least, it would contribute to a wait-and-see attitude that would divert some investment in low-cost early reductions that might otherwise be made. More troubling, if acknowledged political imperatives prevail, then the ceiling price will be set at a modest level; as a result, its discounted value will swamp the risk/reward calculations of many would-be investors in low-cost near-term reductions. Without this plentiful supply of low-cost reductions, the market will lose a significant portion of its power to contain and lower compliance costs by forcing compliance alternatives to compete with each other. As a result, actual compliance costs will rise to the level of the ceiling price and will do so much more quickly than otherwise? -- and, again, the costs will be that much higher than they would be were a greater amount of investment in near-term, bankable low-cost reductions made.

The presence of a ceiling price escape hatch defeats the cost-saving

capacity of an emissions trading market at the higher end of the cost curve as well. As reduction costs rise, firms increasingly will find themselves simply paying the ceiling price and foregoing the achievement or purchase of additional reductions. As a result, the market will simply cease to generate incentives that would otherwise drive innovators and investors to find or use the means to bend high-end costs down. Many potential purchasers of the reductions generated by such innovations will simply pay the ceiling price and "escape" compliance. In their absence, the financial incentive that an emissions trading market would otherwise create to apply downward pressure over the entire cost curve will disappear.

either forecast errors or overinvestment

* For these reasons, the introduction of a ceiling price does not simply provide a beneficent outer bound on compliance costs. Rather, it fundamentally undermines the power of emissions trading markets to minimize compliance costs and generate cost-savings. The optimism that many have that an emissions trading market and the technologies, whose development and use such a market fosters, can keep costs "below the ceiling price" depends on the very cost-saving capacities that the ceiling price subverts. At the same time, the "ceiling price" proposal creates a perverse trade-off: the economic certainties demanded by current decision-makers, and many traditional economists dependent on conventional analytic tools, are won at the price of the future economy's incurring real costs that could be avoided if the emissions trading market were permitted to work at its full capacity.

2. The Ceiling Price Transforms the Emissions Trading Program into a Tax Program, with the Attendant Economic Drag. With the cost-saving dynamics of the emission trading market seriously compromised by the ceiling price escape option, compliance costs over time would approximate the ceiling price level. Increasingly, firms would simply find themselves doing nothing but paying a GHG pollution tax in the form of the "ceiling price" payment to the government. This transfer would operate as a non-productive drag on economic performance without contributing to further reductions in the cost of compliance, or, for that matter, producing the economic and environmental benefits that emissions reductions would. The economic "drag" created by this tax becomes clear in contrast to the productive yield of an emissions trading market. In a trading market, companies that invest in surplus pollution reductions can earn credits that they can then sell in the trading market or bank for future use. Not only do these companies earn a return on their pollution reduction investment, but they provide the companies that buy their credits a lower cost compliance alternative. At the same time, this "cycling" of financial resources through buy-sell transactions contributes to the dissemination of lower cost compliance alternatives for the entire economy. Under the ceiling price proposal, however, companies with high compliance costs would not be contributing resources through the buy-sell cycle to support investment in low-cost compliance. Instead, they would simply be paying the government a fee for pollution, a payment that would come out of their bottom line, disconnected from any incentive to reduce GHG emissions, and would have the effect of deflating the value of investment in actual reductions.

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3. The "Ceiling Price" Would Defeat an Early Reduction Program. On October 6, at the White House Conference on Climate Change, the

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Vice-President stressed his and the President's determination to establish a program, presumably relying on early reduction credits, to achieve GHG emissions reductions prior to the beginning of the first compliance period. The Vice-President's determination is well-founded. Achieving early GHG emissions reductions can provide critical environmental and economic benefits. Because GHG remain in the atmosphere for many decades and thus speed the warming process throughout their long lifetimes, slowing their build-up can be critical to restraining some of the adverse effects of rapid climate change. At the same time, slowing the build-up of GHG emissions during the period prior to the time that the U.S. had to comply with an international GHG emissions mandate will also soften any economic dislocations that might occur in connection with meeting that mandate.

Accordingly, a strategy that gives private firms a positive incentive for making early GHG reductions before mandatory compliance periods is critical. If successful, this strategy would not only provide the environmental and economic benefits associated with slowing GHG emissions build-up in the atmosphere and with lessening economic dislocation, but it could also spur and speed investment in the development and use of the kinds of innovative technologies that can reduce pollution while increasing economic performance, including by minimizing costs.

One way to create such incentives is by awarding to firms that achieve early, surplus reductions GHG emissions credits that they could bank and use against future compliance requirements. The results of the acid rain emissions trading program, under which utilities have achieved more than 30% more sulfur dioxide reductions than required ? and thus created a substantial bank of surplus emissions reductions ? provides strong evidence of how powerful an incentive device early reduction credits can be.

Unfortunately, the ceiling price escape option would fatally blunt that incentive. Again, this option would throw into serious question for many firms the financial wisdom of incurring present-dollar expenditures in the face of an alternative of spending future dollars to meet a fairly modest price to "buy out" of compliance. Because an strategy using early reduction credits is purely an incentive program, the administration simply cannot afford to muddy the incentive signal by forcing firms to contend with the ceiling price option.

At the same time, ironically, the success of such a program in inducing early reduction activity would provide precisely the kind of economic assurance that many are seeking through the "ceiling price" approach. A robust early reduction program not only would soften the increase in GHG emissions prior to the compliance period, thus smoothing economic dislocation and adjustment, but would furnish the economy with a reserve supply of low-cost reductions for meeting compliance.

4. The "Ceiling Price" Eschews a Key Design Lesson of the Acid Rain Program. Some have claimed that a similar "ceiling price" approach was included as part of the acid rain program. This is simply not true. Under the acid rain program, sources do have the option, after a perverse fashion, of paying the government instead of making the required reductions ? but the price they must pay is set at penalty levels far higher than the cost of making reductions or purchasing reductions from other sources.

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no direct
acid rain

More important, such sources would be paying the government not for the privilege of escaping, or being excused from, pollution control obligations. Under one provision, sources would be paying for additional emissions reductions needed to offset the sources' emissions increases, and they would be purchasing from the EPA surplus emissions allowances that had been set aside from the initial allocation by the EPA. Under another provision the sources themselves would be required to make the additional emissions reductions immediately after making the payment, since any excess emissions would be deducted immediately from their emissions allowance allocation. The high penalty encourages sources to find low-cost means of reducing emissions through the emissions trading market, indeed in its both of its first two years the acid rain program has experienced 100% compliance. The fact that they are paying for, or are required to achieve, additional reductions themselves, ensures that the environment remains whole ? and that market itself and its cost-saving dynamics remain whole.

* 5. The "Ceiling Price" Approach Does Save Costs ? But at the Expense of the Environment. To be sure, there is a manner of cost-savings created by the ceiling price escape hatch. Once costs reached a certain level, sources would never have to pay more than at that level. This price-ceiling would be sustained, however, at the direct expense of the environment, since with every "ceiling price" payment GHG emissions would rise above the emissions budget level. Ultimately, then, costs would be saved by not requiring that the program perform to the full extent of the U.S. GHG emissions budget commitment. Again, this approach all but turns the emissions market on its head, since in emissions trading, cost-savings are achieved only by actions that save costs while also achieving the required reductions. Perhaps even more obvious, however, is that the "ceiling price" approach turns the President's commitment to "binding" targets on its head. With the ceiling price escape option in place, the U.S. would defeat its own commitment to achieve a GHG emissions target.

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(See attached file: co2 CEILING PRICE Sarah memo.doc)

EDF



EARLY REDUCTION STRATEGY

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1. It is vital that the President or very senior members of the administration call and speak to companies and ask them to come forward with a commitment to make early reductions in exchange for a commitment to establish an early reduction credit program.
2. The mutual commitments can be expressed on the level of principles and the commitments should be made contingent on working together to work out the details.
3. An early reduction program is the best way to put American ingenuity to work right away on the job of finding low-cost GHG emissions reductions. An early reduction program means that all of the environmental, innovation and cost-savings benefits of the GHG emissions reduction market that the U.S. has already proposed would start to happen immediately.
4. Under such a system, companies can start tapping the benefits of emissions trading immediately. By finding low-cost reductions now and earning tradable credits for the future, companies can ensure that when the time comes to make required reductions they will already have at least one low-cost alternative, in the form of a "bank" of credits, for complying with those requirements. As a result, companies will also have the flexibility of meeting those requirements without having to rush the turnover of capital stock.
5. Meanwhile, the reductions businesses make to earn those credits will have immediate environmental benefits, as well as benefits for the broader economy. The way greenhouse gas emissions affect the climate means that the earlier reductions are made the better it is for the environment.
6. At the same time, the chance to earn valuable emissions credits, would inspire a variety of companies to start the search of low-cost emissions reductions and for long-term innovations that much earlier. As a result, the transition of the U.S. economy from "business as usual" to compliance with future emissions limits would be that much smoother and less prone to abrupt and painful economic dislocations. In addition, with firms mobilizing their resources to discover cost-effective and innovative reduction strategies sooner rather than later, the entire economy will be in that much better a position to keep the costs of meeting future mandatory requirements low.
7. With this approach, the mechanism of a greenhouse gas emission market will be that much more effective in providing the cost-savings needed to protect the U.S. economy from the harm that it otherwise could suffer if inappropriate strategies are adopted to meet mandatory emissions limits.

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8. With this approach it gives the President the ability to create the positive, opportunity for the environment message - - eg. the visual message he would create by having companies standing up with him at the announcement saying they're willing to act now.
9. This approach represents a critical reaffirmation of the President's - and industry's - commitment to the market and to making the market work. At the same time, the President must stand by the market itself. That is why it is also critical that the President has resisted the temptation that would permit firms to pay a tax in lieu of making reductions if a pre-set price ceiling were reached. Like price-control schemes of the past, these seemingly comforting "safety valves" inevitably would introduce distortions that would make meeting emissions limits more, rather than less, expensive and well could defeat incentives for cost-saving early reductions. The presence of these approaches *in any form* would preclude an early reduction strategy from being successful.
10. With a joint government-industry commitment to early reductions in hand U.S. negotiators in Kyoto will have new evidence with which to convince their skeptical counterparts from overseas that flexible, market-based policies can yield environmental results.



KEY POINTS ON EARLY REDUCTION STRATEGY

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The Politics

****1. It is vital that the President or very senior members of the administration call and speak to companies and ask them to come forward with a commitment to make early reductions in exchange for a commitment to establish an early reduction credit program. (The mutual commitments can be expressed on the level of principles and the commitments should be made contingent on working together to work out the details.)**

2. There is NO better way to make the political point about the economics of greenhouse gas emissions reductions and the cost-saving ability of a greenhouse gas emissions trading market than to have real businesses stand up and agree *voluntarily* to make such reductions and use the market to reduce costs.

What the President should say on policy:

1. An early reduction program is the best way to put American ingenuity to work right away on the job of finding low-cost GHG emissions reductions and long-term innovations.

2.. Early reductions will have immediate environmental benefits: the way greenhouse gas emissions affect the climate means that the earlier reductions are made the better it is for the environment.

3. Under an early reduction program a variety of companies will start the search for low-cost emissions reductions and for long-term innovations that much earlier. As a result, the transition of the U.S. economy from "business as usual" to compliance with future emissions limits will be that much smoother and cheaper. In addition, with firms mobilizing their resources to discover cost-effective and innovative reduction strategies sooner rather than later, the entire economy will be in that much better a position to keep the costs of meeting future mandatory requirements low.

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MEMORANDUM

Capital Office
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To: White House Task Force on Climate Change
(By Hand Delivery)

From: Dan Dudek, Senior Economist 
Annie Petsonk, International Counsel *AP*

Date: August 13, 1997

Re: Climate Change Negotiations: Some Progress, Some Potentially Serious Setbacks;
Clarity and Focus Urgently Needed

The Administration's Kyoto Protocol proposal advanced in some significant measure at the seventh session of the AGBM in Bonn last week. But it also suffered potentially serious setbacks and fragmentation on a number of key elements. We are concerned that these problems, which are now embedded in the draft text that will be circulated prior to the eighth session in October, will undermine the President's ability to conduct effective outreach domestically, including, and most particularly, at the White House Conference. We therefore urge the Administration to move swiftly during the intersessional period to rectify these problems. We recommend that the Administration conduct high-level outreach to key negotiating partners and to the Chairman of the AGBM, Ambassador Raul Estrada, to clarify and explain the environmental and economic advantages of the Administration's position, and to focus understanding on the integrated nature of the Administration's proposal. These intersessional consultations are needed to lay the foundation for a clear and decisive Administration follow-through at AGBM-8 and Kyoto; similarly, the Administration's position vis-a-vis Congress can be strengthened by utilizing a parallel very high-level consultation approach with Congress, especially the Senate, during the run-up to the next Bonn and Kyoto meetings.

Our summary of these key points follows. While a number of the points below may seem like fine details, in fact, it is these elements that will form the critical fabric of the new international system for carbon transactions.

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**The Clinton Administration's International Climate Change Policy:
Some Progress, Some Serious Setbacks at AGBM-7; Clarity and Focus Urgently Needed**

The following brief analysis summarizes the outcome of AGBM-7, held in Bonn, Germany, in August 1997, with regard to the key flexibility elements of the Administration's Kyoto Protocol proposal: joint implementation, trading, and the emissions budget infrastructure. A concluding section discusses congressional outreach in light of these results.

I. Emissions Budget System Infrastructure.

A. Vintaging/Traceability, Reporting, Review and Compliance. The Administration's Kyoto Protocol proposal occupies the environmental and economic high ground of credibility in part because of the high level of accountability that can be achieved with a budget-trading-JI system. Accountability depends critically, in particular, on reporting, on traceable "vintaging" - that is, the ability to trace carbon-equivalent units (CEUs) in the trading system back through each transaction all the way to their origin. Accountability also depends on standardized reporting and review, and a staged compliance regime that will actually be deployed in cases of non-compliance. The importance of these "infrastructure" elements, and the way in which they work together to provide the accountability that is key to the environmental and economic success of the system, are not well understood by delegations in the international negotiations.

The Administration needs to explain clearly to key negotiating partners at high levels the importance of the budget infrastructure and the way in which the infrastructure elements interact to provide the environmental and economic accountability that is key to success at Kyoto.

1. Traceable Vintaging

- The Administration needs to clarify that for compliance purposes, it is essential that *in all emissions transactions*, whether joint implementation or trades, *the "vintage" - the country of origin and year of initial transaction history - must be fully traceable all the way back through to its origin.*
 - In the case of JI projects, the carbon-equivalent units (CEUs) should be traceable back to the host country where they were originally generated, with identification of the year in which they were generated.
 - In the case of trades among nations with budgets, the CEUs should be traceable back to the country that originally sold the carbon-equivalent units as part of its national budget, and the year in which the CEUs were originally sold.
- This "trace-back" mechanism¹, coupled with annual reporting on budget performance, provides the critical compliance feedback that is essential to the integrity of the budget and trading system.

¹ The trace-back feature can also be thought of as "sticky" vintaging - "sticky" because the geopolitical and temporal origin of the CEUs "stick" to them throughout their transactable life

→ Traceability could be assured simply by serializing all CEUs internationally, including both emissions budget and JI-generated CEUs, and requiring that all transactions be recorded with the secretariat by serial number. JI projects that generate CEUs would need to report those to the secretariat and record their serialization in order for the CEUs to be transactable. The secretariat would keep a permanent record of the origin of the CEUs by nation, year, and serial number. Such serialization would also facilitate electronic transactions.

- With this approach, the original country of origin and year of origin for any CEUs would be known, regardless of how many times the CEUs had been traded internationally, and regardless of whether the CEUs originated in a national emissions budget or in a JI project. And with annual reporting on national budget performance, the market price of serialized CEUs would reflect market perceptions of the strength of each nation's compliance program. The combination of traceability, annual reporting, review, and staged compliance mechanisms provide powerful feedbacks that direct market forces in favor of compliance. Without this feedback, however, the accountability provided by the integrated reporting, review and compliance system would be severely compromised.

2. Reporting, Review of National Budget Performance, Establishment of Next Budget Levels, and Compliance. The Administration's proposals in each of these areas, and the way that these proposals interact with and form essential components of, the overall budget structure, are not well understood by delegations. For example, delegations do not yet grasp the importance of using the structure of the emissions budget and trading system to promote compliance. Furthermore, the text that came out of AGBM-7 is littered with reporting and review proposals that are unmoored from other system elements. Also a number of proposals have been made that would invite governments to fiddle with budget levels during a budget period. Introducing such uncertainties into the budget process would greatly undermine the credibility of the agreement in the investment and business community, to its environmental detriment. In the intersessional period, the Administration could advance its case considerably if it were to:

- Clarify its explanation of the proposed reporting, performance review, budget-setting, and compliance mechanisms. *The compliance picture would be clearer to countries if the Administration were to explain the timeline of establishing a budget, annual reporting, science and technology reviews, performance reviews, compliance mechanisms, and establishment of the next budget.*
- Make clear its *opposition* to mechanisms that would allow *budgets to be re-set* during a budget period.
- Clarify that a *range of options exists for reviewing national budget performance.* Unfortunately, the "implementation review team" concept is being used against U.S. interests by those who would like to prevent any international agreement. Those who seek to frustrate a Kyoto outcome are using the prospect of in-depth reviews, particularly on policies and measures, to incite fears about intrusions into national sovereignty. To counteract this, the Administration should make clear that Parties may use existing mechanisms that they have already accepted, such as the national accounts analyses prepared by the Organization for Economic Cooperation and Development (OECD), the energy production and consumption analyses done under the auspices of the International Energy Agency (IEA), and the agricultural production and inputs statistics compiled by the Food and Agriculture Organization (FAO). These mechanisms, which may involve international review teams that evaluate national performance, can yield good performance data without raising undue concerns about intrusion into national sovereignty. And, since the performance objective of

a Kyoto Protocol will be set in greenhouse gas emissions terms, what a nation is doing on policies and measures will be far less important than how it is doing with regard to greenhouse gas emissions. The performance-based reviews of the OECD, IEA and FAO are thus a more accurate vehicle than policy-and-measure reviews when it comes to obtaining an independent check on national performance. Furthermore, if vintaging is used, then third party private service will also provide evaluations of creditworthiness

B. Coverage, Budgets, and Length of Budget Period.

1. Coverage. The Administration made significant progress at AGBM-7 in getting delegations to understand that it is highly preferable, environmentally, to include all gases, sources and sinks in the Protocol. The Administration successfully rebuffed attempts to force categorization of GHG-emitting activities by sector and source, and the delegation did a good job of explaining that categorization would be environmentally sub-optimal since it would wind up excluding major emitters. That approach should be maintained through Kyoto. With regard to *sinks*, it was rumored in Bonn that the EU opposes including sinks in national baselines because EU forest cover has declined since 1990. If that rumor is correct, the U.S. should not shrink from making this known more broadly, and *should explain to EU governments and NGOs that including sinks in national baselines would provide powerful incentives to halt and even reverse the rate of forest loss.*

2. Budgets. It now seems that the concept of budgets is generally accepted internationally.

3. Length of Budget Period. The length of the budget period is closely linked to the robustness of the tracing system. Without serialization of CEUs and traceable vintaging, budget periods would need to be short in order to bolster accountability. But short budget periods place greater strain on the international compliance regime, since, given fluctuations in business cycles and weather, it is more likely that more nations will be out of compliance with budgets of a few years, than with budgets of a decade. And strain on the international compliance regime should be avoided if possible, since, in any international agreement, compliance represents the greatest challenge.

- Therefore, when the Administration puts forward its timing and levels proposal, it *should ensure that a decadal budget period, which has the potential to deliver improved environmental and economic performance while providing a stable investment horizon and bolstering the legitimacy of the new international system, is integrally linked to traceable vintaging, reporting, and the staged compliance system proposed by the Administration.*

II. Joint Implementation. JI with developing countries, an essential linchpin of the Administration's proposal, suffered potentially severe setbacks in Bonn. JI is key to addressing the competitiveness and environmental concerns underlying S.Res.98.

A. The Subsidiary Body on Scientific and Technological Advice (SBSTA) decided not to discuss the methodological issues in JI at its next (and last before Kyoto) session. This means there will be no agreed method of crediting for JI, even if JI crediting were to be agreed in principle. Governments at Kyoto will be reluctant to support crediting for JI without first settling the methodological issues. *The Administration should work with other governments at high levels to build support for an extraordinary session of SBSTA to be held immediately prior to COP-3 to resolve the JI methodological issues.* The basic issues, which the Administration should coordinate with other interested governments at high

levels, are straightforward, and include such principles as steady (rather than rolling) project baselines. These issues can be clarified readily in high-level consultations. *The forces of delay must not be allowed to hold JI credit hostage to interminable wrangling over methodologies.*

B. Proposals to subject the JI Pilot Phase to paralysis-by-analysis gained ground. Those who oppose any agreement at all at Kyoto also support subjecting the Pilot Phase of JI to such lengthy and detailed analysis so as to ensure that a political agreement on JI credit will never emerge prior to the Kyoto meeting - or well into the next millennium, either. Contrary to the claims of many, the Berlin Decision on JI does not require a review prior to concluding the Pilot Phase, but rather provides that "the Conference of the Parties *shall take into consideration* the need for a comprehensive review of the pilot phase in order to take a conclusive decision on the pilot phase and the progression beyond that, *no later than the end of the present decade.*" No comprehensive review is necessary; nations participating in the JI pilot phase have generally conducted their own ongoing reviews, which could usefully and readily be compiled; and in any event the reviews indicate what is already widely known: in the absence of credit, the pilot phase has not been robust.

- Rather than acquiescing to those seeking to block agreement at Kyoto by postponing JI for credit, the *Administration should move swiftly and at high levels to build support among key countries for ending the pilot phase at Kyoto and beginning JI crediting promptly in 1998.*
- Beginning crediting in 1998 implies that JI credits earned from 1998 to the start of a first budget period could be credited toward the participating nation(s)' emissions budget(s). *Obtaining clear international agreement on crediting for pre-budget JI would advance domestic support for the Administration case considerably - the Administration should make this a high-level priority.*

C. The current text proposes quantitative limits on JI. The text coming out of AGBM-7 contains (admittedly bracketed) proposals to place quantitative limits on the amount of JI that any industrialized nation may use to satisfy its emissions budget obligation. Such quantitative limits would seriously under-incentivize JI, for, just as any other type of quota or quantitative restriction on trade, prospective investors would refrain from investing in particular JI projects for fear that those particular projects would subsequently be disqualified for having exceeded a national quota. In fact, quantitative limits on JI could give projects a perverse incentive not to do well on reducing emissions - for any one project that did better than expected in reducing emissions could find itself disqualified if those emissions reductions exceeded a national quota in an investor country. And the presence of quantitative limits would vastly and needlessly complicate cooperative projects involving multiple investor nations, because each investor nation would have to ensure that its share of any particular cooperative project did not bump up against its national quota.

- *In the intersessional period, the Administration should clearly and decisively oppose JI quotas, and should make the environmental case for its position known around the world.*

D. The current text provides that JI projects shall not have any "adverse environmental or social effects." This language, while on its face seemingly laudable, would be highly problematic to implement in practice. The language would render every single JI project subject to challenge and disqualification at the international level not based on its emissions performance (which should be grounds for international challenge), but because of any adverse environmental or social effect, no matter how small, no matter how much outweighed by environmental and social benefits. Twenty-seven years ago the U.S. considered adopting such an approach as a tool of national decision-making, and squarely rejected it. Congress chose instead to require federal agencies to assess the environmental impacts of their major

actions, and to allow the agencies to decide, after weighing the impacts and benefits, what course of action to take. Similarly, the decision whether to go forward with a particular JI project should rest squarely with the nations involved in the project, and should be undertaken in a transparent manner. It would be outside the competency of the Framework Convention, which is a convention on climate change, to evaluate the non-GHG environmental and social effects of JI projects. The transaction costs of such assessments would further weaken the economic incentive to undertake JI investments in the first place.

- *The Administration should make clear to its negotiating partners that the responsibility for assessing the environmental and social effects of JI projects - and their consistency with national development plans and priorities - rests squarely and solely with the Parties undertaking those projects.*
- *The Administration should also support a challenge and review procedure whereby JI projects may be subject to international challenge on the basis of an alleged failure to produce claimed GHG reductions; and that any such international challenge would trigger an international review of project performance in terms of GHG emissions.*

III. Emissions Trading. There is now considerable interest in emissions trading among delegations. But the EU remains deeply internally divided on the issue.

A. Emissions Trading and the EU Bubble: A Trade and Competitiveness Issue. As the delegation of Japan pointed out in Bonn, an EU bubble in the absence of a full-access trading and for-credit JI system would confer unfair trade advantage on the EU. Key senators are already well aware of the competitiveness aspect of the EU Bubble, since the point was emphasized in testimony by the Global Climate Coalition before the Foreign Relations Committee and was reiterated by Foreign Relations Committee members in the floor debate on S. Res. 98. Cost and competitiveness issues are becoming acute within the European Union as member states struggle to meet the 3% Maastricht target for monetary union. Thus, the timing is ripe for high-level overtures to key EU officials on trading, JI, and the EU Bubble. Surprisingly, however, international reports released shortly after the Bonn meeting rumored that at AGBM-7, the U.S. relented on its opposition to the EU bubble. It is therefore essential that the U.S. move promptly to clarify its position on trading and the Bubble.

- *During the intersessional period, the Administration should undertake very high level consultations on emissions trading and for-credit JI. These consultations should be undertaken with EU Ministers for Trade and Competitiveness, especially Germany, on the EU side, and with high-ranking trade officials on the U.S. side.*
- *In undertaking these consultations, the Administration should clarify that if the EU bubble is the EU's way of implementing a fully developed, internationally agreed emissions trading system that includes for-credit JI with non-budget nations, then the EU bubble would be acceptable to the United States. Otherwise, the EU bubble would be unacceptable.*

Trading and Policies and Measures. At Bonn, the U.S. opposition to internationally mandated policies and measures was clear and understandable to most delegations. Yet, some EU delegations in particular feel wedded to obtaining some internationally agreed policies and measures. The question then arises as to whether there is a set of environmentally useful international policies and measures that might meet the EU concern for some international agreement, while also addressing the U.S. concern that such policies and measures not operate as trade barriers. The set of international activities that do

not fall neatly into national emissions budgets comes to mind, i.e., greenhouse gas emissions from international bunker fuel consumption (aviation and marine transport).

- *The Administration should explore, at high levels, the possibility of an internationally agreed greenhouse-gas-performance-based policy on bunker fuel emissions. Although international interest in and pressure for an aviation fuel tax remains strong, domestic support for such an approach is weak, and the environmental effectiveness of a moderate tax in reducing bunker fuel emissions is quite doubtful.*
- *Therefore, the Administration's high-level policy discussions on bunker fuel emissions should focus on the concept of an emissions budget and trading system for international aviation and marine bunkers.*
- *While ultimately the Parties could decide that such an approach could be administered through the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO), those entities currently do not provide sufficient transparency and cannot, under the UNFCCC, become Parties to the Rio Treaty. Therefore the preferred approach would be for the Parties to the UNFCCC to decide, as a common policy and measure, to develop an emissions budget and trading system for international aviation and marine bunkers. Such an approach is already currently under consideration within the European Union.*

IV. Congressional Outreach. It is essential that the Administration engage the legislative constituencies, in particular on the Senate side, that are most likely to be concerned about each of these elements. That engagement should be done in an intensive manner during the intersessional period, so that the time of the much larger delegation of congressional observers who will attend the October session will be spent advancing, rather than undercutting, the Administration's proposal. *There are important Senate constituencies that are likely to favor each of the key elements outlined above if given adequate background and opportunity. The remainder of August and the whole of September provide an important time window in which to build those constituencies.*

~~Confidential Addendum To August 13, 1997 Memorandum Re:~~
Climate Change Negotiations Progress, Setbacks, and the Need for Clarity and Focus

1. JI and China. The views of China about JI are changing. Chinese government officials involved in the climate change issue, at all levels but with one well-known and notable exception, have begun to recognize the value of for-credit JI in terms of spurring foreign direct investment in high-efficiency technologies and cleaner energy production. As one Chinese delegate to the climate negotiations said in Bonn last week, "It is meaningless to discuss 'transfer of technology' unless you are discussing JI for credit. China understands that there is no such thing as a free lunch."

China appears poised to propose a slate of JI projects that could be announced as early as the US-China Summit scheduled for later this year. To pursue this opportunity, *the Administration may wish to undertake very high level consultations with Mr. Song Jiam, who was the head of delegation to the United Nations General Assembly Special Session (UNGASS).* These consultations might usefully be coordinated through the Chinese Embassy in Washington. The consultations could approach the upcoming US-China Summit as an important opportunity to present a joint slate of JI projects that the two countries, as sovereign and equal partners, would undertake. It is important to keep in mind, in undertaking these very high level consultations, that the approach of the US Initiative on Joint Implementation (USIJI) is perceived by many in China as paternalistic. It would therefore not be desirable to initiate action through USIJI. *Rather, a shared approach in which the two sovereigns, operating at the highest levels, jointly identify a slate of JI projects, is more likely to achieve real results.*

2. Evolution; developing country commitments. This core issue for the Administration's relationship to Congress, as difficult as it seems, offers real opportunities to reach an agreement in Kyoto, and to pair that agreement with a follow-on agreement on developing country commitments. Most developing countries do not understand the U.S. proposal on growth budgets. Nor do they understand the evolution from JI, with heavy transaction costs of project-by-project certification, to a full and fluid trading system.

- The Administration should clarify, through strategic consultations with key developing nations, including China, India, Brazil and Malaysia, its proposals regarding *growth budgets and JI. These consultations should draw on specific examples to illustrate for developing nations the nature of the evolution from JI to full trading, and the important environmental and economic opportunity presented by the possibility of growth budgets for early adopters.*
- Senate staff attending the Bonn meeting were, overall, quite effective in presenting the Byrd-Hagel resolution to key developing country delegations. These kinds of consultations could usefully be continued at the next meeting *and during the intersessional period.* One important component of the Senate interface is to *build a powerful Senate constituency willing to advocate strongly for emissions trading and JI as part of a Kyoto Protocol. This constituency will understand the role of trading and JI in encouraging, through the mechanism of growth budgets, early commitments by developing nations. This constituency can provide an important outreach mechanism to developing nations.*
- Finally, but only after these consultations have gained momentum, the Administration should undertake quiet further consultations with key Senators, key industrialized and developing nations, and key industry and environmental leaders on a discrete set of proposals for linking industrialized and developing country commitments in the context of a Kyoto Protocol and a follow-on agreement involving large developing country emitters. The Administration should enter into these consultations clear in the understanding that during the period prior to implementation of legally binding targets for developing nations, for-credit JI will play a crucial role.

DETERMINED TO BE AN ADMINISTRATIVE

MARKING INITIALS: JS DATE: 12/4/14
2014-0724-52

Confidential Addendum To August 13, 1997 Memorandum Re:
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MARKING INITIALS:

Ms DATE: 12/2/97
 2014-07-24-52

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Science

Climate

Myth vs. Reality Skeptics in the Media - A Case Study

There is an overwhelming scientific consensus that climate change is real, dangerous and underway. The consensus is among thousands of scientists worldwide conducting independent research through the rigors of the peer-review process. It is captured in the statements of the Intergovernmental Panel on Climate Change, which was created by governments explicitly to investigate the scientific understanding of climate, and a statement signed by over 2,600 scientists that warns global warming is already underway. It is a remarkable consensus, but one most Americans may never know exists. Corporations, individuals and associations who oppose a climate treaty regularly fill the press with distortions and inaccuracies intended to convince the public that climate change is fiction.

A CASE STUDY

Broad claims of industry misinformation are not very informative. It is helpful to examine a specific example, one that is typical in its argument and tactics, and one that demonstrates just how far the "skeptics" are willing to stray from the truth to pursue their agenda. Consider this typical example:

An Op-ed Runs in a Major Newspaper

On August 29, 1997, the *Detroit News* ran an op-ed by George Roche, the president of Hillsdale College in Michigan, which charged that concerns over global warming are "bad science and unjustified environmental hysteria."

To prove his point that global warming is "bad science," Mr. Roche wrote that, "A recent Gallup poll reported that 83 percent of the respondents disagreed with the statement that human burning of fossil fuels causes global warming. These weren't just average citizens. They were from the Meteorological Society and the American Geophysical Society."

Key "Fact" in Op-ed is "totally inaccurate."

Mr. Roche appears to have a compelling argument, particularly since the Gallup Organization is a trusted name to most Americans. In reality, his argument is based on complete fiction and totally erroneous numbers. Mr. Roche's statement that, "83 percent of the respondents disagreed with the statement that human burning of fossil fuels causes global warming" is "totally inaccurate," according to a written statement by Harry Cotugno, a vice president at the Gallup Organization, Inc. Here's the facts:

- It also wasn't "recent." It was done in 1991. In 1992, commentators Ronald Bailey and George Will cited the study, though only claiming that "of those scientists actively involved in global climate research, 53 percent do not believe global warming has occurred."
- Mr. Roche somehow reinterprets the data to arrive at "83 percent" but even the 53 percent figure "is not a proper interpretation of the survey findings," according to Gallup. In asking Bailey, Will and others to run corrections, Gallup stated, "...most scientists involved in research in this area do believe human-induced global warming is occurring now."

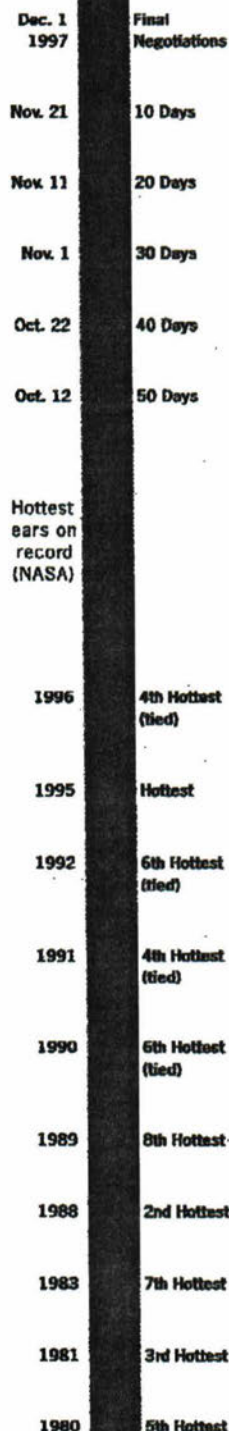
There's More

The erroneous Gallup Organization polling numbers cited by Mr. Roche appear over and over in the media. This is very typical of "facts" used by those opposing a climate treaty. They make the

(more)

Climate Countdown is a project of the
Environmental Information Center

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Skeptics in the Media - A Case Study

Page 2

same arguments over and over, regardless of their inaccuracy. A database search reveals that in a recent two month period, alone, the following references occurred:

- *St. Louis Post Dispatch*, 8/2/97
- *Asian Wall Street Journal*, 7/29/97
- *New Orleans Times-Picayune*, 7/11/97
- *New York Times*, 6/27/97
- *Arizona Republic*, 6/25/97
- *Chicago Tribune*, 6/4/97
- Furthermore, there are dozens, if not hundreds, of earlier mentions, including citations in both of Rush Limbaugh's books.

A Typical Example

The example of George Roche's op-ed in the *Detroit News* is typical of most of public arguments made by opponents of action to mitigate climate change, for these reasons:

- It takes one piece of wrong information and uses it to argue a scientific consensus does not exist. The tactic works well in the rhetoric of an op-ed, but a single Gallup poll, even if it existed, should not be given equal weight as thousands of peer-reviewed studies and research by our very best scientists in government, academia and those conducting independent research.
- It restates a wrong piece of information. Time and again opponents recycle arguments, each time presenting them as "new" information. In every case the "new" information has either been rejected by the peer-review process as scientifically flawed or shown to be complete fiction or otherwise misleading.
- The person making the argument will often appear as a "disinterested" party offering an objective opinion, but is actually motivated by profit or politics. Although Mr. Roche is identified only as the president of Hillsdale College in his op-ed, he is also a member of the far right policy group, the Council on National Policy, whose members are not scientists and economists but such figures as Phyllis Schlafly, Pat Robertson and Jesse Helms -- clearly people motivated by politics and not scientific truth. Additionally, Roche is trustee emeritus for the Foundation for Economic Education, and he serves on the National Advisory Council of the Citizen's Committee for the Right to Keep and Bear Arms. The point of this is not to tar him with the paintbrush of being conservative, but to point out that he's hardly the dispassionate, objective academic he might seem to be with the simple description of "college president."

Attached: Gallup's Response

RELATIONSHIP TO 1605

▲ Pre-Pool Submissions

- ▶ Documentation Submitted to Pool for Qualification
- ▶ Assessed by Pool Qualifying Criteria
- ▶ Qualifying Reductions Added to Inventory

▲ Post-Pool Reductions

- ▶ Annual Pool Performance Results Reported to 1605



POLICY ELEMENTS

▲ Assurance of Credit

- ▶ Specific contract
- ▶ Moral commitment

▲ Provision of Supply of Credit

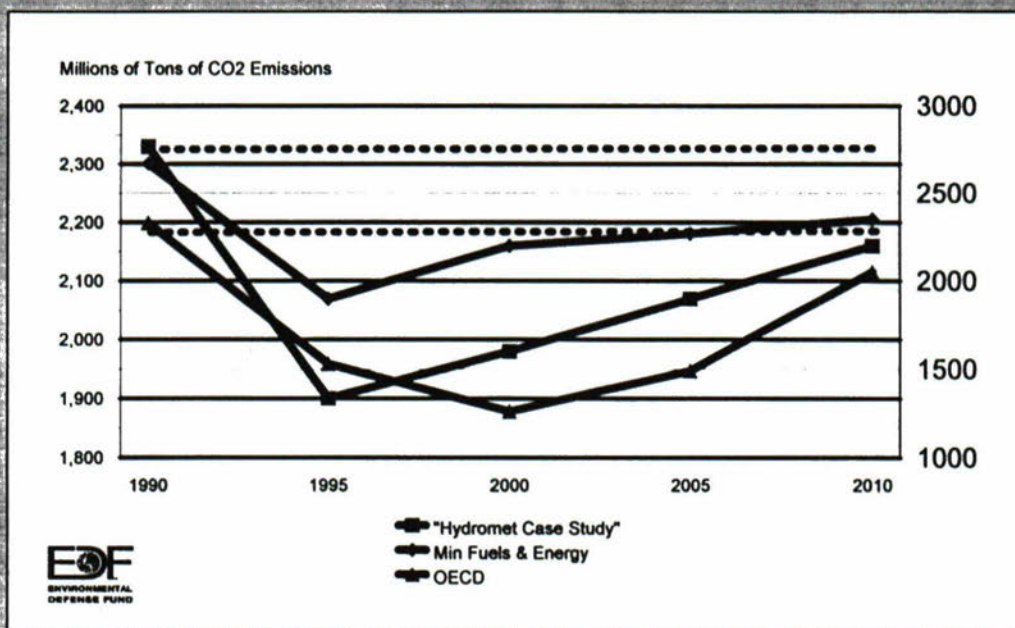
- ▶ From first budget allocation
- ▶ From an internationally purchase from a government or through joint implementation

▲ Legal Hammer

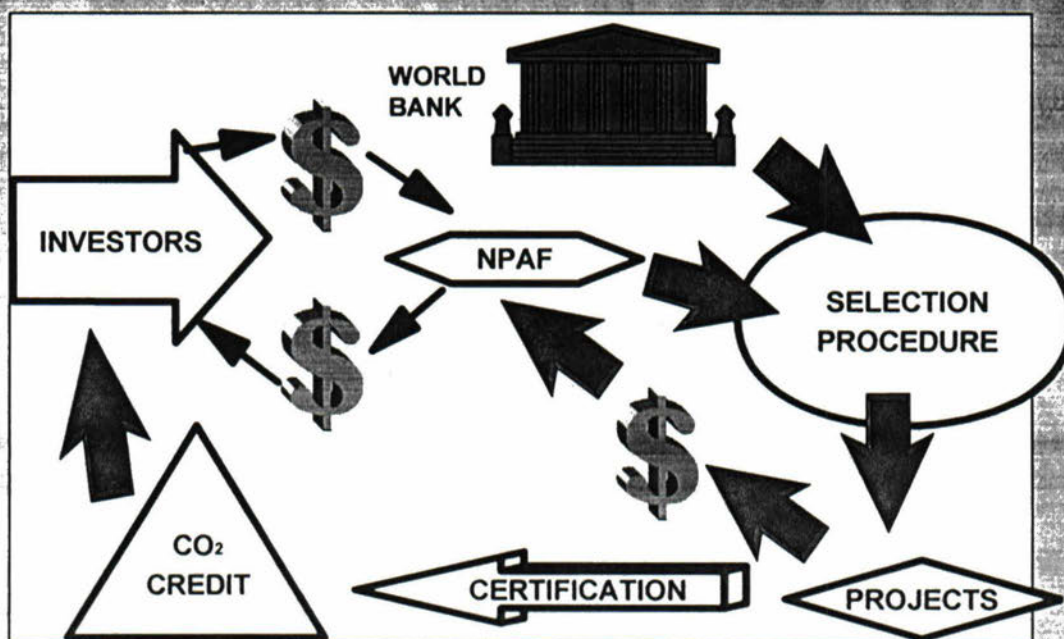
- ▶ Companies participating in a qualifying GHG pool by 2000 will receive bonus allowances consistent with pool performance
- ▶ Companies that fail to join a qualifying pool will have their emissions capped at 1990 levels in 2005



FORECASTS OF RUSSIAN CO₂ EMISSIONS



RUSSIAN GHG REDUCTION INVESTMENT MECHANISM



POOL BENEFITS

- ▲ Builds a Credible Domestic Policy Response to Kyoto
- ▲ Demonstrates Practicality and Environmental Benefits of Emissions Trading
- ▲ Facilitates the Development of Climate Friendly Product Markets
- ▲ Builds a Compliance Reserve to Manage Future Emissions Reduction Responsibilities

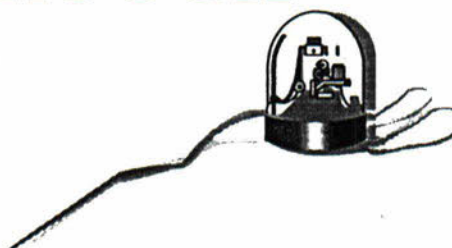


NEXT STEPS

- ▲ Identify Core Group of Founding Members
- ▲ Develop Detailed Pool Structure
- ▲ Establish Pool Contracts
- ▲ Expand Membership and Public Awareness



MANAGING GREENHOUSE GAS RISKS THROUGH POOLING



Building an Operational
Greenhouse Gas Trading System



THE POLICY CONTEXT

- ▲ Third Conference of the Parties, Kyoto
 - ▶ No matter the outcome some form of voluntary action necessary
 - ▶ US emissions will be significantly higher than 1990 levels in 2000 and 2010
 - ▶ Challenge is to bend the "BAU" emissions trajectory down to create a soft landing
- ▲ Domestic Response to Kyoto
 - ▶ Utility industry is ready to move
 - ▶ Other major industrial players are interested as well
 - ▶ Key is credit for additional voluntary efforts



GHG POOL OBJECTIVES

- ▲ Create Support for Administration's Climate Change Proposals
 - ▶ public
 - ▶ Congress
 - ▶ other nations
- ▲ Generate Incentives for Early Reductions
- ▲ Develop Protocols for Effective Emissions Trading
- ▲ Demonstrate Financial and Environmental Effectiveness of the Policy

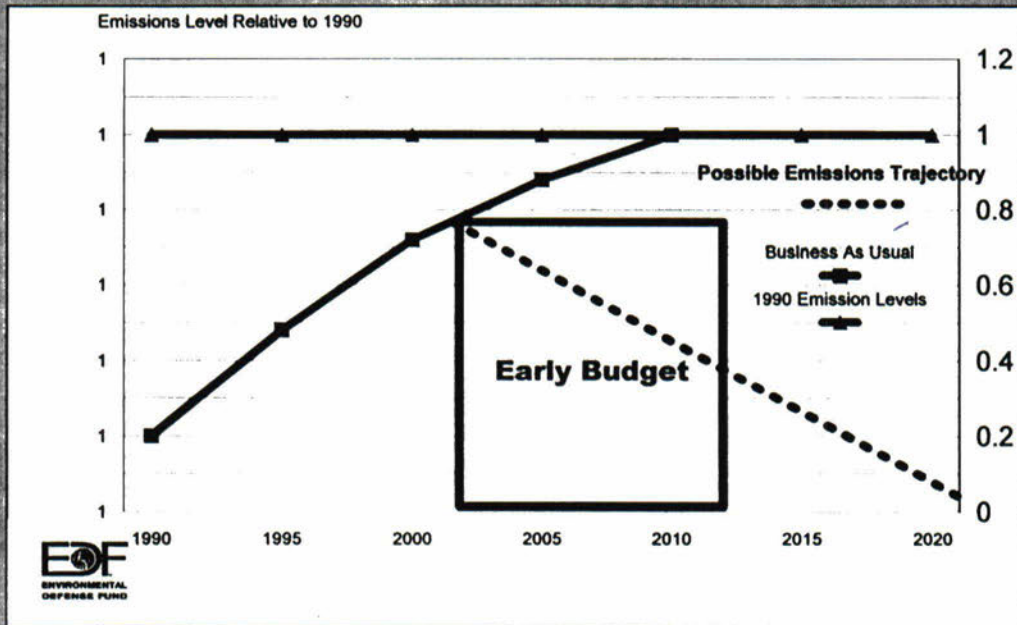


POOL CONCEPT

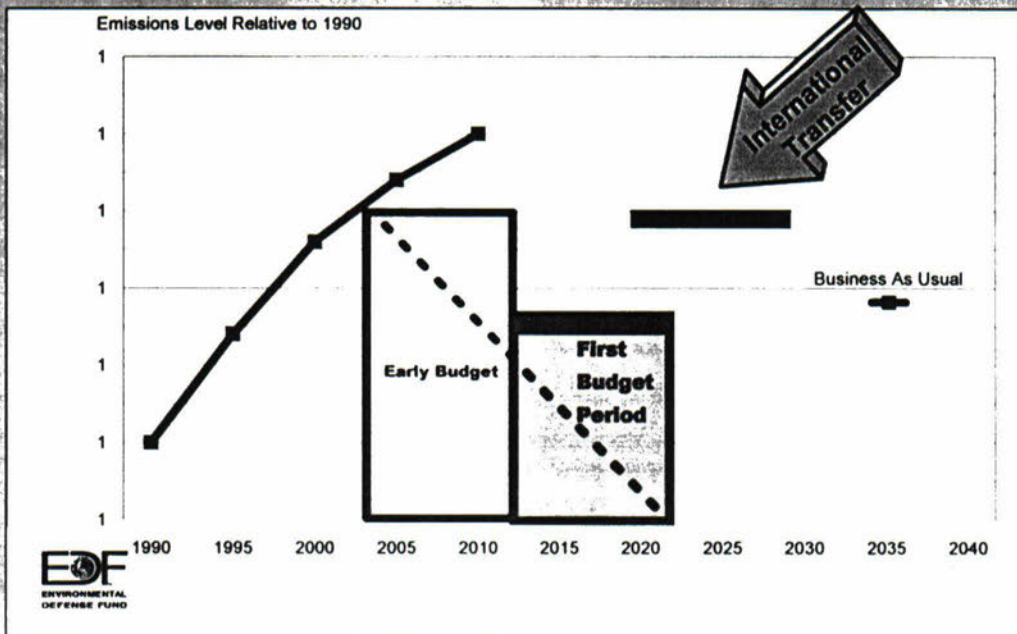
- ▲ Pool is a voluntary agreement that is legally enforceable among members
- ▲ Each member has a decadal emissions limitation which is negotiated with the pool
- ▲ Each member complies with pool obligation by meeting its emissions limitation including through the use of trading within pool, purchasing options, banking, or (if certified by the pool) trading outside the pool



CHANGING DIRECTION



SOURCE OF EARLY REDUCTION CREDITS

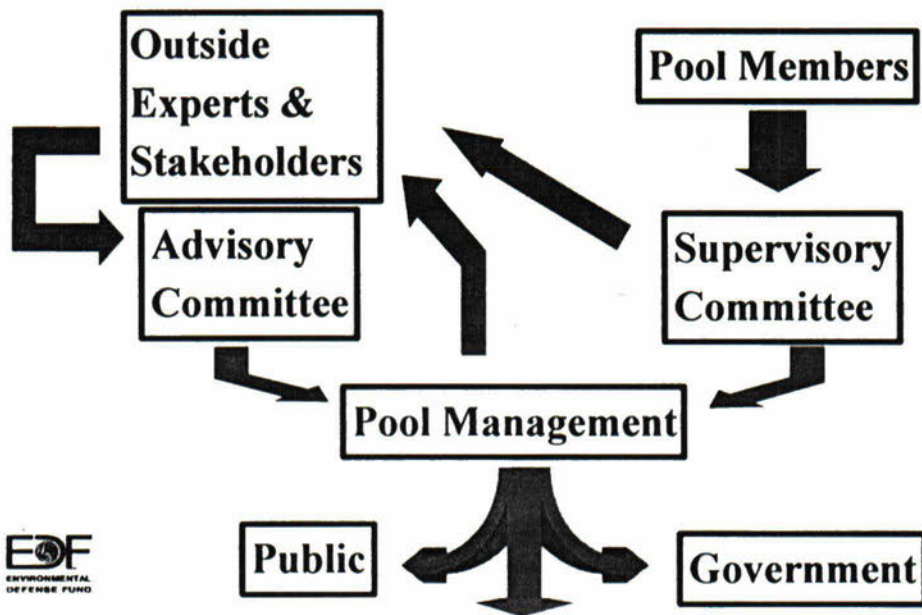


COMMITMENT ELEMENTS

- ▲ Cumulative Emissions Budget
- ▲ Annual Emission Milestones
- ▲ Annual Reporting of Emissions, Reductions, Transactions
- ▲ Meet Annual Emissions Milestone
 - ▶ Own Reductions
 - ▶ Purchase of Qualifying Reductions
 - ▶ Options on Reductions from Pool Members
 - ▶ Direct Purchase from the Pool



POOL STRUCTURE



POOL FUNCTIONING

- ▲ Monitor Member Compliance with Contractual Obligations
- ▲ Management of CEU Accounting System
- ▲ Review and Approval of Nonmember Transactions
- ▲ Provide Liquidity
- ▲ Reporting of Results of Pool Operations



RELATIONSHIP TO NONMEMBERS

- ▲ Pool Members Free to Sell to Nonmembers
- ▲ Nonmembers Cannot Buy Directly From the Pool
- ▲ Nonmembers' Reductions Must Be Qualified If Offered For Placement
 - ▶ Nonmembers Pay For Qualification Unless Transacting with a Member
 - ▶ Nonmembers Pay a Consignment Fee
- ▲ Nonmembers Cannot Sell Options





1967 **30** 1997
YEARS

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TO: Beth Viola

FROM: Michael Oppenheimer
Chief Scientist

DATE: September 9, 1997

RE: Ross Gelbspan's The Heat Is On

During the trip to Glacier National Park last week, Mr. Gore asked me to provide him with a list of errors in Ross Gelbspan's The Heat Is On, as a cautionary note for the President who is now reading the book. Below I cite a handful of specific places in the book where the President ought to be aware of significant errors or overstatements. I have also attached a review written by me for the *Los Angeles Times* that summarizes my views on both the strengths and weaknesses of the book. My general opinion of the The Heat Is On is very positive.

- pp. 1-2, 146-7 – The Antarctic Peninsula has warmed by about 2 degrees Fahrenheit in the past twenty years not "20 degrees Fahrenheit in the last twenty years". This section also implies that the observed breakup of floating ice shelves around the Antarctic Peninsula is a precursor of "catastrophic flooding". In fact, it is the disintegration of ice sheets based on land rather than floating ice shelves that leads to sea level rise and flooding. There is no indication that the observed melting of ice shelves around the Antarctic Peninsula is leading to disintegration of land-based ice there. However, if the much larger Ross and Filchner-Ronne ice shelves far to the south of the peninsula begin to fragment due to warming, this might lead to accelerated loss of ice based on land, and catastrophic flooding in the distant future. It would take several centuries for this scenario to unfold, but sufficient warming could occur during the 21st century to make it inevitable.
- pp. 3, 49 – The "recent weather record" has not been marked by "stronger hurricanes". Throughout the book, it is implied that hurricanes are becoming stronger and more frequent and that this change is a sign of global warming. However, no long term trend in hurricane strength has been found, and although hurricane frequency was indeed high during 1995 and 1996, it was anomalously low during the 1960's through 1980's. Nevertheless, some studies have indicated that both strength and intensity of hurricanes may increase if the world continues to warm, although there is not yet a consensus on these points.
- pp. 11, 48 "Colder cold" is not a necessary outcome of global warming. Throughout the book, it is implied that all types of climate phenomena, including cold waves, will become more extreme. Actually, some climate extremes are expected to be moderated at most locations by global warming, and extreme winter cold is one of them. However, some scenarios suggest that North Atlantic ocean circulation could be disrupted by global warming and this change could lead to colder winters for northern Europe.
- p. 18 – The pre-industrial concentration of carbon dioxide in the atmosphere was 0.03%, not 0.3%.
- pp. 147, 162 – "Three feet" is the uppermost estimate of sea level rise projected for the next century. The range projected is 1/2 to 3 feet.

Hot Stuff

MICHAEL OPPENHEIMER

**THE HEAT IS ON
The High Stakes
Battle Over Earth's
Threatened Climate
By Ross Gelbspan**

Addison-Wesley: 278 pp., \$23

Forty years ago, Vice President Al Gore's environmental mentor, Roger Revelle, warned that "human beings are now carrying out a large scale geophysical experiment . . . on Earth. Burning coal, oil and natural gas to produce electricity, drive automobiles and power industry was causing a buildup of carbon dioxide that traps heat in the atmosphere that would otherwise escape into space. Would the result be a significant warming of the global climate?"

Initial results on the "experiment" are now available. "The balance of evidence suggests that there is a discernible human influence on global climate," according to the 1996 report of the United Nations' Intergovernmental Panel on Climate Change, a worldwide body of 2,500 scientists assembled to advise governments on the scientific facts of life on global warming. This outcome was based on detailed analysis of historical records and super-computer simulations of temperature that show the characteristic fingerprint of human activity superimposed on the normal background of climatic variation.

To many scientists, the conclusions of this report came as no surprise because, in the decades since Revelle's warning, research has provided evidence that humans were changing the atmosphere. Among the key findings are that the atmospheric level of carbon dioxide has increased by 30% since the Industrial Revolution and that the Earth has warmed about one degree Fahrenheit since the latter part of the 19th century. Furthermore, samples of air trapped in ancient ice show that at earlier times, natural climate variations were closely associated with natural variations in carbon dioxide and other heat-trapping greenhouse gases, which have now attained their highest atmospheric levels in more than 200,000 years because of human emissions.

Ross Gelbspan, formerly a reporter and editor for the *Boston Globe*, has monitored the progress of global environmental issues for 25 years, and "The Heat Is On" bears the mark of someone who has reported on the environment for a long time and brings to the subject a deep perspective. But Gelbspan's focus is less on the details of the scientific experiment than on the sociopolitical experiment that has begun as governments attempt to grapple with solutions to the problem. In 1992, after 18 months of wrangling, governments of the industrialized countries—including the United States, Europe and Japan—agreed to make attempts to return emis-

sions to 1990 levels by 2000. The treaty, the United Nations Framework Convention on Climate Change, was signed at the Earth Summit in Rio de Janeiro. But negotiations continue because the initial limits were insufficient, and most countries, including the United States, are expected to fail to meet the objective of the accord in any event.

A fracas that had been brewing slowly for several years broke out as fossil-fuel interests—both oil and coal companies and oil-producing nations—realized that their lifeblood was threatened. One way or another, slowing global warming means slashing fossil fuel use and replacing it with renewable sources like solar energy. Various industry combinations geared up for battle. One industry group has retained its own representative, who attends the negotiations as a supposed observer but, in fact, appears to orchestrate the negotiating positions of the Saudi and Kuwaiti delegates. As oil-producing nations, Saudi Arabia and Kuwait are not thrilled about the prospect of an energy transition away from fossil fuels.

The inside glimpse at how these interests go about the business of influencing policy on an issue where global habitability is at stake is both revealing and appalling. The most troubling episode occurred when those opposed to emissions limitation launched a public relations war that included a nasty attack on the integrity of scientists doing the fundamental research on the climate fingerprint.

Gelbspan is particularly insightful on the effectiveness with which this campaign has obfuscated the issue and dazed the body politic by deploying arguments of a handful of scientists whose views conflict sharply with the rest of the scientific community. Yet their arguments have generated columns of ink in great disproportion to their numbers and their influence among other scientists. Gelbspan blames the industry groups, who provide resources for public relations efforts that amplify fringe science in the public arena. He also takes the press to task for its adherence to a "fairness" model that is more fittingly applied to political arguments because it provides equal time to all sides. With science, unlike politics, there is usually only one truth.

The author presents a disturbing replay of a series of hearings held after the Republican majority took control of the Congress in 1994, hearings that saw the scientists with fringe views treated with great deference and saw the views of respected mainstream scientists derided with such retorts as Rep. John T. Doolittle (R-Rocklin): "I'm not going to get involved in a mumbo-jumbo of peer-reviewed documents." (For readers who don't follow science, peer review is the process that filters out the credible from the indefensible before it is published.) And consider what Rep. Dana Rohrabacher (R-Huntington Beach) asserted about global warming: "At best it's non-proven, and at worst it's liberal

claptrap." Such uninformed rambling would be merely humorous if the result had not been significant reductions in the science research budget for this issue.

People need to read this book, whether they are concerned about slowing global warming or about the use and abuse of science in the political arena or about the struggle in the world between the haves and the have-nots, a struggle that repeats itself over issues of population limitation to trade to disarmament. The chapter "After Rio: The Swamp of Diplomacy" is particularly insightful; it will no doubt make some readers deeply skeptical that negotiation-as-usual can produce a solution in time to avert disruptive climate changes.

But readers should be aware of a few significant shortcomings in the book. The presentation of scientific details is far from the best available. In more than a few instances, the descriptions confuse rather than clarify the issues and misrepresent the level of scientific understanding by using "will" rather than "may" in projecting potential outcomes of warming or, in a few instances, are just incorrect. For example, Gelbspan argues that "the recent weather record has been marked by stronger hurricanes . . ." that are "nature's expressions of the early stages of the heating of the atmosphere." In fact, the average strength of North Atlantic hurricanes has decreased since the 1940s, and there is little evidence of a trend in hurricane frequency. There was a large number of such storms in 1995 and 1996, but it came after several decades of unusually low hurricane incidence. As for the future, an argument can be made that strong hurricanes may get stronger in a warmer world, but there is not yet a consensus on the matter. The author also leaves the impression that all extremes of climate are bound to occur more frequently. To the contrary, some extremes, like the frequency of extreme cold, are likely to become less common at most locations.

His solution—essentially a public takeover of the energy sector accompanied by a massive public relations campaign to quickly convert the public—is draconian and unlikely to attract many adherents. It seems to reflect Gelbspan's understandable impatience with the fact that the future of the world is tied up in the vagaries of international diplomacy and the unruliness of the market. Others have argued more persuasively and realistically that the solution to the problem—implementing high-efficiency technology and solar energy sources—would be better achieved using incentives and disincentives than technology mandates and confiscation.

Some observers disagree about the pace of the negotiations, arguing that progress has been rapid indeed, compared to work on other international issues such as nuclear weapons testing. Nevertheless, greenhouse gases keep building up, the climate is beginning to change and the consequences will be largely irreversible. Can we really blame Gelbspan for being impatient? ■

Michael Oppenheimer is chief scientist and chairman of the Global/Regional Air Program at the Environmental Defense Fund in New York.

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'97 SEP 10 PM3:38

→ Resend - 7 pages
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Message: Attached please find excerpts from the National Academy of Sciences 1991 Report, "Policy Implications of Greenhouse Warming," pages 62-63, and 105-106.

-Annie Petsonk

POLICY IMPLICATIONS OF GREENHOUSE WARMING

Policy Implications of Greenhouse Warming—Synthesis Panel

Committee on Science, Engineering, and Public Policy

National Academy of Sciences
National Academy of Engineering
Institute of Medicine

NATIONAL ACADEMY PRESS
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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council (NRC), whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the panel responsible for this report were chosen for their special competences and with regard for appropriate balance. This report is the result of work done by an independent panel appointed by the Committee on Science, Engineering, and Public Policy, which has authorized its release to the public.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee and by the Committee on Science, Engineering, and Public Policy. Both consist of members of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine.

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TABLE 6.3 Cost-Effectiveness Ordering of Geoengineering Mitigation Options

Mitigation Option	Net Implementation Cost	Potential Emission Mitigation (1 CO ₂ equivalent per year)
Low stratospheric snow	Low	8 billion to 25 billion
Low stratospheric dust, aircraft delivery	Low	8 billion to 80 billion
Stratospheric dust (guns or balloon lift)	Low	4 trillion or amount desired
Cloud stimulated by provision of cloud condensation nuclei	Low	4 trillion or amount desired
Stimulation of ocean biomass with iron	Low to moderate	7 billion or amount desired
Stratospheric bubbles (multiple balloons)	Low to moderate	4 trillion or amount desired
Space mirrors	Low to moderate	4 trillion or amount desired
Atmospheric CFC removal	Unknown	Unknown

NOTE: The feasibility and possible side-effects of these geoengineering options are poorly understood. Their possible effects on the climate system and its chemistry need considerably more study and research. They should not be implemented without careful assessment of their direct and indirect consequences.

Cost-effectiveness estimates are categorized as either savings (for less than 0), low (\$0 to \$9/t CO₂ equivalent), moderate (\$10 to \$99/t CO₂ equivalent), or high (>\$100/t CO₂ equivalent). Potential emission savings (which in some cases include not only the annual emissions, but also changes in atmospheric concentrations already in the atmosphere—stock) for the geoengineering options are also shown. These options do not reduce the flow of emissions into the atmosphere but rather alter the amount of warming resulting from those emissions. Mitigation options are placed in order of cost-effectiveness.

The CO₂-equivalent reductions are determined by calculating the equivalent reduction in radiative forcing.

Here and throughout this report, tons are metric.

SOURCE: Chapter 11 of the report of the Mitigation Panel.

COMPARING OPTIONS

Table 6.2 shows estimates of net cost and emission reductions for several options. It must be emphasized that the table presents the panel's estimates of the technical potential for each option. For example, the calculation of cost-effectiveness of high-efficiency light bulbs (one of the building efficiency options) does not consider whether the supply of light bulbs could meet the demand with current production capacities. It does not consider the trade-off between expenditures on light bulbs and on health care, educa-

tion, or basic shelter for low-income families. Nor does it consider aesthetic issues about different sources of illumination.

Care must be taken in developing such a table because there is some "double-counting" among potential mitigation options. For example, implementation of both the nuclear and the natural gas energy options assumes replacement of the same coal-fired power plants. Thus, simply summing up the emission reductions of all options to give total reduction in emissions would overstate the actual potential. The options presented in Table 6.2 have been selected to eliminate double-counting.

Finally, although there is evidence that efficiency programs can pay, there is no field evidence showing success with programs on the massive scale suggested here. There may be very good reasons why options exhibiting net benefit on the table are not fully implemented today.

Figure 6.3 illustrates the results of different rates of implementation of those options. The many uncertainties in the calculations of both costs and emission reductions have been collapsed into two lines. The line labeled "25% Implementation/High Cost" assumes incomplete implementation of each option (25 percent implementation of feasible opportunities) and the high end of the range of cost estimates for that option (high cost). This line shows a lower bound of what is reasonable to achieve. The line labeled

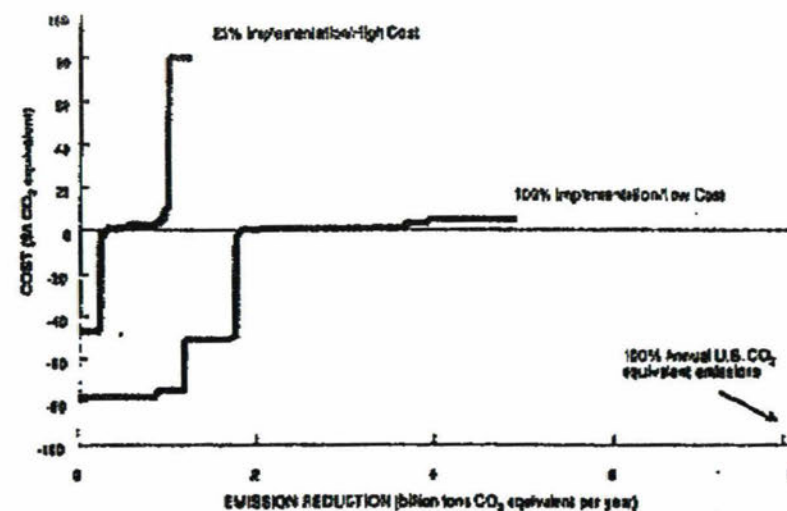


FIGURE 6.3 Comparison of mitigation options. Total potential reduction of CO₂-equivalent emissions is compared to the cost in dollars per ton of CO₂ reduction. Options are ranked from left to right in CO₂ emissions according to cost. Some options show the possibility of reductions of CO₂ emissions at a net savings. See text for explanation.

SOURCE: Chapter 11 of the report of the Mitigation Panel.

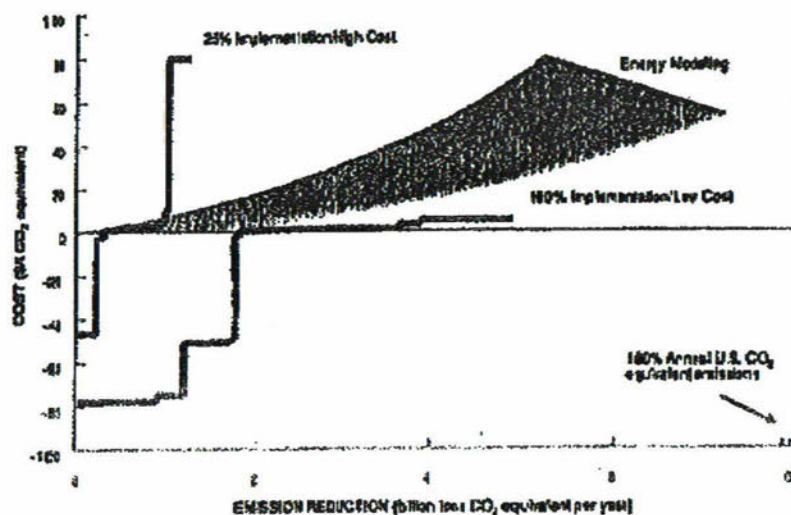


FIGURE 6.4 Comparison of mitigation options using technological costing and energy modeling calculations.

SOURCE: Chapter 14 of the report of the Mitigation Panel.

"100% Implementation/Low Cost" assumes complete implementation of each option (100 percent implementation) combined with the low range of cost estimates for that option (low cost). This line indicates the upper bound that could be achieved with all options shown. A complete analysis would calculate appropriate implementation rates for each option. That is beyond the scope of this study. It should be realistic to achieve emission reduction and cost results somewhere between the two lines in Figure 6.3.

As pointed out earlier in this chapter, technological costing and energy modeling sometimes yield different results. For this reason, both are presented in Figure 6.4. The "100% Implementation/Low Cost" and "25% Implementation/High Cost" curves are repeated from Figure 6.3, and the range typical of energy modeling is shown. As can be seen from Figure 6.4, the United States should be able to achieve substantial reduction in greenhouse gas emissions at low cost, or perhaps even a small net savings.

IMPLEMENTING MITIGATION OPTIONS

An array of policy instruments of two different types are available: regulation and incentives. Regulatory instruments mandate action and include controls on consumption (bans, quotas, required product attributes), produc-

tion (quotas on products or substances), and factors in design or production (efficiency, durability, processes). Incentive instruments are designed to influence decisions by individuals and organizations and include taxes and subsidies on production factors (carbon tax, fuel tax) and on products and other outputs (emission taxes, product taxes), financial inducements (tax credits, subsidies), and transferable emission rights (tradable emission reductions, tradable credits).

Interventions at all levels could effectively reduce greenhouse warming. For example, individuals could reduce energy consumption, recycle goods, and reduce consumption of deleterious materials. Local governments could control emissions from buildings, transport fleets, waste processing plants, and landfill dumps. State governments could restructure electric utility pricing structures and stimulate a variety of efficiency incentives. National governments could pursue action in most of the policy areas of relevance. International organizations could coordinate programs in various parts of the world, manage transfers of resources and technologies, and facilitate exchange of monitoring and other relevant data.

The choice of policy instrument depends on the objective to be served. Although this analysis of mitigation options does not include all possibilities, the panel is hopeful that it does identify the most promising options. This analysis provides the beginnings of a structure and a process for identifying those strategies that could appropriately mitigate the prospect of greenhouse warming.

CONCLUSIONS

There is a potential to inexpensively reduce or offset greenhouse gas emissions in the United States. In particular, the maximum feasible potential reduction for the options labeled "net benefit" and "low cost" in Table 6.2 totals about 3.6 billion tons (3.6 Gt) of CO₂-equivalent emissions per year. (Here, as elsewhere in the report, tons are metric.) This is a little more than one-third of the total 1990 greenhouse gas emissions in the United States and represents an optimistic upper bound on what could be achieved using these options.

A lower bound can be estimated from Figure 6.4. Arbitrarily using a cutoff of between \$10 and \$20 per ton of CO₂-equivalent emission reduction would produce a level of about 1 Gt of CO₂-equivalent emissions per year, or a little more than 10 percent of current greenhouse gas emissions in the United States.

This analysis suggests that the United States could reduce its greenhouse gas emissions by between 10 and 40 percent of the 1990 level at very low cost. Some reductions may even be at a net savings if the proper policies are implemented.

TABLE A.4 Estimated 1985 Global Greenhouse Gas Emissions from Human Activities

	Greenhouse Gas Emissions (Mt/yr)	CO ₂ -equivalent Emissions ^a (Mt/yr)	
CO₂ Emissions			
Commercial energy	18,800	18,800	(57)
Tropical deforestation	2,600	2,600	(8)
Other	400	400	(1)
TOTAL	21,800	21,800	(66)
CH₄ Emissions			
Fuel production	60	1,300	(4)
Enteric fermentation	70	1,500	(5)
Rice cultivation	110	2,300	(7)
Landfills	30	600	(2)
Tropical deforestation	20	400	(1)
Other	30	600	(2)
TOTAL	320	6,700	(20)^b
CFC-11 and CFC-12 Emissions			
TOTAL	0.6	3,200	(10)
N₂O Emissions			
Coal combustion	1	290	(>1)
Fertilizer use	1.5	440	(1)
Gain of cultivated land	0.4	120	(>1)
Tropical deforestation	0.5	150	(>1)
Fuel wood and industrial biomass	0.2	60	(>1)
Agricultural wastes	0.4	120	(>1)
TOTAL	4	1,180	(4)
TOTAL		32,880	(100)

^aCO₂-equivalent emissions are calculated from the Greenhouse Gas Emissions column by using the following multipliers:

CO ₂	1
CH ₄	21
CFC-11 and -12	5,400
N ₂ O	290

Numbers in parentheses are percentages of total.

^bTotal does not sum due to rounding errors.

NOTE: Mt/yr = million (10⁶) metric tons (t) per year. All entries are rounded because the exact values are controversial.

SOURCE: Adapted from U.S. Department of Energy. 1990. *The Economics of Long-Term Global Climate Change: A Preliminary Assessment—Report of an Interagency Task Force*. Springfield, Va.: National Technical Information Service.

CO₂ that would produce the same amount of forcing at the surface is calculated. This is the CO₂ equivalent for that specific concentration of the other greenhouse gas. The respective costs per ton for different options can then be compared directly. It is important to recognize, however, that these calculations allow comparison only of initial contributions. They do not account for changes in energy-trapping effectiveness over the various lifetimes of these gases in the atmosphere.

35. What mitigation options are most cost-effective?

The panel ranks options for reducing greenhouse gas emissions or removing greenhouse gases from the atmosphere according to their cost-effectiveness. Some of these options have net savings or very low net implementation costs compared to other investments. The options range from net savings more than \$100 per metric ton of CO₂-equivalent emissions avoided or removed from the atmosphere. The most cost-effective mitigation options are presented in Table A.5.

36. What are examples of options with large potential to reduce or offset emissions?

The so-called geoengineering options have the potential of substantially affecting atmospheric concentrations of greenhouse gases. They have the ability to screen incoming sunlight, stimulate uptake of CO₂ by plants and animals in the oceans, or remove CO₂ from the atmosphere. Although they appear feasible, they require additional investigation because of their potential environmental impacts.

37. How much would it cost to significantly reduce current U.S. greenhouse gas emissions?

It depends on the level of emission reduction desired and how it is done. The most cost-effective options are those that enhance efficient use of energy: efficiency improvements in lighting and appliances, white roofs, paving to enhance reflectivity, and improvement in building and construction practices.

Figure A.4 compares mitigation options, and Table A.5 gives the panel's estimates of net cost and emission reductions for several options. It must be emphasized that the table presents the panel's estimates of the maximum technical potential for each option. The calculation of cost-effectiveness for lighting efficiency, for example, does not consider whether the supply of light bulbs could meet the demand with current production capacities. It does not consider the trade-off between expenditures on light bulbs and health care, education, or basic shelter for low-income families. In addition, there is a danger of some "double counting." For example, in the case of energy supply both nuclear and natural gas energy options assume

TABLE A.5 Comparison of Selected Mitigation Options in the United States

Mitigation Option	Not Implementation Cost ^a	Potential Emission ^b Reduction (1 CO ₂ equivalent per year)
Building energy efficiency	Net benefit	910 million ^c
Vehicle efficiency (no fleet change)	Net benefit	300 million
Industrial energy management	Net benefit to low cost	500 million
Transportation system management	Net benefit to low cost	50 million
Power plant heat rate improvements	Net benefit to low cost	50 million
Landfill gas collection	Low cost	200 million
Halocarbon-CFC usage reduction	Low cost	1410 million
Agriculture	Low cost	200 million
Reforestation	Low to moderate cost ^d	200 million
Electricity supply	Low to moderate cost ^d	1000 million ^e

^aNet benefit = cost less than or equal to zero.

Low cost = cost between \$1 and \$9 per ton of CO₂ equivalent.

Moderate cost = cost between \$10 and \$99 per ton of CO₂ equivalent.

High cost = cost of \$100 or more per ton of CO₂ equivalent.

^bThis "maximum feasible" potential emission reduction assumes 100 percent implementation of each option in reasonable applications and is an optimistic "upper bound" on emission reductions.

^cThis depends on the actual implementation level and is controversial. This represents a middle value of possible rates.

^dSome portions do fall in low cost, but it is not possible to determine the amount of reductions obtainable at that cost.

^eThe potential emission reduction for electricity supply options is actually 1700 Mt CO₂ equivalent per year, but 1000 Mt is shown here to remove the double-counting effect.

NOTE: Here and throughout this report, tons are metric.

SOURCE: Chapter 11 of the Mitigation Panel report.

placement of the same coal-fired power plants. Table A.5, however, presents only options that avoid double counting. Finally, although there is evidence that efficiency programs can pay, there is no field evidence showing success with programs on the massive scale suggested here. Thus there may be very good reasons why "negative cost options" on the figure are not implemented today.

The United States could reduce its greenhouse gas emissions by between 10 and 40 percent of the 1990 levels at low cost, or perhaps some net savings, if proper policies are implemented.

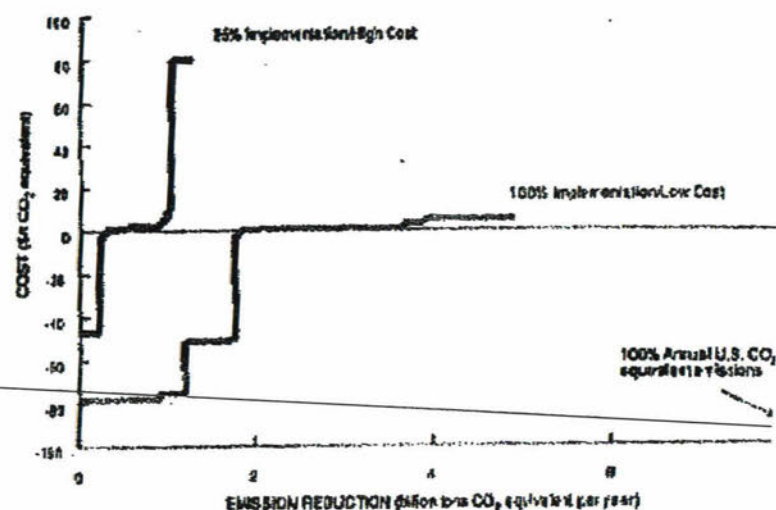


FIGURE A.4 Comparison of mitigation options. Total potential reduction of (C) equivalent emissions is compared to the cost in dollars per ton of CO₂ reduction. Options are ranked from left to right in CO₂ emissions according to cost. Some options show the possibility of reductions of CO₂ emissions at a net savings.

SOURCE: Chapter 11 of the report of the Mitigation Panel.

ADAPTING TO ADDITIONAL GREENHOUSE WARMING

38. Will human and natural systems adapt without assistance?

Farmers adjust their crops and cultivation practices in response to weather patterns over time. Natural ecosystems also adapt to changing conditions. The real issue is the rate at which human and natural systems will be able to adjust.

39. At what rates can human and natural systems adapt?

Many human systems have decision and investment cycles that are longer than the time in which impacts of climate change would become noticeable. These systems in the United States should be able to adjust to climate change without governmental intervention, as long as it is gradual. Information about the rates of change is widely available. This applies to agriculture, commercial forestry, and most of industry. Industrial systems with extremely long investment cycles (e.g., transport systems, urban infrastructure, and major structures and facilities) or requiring high volatility in water may require special attention. Coastal urban settlements with

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Additional

Message: Attached please find an excerpt from the National Academy of Sciences 1991 Report, "Policy Implications of Greenhouse Warming,"

pages 62-63

105-106

—Annie Petsonk

3 ~~5~~ pages total

TABLE A.4 Estimated 1985 Global Greenhouse Gas Emissions from Human Activities

	Greenhouse Gas Emissions (Mt/yr)	CO ₂ -equivalent Emissions ^a (Mt/yr)	
CO₂ Emissions			
Commercial energy	18,800	18,800	(57)
Tropical deforestation	2,600	2,600	(8)
Other	400	400	(1)
TOTAL	21,800	21,800	(66)
CH₄ Emissions			
Fuel production	60	1,300	(4)
Enteric fermentation	70	1,500	(5)
Rice cultivation	110	2,300	(7)
Landfills	30	600	(2)
Tropical deforestation	20	400	(1)
Other	30	600	(2)
TOTAL	320	6,700	(20)^b
CFC-11 and CFC-12 Emissions			
TOTAL	0.6	3,200	(10)
N₂O Emissions			
Coal combustion	1	290	(>1)
Fertilizer use	1.5	440	(1)
Grain of cultivated land	0.4	120	(>1)
Tropical deforestation	0.5	150	(>1)
Fuel wood and industrial biomass	0.2	60	(>1)
Agricultural wastes	0.4	120	(>1)
TOTAL	4	1,180	(4)
TOTAL		32,880	(100)

^aCO₂-equivalent emissions are calculated from the Greenhouse Gas Emissions column by using the following multipliers:

CO ₂	1
CH ₄	21
CFC-11 and -12	5,400
N ₂ O	290

Numbers in parentheses are percentages of total.

^bTotal does not sum due to rounding errors.

NOTE: Mt/yr = million (10⁶) metric tons (t) per year. All entries are rounded because the exact values are controversial.

SOURCE: Adapted from U.S. Department of Energy, 1990. *The Economics of Long-Term Global Climate Change: A Preliminary Assessment—Report of an Interagency Task Force*. Springfield, Va.: National Technical Information Service.

CO₂ that would produce the same amount of forcing at the surface is calculated. This is the CO₂ equivalent for that specific concentration of the other greenhouse gas. The respective costs per ton for different options can then be compared directly. It is important to recognize, however, that these calculations allow comparison only of initial contributions. They do not account for changes in energy-trapping effectiveness over the various lifetimes of these gases in the atmosphere.

35. What mitigation options are most cost-effective?

The panel ranks options for reducing greenhouse gas emissions or removing greenhouse gases from the atmosphere according to their cost-effectiveness. Some of these options have net savings or very low net implementation costs compared to other investments. The options range from net savings to more than \$100 per metric ton of CO₂-equivalent emissions avoided or removed from the atmosphere. The most cost-effective mitigation options are presented in Table A.5.

36. What are examples of options with large potential to reduce or offset emissions?

The so-called geoengineering options have the potential of substantially affecting atmospheric concentrations of greenhouse gases. They have the ability to screen incoming sunlight, stimulate uptake of CO₂ by plants and animals in the oceans, or remove CO₂ from the atmosphere. Although they appear feasible, they require additional investigation because of their potential environmental impacts.

37. How much would it cost to significantly reduce current U.S. greenhouse gas emissions?

It depends on the level of emission reduction desired and how it is done. The most cost-effective options are those that enhance efficient use of energy: efficiency improvements in lighting and appliances, white roofs and paving to enhance reflectivity, and improvement in building and construction practices.

Figure A.4 compares mitigation options, and Table A.5 gives the panel's estimates of net cost and emission reductions for several options. It must be emphasized that the table presents the panel's estimates of the *maximum* technical potential for each option. The calculation of cost-effectiveness of lighting efficiency, for example, does not consider whether the supply of light bulbs could meet the demand with current production capacities. Nor does it consider the trade-off between expenditures on light bulbs and on health care, education, or basic shelter for low-income families. In addition, there is a danger of some "double counting." For example, in the area of energy supply both nuclear and natural gas energy options assume re-

TABLE A.5 Comparison of Selected Mitigation Options in the United States

Mitigation Option	Net Implementation Cost ^a	Potential Emission Reduction (1 CO ₂ equivalent per year)
Building energy efficiency	Net benefit	900 million ^c
Vehicle efficiency (no fleet change)	Net benefit	300 million
Industrial energy management	Net benefit to low cost	300 million
Transportation system management	Net benefit to low cost	50 million
Power plant heat rate improvements	Net benefit to low cost	50 million
Landfill gas collection	Low cost	200 million
Halocarbons-CFC usage reduction	Low cost	1400 million
Agriculture	Low cost	200 million
Reforestation	Low to moderate cost ^d	200 million
Electricity supply	Low to moderate cost ^e	1000 million ^c

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SOURCE: Chapter 11 of the Mitigation Panel report.

placement of the same coal-fired power plants. Table A.5, however, presents only options that avoid double counting. Finally, although there is evidence that efficiency programs can pay, there is no field evidence showing success with programs on the massive scale suggested here. Thus there may be very good reasons why "negative cost options" on the figure are not implemented today.

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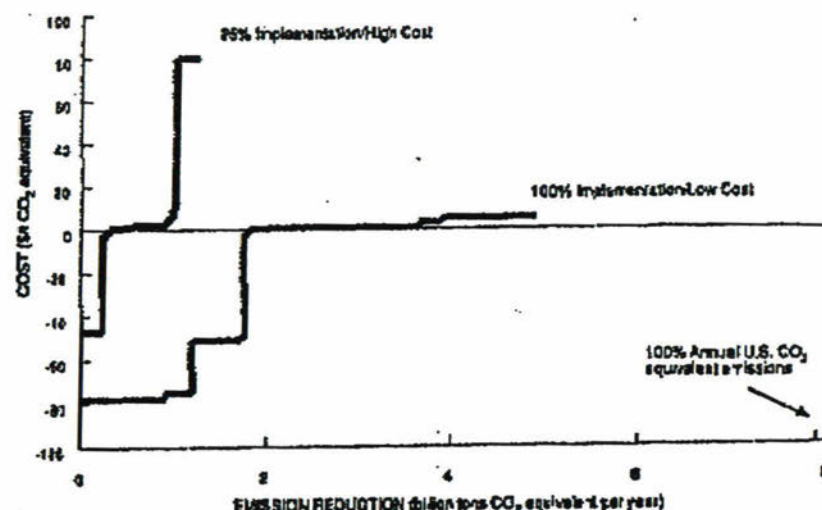


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SOURCE: Chapter 11 of the report of the Mitigation Panel.

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pages 62-63

-Annie Petsonk

4 pages total

POLICY IMPLICATIONS OF GREENHOUSE WARMING

Policy Implications of Greenhouse Warming—Synthesis Panel

Committee on Science, Engineering, and Public Policy

**National Academy of Sciences
National Academy of Engineering
Institute of Medicine**

**NATIONAL ACADEMY PRESS
Washington, D.C. 1991**

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council (NRC), whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the panel responsible for this report were chosen for their special competences and with regard for appropriate balance. This report is the result of work done by an independent panel appointed by the Committee on Science, Engineering, and Public Policy, which has authorized its release to the public.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee and by the Committee on Science, Engineering, and Public Policy. Both consist of members of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine.

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Memorandum

To: Bill Antholis
From: Dan Dudek
Date: August 20, 1997
Re: Winstar Decision Summary

From the Legal Information Institute and Project Hermes

[Other parts of the opinion, WordPerfect versions, and related documents]

NOTE: Where it is feasible, a syllabus (headnote) will be released, as is being done in connection with this case, at the time the opinion is issued. The syllabus constitutes no part of the opinion of the Court but has been prepared by the Reporter of Decisions for the convenience of the reader. See *United States v. Detroit Lumber Co.*, 200 U.S. 321, 337.

SUPREME COURT OF THE UNITED STATES

Syllabus

UNITED STATES v. WINSTAR CORP. et al.

certiorari to the united states court of appeals for the federal circuit

No. 95-865. Argued April 24, 1996 -- Decided July 1, 1996

Realizing that the Federal Savings and Loan Insurance Corporation (FSLIC) lacked the funds to liquidate all of the failing thrifts during the savings and loan crisis of the 1980's, the Federal Home Loan Bank Board encouraged healthy thrifts and outside investors to take over ailing thrifts in a series of "supervisory mergers." As inducement, the Bank Board agreed to permit acquiring entities to designate the excess of the purchase price over the fair value of identifiable assets as an intangible asset referred to as supervisory goodwill, and to count such goodwill and certain capital credits toward the capital reserve

requirements imposed by federal regulations. Congress's subsequent passage of the Financial Institutions Reform, Recovery, and Enforcement Act of 1989 (FIRREA) forbade thrifts from counting goodwill and capital credits in computing the required reserves. Respondents are three thrifts created by way of supervisory mergers. Two of them were seized and liquidated by federal regulators for failure to meet FIRREA's capital requirements, and the third avoided seizure through a private recapitalization. Believing that the Bank Board and FSLIC had promised that they could count supervisory goodwill toward regulatory capital requirements, respondents each filed suit against the United States in the Court of Federal Claims, seeking damages for, *inter alia*, breach of contract. In granting each respondent summary judgment, the court held that the Government had breached its contractual obligations, and rejected the Government's "unmistakability defense"--that surrenders of sovereign authority, such as the promise to refrain from regulatory changes, must appear in unmistakable terms in a contract in order to be enforceable, see *Bowen v. Public Agencies Opposed to Social Security Entrapment*, 477 U.S. 41, 52--and its "sovereign act defense"--that a "public and general" sovereign act, such as FIRREA's alteration of capital reserve requirements, could not trigger contractual liability, see *Horowitz v. United States*, 267 U.S. 458, 461. The cases were consolidated, and the en banc Federal Circuit ultimately affirmed.

Held: The judgment is affirmed, and the case is remanded.

64 F. 3d 1531, affirmed and remanded.

Justice Souter, joined by Justice Stevens, Justice O'Connor, and Justice Breyer, concluded in Parts II, III, IV, and IV-C, that the United States is liable to respondents for breach of contract. Pp. 19-57; 66-72.

(a) There is no reason to question the Federal Circuit's conclusion that the Government had express contractual obligations to permit respondents to use goodwill and capital credits in computing their regulatory capital reserves. When the law as to capital requirements changed, the Government was unable to perform its promises and became liable for breach under ordinary contract principles. Pp. 19-30.

(b) The unmistakability doctrine is not implicated here because enforcement of the contractual obligation alleged would not block the Government's exercise of a sovereign power. The courts below did not construe these contracts as binding the Government's exercise of authority to modify its regulation of thrifts, and there has been no demonstration that awarding damages for breach would be tantamount to such a limitation. They read the contracts as solely risk shifting agreements, and respondents seek nothing more than the benefit of promises by the Government to insure them against any losses arising from future regulatory change. Applying the unmistakability doctrine to such contracts would not only represent a conceptual expansion of the doctrine beyond its historical and practical warrant, but would compromise the Government's practical capacity to make contracts, which is "of the essence of sovereignty" itself, *United States v. Bekins*, 304 U.S. 27, 51-52. Pp. 31-48.

(c) The answer to the Government's unmistakability argument also meets its two related *ultra vires* contentions: that, under the reserved powers doctrine, Congress's power to change the law in the future was an essential attribute of its sovereignty that the Bank Board and FSLIC had no authority to bargain away; and that in any event no such authority can be conferred without an express delegation to that effect. A contract to adjust the risk of subsequent legislative change does not strip the Government of its legislative sovereignty, and the contracts did not surrender the Government's sovereign power to regulate. And there is no serious question that FSLIC (and the Bank Board acting through it) lacked authority to guarantee respondents against losses arising from subsequent regulatory changes. Pp. 49-52.

(d) The facts of this case do not warrant application of the sovereign act doctrine. That doctrine balances the Government's need for freedom to legislate with its obligation to honor its contracts by asking whether the sovereign act is properly attributable to the Government as contractor. If the answer is no, the Government's defense to liability depends on whether that act would otherwise release the Government from liability under ordinary contract principles. Pp. 52-57.

(e) Even if FIRREA were to qualify as a "public and general" act, the sovereign act doctrine cannot excuse the Government's breach here. Since the object of the doctrine is to place the Government as contractor on par with a private contractor in the same circumstances, *Horowitz v. United States*, 267 U. S., at 461, the Government, like any other defending party in a contract action, must show that passage of the statute rendering its performance impossible was an event contrary to the basic assumptions on which the parties agreed, and, ultimately, that the language or circumstances do not indicate that the Government should be liable in any case. The Government has not satisfied these conditions. There is no doubt that some changes in the regulatory structure governing thrift capital reserves were both foreseeable and likely when the parties contracted with the Government. In addition, any governmental contract that not only deals with regulatory change but allocates the risk of its occurring will, by definition, fail the further condition of a successful impossibility defense, for it will indeed indicate that the parties' agreement was not meant to be rendered nugatory by a change in the regulatory law. That the Bank Board and FSLIC could not themselves preclude Congress from changing the regulatory rules does not stand in the way of concluding that those agencies assumed the risk of such change, for determining the consequences of legal change was the point of the agreements. Pp. 66-72.

Justice Souter, joined by Justice Stevens and Justice Breyer, concluded in Parts IV-A and IV-B, that, since the Government should not be excused by legislation when the substantial effect of regulation was to help itself out of improvident agreements, it is impossible to attribute the exculpatory "public and general" character to FIRREA. That statute not only had the purpose of eliminating the very accounting "gimmicks" that acquiring thrifts had been promised, but the congressional debates indicate Congress's expectation, which there is no reason to question, that FIRREA would have a substantial effect on the Government's contractual obligations. The evidence of Congress's intense concern with contracts like those at issue is not neutralized by the fact that FIRREA did not formally target particular transactions or by FIRREA's broad purpose to advance the general welfare. Pp. 58-65.

Justice Scalia, joined by Justice Kennedy and Justice Thomas, agreed that the Government was contractually obligated to afford respondents favorable accounting treatment, and violated its obligations when it discontinued that treatment under FIRREA. The Government's sovereign defenses cannot be avoided by characterizing its obligations as not entailing a limitation on the exercise of sovereign power; that approach, although adopted by the plurality, is novel and fails to acknowledge that virtually every contract regarding future conduct operates as an assumption of liability in the event of nonperformance. Accordingly, it is necessary to address the Government's various sovereign defenses, particularly its invocation of the "unmistakability" doctrine. That doctrine simply embodies the common sense presumption that governments do not ordinarily agree to curtail their sovereign or legislative powers. Respondents have overcome that presumption here in establishing that the Government promised, in unmistakable terms, to regulate them in a particular fashion, into the future. The Government's remaining arguments are readily rejected. The "reserved powers" doctrine cannot defeat a claim to recover damages for breach of contract where subsequent legislation has sought to minimize monetary risks assumed by the Government. The "express delegation" doctrine is satisfied here by the statutes authorizing the relevant federal bank regulatory agencies to enter into the agreements at issue. Finally, the "sovereign acts" doctrine adds little, if anything, to the "unmistakability" doctrine, and cannot be relied upon where the Government has attempted to abrogate the essential bargain of the contract. Pp. 1-6.

Souter, J., announced the judgment of the Court and delivered an opinion, in which Stevens and Breyer, JJ., joined, and in which O'Connor, J., joined except as to Parts IV-A and IV-B. Breyer, J., filed a concurring opinion. Scalia, J., filed an opinion concurring in the judgment, in which Kennedy and Thomas, JJ., joined. Rehnquist, C. J., filed a dissenting opinion, in which Ginsburg, J., joined as to Parts I, III, and IV.

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PRELIMINARY DRAFT: CLOSE HOLD
CLIMATE CHANGE EARLY ACTION CREDIT PROGRAM

August 25, 1997

Proposal: A Presidential announcement of Administration support for credit for early action by companies to reduce greenhouse gas emissions.

Such an announcement could provide a concrete display of our commitment to protect the environment by using market-based incentives. For example, the President could use the October White House Conference on Global Warming and Climate Change to announce that a select group of key energy-producing or consuming companies have agreed to take on emission reduction commitments to help meet our international obligations. He would also announce that, working together with these companies, we will undertake to develop a policy consistent with a list of principles that allows companies to gain credit for such early action. He would also reaffirm his commitment to an international protocol framework that combines realistic, binding emissions limits with maximum flexibility -- including international emissions trading and joint implementation.

Underlying Objective: Generating Corporate Support

A critical component of gaining public support for U.S. efforts to address climate change will be convincing a core set of industries that our policies will protect the environment without threatening economic growth -- and that the sooner they get involved, the easier the transition will be for them. An early action plan could be a central demonstration in this effort to gain corporate support. Several companies have already been taking action to reduce emissions, and we know that they and other companies are prepared to undertake even more efforts, but are seeking assurances that any emissions reductions they take now will earn them credit under whatever future regulatory framework may be established. Companies most likely to be interested in pursuing early credit would be a core group of energy and electric utility companies, as well as extremely energy-intensive industries such as aluminum and concrete producers.

Issues

Preliminary discussions with representatives from DOE, Treasury, CEA, Commerce, and EPA have revealed several difficult issues that -- depending on the specificity of the announcement -- may need to be resolved before we could announce an early credit proposal. Some are worried that these issues are sufficiently intractable as to raise fundamental doubts about the viability of the proposal itself.

- Degree of Administration commitment. The range of the Administration's commitment could extend from a simple statement that we support an early credit program as part of whatever emissions reduction system we submit for legislative approval, to a more detailed program that we negotiate with industry.

Ultimately, the program itself is very likely to require domestic legislation and may have elements that will have to be included in the international agreement. Industry groups are evaluating whether an Administration-only agreement would provide a legal basis upon which they would be able to gain credit for early action, even if subsequent legislative action altered the regulatory framework. (They cite a recent Supreme Court case, *U.S. v. Winstar Corp.*) But initial staff reactions to this argument revealed much skepticism about its practical feasibility, if not its legal standing.

In any case, it may be possible for the President to make a *conditional* commitment now -- that he will fight to include an early credit program in the relevant legislation -- and to have firms express an interest in participating *should the program become operational*. Three issues will need to be discussed further:

-- How much corporate support will materialize while the legislative details remain ambiguous (i.e., perhaps for the next few years)?

-- Is there any danger that firms will sue the U.S. Government if the program is not implemented because we fail to impose binding targets on emissions?

-- How much will the corporate sector "pocket" this program -- and thus deny us any support when we need it -- if the early credit idea is floated before the targets and timetables are released? Is there a way to link more closely support for the early credit idea to support for (or at least reduced criticism of) binding targets?

- Baselines. In order to measure "early action," we need a baseline. We need to ensure that credits are only awarded for real improvements measured from the baseline. There are several possibilities:

-- The business-as-usual projection for the firm's sector;

-- The firm's 1990, 1995, 1997, or 2000 emissions;

-- The firm's 1990, 1995, 1997, or 2000 emissions, adjusted either upward or downward by a given percentage per year or in total

- Retroactivity and equity. We need to define eligibility not only in terms of actions relative to a baseline, but also the *timing* of those actions. Will actions only be eligible after the program is formally implemented in legislation? Or after it was initially announced by the President? Will firms that participated in the Green Lights program, or any of the other Climate Action Plan programs be allowed to get credit for those past efforts? If not, will they claim that they are being punished (relative to firms that act after the program is in effect) for helping the Administration try to meet its voluntary targets? The longer the retroactivity period, and thus the more activity that is "counted," the more

expensive the early action program could be -- or the less valuable the early action credits. And what about new firms -- will they complain that the program is an unfair give-away to existing firms?

- Providing the future benefits. There are two broad choices for providing a future benefit.

1. We could promise some specific future benefit for a given current action -- for example, every metric ton of carbon emissions cut below the baseline today will produce the equivalent of an x metric ton emissions right in the first year or first several years in which carbon permits are required. The attraction of this approach is that it provides some physical (although not necessarily financial) certainty to the benefit that firms will receive early action. The cost is that the government's liabilities are open-ended -- and if the initial permit year is sufficiently delayed, the early action credits could eventually represent a substantial share of the total value of the permits.

2. We could cap the total benefits paid out under the early action program at some percentage of the total national emissions rights for the initial permit years. For example, we could cap the total benefits at X percent of the initial Y permit years. We would then give "early action credits" or "early action points" for appropriate actions. The benefit for each firm would then be determined by its share of total early action points multiplied by the aggregate capped value. The benefits themselves would presumably depend on the form of the domestic implementation package.

-- Under an auctioned permit system, the credits could take the form of a "pioneer price preference" -- a reduction in the auction price for firms with early credits.

-- Under a grandfathered permit system, they could take the form of grants of the permits themselves (this is also possible under an auction system, by carving out some portion of the permits for early credit give-aways rather than being auctioned).

-- Under other possible implementation packages, some reimbursement system could be devised.

It is important to note that regardless of how the benefits are provided -- unless they are defined in dollar terms now -- firms will not be able to determine with any precision the value of the early credits without knowing the U.S. target and timetable, the domestic implementation package, and the other details of the carbon emission reduction system. Thus, their commitments are likely to be conditional on achieving a reasonable target and timetable, combined with other flexibility provisions in the U.S. protocol proposal.

- Impact on national target. It is generally agreed that early domestic actions will not lift the U.S. national target for the initial permit years -- that is, any permits rewarded (either sold at a preference or given away) in exchange for early action will *not* be above and

beyond the U.S. national total for the initial permit years. As one specific example, a capped carve-out for early credit coupled with an auctioned permit system would involve reducing the number of permits to be auctioned by the amount of the capped carve-out -- not adding the capped amount on top of the U.S. total (which would cause the U.S. to exceed its international obligation). For early JI programs, the situation could be more complicated (see below).

- Joint implementation. Many corporations are interested in receiving early action credit for JI programs. In addition to raising questions about verifying additionality, such early credit for JI raises other issues -- such as whether the U.S. national target in the initial permit years should be adjusted for early JI credits. (Permission for such adjustments to the U.S. national cap would presumably have to be included in the international agreement. And implementing the system would require an international body to sanction and approve the JI programs before the initial permit year.) In addition, we must decide whether all JI programs -- including ones under the current pilot program -- should be eligible, or only JI programs begun after the conclusion of the pilot program. For example, we could choose to reward early action by providing credits that any projects generate after the conclusion of the pilot phase, provided the international agreement allows it.

Timing

In order for any announcement to happen, the Administration will have to quickly decide that it is ready to develop such a program, and to meet with a core group of the interested companies to nail down the details of how we would together develop a program outline. We need to determine how explicit our discussions with industry should be in determining: how emissions base-lines are established (against which any early action is measured and credited); how emissions compliance are reported and monitored prior to the establishment of any regulatory framework; and whether overseas emissions-reductions by U.S. companies will gain credit (i.e., joint implementation).

Process to resolve issues

If the Administration agrees to explore a program for early action credit, we would begin by preparing for a Presidential announcement on October 6 of an agreement for future collaboration. Following the conference, we would then make more explicit the content of such a program, with an aim of announcing it at some point in the run-up to Kyoto. Preparing the initial announcement for the conference will require the following meetings to take place:

- 9/5: Core group meeting to discuss and approve beginning discussions with a working group of interested businesses.
- 9/9: Initial meeting with industry group. Signal from Administration that collaborating on a program for early action credit is being given serious

consideration, but it has to be met with serious commitment and serious legal framework on the part of companies. The meeting would send those companies away with a mission to come back with a) what is acceptable as an early reduction crediting device; b) what commitment they need from the Administration to commit to early reductions; c) what level of early action the companies would be willing to commit to; d) what legal framework they would establish or submit themselves.

9/16: Second meeting with industry group; formal presentation on these four points.

9/16-29: Finalize the outline for a cooperative program, and plan roll-out.

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'97 SEP 10 PM3:38

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Message: Attached please find an excerpt from the National Academy of Sciences 1991
Report, "Policy Implications of Greenhouse Warming,"

pages 62-63

--Annie Petsonk

4 pages total

POLICY IMPLICATIONS OF GREENHOUSE WARMING

Policy Implications of Greenhouse Warming—Synthesis Panel

Committee on Science, Engineering, and Public Policy

**National Academy of Sciences
National Academy of Engineering
Institute of Medicine**

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee and by the Committee on Science, Engineering, and Public Policy. Both consist of members of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine.

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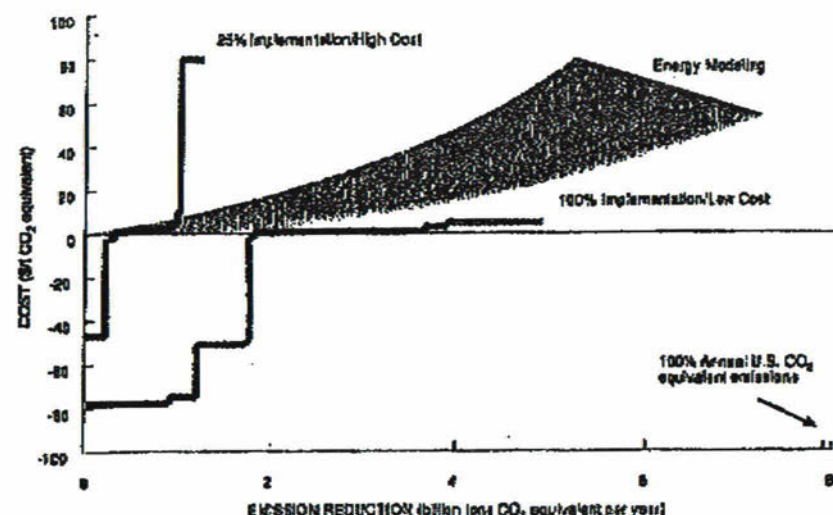


FIGURE 6.4 Comparison of mitigation options using technological costing and energy modeling calculations.

SOURCE: Chapter 11 of the report of the Mitigation Panel.

"100% Implementation/Low Cost" assumes complete implementation of each option (100 percent implementation) combined with the low range of cost estimates for that option (low cost). This line indicates the upper bound that could be achieved with all options shown. A complete analysis would calculate appropriate implementation rates for each option. That is beyond the scope of this study. It should be realistic to achieve emission reduction and cost results somewhere between the two lines in Figure 6.3.

As pointed out earlier in this chapter, technological costing and energy modeling sometimes yield different results. For this reason, both are presented in Figure 6.4. The "100% Implementation/Low Cost" and "25% Implementation/High Cost" curves are repeated from Figure 6.3, and the range typical of energy modeling is shown. As can be seen from Figure 6.4, the United States should be able to achieve substantial reduction in greenhouse gas emissions at low cost, or perhaps even a small net savings.

IMPLEMENTING MITIGATION OPTIONS

An array of policy instruments of two different types are available: regulation and incentives. Regulatory instruments mandate action and include controls on consumption (bans, quotas, required product attributes), produc-

tion (quotas on products or substances), and factors in design or production (efficiency, durability, processes). Incentive instruments are designed to influence decisions by individuals and organizations and include taxes and subsidies on production factors (carbon tax, fuel tax) and on products and other outputs (emission taxes, product taxes), financial inducements (tax credits, subsidies), and transferable emission rights (tradable emission reductions, tradable credits).

Interventions at all levels could effectively reduce greenhouse warming. For example, individuals could reduce energy consumption, recycle goods, and reduce consumption of deleterious materials. Local governments could control emissions from buildings, transport fleets, waste processing plants, and landfill dumps. State governments could restructure electric utility pricing structures and stimulate a variety of efficiency incentives. National governments could pursue action in most of the policy areas of relevance. International organizations could coordinate programs in various parts of the world, manage transfers of resources and technologies, and facilitate exchange of monitoring and other relevant data.

The choice of policy instrument depends on the objective to be served. Although this analysis of mitigation options does not include all possibilities, the panel is hopeful that it does identify the most promising options. This analysis provides the beginnings of a structure and a process for identifying those strategies that could appropriately mitigate the prospect of greenhouse warming.

CONCLUSIONS

There is a potential to inexpensively reduce or offset greenhouse gas emissions in the United States. In particular, the maximum feasible potential reduction for the options labeled "net benefit" and "low cost" in Table 6.2 totals about 3.6 billion tons (3.6 Gt) of CO₂-equivalent emissions per year. (Here, as elsewhere in the report, tons are metric.) This is a little more than one-third of the total 1990 greenhouse gas emissions in the United States and represents an optimistic upper bound on what could be achieved using these options.

A lower bound can be estimated from Figure 6.4. Arbitrarily using a cutoff of between \$10 and \$20 per ton of CO₂-equivalent emission reduction would produce a level of about 1 Gt of CO₂-equivalent emissions per year, or a little more than 10 percent of current greenhouse gas emissions in the United States.

This analysis suggests that the United States could reduce its greenhouse gas emissions by between 10 and 40 percent of the 1990 level at very low cost. Some reductions may even be at a net savings if the proper policies are implemented.

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Additional

Message: Attached please find an excerpt from the National Academy of Sciences 1991 Report, "Policy Implications of Greenhouse Warming."

pages 62-63

105-106

-Annie Petsonk

3 ~~5~~ pages total

TABLE A.4 Estimated 1985 Global Greenhouse Gas Emissions from Human Activities

	Greenhouse Gas Emissions (Mt/yr)	CO ₂ -equivalent Emissions ^a (Mt/yr)	
CO₂ Emissions			
Commercial energy	18,800	18,800	(57)
Tropical deforestation	2,600	2,600	(8)
Other	400	400	(1)
TOTAL	21,800	21,800	(66)
CH₄ Emissions			
Fuel production	60	1,300	(4)
Enteric fermentation	70	1,500	(5)
Rice cultivation	110	2,300	(7)
Landfills	30	600	(2)
Tropical deforestation	20	400	(1)
Other	30	600	(2)
TOTAL	320	6,700	(20)^b
CFC-11 and CFC-12 Emissions			
TOTAL	0.6	3,200	(10)
N₂O Emissions			
Coal combustion	1	290	(>1)
Fertilizer use	1.5	440	(1)
Gain of cultivated land	0.4	120	(>1)
Tropical deforestation	0.5	150	(>1)
Fuel wood and industrial biomass	0.2	60	(>1)
Agricultural wastes	0.4	120	(>1)
TOTAL	4	1,180	(4)
TOTAL		32,880	(100)

^aCO₂-equivalent emissions are calculated from the Greenhouse Gas Emissions column by using the following multipliers:

CO ₂	1
CH ₄	21
CFC-11 and -12	5,400
N ₂ O	290

Numbers in parentheses are percentages of total.

^bTotal does not sum due to rounding errors.

NOTE: Mt/yr = million (10⁶) metric tons (t) per year. All entries are rounded because the exact values are controversial.

SOURCE: Adapted from U.S. Department of Energy, 1990. *The Economics of Long-Term Global Climate Change: A Preliminary Assessment—Report of an Interagency Task Force*. Springfield, Va.: National Technical Information Service.

CO₂ that would produce the same amount of forcing at the surface is calculated. This is the CO₂ equivalent for that specific concentration of the other greenhouse gas. The respective costs per ton for different options can then be compared directly. It is important to recognize, however, that these calculations allow comparison only of initial contributions. They do not account for changes in energy-trapping effectiveness over the various lifetimes of these gases in the atmosphere.

35. What mitigation options are most cost-effective?

The panel ranks options for reducing greenhouse gas emissions or removing greenhouse gases from the atmosphere according to their cost-effectiveness. Some of these options have net savings or very low net implementation costs compared to other investments. The options range from net savings to more than \$100 per metric ton of CO₂-equivalent emissions avoided or removed from the atmosphere. The most cost-effective mitigation options are presented in Table A.5.

36. What are examples of options with large potential to reduce or offset emissions?

The so-called geoengineering options have the potential of substantially affecting atmospheric concentrations of greenhouse gases. They have the ability to screen incoming sunlight, stimulate uptake of CO₂ by plants and animals in the oceans, or remove CO₂ from the atmosphere. Although they appear feasible, they require additional investigation because of their potential environmental impacts.

37. How much would it cost to significantly reduce current U.S. greenhouse gas emissions?

It depends on the level of emission reduction desired and how it is done. The most cost-effective options are those that enhance efficient use of energy: efficiency improvements in lighting and appliances, white roofs and paving to enhance reflectivity, and improvement in building and construction practices.

Figure A.4 compares mitigation options, and Table A.5 gives the panel's estimates of net cost and emission reductions for several options. It must be emphasized that the table presents the panel's estimates of the *maximum* technical potential for each option. The calculation of cost-effectiveness of lighting efficiency, for example, does not consider whether the supply of light bulbs could meet the demand with current production capacities. Nor does it consider the trade-off between expenditures on light bulbs and on health care, education, or basic shelter for low-income families. In addition, there is a danger of some "double counting." For example, in the area of energy supply both nuclear and natural gas energy options assume re-

TABLE A.5 Comparison of Selected Mitigation Options in the United States

Mitigation Option	Net Implementation Cost ^a	Potential Emission Reduction (1 CO ₂ equivalent per year)
Building energy efficiency	Net benefit	900 million ^c
Vehicle efficiency (no fleet change)	Net benefit	300 million
Industrial energy management	Net benefit to low cost	500 million
Transportation system management	Net benefit to low cost	50 million
Power plant heat rate improvements	Net benefit to low cost	50 million
Landfill gas collection	Low cost	200 million
Halocarbons-CFC usage reduction	Low cost	1400 million
Agriculture	Low cost	200 million
Reforestation	Low to moderate cost ^d	200 million
Electricity supply	Low to moderate cost ^d	1000 million ^e

^aNet benefit = cost less than or equal to zero

Low cost = cost between \$1 and \$9 per ton of CO₂ equivalent

Moderate cost = cost between \$10 and \$99 per ton of CO₂ equivalent

High cost = cost of \$100 or more per ton of CO₂ equivalent

^bThis "maximum feasible" potential emission reduction assumes 100 percent implementation of each option in reasonable applications and is an optimistic "upper bound" on emission reductions.

^cThis depends on the actual implementation level and is controversial. This represents a middle value of possible rates.

^dSome portions do fall in low cost, but it is not possible to determine the amount of reductions obtainable at that cost.

^eThe potential emission reduction for electricity supply options is actually 1700 Mt CO₂ equivalent per year, but 1000 Mt is shown here to remove the double-counting effect.

NOTE: Here and throughout this report, tons are metric.

SOURCE: Chapter 11 of the Mitigation Panel report.

placement of the same coal-fired power plants. Table A.5, however, presents only options that avoid double counting. Finally, although there is evidence that efficiency programs can pay, there is no field evidence showing success with programs on the massive scale suggested here. Thus there may be very good reasons why "negative cost options" on the figure are not implemented today.

The United States could reduce its greenhouse gas emissions by between 10 and 40 percent of the 1990 levels at low cost, or perhaps some net savings, if proper policies are implemented.

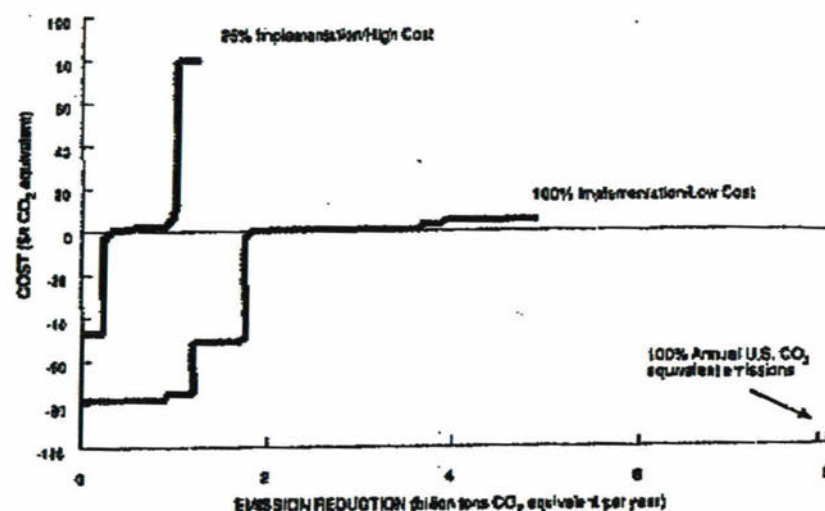


FIGURE A.4 Comparison of mitigation options. Total potential reduction of CO₂-equivalent emissions is compared to the cost in dollars per ton of CO₂ reduction. Options are ranked from left to right in CO₂ emissions according to cost. Some options show the possibility of reductions of CO₂ emissions at a net savings.

SOURCE: Chapter 11 of the report of the Mitigation Panel.

ADAPTING TO ADDITIONAL GREENHOUSE WARMING

38. Will human and natural systems adapt without assistance?

Farmers adjust their crops and cultivation practices in response to weather patterns over time. Natural ecosystems also adapt to changing conditions. The real issue is the rate at which human and natural systems will be able to adjust.

39. At what rates can human and natural systems adapt?

Many human systems have decision and investment cycles that are shorter than the time in which impacts of climate change would become manifest. These systems in the United States should be able to adjust to climate change without governmental intervention, as long as it is gradual and information about the rates of change is widely available. This applies to agriculture, commercial forestry, and most of industry. Industrial sectors with extremely long investment cycles (e.g., transport systems, urban infrastructure, and major structures and facilities) or requiring high volumes of water may require special attention. Coastal urban settlements would be

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—Annie Petsonk

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POLICY IMPLICATIONS OF GREENHOUSE WARMING

Policy Implications of Greenhouse Warming—Synthesis Panel

Committee on Science, Engineering, and Public Policy

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TABLE 6.3 Cost-Effectiveness Ordering of Geoengineering Mitigation Options

Mitigation Option	Net Implementation Cost	Potential Emission Mitigation (1 CO ₂ equivalent per year)
Low stratospheric soot	Low	8 billion to 25 billion
Low stratospheric dust, aircraft delivery	Low	8 billion to 80 billion
Stratospheric dust (guns or balloon lift)	Low	4 trillion or amount desired
Cloud stimulated by provision of cloud condensation nuclei	Low	4 trillion or amount desired
Stimulation of ocean biomass with iron	Low to moderate	7 billion or amount desired
Stratospheric bubbles (multiple balloons)	Low to moderate	4 trillion or amount desired
Space mirrors	Low to moderate	4 trillion or amount desired
Atmospheric CFC removal	Unknown	Unknown

NOTE: The feasibility and possible side-effects of these geoengineering options are poorly understood. Their possible effects on the climate system and its chemistry need considerably more study and research. They should not be implemented without careful assessment of their direct and indirect consequences.

Cost-effectiveness estimates are categorized as either savings (for less than 0), low (0 to \$9/t CO₂ equivalent), moderate (\$10 to \$99/t CO₂ equivalent), or high (>\$100/t CO₂ equivalent). Potential emission savings (which in some cases include not only the annual emissions, but also changes in atmospheric concentrations already in the atmosphere—stock) for the geoengineering options are also shown. These options do not reduce the flow of emissions into the atmosphere but rather alter the amount of warming resulting from those emissions. Mitigation options are placed in order of cost-effectiveness.

The CO₂-equivalent reductions are determined by calculating the equivalent reduction in radiative forcing.

Here and throughout this report, tons are metric.

SOURCE: Chapter 11 of the report of the Mitigation Panel.

COMPARING OPTIONS

Table 6.2 shows estimates of net cost and emission reductions for several options. It must be emphasized that the table presents the panel's estimates of the technical potential for each option. For example, the calculation of cost-effectiveness of high-efficiency light bulbs (one of the building efficiency options) does not consider whether the supply of light bulbs could meet the demand with current production capacities. It does not consider the trade-off between expenditures on light bulbs and on health care, educa-

tion, or basic shelter for low-income families. Nor does it consider aesthetic issues about different sources of illumination.

Care must be taken in developing such a table because there is some "double-counting" among potential mitigation options. For example, implementation of both the nuclear and the natural gas energy options assumes replacement of the same coal-fired power plants. Thus, simply summing up the emission reductions of all options to give total reduction in emissions would overstate the actual potential. The options presented in Table 6.2 have been selected to eliminate double-counting.

Finally, although there is evidence that efficiency programs can pay, there is no field evidence showing success with programs on the massive scale suggested here. There may be very good reasons why options exhibiting net benefit on the table are not fully implemented today.

Figure 6.3 illustrates the results of different rates of implementation of those options. The many uncertainties in the calculations of both costs and emission reductions have been collapsed into two lines. The line labeled "25% Implementation/High Cost" assumes incomplete implementation of each option (25 percent implementation of feasible opportunities) and the high end of the range of cost estimates for that option (high cost). This line shows a lower bound of what is reasonable to achieve. The line labeled

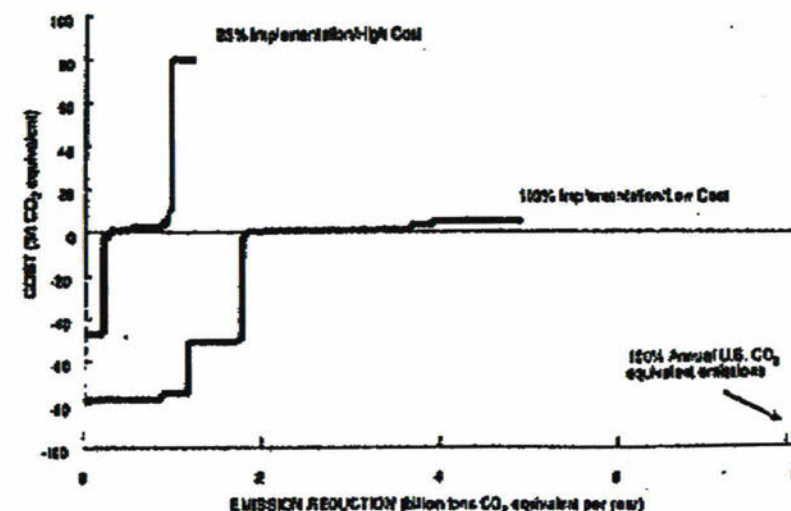


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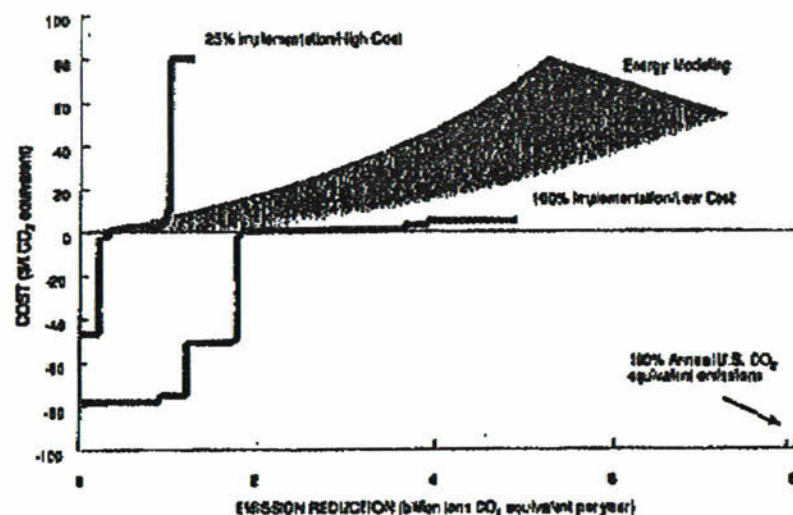


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The choice of policy instrument depends on the objective to be served. Although this analysis of mitigation options does not include all possibilities, the panel is hopeful that it does identify the most promising options. This analysis provides the beginnings of a structure and a process for identifying those strategies that could appropriately mitigate the prospect of greenhouse warming.

CONCLUSIONS

There is a potential to inexpensively reduce or offset greenhouse gas emissions in the United States. In particular, the maximum feasible potential reduction for the options labeled "net benefit" and "low cost" in Table 6.2 totals about 3.6 billion tons (3.6 Gt) of CO₂-equivalent emissions per year. (Here, as elsewhere in the report, tons are metric.) This is a little more than one-third of the total 1990 greenhouse gas emissions in the United States and represents an optimistic upper bound on what could be achieved using these options.

A lower bound can be estimated from Figure 6.4. Arbitrarily using a cutoff of between \$10 and \$20 per ton of CO₂-equivalent emission reduction would produce a level of about 1 Gt of CO₂-equivalent emissions per year, or a little more than 10 percent of current greenhouse gas emissions in the United States.

This analysis suggests that the United States could reduce its greenhouse gas emissions by between 10 and 40 percent of the 1990 level at very low cost. Some reductions may even be at a net savings if the proper policies are implemented.

TABLE A.4 Estimated 1985 Global Greenhouse Gas Emissions from Human Activities

	Greenhouse Gas Emissions (Mt/yr)	CO ₂ -equivalent Emissions* (Mt/yr)	
CO₂ Emissions			
Commercial energy	18,800	18,800	(57)
Tropical deforestation	2,600	2,600	(8)
Other	400	400	(1)
TOTAL	21,800	21,800	(66)
CH₄ Emissions			
Fuel production	60	1,300	(4)
Enteric fermentation	70	1,500	(5)
Rice cultivation	110	2,300	(7)
Landfills	30	600	(2)
Tropical deforestation	20	400	(1)
Other	30	600	(2)
TOTAL	320	6,700	(20)^b
CFC-11 and CFC-12 Emissions			
TOTAL	0.6	3,200	(10)
N₂O Emissions			
Coal combustion	1	290	(>1)
Fertilizer use	1.5	440	(1)
Gain of cultivated land	0.4	120	(>1)
Tropical deforestation	0.5	150	(>1)
Fuel wood and industrial biomass	0.2	60	(>1)
Agricultural wastes	0.4	120	(>1)
TOTAL	4	1,180	(4)
TOTAL		32,880	(100)

*CO₂-equivalent emissions are calculated from the Greenhouse Gas Emissions column by using the following multipliers:

CO ₂	1
CH ₄	21
CFC-11 and -12	5,400
N ₂ O	290

Numbers in parentheses are percentages of total.

^bTotal does not sum due to rounding errors.

NOTE: Mt/yr = million (10⁶) metric tons (t) per year. All entries are rounded because the exact values are controversial.

SOURCE: Adapted from U.S. Department of Energy. 1990. *The Economics of Long-Term Global Climate Change: A Preliminary Assessment—Report of an Interagency Task Force*. Springfield, Va.: National Technical Information Service.

CO₂ that would produce the same amount of forcing at the surface is calculated. This is the CO₂ equivalent for that specific concentration of the other greenhouse gas. The respective costs per ton for different options can then be compared directly. It is important to recognize, however, that these calculations allow comparison only of initial contributions. They do not account for changes in energy-trapping effectiveness over the various lifetimes of these gases in the atmosphere.

35. What mitigation options are most cost-effective?

The panel ranks options for reducing greenhouse gas emissions or removing greenhouse gases from the atmosphere according to their cost-effectiveness. Some of these options have net savings or very low net implementation costs compared to other investments. The options range from net savings to more than \$100 per metric ton of CO₂-equivalent emissions avoided or removed from the atmosphere. The most cost-effective mitigation options are presented in Table A.5.

36. What are examples of options with large potential to reduce or offset emissions?

The so-called geoengineering options have the potential of substantially affecting atmospheric concentrations of greenhouse gases. They have the ability to screen incoming sunlight, stimulate uptake of CO₂ by plants and animals in the oceans, or remove CO₂ from the atmosphere. Although they appear feasible, they require additional investigation because of their potential environmental impacts.

37. How much would it cost to significantly reduce current U.S. greenhouse gas emissions?

It depends on the level of emission reduction desired and how it is done. The most cost-effective options are those that enhance efficient use of energy: efficiency improvements in lighting and appliances, white roofs and paving to enhance reflectivity, and improvement in building and construction practices.

Figure A.4 compares mitigation options, and Table A.5 gives the panel's estimates of net cost and emission reductions for several options. It must be emphasized that the table presents the panel's estimates of the maximum technical potential for each option. The calculation of cost-effectiveness of lighting efficiency, for example, does not consider whether the supply of light bulbs could meet the demand with current production capacities. Nor does it consider the trade-off between expenditures on light bulbs and on health care, education, or basic shelter for low-income families. In addition, there is a danger of some "double counting." For example, in the area of energy supply both nuclear and natural gas energy options assume the

TABLE A.5 Comparison of Selected Mitigation Options in the United States

Mitigation Option	Net Implementation Cost ^a	Potential Emission ^b Reduction (1 CO ₂ equivalent per year)
Building energy efficiency	Net benefit	900 million ^c
Vehicle efficiency (no fleet change)	Net benefit	300 million
Industrial energy management	Net benefit to low cost	500 million
Transportation system management	Net benefit to low cost	30 million
Power plant heat rate improvements	Net benefit to low cost	50 million
Landfill gas collection	Low cost	200 million
Halocarbon-CFC usage reduction	Low cost	1400 million
Agriculture	Low cost	200 million
Reforestation	Low to moderate cost ^d	200 million
Electricity supply	Low to moderate cost ^d	1000 million ^e

^aNet benefit = cost less than or equal to zero

Low cost = cost between \$1 and \$9 per ton of CO₂ equivalent

Moderate cost = cost between \$10 and \$99 per ton of CO₂ equivalent

High cost = cost of \$100 or more per ton of CO₂ equivalent

^bThis "maximum feasible" potential emission reduction assumes 100 percent implementation of each option in reasonable applications and is an optimistic "upper bound" on emission reductions.

^cThis depends on the actual implementation level and is controversial. This represents a middle value of possible rates.

^dSome portions do fall in low cost, but it is not possible to determine the amount of reductions obtainable at that cost.

^eThe potential emission reduction for electricity supply options is actually 1700 Mt CO₂ equivalent per year, but 1000 Mt is shown here to remove the double-counting effect.

NOTE: Here and throughout this report, tons are metric.

SOURCE: Chapter 11 of the Mitigation Panel report.

placement of the same coal-fired power plants. Table A.5, however, presents only options that avoid double counting. Finally, although there is evidence that efficiency programs can pay, there is no field evidence showing success with programs on the massive scale suggested here. Thus there may be very good reasons why "negative cost options" on the figure are not implemented today.

The United States could reduce its greenhouse gas emissions by between 10 and 40 percent of the 1990 levels at low cost, or perhaps some net savings, if proper policies are implemented.

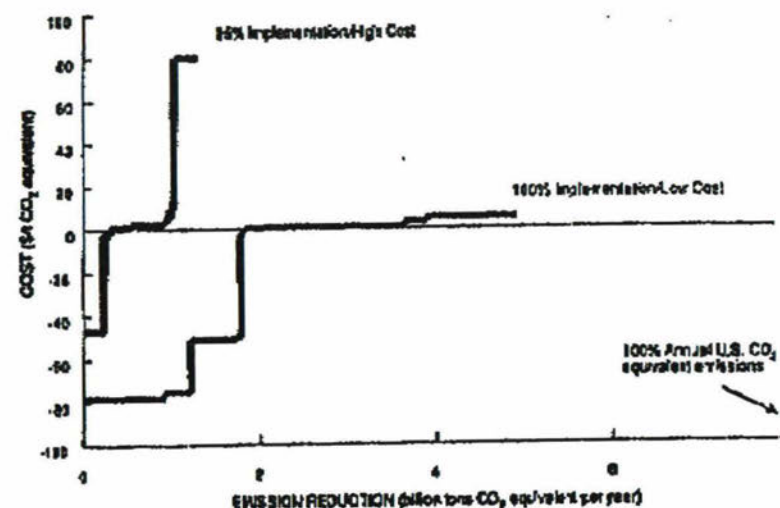


FIGURE A.4 Comparison of mitigation options. Total potential reduction of CO₂ equivalent emissions is compared to the cost in dollars per ton of CO₂ reduction. Options are ranked from left to right in CO₂ emissions according to cost. Some options show the possibility of reductions of CO₂ emissions at a net savings.

SOURCE: Chapter 11 of the report of the Mitigation Panel.

ADAPTING TO ADDITIONAL GREENHOUSE WARMING

38. Will human and natural systems adapt without assistance?

Farmers adjust their crops and cultivation practices in response to weather patterns over time. Natural ecosystems also adapt to changing conditions. The real issue is the rate at which human and natural systems will be able to adjust.

39. At what rates can human and natural systems adapt?

Many human systems have decision and investment cycles that are shorter than the time in which impacts of climate change would become manifest. These systems in the United States should be able to adjust to climate change without governmental intervention, as long as it is gradual and information about the rates of change is widely available. This applies to agriculture, commercial forestry, and most of industry. Industrial sectors with extremely long investment cycles (e.g., transport systems, urban infrastructure, and major structures and facilities) or requiring high volumes of water may require special attention. Coastal urban settlements would

THE WHITE HOUSE
WASHINGTON

August 19, 1997

TO: Peter Orszag
David Sandalow
John Gruber
Bob Boorstin
Larry Summers
Jim Steinberg
Gene Sperling
Dan Tarullo
Katie McGinty

For your information.

Todd Stern
Staff Secretary

CC:

- Peter Daszay
- David Sandak
- John Gruber (Treas.)
- Bob Berstein "
- Larry Summers "
- Jim Steinberg
- Gene Sperling
- Dan Thurlow
- Katie Maginty

8-19-97

Todd —
all copies
have been
sent. —

Deb

MEMORANDUM

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To: White House Task Force on Climate Change
(By Hand Delivery)

From: Dan Dudek, Senior Economist
Annie Petsonk, International Counsel 

Date: August 13, 1997

Re: Climate Change Negotiations: Some Progress, Some Potentially Serious Setbacks;
Clarity and Focus Urgently Needed

The Administration's Kyoto Protocol proposal advanced in some significant measure at the seventh session of the AGBM in Bonn last week. But it also suffered potentially serious setbacks and fragmentation on a number of key elements. We are concerned that these problems, which are now embedded in the draft text that will be circulated prior to the eighth session in October, will undermine the President's ability to conduct effective outreach domestically, including, and most particularly, at the White House Conference. We therefore urge the Administration to move swiftly during the intersessional period to rectify these problems. We recommend that the Administration conduct high-level outreach to key negotiating partners and to the Chairman of the AGBM, Ambassador Raul Estrada, to clarify and explain the environmental and economic advantages of the Administration's position, and to focus understanding on the integrated nature of the Administration's proposal. These intersessional consultations are needed to lay the foundation for a clear and decisive Administration follow-through at AGBM-8 and Kyoto; similarly, the Administration's position vis-a-vis Congress can be strengthened by utilizing a parallel very high-level consultation approach with Congress, especially the Senate, during the run-up to the next Bonn and Kyoto meetings.

Our summary of these key points follows. While a number of the points below may seem like fine details, in fact, it is these elements that will form the critical fabric of the new international system for carbon transactions.

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**The Clinton Administration's International Climate Change Policy:
Some Progress, Some Serious Setbacks at AGBM-7; Clarity and Focus Urgently Needed**

The following brief analysis summarizes the outcome of AGBM-7, held in Bonn, Germany, in August 1997, with regard to the key flexibility elements of the Administration's Kyoto Protocol proposal: joint implementation, trading, and the emissions budget infrastructure. A concluding section discusses congressional outreach in light of these results.

I. Emissions Budget System Infrastructure.

A. Vintaging/Traceability, Reporting, Review and Compliance. The Administration's Kyoto Protocol proposal occupies the environmental and economic high ground of credibility in part because of the high level of accountability that can be achieved with a budget-trading-JI system. Accountability depends critically, in particular, on reporting, on traceable "vintaging" - that is, the ability to trace carbon-equivalent units (CEUs) in the trading system back through each transaction all the way to their origin. Accountability also depends on standardized reporting and review, and a staged compliance regime that will actually be deployed in cases of non-compliance. The importance of these "infrastructure" elements, and the way in which they work together to provide the accountability that is key to the environmental and economic success of the system, are not well understood by delegations in the international negotiations.

The Administration needs to explain clearly to key negotiating partners at high levels the importance of the budget infrastructure and the way in which the infrastructure elements interact to provide the environmental and economic accountability that is key to success at Kyoto.

1. Traceable Vintaging

- The Administration needs to clarify that for compliance purposes, it is essential that *in all emissions transactions*, whether joint implementation or trades, *the "vintage" - the country of origin and year of initial transaction history - must be fully traceable* all the way back through to its origin.

→ In the case of JI projects, the carbon-equivalent units (CEUs) should be traceable back to the host country where they were originally generated, with identification of the year in which they were generated.

→ In the case of trades among nations with budgets, the CEUs should be traceable back to the country that originally sold the carbon-equivalent units as part of its national budget, and the year in which the CEUs were originally sold.

- This "trace-back" mechanism¹, coupled with annual reporting on budget performance, provides the critical compliance feedback that is essential to the integrity of the budget and trading system.

¹ The trace-back feature can also be thought of as "sticky" vintaging - "sticky" because the geopolitical and temporal origin of the CEUs "stick" to them throughout their transactable life

→ Traceability could be assured simply by serializing all CEUs internationally, including both emissions budget and JI-generated CEUs, and requiring that all transactions be recorded with the secretariat by serial number. JI projects that generate CEUs would need to report those to the secretariat and record their serialization in order for the CEUs to be transactable. The secretariat would keep a permanent record of the origin of the CEUs by nation, year, and serial number. Such serialization would also facilitate electronic transactions.

- With this approach, the original country of origin and year of origin for any CEUs would be known, regardless of how many times the CEUs had been traded internationally, and regardless of whether the CEUs originated in a national emissions budget or in a JI project. And with annual reporting on national budget performance, the market price of serialized CEUs would reflect market perceptions of the strength of each nation's compliance program. The combination of traceability, annual reporting, review, and staged compliance mechanisms provide powerful feedbacks that direct market forces in favor of compliance. Without this feedback, however, the accountability provided by the integrated reporting, review and compliance system would be severely compromised. } why?

2. Reporting, Review of National Budget Performance, Establishment of Next Budget Levels, and Compliance. The Administration's proposals in each of these areas, and the way that these proposals interact with and form essential components of, the overall budget structure, are not well understood by delegations. For example, delegations do not yet grasp the importance of using the structure of the emissions budget and trading system to promote compliance. Furthermore, the text that came out of AGBM-7 is littered with reporting and review proposals that are unmoored from other system elements. Also a number of proposals have been made that would invite governments to fiddle with budget levels during a budget period. Introducing such uncertainties into the budget process would greatly undermine the credibility of the agreement in the investment and business community, to its environmental detriment. In the intersessional period, the Administration could advance its case considerably if it were to:

- Clarify its explanation of the proposed reporting, performance review, budget-setting, and compliance mechanisms. *The compliance picture would be clearer to countries if the Administration were to explain the timeline of establishing a budget, annual reporting, science and technology reviews, performance reviews, compliance mechanisms, and establishment of the next budget.*
 - Make clear its *opposition* to mechanisms that would allow *budgets to be re-set* during a budget period.
 - Clarify that a *range of options exists for reviewing national budget performance.*
- Unfortunately, the "implementation review team" concept is being used against U.S. interests by those who would like to prevent any international agreement. Those who seek to frustrate a Kyoto outcome are using the prospect of in-depth reviews, particularly on policies and measures, to incite fears about intrusions into national sovereignty. To counteract this, the Administration should make clear that Parties may use existing mechanisms that they have already accepted, such as the national accounts analyses prepared by the Organization for Economic Cooperation and Development (OECD), the energy production and consumption analyses done under the auspices of the International Energy Agency (IEA), and the agricultural production and inputs statistics compiled by the Food and Agriculture Organization (FAO). These mechanisms, which may involve international review teams that evaluate national performance, can yield good performance data without raising undue concerns about intrusion into national sovereignty. And, since the performance objective of

a Kyoto Protocol will be set in greenhouse gas emissions terms, what a nation is doing on policies and measures will be far less important than how it is doing with regard to greenhouse gas emissions. The performance-based reviews of the OECD, IEA and FAO are thus a more accurate vehicle than policy-and-measure reviews when it comes to obtaining an independent check on national performance. Furthermore, if vintaging is used, then third party private service will also provide evaluations of creditworthiness

B. Coverage, Budgets, and Length of Budget Period.

1. Coverage. The Administration made significant progress at AGBM-7 in getting delegations to understand that it is highly preferable, environmentally, to include all gases, sources and sinks in the Protocol. The Administration successfully rebuffed attempts to force categorization of GHG-emitting activities by sector and source, and the delegation did a good job of explaining that categorization would be environmentally sub-optimal since it would wind up excluding major emitters. That approach should be maintained through Kyoto. With regard to *sinks*, it was rumored in Bonn that the EU opposes including sinks in national baselines because EU forest cover has declined since 1990. If that rumor is correct, the U.S. should not shrink from making this known more broadly, and *should explain to EU governments and NGOs that including sinks in national baselines would provide powerful incentives to halt and even reverse the rate of forest loss.*

2. Budgets. It now seems that the concept of budgets is generally accepted internationally.

3. Length of Budget Period. The length of the budget period is closely linked to the robustness of the tracing system. Without serialization of CEUs and traceable vintaging, budget periods would need to be short in order to bolster accountability. But short budget periods place greater strain on the international compliance regime, since, given fluctuations in business cycles and weather, it is more likely that more nations will be out of compliance with budgets of a few years, than with budgets of a decade. And strain on the international compliance regime should be avoided if possible, since, in any international agreement, compliance represents the greatest challenge.

- Therefore, when the Administration puts forward its timing and levels proposal, it *should ensure that a decadal budget period, which has the potential to deliver improved environmental and economic performance while providing a stable investment horizon and bolstering the legitimacy of the new international system, is integrally linked to traceable vintaging, reporting, and the staged compliance system proposed by the Administration.*

II. Joint Implementation. JI with developing countries, an essential linchpin of the Administration's proposal, suffered potentially severe setbacks in Bonn. JI is key to addressing the competitiveness and environmental concerns underlying S.Res.98.

A. The Subsidiary Body on Scientific and Technological Advice (SBSTA) decided not to discuss the methodological issues in JI at its next (and last before Kyoto) session. This means there will be no agreed method of crediting for JI, even if JI crediting were to be agreed in principle. Governments at Kyoto will be reluctant to support crediting for JI without first settling the methodological issues. *The Administration should work with other governments at high levels to build support for an extraordinary session of SBSTA to be held immediately prior to COP-3 to resolve the JI methodological issues.* The basic issues, which the Administration should coordinate with other interested governments at high

levels, are straightforward, and include such principles as steady (rather than rolling) project baselines. These issues can be clarified readily in high-level consultations. *The forces of delay must not be allowed to hold JI credit hostage to interminable wrangling over methodologies.*

B. Proposals to subject the JI Pilot Phase to paralysis-by-analysis gained ground. Those who oppose any agreement at all at Kyoto also support subjecting the Pilot Phase of JI to such lengthy and detailed analysis so as to ensure that a political agreement on JI credit will never emerge prior to the Kyoto meeting - or well into the next millennium, either. Contrary to the claims of many, the Berlin Decision on JI does not require a review prior to concluding the Pilot Phase, but rather provides that "the Conference of the Parties *shall take into consideration* the need for a comprehensive review of the pilot phase in order to take a conclusive decision on the pilot phase and the progression beyond that, *no later than the end of the present decade.*" No comprehensive review is necessary; nations participating in the JI pilot phase have generally conducted their own ongoing reviews, which could usefully and readily be compiled; and in any event the reviews indicate what is already widely known: in the absence of credit, the pilot phase has not been robust.

- Rather than acquiescing to those seeking to block agreement at Kyoto by postponing JI for credit, the *Administration should move swiftly and at high levels to build support among key countries for ending the pilot phase at Kyoto and beginning JI crediting promptly in 1998.*
- Beginning crediting in 1998 implies that JI credits earned from 1998 to the start of a first budget period could be credited toward the participating nation(s)' emissions budget(s). *Obtaining clear international agreement on crediting for pre-budget JI would advance domestic support for the Administration case considerably - the Administration should make this a high-level priority.*

C. The current text proposes quantitative limits on JI. The text coming out of AGBM-7 contains (admittedly bracketed) proposals to place quantitative limits on the amount of JI that any industrialized nation may use to satisfy its emissions budget obligation. Such quantitative limits would seriously under-incentivize JI, for, just as any other type of quota or quantitative restriction on trade, prospective investors would refrain from investing in particular JI projects for fear that those particular projects would subsequently be disqualified for having exceeded a national quota. In fact, quantitative limits on JI could give projects a perverse incentive not to do well on reducing emissions - for any one project that did better than expected in reducing emissions could find itself disqualified if those emissions reductions exceeded a national quota in an investor country. And the presence of quantitative limits would vastly and needlessly complicate cooperative projects involving multiple investor nations, because each investor nation would have to ensure that its share of any particular cooperative project did not bump up against its national quota.

- *In the intersessional period, the Administration should clearly and decisively oppose JI quotas, and should make the environmental case for its position known around the world.*

D. The current text provides that JI projects shall not have any "adverse environmental or social effects." This language, while on its face seemingly laudable, would be highly problematic to implement in practice. The language would render every single JI project subject to challenge and disqualification at the international level not based on its emissions performance (which should be grounds for international challenge), but because of any adverse environmental or social effect, no matter how small, no matter how much outweighed by environmental and social benefits. Twenty-seven years ago the U.S. considered adopting such an approach as a tool of national decision-making, and squarely rejected it. Congress chose instead to require federal agencies to assess the environmental impacts of their major

actions, and to allow the agencies to decide, after weighing the impacts and benefits, what course of action to take. Similarly, the decision whether to go forward with a particular JI project should rest squarely with the nations involved in the project, and should be undertaken in a transparent manner. It would be outside the competency of the Framework Convention, which is a convention on climate change, to evaluate the non-GHG environmental and social effects of JI projects. The transaction costs of such assessments would further weaken the economic incentive to undertake JI investments in the first place.

- *The Administration should make clear to its negotiating partners that the responsibility for assessing the environmental and social effects of JI projects - and their consistency with national development plans and priorities - rests squarely and solely with the Parties undertaking those projects.*
- *The Administration should also support a challenge and review procedure whereby JI projects may be subject to international challenge on the basis of an alleged failure to produce claimed GHG reductions; and that any such international challenge would trigger an international review of project performance in terms of GHG emissions.*

III. Emissions Trading. There is now considerable interest in emissions trading among delegations. But the EU remains deeply internally divided on the issue.

A. Emissions Trading and the EU Bubble: A Trade and Competitiveness Issue. As the delegation of Japan pointed out in Bonn, an EU bubble in the absence of a full-access trading and for-credit JI system would confer unfair trade advantage on the EU. Key senators are already well aware of the competitiveness aspect of the EU Bubble, since the point was emphasized in testimony by the Global Climate Coalition before the Foreign Relations Committee and was reiterated by Foreign Relations Committee members in the floor debate on S. Res. 98. Cost and competitiveness issues are becoming acute within the European Union as member states struggle to meet the 3% Maastricht target for monetary union. Thus, the timing is ripe for high-level overtures to key EU officials on trading, JI, and the EU Bubble. Surprisingly, however, international reports released shortly after the Bonn meeting rumored that at AGBM-7, the U.S. relented on its opposition to the EU bubble. It is therefore essential that the U.S. move promptly to clarify its position on trading and the Bubble.

- *During the intersessional period, the Administration should undertake very high level consultations on emissions trading and for-credit JI. These consultations should be undertaken with EU Ministers for Trade and Competitiveness, especially Germany, on the EU side, and with high-ranking trade officials on the U.S. side.*
- *In undertaking these consultations, the Administration should clarify that if the EU bubble is the EU's way of implementing a fully developed, internationally agreed emissions trading system that includes for-credit JI with non-budget nations, then the EU bubble would be acceptable to the United States. Otherwise, the EU bubble would be unacceptable.*

Trading and Policies and Measures. At Bonn, the U.S. opposition to internationally mandated policies and measures was clear and understandable to most delegations. Yet, some EU delegations in particular feel wedded to obtaining some internationally agreed policies and measures. The question then arises as to whether there is a set of environmentally useful international policies and measures that might meet the EU concern for some international agreement, while also addressing the U.S. concern that such policies and measures not operate as trade barriers. The set of international activities that do

not fall neatly into national emissions budgets comes to mind, i.e., greenhouse gas emissions from international bunker fuel consumption (aviation and marine transport).

- *The Administration should explore, at high levels, the possibility of an internationally agreed greenhouse-gas-performance-based policy on bunker fuel emissions.* Although international interest in and pressure for an aviation fuel tax remains strong, domestic support for such an approach is weak, and the environmental effectiveness of a moderate tax in reducing bunker fuel emissions is quite doubtful.
- *Therefore, the Administration's high-level policy discussions on bunker fuel emissions should focus on the concept of an emissions budget and trading system for international aviation and marine bunkers.*
- *While ultimately the Parties could decide that such an approach could be administered through the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO), those entities currently do not provide sufficient transparency and cannot, under the UNFCCC, become Parties to the Rio Treaty. Therefore the preferred approach would be for the Parties to the UNFCCC to decide, as a common policy and measure, to develop an emissions budget and trading system for international aviation and marine bunkers.* Such an approach is already currently under consideration within the European Union.

IV. *Congressional Outreach.* It is essential that the Administration engage the legislative constituencies, in particular on the Senate side, that are most likely to be concerned about each of these elements. That engagement should be done in an intensive manner during the intersessional period, so that the time of the much larger delegation of congressional observers who will attend the October session will be spent advancing, rather than undercutting, the Administration's proposal. *There are important Senate constituencies that are likely to favor each of the key elements outlined above if given adequate background and opportunity. The remainder of August and the whole of September provide an important time window in which to build those constituencies.*

~~**Confidential Addendum To August 13, 1997 Memorandum Re:
Climate Change Negotiations Progress, Setbacks, and the Need for Clarity and Focus**~~

1. JI and China. The views of China about JI are changing. Chinese government officials involved in the climate change issue, at all levels but with one well-known and notable exception, have begun to recognize the value of for-credit JI in terms of spurring foreign direct investment in high-efficiency technologies and cleaner energy production. As one Chinese delegate to the climate negotiations said in Bonn last week, "It is meaningless to discuss 'transfer of technology' unless you are discussing JI for credit. China understands that there is no such thing as a free lunch."

China appears poised to propose a slate of JI projects that could be announced as early as the US-China Summit scheduled for later this year. To pursue this opportunity, *the Administration may wish to undertake very high level consultations with Mr. Song Jiam, who was the head of delegation to the United Nations General Assembly Special Session (UNGASS). These consultations might usefully be coordinated through the Chinese Embassy in Washington. The consultations could approach the upcoming US-China Summit as an important opportunity to present a joint slate of JI projects that the two countries, as sovereign and equal partners, would undertake. It is important to keep in mind, in undertaking these very high level consultations, that the approach of the US Initiative on Joint Implementation (USIJI) is perceived by many in China as paternalistic. It would therefore not be desirable to initiate action through USIJI. Rather, a shared approach in which the two sovereigns, operating at the highest levels, jointly identify a slate of JI projects, is more likely to achieve real results.*

2. Evolution; developing country commitments. This core issue for the Administration's relationship to Congress, as difficult as it seems, offers real opportunities to reach an agreement in Kyoto, and to pair that agreement with a follow-on agreement on developing country commitments. Most developing countries do not understand the U.S. proposal on growth budgets. Nor do they understand the evolution from JI, with heavy transaction costs of project-by-project certification, to a full and fluid trading system.

- The Administration should clarify, through strategic consultations with key developing nations, including China, India, Brazil and Malaysia, its proposals regarding *growth budgets and JI. These consultations should draw on specific examples to illustrate for developing nations the nature of the evolution from JI to full trading, and the important environmental and economic opportunity presented by the possibility of growth budgets for early adopters.*
- Senate staff attending the Bonn meeting were, overall, quite effective in presenting the Byrd-Hagel resolution to key developing country delegations. These kinds of consultations could usefully be continued at the next meeting *and during the intersessional period. One important component of the Senate interface is to build a powerful Senate constituency willing to advocate strongly for emissions trading and JI as part of a Kyoto Protocol. This constituency will understand the role of trading and JI in encouraging, through the mechanism of growth budgets, early commitments by developing nations. This constituency can provide an important outreach mechanism to developing nations.*
- Finally, but only after these consultations have gained momentum, the Administration should undertake quiet further consultations with key Senators, key industrialized and developing nations, and key industry and environmental leaders on a discrete set of proposals for linking industrialized and developing country commitments in the context of a Kyoto Protocol and a follow-on agreement involving large developing country emitters. The Administration should enter into these consultations clear in the understanding that during the period prior to implementation of legally binding targets for developing nations, for-credit JI will play a crucial role.

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August 13, 1997

The Hon. Todd Stern
Staff Secretary
The White House
Washington, DC 20502

Dear Todd:

You may recall my mentioning EDF's upcoming report, "Seasons of Change: Global Warming and New England's White Mountains" at dinner at Senator Kerry's house on July 31. I enclose the final draft. The report, to be released at a press conference in Boston on September 2, discusses the potential ecological and economic impact of global warming on New England in general and the White Mountains in particular. Please note that the report is embargoed until September 2. The highlights include:

Disruption of the fall foliage season: Fall foliage displays could be muted due to an increase in dead and dying trees as climate changes. Eventually a change in tree species composition may occur, from northern hardwoods and conifers, like the brilliant red sugar maples and dark green spruce and fir to more southerly species like oak. Even earlier, if summer droughts become more common, as is predicted by some climate models, the quality of the display may dim. Some trees will drop leaves early, others may never produce vibrant colors before dropping.

A shortened ski season: The length of the ski season and therefore the success of the ski industry is inherently tied to weather. There is a potential for shorter ski seasons as a result of climate change though added investment in snowmaking could mitigate this somewhat. In the report, we discuss a scenario that shows a loss of 10 and 20% in the number of winter season days with a 3.6 and 7.2 degree Fahrenheit warming respectively.

A dramatic decrease in trout habitat: According to a recent EPA study on recreational fishing, suitable habitat for cold-water fish including rainbow, brook and brown trout may be partially or completely eliminated in the White Mountains as well as other areas in northern New England if warming occurs as projected by the middle to end of the next century. Warmer air temperatures will lead to warmer stream temperatures eventually making habitat unsuitable for cold-water fishes. Lower water levels and reduced flows due to droughts could also decrease food availability and prevent fish migration to spawning grounds. Warm-water fish may have trouble colonizing these streams because they may be unable to tolerate the inherently fast stream flow rates found in the White Mountains.

We believe the report, the first in a series, will provide valuable perspective for citizens on the risks posed by climate change. If you have any questions, please feel free to call me. Since I will be unavailable part of the time between now and the release, you may also want to call Allan Margolin or Bill Roberts, both at EDF in NY.

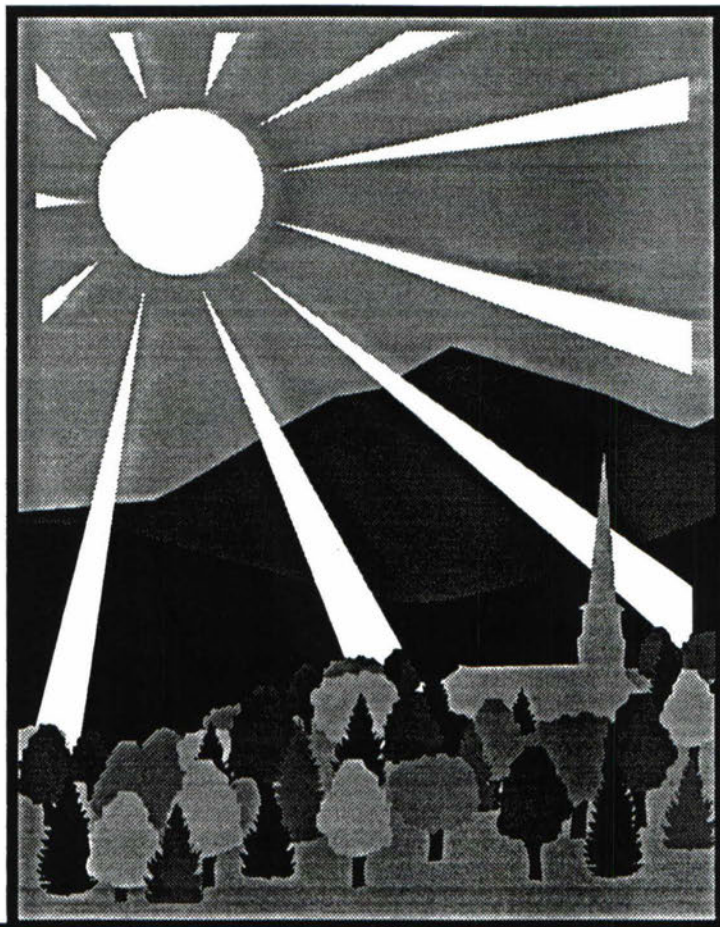
Sincerely,

A handwritten signature in black ink, appearing to read 'MO' with 'AP' written below it.

Michael Oppenheimer
Chief Scientist

MO:gp
Enclosure

SEASONS OF CHANGE



Global Warming
and New England's
White Mountains

SEASONS OF CHANGE

Global Warming and New England's White Mountains

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EXECUTIVE SUMMARY

There is a scientific consensus that emissions of greenhouse gases arising from fossil fuel combustion, deforestation and agriculture have probably contributed to and will continue to cause global climate change. Current climate models used by the Intergovernmental Panel on Climate Change, an international group of more than 2,000 scientists, project that the Earth will warm by two to six degrees Fahrenheit by the year 2100. For New England in general and the White Mountains specifically, global climate change of this speed and magnitude could mean significant and, in some cases, significantly negative, impacts to its natural resources, health, and way of life. In addition to changes in forest and ecosystem types and productivity, there exists a significant risk of disruption of the fall foliage season, declines in maple syrup production, a shortened ski season, a dramatic decrease in trout habitat, and changes in the productivity of the timber industry.

While comprising a relatively small geographical area, the White Mountain region is home to a diverse selection of communities, local industries, and ecosystem types, all of which serve different segments of the regional and extra-regional economy in valuable ways. These include the long-standing traditions of timber management, maple-syrup gathering, and fishing, as well as the more modern economies of skiing, foliage viewing, and other tourism and outdoor recreation activities. Serving local working communities, businesses, second-home seasonal residents, far-flung visitors, and consumers from around the world, the White Mountains are a productive, well-known region of historical, natural, and economic significance. The continued importance of the White Mountains relies in large part on the persistence of historical climate patterns, which are now poised to change substantially over the next century.

By analyzing global and regional climate models, and the structure of local economies and ecosystem types, this study illustrates a variety of potential outcomes of *not* acting to slow climatic change that could affect the White Mountains region over the next few decades and century. Evidence suggests that the shorter winters; longer, drier summers; and increased frequency of flooding, winter thaws, and summer droughts associated with global warming, would be expected to occur in the White Mountains as well. These changes could have profound effects on the forest composition, water resources, snowfall, growing season, atmospheric visibility, local weather patterns, and ecosystem functions of the White Mountains.

These changes could lead to negative impacts on industries such as maple-syrup gathering, skiing, and fishing, and mixed, but likely negative, impacts on the overall tourism, recreation, and forest products industries. Quality of life and environment, although primarily subjective phenomena, are predicted to change dramatically as weather becomes more extreme, species composition changes, and economies are forced into rapid transitions.

The report considers in detail impacts on the following features:

Fall Foliage

The fall foliage season in the White Mountains brings visitors from around the world to view its brilliant natural display. The weekends during the fall foliage season, running between mid-September and mid-October are often the busiest of the year for the tourist industry. This display is susceptible to climate change in a variety of ways. The existing forests are vulnerable to decline as a result of climate change. Higher numbers of dead and dying trees would mute the hillsides of brilliant colors. As climate change continued, trees from further south are projected to start to replace the northern hardwood and spruce/fir forests leading to changes in the colors visitors see, such as more brown oaks and less brilliant red sugar maples and dark green evergreens. Even earlier, if summer droughts

become more common, as is predicted by some climate models, the quality of the display may dim. Some trees will drop leaves early, others may never produce vibrant colors before dropping.

Ski Industry

The ski industry in New Hampshire plays a significant role in the state's economy and especially in the economy of the White Mountains region. Direct spending by ski area visitors in New Hampshire during the 1995-96 ski season totaled nearly \$190 million, 8.6 percent of the state-wide total for direct visitor spending. The length of the ski season and therefore the success of the ski industry is inherently tied to weather. There is a potential for shorter ski seasons as a result of climate change though added investment in snowmaking could mitigate this somewhat. One scenario shows a loss of 10 and 20% in the number of winter season days with a 3.6 and 7.2 degree Fahrenheit warming respectively.

Recreational Fishing

According to a recent EPA study on recreational fishing, suitable habitat for cold-water fish including rainbow, brook and brown trout may be partially or completely eliminated in the White Mountains as well as other areas in New England if warming occurs as projected by the middle to end of the next century. Warmer air temperatures will lead to warmer stream temperatures eventually making habitat unsuitable for cold-water fishes. Lower water levels and reduced flows due to droughts could also decrease food availability and prevent fish migration to spawning grounds. Warm-water fish may have trouble colonizing these streams because they may be unable to tolerate the inherently fast stream flow rates found there. In the EPA model, the worst case result showed that nationally, the number of cold- and cool-water fishing days (defined as person-days spent fishing) declined by 50 million while the number of warm-water and rough guild fishing days increased by 64 million. However, because of the greater economic value of cool- and cold-water fishing there was a net annual loss of \$320 million nationally.

Hiking and Nature Walking

The White Mountains region is a mecca for hiking and summer-time recreation attracting millions of visitors from sightseers to mountaineers with its spectacular peaks, alpine meadows, and verdant forests. The summit of Mount Washington, found within the borders of the White Mountain National Forest, is one of the most popular vistas in the world. While global warming will probably lead to a longer hiking season for the White Mountains region, it might also be much less enjoyable due to hotter, and potentially drier, smoggier summers and larger areas with dead and dying trees. Ground level ozone is already a problem in the White Mountains region. An Appalachian Mountains Club study has shown that ozone in this area is comparable to that of urban areas in southern New England. Higher heat will exacerbate this further. High ozone levels are damaging to both human and forest health. With warmer temperatures and altered climate, the types of forest trees in the region are predicted to change. High elevation spruce and fir may disappear early followed by susceptible members of the northern hardwood forest community. The process of forest decline may include increases in pest and pathogen outbreaks and more frequent forest fires. Eventually new forests may become established but during the time of transition, there may well be large amounts of dead and dying trees making for a more open but significantly less attractive forest for recreation.

Maple Syrup Industry

Sugaring, the harvesting of sugar maple sap to produce maple syrup, is a tradition in the White Mountains region and throughout New England that dates back to pre-colonial days. To residents and tourists alike, it wouldn't be spring in New England without the Maple syrup season. Sugar maple sap flows best when night temperatures are cold (less than 25°F) and day temperatures are rel-

atively warm (greater than 40°F). But both the records of the last century and some climate scenarios for future warming suggest that temperatures may warm more at night than during the day. This could significantly decrease the number of days for sap flow. Scenarios of temperature increases of 3.6°F and 7.2°F with warming occurring predominantly at night resulted in a decrease in the number of optimal sap flow days by 17 and 39% respectively.

Sugar maple are also susceptible to mid-winter thaws and summer drought, which may accompany climate change. When snow cover is lost during the winter through a mid-winter thaw, sugar maple's shallow roots can be killed when temperatures drop again. Large-scale die-offs or declines have occurred during the last century when temperatures were warmer than normal. Even before the trees die, sap production lessens as trees sicken. In addition, if warming occurs more in the spring than in the winter (as some models project), buds may break early, making the sap bitter and leading to a shorter, less productive season.

Timber Industry

The timber industry is a vital component of the White Mountains region. Timber management occurs within the White Mountain National Forest, the largest management unit in the region, as well as in forests owned and managed by private individuals, large timber companies, and the state government. One EPA model of the effect of warming on the yield of timber species in New England showed increases in hardwoods, but decreases in softwoods (conifers). However, in models where forest species are allowed to migrate in response to changing climate, some timber species associated with this region currently may no longer be able to grow there in the future. The timber industry in New England has been remarkably flexible in the last few centuries since colonization by Europeans began. The industry thus may well be able to adapt to potential losses of spruce and fir and some northern hardwood species by potential increases in white pine or oak. However, during transition periods before establishment of new forest species, productivity could be greatly reduced. At this point we can only suggest that there are potential risks and benefits to the timber industry of this region and that further development of forest models is necessary before more accurate economic models can be developed.

These predictions, though based on current ecosystem and climate models and observable phenomena, can only serve as an illustration of potential outcomes of climate change; no one can predict with certainty whether the climatic and ecological response will undermine, destroy, or even benefit local communities and economies in the long run. Available evidence and informed judgment indicate, however, that climate change will dramatically reduce many of the values we currently associate with the White Mountains region, and that the people of the region face a very uncertain future if current trends continue.

The most effective means to safeguard the existing mosaic of industries, ecosystems, and communities in the White Mountains from the consequences of climate change is to slow and eventually reduce the emissions of greenhouse gases. Such a change cannot be effected by the people of New England alone. As with all other regional economies and ecosystems, their fate is tied to the wisdom of nations and people around the globe, specifically to international commitments to stem pollution. A better future for the White Mountains can be secured by local, national, and international cooperation to combat global climate change by reducing greenhouse gas emissions. Failure to do so may well have profound repercussions for all regions. This study offers a detailed picture of just one of those regions, New England's White Mountains, and an example of how global climate change can have tangible impacts at the local level.

PROLOGUE

There is a consensus among climate scientists that emissions of greenhouse gases due to fossil fuel use, deforestation and agriculture have probably caused and will continue to cause global climate change. Computer models of the climate are beginning to provide improved estimates of how much and how fast climate will change. Because several greenhouse gases survive in the atmosphere for many decades or even centuries after release, continued emissions near or above current rates would mean continued climate change and warming for centuries. Decision-making on emissions limitation would be improved by increased understanding of how climate changes could affect our natural resources, our health and our way of life.

To begin to approach this issue, we decided to look at a specific location, the White Mountains region of New England, and to illustrate a variety of potential outcomes of *not* acting to reduce emissions. We portray a range of visions based on what we know about the vulnerabilities of this system to climate change as it relates to different sectors and users of resources in this region. We have also looked at what values are at risk, both in terms of the economic cost to society and also in less quantifiable ways—for example, being able to return with our children to a favorite trout stream we visited as a child or smelling the maple syrup boiling in the air of a cold, early spring morning.

The issue is very complicated, especially when we look at how it will affect us personally, where we work and play. This is because we must examine not only how climate change could affect our forests, towns, and health directly—but how climate changes interacting with all the stresses that have already been imposed by natural and human causes—would affect these things. Another problem is assessing how our behavior might be altered in response to these changes.

This report presents a preliminary and largely qualitative attempt at portraying how integral climate is to the people who live in, visit and appreciate the White Mountains region. More research is needed to quantify the projected alterations. But it is clear that, according to our current understanding, the magnitude and rate of climate change projected to occur in the next hundred years—that is, within our children and grandchildren's lifetimes—is sufficient to substantially change the White Mountains region.

THE WHITE MOUNTAINS AND CLIMATE CHANGE

The White Mountains region of New England is located within the states of New Hampshire and Maine. It lies in the northern portion of New Hampshire within the counties of Grafton, Carroll and Coos in New Hampshire and Oxford county in Maine. It also includes the White Mountain National Forest in New Hampshire and Maine (770,000 acres). The White Mountain National Forest is a beautiful and popular recreation area. Heavily forested and mountainous, it includes wilderness, timber and wildlife management areas and the largest alpine area east of the Rocky Mountains and south of Canada. The Presidential Range of mountains, found within the borders of the National Forest, include 5 peaks above 5,000 ft (1524m) with Mt. Washington, at 6,288 ft (1916m), renowned for its spectacular views and equally extreme weather. Over 6 million people visit the National Forest each year for hiking, skiing, fishing, viewing fall foliage, or simply to enjoy the view, making it one of most visited in the country. Beyond the National Forest, the White Mountains region contains hundreds of towns that rely on tourism, as well as the timber industry, for their livelihood. The way of life for many residents of the region is to combine several different enterprises such as making maple syrup, farming, and working in the service and retail sectors catering to tourists. Residents and tourists alike are strongly attached to the rich natural landscape of forest, streams, and mountains.

This report will focus on the vulnerabilities and risks of climate change to the people and industries of the White Mountains region. While many uncertainties remain, there is a consensus among climate scientists that human activities, primarily the burning of fossil fuels, are changing the Earth's climate.¹ One predicted repercussion is an increase in global average temperature above 1990 levels of from 1.8 to 6.3°F (1.0 to 3.5°C) by the year 2100.² On a global scale, rain and snowfall amounts and timing are projected to change, as well as the frequency and severity of storms and the incidence of both drought and flooding.³ Global climate change of this magni-

tude and speed is unprecedented in the last 10,000 years.⁴

In this report we will explore which sectors and users could be most affected by projected climate change. Our focus will be on what activities and industries are particularly vulnerable to changes in climate and what factors might contribute to that vulnerability. Vulnerability is contingent both on how dependent an activity or industry is on climate (e.g., a successful ski season is dependent on a cold winter) and how current stresses like pollution and development might increase its sensitivity to climate change. Our analysis of these vulnerabilities paints a preliminary picture of the risks to this region from climate change. This report contains scenarios, syntheses of existing model results, and suggestions as to how models could be improved—as well as some speculation based on our basic understanding of the systems involved. Our goal is to highlight where vulnerabilities exist, who would profit or lose from changes, and what these changes could mean to us as a society. Further research at the local and regional scales will clarify what the coming decades may be like in a world where climate is changing.

The following sections will discuss how climate change could affect a variety of activities and industries dependent on natural resources in the White Mountains. We explore the potentials for the disruption of the fall foliage season, declines in maple-syrup production, a shortened ski season, a decrease in trout habitat, and changes in the productivity of the timber industry. In addition, we explore how changes to the natural resources base of the White Mountains region could affect the lifestyle and economies of towns that are dependent on natural resources as their primary source of income.

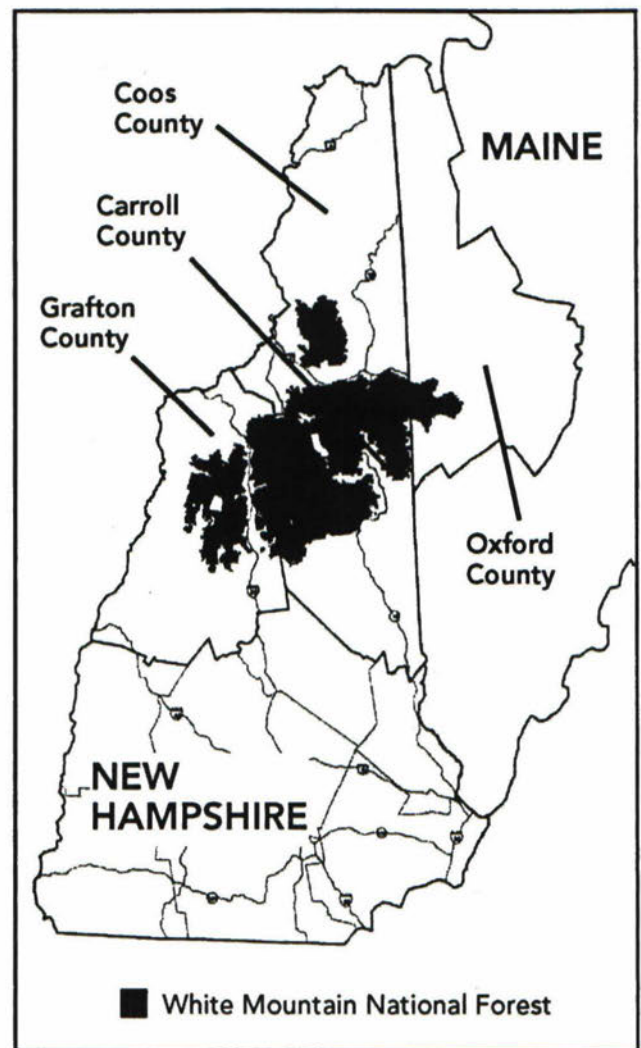
Understanding what sectors are vulnerable to climate change, the risks involved, and some of the underlying reasons why specific changes may come to pass will help us all make decisions on what actions we can take now to reduce these threats.

The Greenhouse Effect and Global Warming: How Will the Climate of the White Mountains Change?

The burning of fossil fuels such as oil, coal and natural gas, by cars, trucks, power plants and factories has substantially increased the amounts of greenhouse gases in the atmosphere relative to pre-industrial levels. Large-scale deforestation has also added significantly to greenhouse gas concentrations in the atmosphere. Today's atmospheric concentrations of CO₂ are 30 percent above the pre-industrial levels of 200 years ago⁵. Other greenhouse gases, including methane, nitrous oxide and tropospheric ozone, have also been increasing due to a variety of sources of emissions including agriculture, biomass burning, and landfills - in addition to fossil fuel use and deforestation.

Greenhouse gases are known to affect the climate. The earth and atmosphere absorb solar radiation and radiate heat back into space. Greenhouse gases, both natural and human-generated, trap a portion of this heat that would otherwise escape into space. This baseline "greenhouse effect" is essential to the earth's climate: without it the average temperature would be about 0°F (-18°C) instead of 60°F (16°C). However, human-generated greenhouse gases have augmented the concentrations of naturally occurring greenhouse gases to the extent that they are beginning to affect earth's climate. Current climate models predict that continued growth in concentrations of greenhouse gases will lead to increased surface temperatures (global warming) and changes in the amount, frequency, and timing of precipitation. The average global temperature has risen by 0.5 to 1°F (0.3 - 0.6°C) over the past 100 years and the eleven warmest years in the past 100 have occurred since 1980. Glaciers at mid-latitudes are receding. Intense rain and snow storms, fewer extremely low minimum temperatures, and other climate anomalies consistent with predictions of climate change have been observed with increasing frequency.⁶

Applying global climate model predictions to a specific location like the White Mountains region is a very difficult task. First of all, many geographic features such as lakes, mountains, and rivers—which are very important in determining climate and weather at local scales—are too small to be resolved by existing continent and region-scale cli-



The White Mountains region lies within Grafton, Carroll and Coos counties in New Hampshire and Oxford county in Maine and includes the White Mountain National Forest in New Hampshire and Maine.

mate models. Yet these features can make a big difference in exactly what climate or weather a particular location will experience. Weather refers to the changes in temperature and precipitation we experience on a day-to-day basis while climate refers to larger seasonal patterns. While it is hard to predict weather more than a few days in advance, climate can be modeled over long periods of time with a high-degree of accuracy. Models are being developed that will be able to project climate accurately for smaller regions. However, storm and drought frequency, and unseasonably cold or hot periods for particular locations are beyond the predictive capacity of existing models.¹³ Unfortunately, it is just this scale of climate information that is most important in assessing affects on natural ecosystems. Currently, we can obtain the results of global

Box 1. Global climate models

General Circulation Models (GCMs) are the primary tools scientists use to predict the impact of increased CO₂ and other greenhouse gases on the global climate system. A variety of models have been put forward which provide a range of predicted climate scenarios over time. The models represent many complex processes concerning land, ocean and atmospheric dynamics, using both empirical relationships and physical laws. By varying the amounts of greenhouse gases in the model's representation of the atmosphere, future climate can be projected globally as well as regionally. However, GCMs are currently not reliable at scales much smaller than a continent. The highest numerical resolution of current models is 05° latitude by 05° longitude (roughly 1200 square miles). Even at this scale, the output should be taken as a representation of a trend and not as a precise prediction of climate at a particular date and location⁷.

Since 1990, climate models have begun to incorporate the effects of sulfate aerosols. Atmospheric aerosols are small particles and very small droplets formed as by-products of the burning of fossil fuels in power plants, as well as through natural events such as volcanic eruptions⁸. Anthropogenic aerosols include sulfates, fossil fuel soot and organic aerosols from biomass burning.⁹ These particles both absorb and reflect sunlight: sulfate aerosols in particular reflect sunlight and cool the earth, partially mitigating the impact of the greenhouse gases. Sulfate aerosols also lead to formation of cloud droplets that reflect sunlight. Volcanic eruptions, like that of Mount Pinatubo in 1991, release so much particulate matter into the atmosphere that they, too, can have a global cooling influence which has been modeled by GCM's. However, since human-generated sulfate aerosols also produce many negative impacts when they fall to the earth, such as acid rain, there has been strong support for abatement of their emissions. These aerosols have a much shorter life time in the atmosphere than CO₂ and affect the areas close to their source most strongly. Thus, future concentrations in the atmosphere will be closely tied with reductions at the source. Without their cooling influence, a greater warming due to greenhouse gases may be felt.

To predict future climates, modelers developed a series of scenarios of CO₂ emissions for the next century, based on estimates of population growth; rates of deforestation; what types of fuels are used (e.g., coal, natural gas, renewables); how much fossil fuel use increases, especially by developing nations; and how much sulfur emissions control is enacted and enforced. In one scenario, sulfate aerosol remains constant at current levels, while in others sulfate increases initially and then either decreases or continues to increase.¹⁰ These scenarios allow us to estimate how global mean temperature would change in a variety of possible future worlds. For a range of scenarios and models, global mean temperature is projected to warm between 1.8 and 6.3°F (1.0 and 3.5°C) by the year 2100.¹¹ If it is assumed that sulfur emissions remain constant, the warming may be as high as 8°F (4.5°C).¹²

climate models that show temperature and precipitation projections for central North America as a whole and, for some models, New England. From this we can make some educated guesses as to what these forecasts might mean for the White Mountains region specifically. It should be borne in mind, however, that as regional and smaller scale models improve, climate predictions for specific locations will improve but may diverge from our current estimates.

In general, warming is predicted to increase with latitude, with the largest warming predicted to occur in late autumn and winter. Therefore New England and the White Mountains will generally experience higher than the globally averaged temperature

increases.¹⁴ In scenarios where CO₂ concentrations doubled and climate was allowed to reach equilibrium, which would occur several decades thereafter, New England's average annual temperatures were predicted to increase by 6 to 14°F (3 to 8°C).¹⁵ (see Figure 1). In a business-as-usual scenario, concentrations of CO₂ are projected to double over pre-industrial concentrations by about the year 2060. Two "transient" climate model runs show the rate at which equilibrium is approached and project warming of about 3°F (2°C) for New England for the year 2060 (see Figure 1). One of these transient models, UKMO-TR, includes sulfate aerosols, which leads to less pronounced warming (see Box1). In general, transient models underestimate the eventual equilib-

rium warming associated with the concentration of greenhouse gases in the model at any particular time. This is because the atmosphere responds relatively slowly to additions of greenhouse gases, with a time lag of at least several decades. Even without further increases in greenhouse gas concentrations beyond what is projected for the year 2060, temperatures would continue to rise substantially over the next several decades. The higher end of the range of warming predictions for New England includes models that do not include sulfate aerosols and that have been allowed to equilibrate at twice the pre-industrial levels of carbon dioxide. These equilibrium models give an idea of the maximum warming that would be associated with greenhouse gas concentrations projected for the year 2060.

With increasing concentrations of greenhouse gases, models predict an increase in global mean precipitation.¹⁶ When sulfate aerosols are included in the models, increases in precipitation are smaller. However, it is hard to predict how precipitation will change at the regional level. For central North America, there is a range in projections of precipitation, with different models predicting increases, decreases or similar amounts of precipitation.¹⁷ In most cases, precipitation is expected to increase in the winter in central North America.¹⁸

Even if precipitation increases on an annual or seasonal basis, it is the soil moisture (how wet or dry the soil is at any particular time) that is crucial to the health and well-being of plants. In general, soil moisture depends on the total amount of pre-

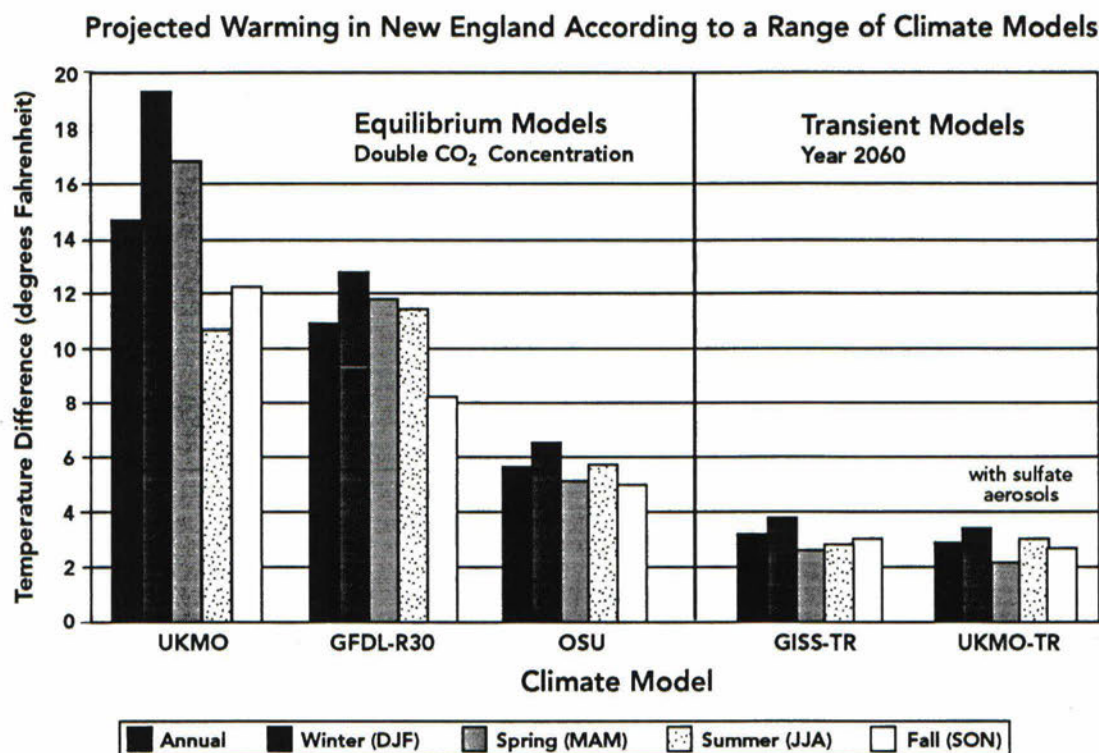


Figure 1. Increase in surface air temperature (in degrees Fahrenheit) for three climate models at double CO₂ concentrations compared to pre-industrial levels and for two transient models for the year 2060 as compared to 1990 temperatures. Equilibrium models shown are the UKMO (United Kingdom Meteorological Office), GFDL-R30 Geophysical Fluid Dynamics Laboratory), and OSU (Oregon State University) models. Transient models include the GISS-TR (Goddard Institute of Space Studies transient model), and UKMO-TR (UKMO transient model). Only the UKMO-TR model includes sulfate aerosols.

Sources: UKMO, GFDL-R30, and OSU: Kittel, TGF, Rosenbloom TH, Painter TH, Schimel DS, and VEMAP Modeling Participants (1995) The VEMAP integrated database for modeling United States ecosystem/vegetation sensitivity to climate change. *Journal of Biogeography* 22(4-5) 857-862; VEMAP members (1995) Vegetation/ecosystem modeling and analysis project: Comparing biogeography and biogeochemistry models in a continental-scale study of terrestrial ecosystem responses to climate change and CO₂ doubling. *Global Biogeochemical Cycles* 9(4) 407-437. UKMO-TR: Murphy, JM (1995) Transient response of the Hadley Centre coupled ocean-atmosphere model to increasing carbon dioxide. Part I: Control climate and flux adjustment. *Journal of Climate* 8: 36-56.; Murphy, JM and Mitchell, JFB (1995). Transient response of the Hadley Centre coupled ocean-atmosphere model to increasing carbon dioxide. Part II: Spatial and temporal structure of response. *Journal of Climate* 8: 57-80. GISS-TR: Russell, GL, Miller, JR and D Rind 1995. A coupled atmosphere-ocean model for transient climate change studies. *Atmos.-Ocean* 33: 683-730.

Box 2: Climate and Forests in the White Mountains: 14000 Years of Change

The forests of the White Mountains region that we visit today haven't always looked as they do now. Climate has a dramatic influence on which trees, shrubs, wildflowers and animals make up any forest community. In the White Mountains, temperatures in the past have been both considerably cooler and warmer than they are today, though records indicate that they have rarely if ever changed as rapidly as is projected to occur due to greenhouse gas warming in the coming years.²³ Natural disturbances such as fire and flooding have also shaped the character of forests in the White Mountains region.²⁴ For example, while fire is generally unimportant as a disturbance factor in the White Mountains region currently, during a warm, dry period approximately 7000 to 9,000 years ago, fires became much more common.²⁵ These and other disturbances, such as pathogen and pest outbreaks and strong storms have significantly affected the species and character of the White Mountains forests.²⁶ Disturbances may increase in both frequency and severity at a global level with greenhouse-gas driven climate change.²⁷ Determining whether this increase in disturbance frequency will occur in the White Mountains with climate change is an important research task for the future. If disturbance frequency and severity do increase, it could mean dramatic changes in the forest ecosystems of this region.

Trees and forests have responded in dramatic ways to changing temperatures. Spruce is an example of a tree species in the White Mountains region that responds to temperature changes. Today, spruce in the White Mountains region grows only at relatively high elevations, between 2500 and 3300 feet (750 - 1,000m), where the microclimate (local climate) is cool and relatively moist.²⁸ Under these conditions, spruce have a significant competitive advantage over other species. However, when temperatures are too warm or too cold, other species may dominate. As the last glaciers began to recede from the White Mountains about 14,000 years ago, the region's mean annual temperatures were probably about 7.2 to 10.8°F (4 to 6°C) on average below today's.²⁹ Only sparse tundra was able to grow there. As temperatures warmed, the fossil pollen record shows that spruce began to colonize the area. By 6000 years ago, summer temperatures in North America were estimated to be 36 to 72°F (2 to 4°C) higher than today's, and were associated with the dramatic decline of spruce populations throughout the region.³⁰ Spruce maintained populations only in the cooler, higher elevations and farther north into Canada. As spruce populations declined, fir, larch, poplar, and paper birch populations moved into the newly opened areas. During a subsequent cooling trend beginning 5000 years ago, spruce populations were very successful at expanding their range again. Spruce were able to supplant northern hardwood at elevations between 2500 and 4000 ft (750-1220m).³¹

Forests have been fairly stable in the White Mountains for the last few thousands of years. At lower elevations, northern hardwoods - similar to those found today - began to appear around 7000 years ago. In general, forests indistinguishable from those seen today were established about 2000 years ago.³²

cipitation, as well as its timing (seasonally), frequency, and intensity. Higher temperatures may cause the soil to be drier even if precipitation increases, because the added heat causes water to evaporate from soil and vegetation more quickly. In general, soil moisture is predicted to increase in the winter and to increase or decrease in the summer depending on location. When sulfate aerosols are included in the models, soil moisture is increased further. Frequency and intensity of rain in the summer can make a big difference in soil moisture. For example, the same average amount of monthly precipitation may fall as daily low-intensity drizzle or as twice monthly high-intensity downpours. Intense rains can lead to increases in erosion, mudslides and tree falls, which can cause dramatic changes to the

landscape.¹⁹ But, between infrequent heavy downpours, soils would dry much more than if light rain fell frequently. The end result would be much drier soil conditions leading to water stress for the trees and other plants. However, because of the dramatic topographic relief of the White Mountains region, soil moisture may not be as great a problem, since this area may still have ample rainfall, especially in the high-elevation areas, even if the region as a whole becomes drier.

On a global scale, climate change is often expressed or discussed in terms of average warming. But at a local scale, the climate and weather we experience is more variable, and how individual events will change is important to humans and ecosystems. Thus a general warming may lead to

an increase in extremely high temperature days or heat waves, and an increase in consecutive dry days or droughts.²⁰ Increased precipitation may lead to a greater likelihood of heavy downpours. In fact, precipitation and temperature records made at hundreds of sites in the United States and a few other continental locations indicate that precipitation patterns have already changed substantially in the past hundred years, possibly as a result of greenhouse gas-driven climate change. For example, moderate precipitation events have decreased while extremely heavy precipitation events (greater than 2 inches per day) have increased.²¹

Greater warming is also predicted to occur at night than during the day. Most of the warming in the past century has occurred during the nighttime, leading to less differences between day and night temperatures. Minimum nighttime temperatures have risen almost three times as fast as the maximum daytime temperatures over much of the world. For the northeastern United States, annual diurnal temperature range (the difference between day and night temperatures) has decreased 1.8 to 3.6°F (1 to 2°C).²² However, because nighttime warming is related to amounts of sulfate aerosols in the atmosphere, this differential may decrease over time if reductions in sulfur emissions occur (see Box 1).

Ecologists and other plant and animal scientists use projections of temperature and precipitation, as well as other climate variables, obtained as outputs from the GCM models, to create models of how natural and managed areas, and the plants and animals they support, could be affected by climate change. Since the latest GCM outputs have only recently been made available to the larger scientific community, many of the terrestrial models reported here are based on GCM runs that did not include the effects of sulfate and other aerosols and thus represent the higher range of projections.

ECOLOGICAL CONSEQUENCES FOR FORESTS OF THE WHITE MOUNTAINS REGION³³

Most of the values and activities we associate with the White Mountains region are dependent on a healthy forest resource. Forest health has been characterized in a variety of ways but in this report we define it as a forest that is both robust and resilient to multiple natural disturbances such as

fire, pest and pathogen outbreaks, and wind. It is further characterized as a forest ecosystem in which the multiple uses of timber production, water resources and other ecosystem services, as well as recreational and ecological values are maintained in a sustainable fashion.

From maple sugaring in the spring to hiking in the summer to viewing foliage in the fall to skiing in the winter, the economic and recreational calendar of the White Mountains is built around forests. Healthy forests are also the backbone of the timber industry, an important economic resource for this region. Climate change of the magnitude predicted by current climate models has the potential to both alter the species of trees and cause decline and widespread mortality in the forests of the White Mountains. However, it is difficult to predict with accuracy the fate of these forests; some models show increased productivity due to the longer growing season that would occur with warmer average temperatures. To address these issues, we present first, a synthesis of current model predictions—both in terms of species shift and productivity—and second, suggestions as to where forests are vulnerable to climate change in ways that have not as yet been adequately addressed by models. Since most ecological models are not yet accurate beyond a regional scale, we will look at the results of models applied to the forests of the northeastern United States as a whole and apply the relevant parts of their results to the White Mountains region.

Changes in Forest Species and Forest Types Predicted by Current Ecological Models

In general, ecological models predict that warmer temperatures would move optimal conditions for the growth of northern hardwood forest species northwards—including those we generally associate with the brilliant displays of fall colors in the White Mountains region—by at least 100 to 300 miles by the end of the next century.³⁴ Northern hardwood forest species may also move upward in elevation to maintain current climate conditions. However, while tree line will probably increase in elevation with warming, soils at higher elevations are often thin and acidic, and they could prove inhospitable, especially in the short term. High winds, common to high-elevation sites, may also limit upward expansion of the hardwoods. Forests

Box 3. Exploring the potential impacts of climate change and detecting its "fingerprint" in the ecosystems of the White Mountains: The importance of long-term data

Because climate change is projected to occur over the course of decades, detection of its "fingerprint" on the ecosystems of the White Mountains as early as possible will be essential both to improve our understanding of the impacts of climate change on the region and to plan and cope with future alterations. But the large natural variability in the weather, disturbance regimes, stream flows and other patterns and processes that occur in the White Mountains may make it difficult to recognize climate-induced changes if and/or when they occur. Detecting change will be dependent on understanding the forest and other ecosystems well enough to separate natural variability from the effects of a changing climate. To do this, scientists will need to use data that have been collected over a period of time long enough to be able to characterize normal variation (see Figure 2).

Reliable "long-term" ecological data, extending over a period of decades, exists for only a few areas in the world. Luckily, one of those areas is the White Mountains. The Hubbard Brook Experimental Forest, in West Thornton, New Hampshire in the heart of the White Mountains has been a focus of long-term research, research that pioneered the integration of ecosystem-level experiments and observations on the scale of small watersheds.³⁵ Research at Hubbard Brook is coordinated by the USDA Forest Service and represents a cooperative effort among researchers from numerous universities, research institutions and government agencies. As a result of the ongoing work of over a hundred scientists over the period of the last four decades, there exists a large body of continuously measured data on weather, forest growth and species composition, hydrology, precipitation, lake and stream chemistry, lake and stream biology and biogeochemistry for the Hubbard Brook Experimental Forest.³⁶ Though most of the research has not focused explicitly on climate change, the data amassed provide a detailed understanding of how chemical nutrients, precipitation, stream water, pollutants, and vegetation interact in this northern hardwood forest, its streams, and a naturally nutrient-poor, low-productivity (oligotrophic) lake found within the forest.³⁷ The data generated by this effort are complemented by 60 years of forest inventory data available from the Bartlett Experimental Forest, Bartlett, New Hampshire, also located within the White Mountains.³⁸

Beyond simply detecting change due to global warming, these long-term data could also be used to generate detailed projections of the potential impacts of climate change on the forests of the White Mountains. Projections could go beyond current models that focus on the effects of temperature and precipitation changes alone to include the multiple, interactive effects that actually define how ecosystems function and respond. For example, changes in precipitation patterns could lead to alterations in stream flow and chemistry that could affect forest productivity. In one scenario, acid precipitation, of the magnitude currently occurring, combined with more intense storm events could decrease soil available calcium, thereby increasing the amount of calcium leaving the forest in stream water and ultimately lowering forest productivity. Without a detailed, long-term record of forest productivity, stream chemistry, and acidic deposition, this type of interaction would be impossible to identify. Other examples of interactive effects that could be studied using these long-term data sets include examining the movement of nitrogen in soils as a result of greater warming at night relative to the day, the impacts of increased loss of water through soils and foliage due to warmer temperatures (evapotranspiration) on tree growth, and the relationship between climate and disturbance patterns like increased fire or pest and pathogen outbreaks and their affect on forest productivity.

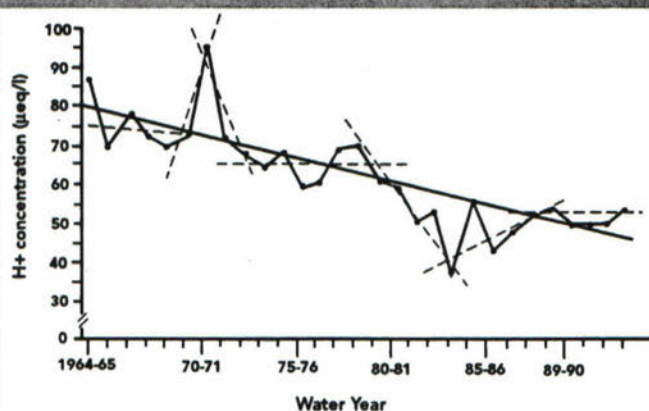


Figure 2. An example of natural variability in long-term ecological data sets. Trends are apparent with 30 years of record that would be difficult to distinguish if only 3 or 5 years had been measured. The graph depicts the annual, volume-weighted concentration ($\mu\text{eq/liter}$) of hydrogen ion (a measure of acidity) for a portion of the Hubbard Brook Experimental Forest from 1964-1965 to 1992-1993. From Likens, GE and Bormann, FH, (1995). *Biogeochemistry of a Forested Ecosystem*, Second Edition, Springer-Verlag New York. 159pp.

Simulated Vegetation Distribution in New England: Current vs. Double CO₂ Atmosphere

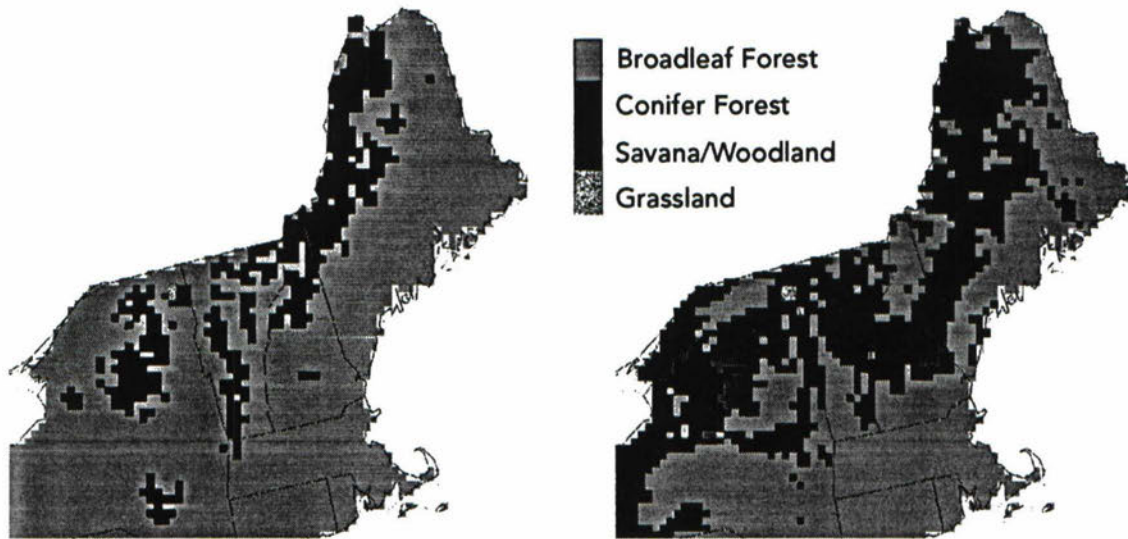


Figure 3. Current (left) and future (right) potential vegetation for New England using the MAPSS vegetation model with climate simulated by the GFDL-R30 equilibrium climate model, which projects temperature and precipitation changes for a double CO₂ atmosphere that are approximately the middle-of-the-range of equilibrium climate models (see Figure 1). As can be seen, conifer forests largely disappear from the region and much of the northern hardwood forest is replaced by savanna/woodland.

Source: Neilson, RP (1995). A model for predicting continental-scale vegetation distribution and water balance. *Ecological Applications* 5: 362-385; VEMAP Members. 1995. Vegetation/ecosystem modeling and analysis project: Comparing biogeography and biogeochemistry models in a continental-scale study of terrestrial ecosystem responses to climate change and CO₂ doubling. *Global Biogeochemical Cycles* 9:407-437.

that currently grow at higher altitudes (2500 to 4800 ft, 762 to 1463m), like the red spruce and balsam fir communities, could have little room to migrate upward as they approach the tree line. As optimal conditions for growth of forest species change due to changing climate, forests would be at greater risk to disturbances like fires, and pest and pathogen outbreaks, as well as to unusual weather such as mid-winter thaws or winters with little snow cover. In general, this could lead to decreased health and increased mortality. Given sufficient warming, these spruce forests could be lost or reduced significantly in size. There are indications that climate-related mortality has already been occurring in the spruce/fir community (see Box 4).

One model (MAPSS) estimated changes in forest types with a climate change scenario of doubled CO₂ concentrations including direct CO₂ fertilization in northeastern US forests as a whole (Figure 3).³⁹ The results included widespread tree mortality, decreases in vegetation density of 25-75 percent, extensive wildfires, and a lag in establish-

ment of new forests of several decades.⁴⁰ Forests that were constrained to cool climates, such as northeastern hardwoods and high-altitude forests were lost or reduced significantly in size.

Changes in Forest Productivity Predicted by Current Ecological Models

Warmer temperatures, combined with higher CO₂ concentrations in the atmosphere, could cause forests to be more productive, accumulating more carbon as biomass. One model of forest productivity that covers the northeastern United States (PnET-II)³², used a scenario of increased temperature (10.8°F (6°C)) and decreased precipitation (15%), which resulted in an increase in wood production in all stands due to the increased length of the growing season and warmer temperatures. In the model, increased CO₂ allowed the trees to use water much more efficiently, thus overcoming possible problems with drought.

Another forest ecosystem model, Terrestrial Ecosystem Model (TEM)⁵³ also found that climate

Box 4. Spruce decline

Many of the high-elevation red spruce forests of eastern North America have experienced rapid population declines in the last 30 years.⁴¹ Tree ring widths, a measure of tree growth, began to decrease simultaneously through the Catskills, Adirondacks, and the Green and White Mountains after about 1960, regardless of disturbance history or tree age.⁴² The mortality of red spruce increased with increasing elevation.⁴³ The increased mortality was probably not primarily due to senescence, stand age, drought or pathogens.⁴⁴

Spruce decline has been related to a complex combination of factors, which include acid precipitation, winter injury, ozone injury and climate change.⁴⁵ Long-term data collected at the Hubbard Brook Experimental Forest in the White Mountains of New Hampshire suggests that acid rain may be responsible for the loss of large amounts of calcium and magnesium, nutrients essential for plant growth, from the soil.⁴⁶ Loss of calcium may also lead to the release of aluminum in soils, which is toxic to tree roots in high enough concentrations.⁴⁷ Acid precipitation has been related to direct foliar damage by dissolving the waxes that protect needles (cuticles) and by causing red-brown needle discoloration.⁴⁸

Climate-related factors that may contribute to increased spruce mortality and that may increase with projected climate change, include rapid thawing events during the winter followed by hard frost, which could increase the frequency and severity of winter injury.⁴⁹

Long-term records also point to a connection between climate and spruce mortality. When records of spruce distribution are examined, there appears to be a decline in spruce abundance at middle-elevation sites from 1800 to the present.⁵⁰ The major driving force of the decline appears to be a warming trend in both mean annual and mean summer temperatures. Climate records from Hanover, NH show a 3°F (1.7°C) increase in yearly temperatures and a 4°F (2.2°C) increase in summer temperatures over the past 150 years.⁵¹

change consistent with doubled CO₂ led to increased productivity for the northeastern forests. In this model, the boreal forest type (spruce/fir forests) showed particularly dramatic increases. This may be because these forests are generally limited by nitrogen availability. The warmer temperatures led to more decay of dead needles and wood on the forest floor, releasing more nitrogen - an essential nutrient for plant and tree growth which is usually limited in supply in these forest types. However, atmospheric nitrogen deposition due to pollution in the northeastern United States is currently 10 to 20 times above historic background levels. These high nitrogen inputs could eventually saturate the nitrogen retention capacity of the forest, lessening growth enhancement over time.⁵⁴

The effect of increased carbon dioxide on forest productivity

Carbon dioxide makes up the largest fraction of the human-generated greenhouse gases which cause global warming. Carbon dioxide also has a crucial biological role in plants; it is the source of carbon that plants use to grow and make leaves, wood, and roots. Plants may experience both warmer tempera-

tures and significantly higher concentrations of CO₂ in the coming century. Elevated CO₂ is thought to both increase productivity and allow plants to use water and nitrogen more efficiently, which could also result in greater resistance to drought. While individual plants grown under controlled conditions have been shown to grow more quickly under higher concentrations of CO₂,⁵⁵ how natural forests could react is much less well known.⁵⁶ There are several scientific reasons for this:

- Studies performed on young plants or seedlings that showed large enhancements of growth may not apply to mature forest trees.⁵⁷
- Since different species or genotypes within species are known to react differently to increased CO₂, competition may lead to shifts in species composition that are hard to predict.⁵⁸
- Higher temperatures could depress some of the increased efficiency of water use by the plant.⁵⁹
- Some species may stop responding to higher than double CO₂ concentrations due to saturation,⁶⁰ yet greenhouse gas levels could continue to increase well beyond this level.
- Over time, species may adapt to increased CO₂ levels and stop their increased growth response.⁶¹

- Early growth increases may disappear as other essential plant nutrients (e.g., nitrogen) or water become limiting. However, this effect may be mitigated in some areas like the northeastern United States where nitrogen is being added to soils from air-borne pollution sources.

Despite these difficulties inherent in applying the CO₂ fertilization effect to natural forests given our current state of knowledge, most forest productivity models (such as TEM and PnET-II described above) apply the CO₂ fertilization effect by increasing growth rate of all modeled forest species uniformly. This has a profound impact on the final results, in some cases completely mitigating any negative effects of climate change, resulting in large increases in predicted productivity for northeastern US forests. These high-productivity estimates should be viewed with caution until a fuller understanding of the impact of higher CO₂ concentrations on natural forests is gained from further research.

Transient vs. equilibrium models

Most ecosystem models with results available for New England, including the three discussed above (PnET-II, TEM, and MAPSS),⁶² are so-called equilibrium models. This means that the model looks at the difference between climate as it exists today and conditions under climate at a set point in the future. In these models, scenarios are built of future climate, commonly with CO₂ at double the pre-industrial levels though others exist using higher concentrations. The models assume that an equilibrium has been reached in terms of both vegetation response and climate change. Even if CO₂ concentrations stop increasing after they reach double the pre-industrial levels—an unlikely scenario—which is predicted to occur by around the year 2060, it would be many decades before climate reached an equilibrium, and perhaps centuries before vegetation would equilibrate as well. Equilibrium modeling can give us an idea of what the forest or ecosystem might look like under various ultimate scenarios - in a world with a stable but warmer and possibly drier climate. However this type of model misses a lot of the complexity of how forests respond to rapidly *changing* climate.

One factor that is predicted to increase as climate changes is disturbances.⁶³ While disturbances, such as pest and pathogen outbreaks, flooding, and wind damage, have always been an

important part of the dynamic landscapes of the White Mountains region, climate change may increase their frequency and severity. Disturbances can kill large numbers of trees and forests. When forests come back, their species composition, the types of trees that will grow there, is often different than before the disturbance. For example, a sudden drop in hemlock populations in the White Mountains and other sites in eastern US and Canada 4,800 years ago has been attributed to a pathogen outbreak similar to ones that have caused the modern-day declines of chestnut and elm. Hemlock persisted at low levels but only returned to its pre-decline abundance after about 2,000 years.⁶⁴ An equilibrium model would miss this type of phenomenon because it looks only at current and future states, not at how the change occurred. Transient modeling, which models both climate changes and forest responses at yearly or even monthly intervals, at a fine enough scale to capture these types of occurrences is extremely difficult but is being actively pursued. One class of models, individual-tree-based “gap” models holds perhaps the best promise for exploration of transient forest responses to climate change.⁶⁵

Vulnerability of White Mountain Forests to Extreme or Unusual Weather, Pollution and Disturbances: Going beyond existing models

All models are by necessity simplifications of reality; we are not yet able to build in all factors that could affect forests. Three important factors that have not been adequately incorporated into models (though there is on-going work to include them), but that are predicted to increase with climate change, are the impact of extreme and unusual weather events, pollution and disturbances on forests.

Extreme or unusual weather

Extreme events or unusual weather patterns—like periods of winter thaw followed by intense cold; spring and summer drought; and summer heat stress—can have profound impacts on the forests of the White Mountains region. These types of extreme events or unusual weather patterns have been tied to diebacks and declines in several northern hardwood species in New England in the last hundred years.⁶⁶ Because these forest types occur within the White Mountains region, if certain types



An example of physical damage to trees that can accompany high winds during storms. (photography: Marny Ashburn/AMC).

of extreme weather events and unusual weather patterns increase as is predicted by climate models, the forests of the White Mountains region may be vulnerable to widespread mortality from forest decline.

In the past, episodes of rapid warming have been closely tied with the onset of widespread crown dieback and decline in eastern Canada for several northern hardwood tree species: ash in the mid 1920s, birch from 1935-1955, and sugar maple from the 1980s to the present.⁶⁷ These dieback episodes corresponded to widespread increases in annual mean temperatures, increases in certain types of extreme events, and summer droughts.⁶⁸

More recently, episodes of sugar maple declines in southeastern Quebec in the 1980s have been tied to a combination of winters with periods of loss of snow cover, followed by deep freezes, and in turn followed by summer drought. A variety of physiological mechanisms may be responsible for these dieback episodes. Roots are more sensitive than

other tree organs to temperature extremes; without snowcover, any hard frost can lead to increased root mortality. In northern hardwoods, persistent winter snowcover typically provides protection to the fine roots from extreme cold. This may help to explain the observation that the southern limit of northern hardwoods corresponds more or less to the incidence of persistent winter snow accumulation.⁶⁹ Fine roots, like those of the shallow-rooted sugar maple, are most susceptible when close to the surface. Trees whose root systems are already limited (e.g., by drought or shallow soils) are also highly susceptible to dieback.

Unusual thaws can also cause buds to break their winter dormancy prematurely and open long before spring. The buds can subsequently be killed by a return to freezing temperatures.⁷⁰ A tree already weakened from loss of fine roots due to thaw-freeze events in winter can be further stressed by summer droughts. Drought causes a depletion of sugar reserves due to lower photosynthetic performance.

Recent studies have shown that mature forest age is a pre-condition for the climate to incite dieback by freezing injuries as described above. Large dieback episodes correspond especially well with the point at which ash, birch, maple and red spruce stands attain maturity.⁷¹ This means that a large portion of the NE forests could be threatened by climate-induced injury because the NE forests in general are aging and a sizable area is at or near maturity.

There are some indications that the duration of winter snow-cover has already been decreasing in the northeastern United States since the mid 1970's. For example, records from Lennoxville, in southern Quebec, have shown a marked increase in the number of days during the winter without snowpack in the last 20 years from 35 to 95 days (taken as a 5 year average).⁷² In general, northern hemisphere snow-cover has been consistently below the 21-year average (1974-1994) since 1988.⁷³

Pollution

Pollution can weaken trees, making them more susceptible to climate changes due to greenhouse-gas-driven warming. Pollution, including acid deposition, nitrogen deposition, and high ozone concentrations already affects forests in the Northeast, and certain pollutant emissions, particularly those that generate ozone, may increase in the

coming century.⁷⁴ Once weakened, the trees often succumb to pests and pathogens they might otherwise easily combat when healthy.⁷⁵

When acidic mist or rain falls, nutrients can be leached directly out of the leaves. Acid rain falling on soils can leach important nutrients like calcium out of the ground lowering its availability to the trees,⁷⁶ which can lead to the release of toxic elements including aluminum that can kill tree roots. Trees that lack important nutrients are weakened, becoming more susceptible to attack by insects and pathogens, and more vulnerable to certain types of extreme events associated with climate change, like droughts and thaw/freeze events in winter.⁷⁷

Disturbance

Disturbances including fire, wind, flooding, and pest and pathogen outbreaks are common occurrences in forests and, most of the time, forests can recover and grow well after them. In fact, forest health is probably dependent on regular natural disturbances. However, more severe disturbances caused by human activities and climate change may be much more difficult to recover from. Climate change could be directly responsible for increased disturbance; for example, warmer temperatures could increase the range of pests into new areas. Climate change could also be indirectly responsible; dry hot weather and higher numbers of dead or dying trees would make conditions better suited for wildfire.⁷⁸ In addition, natural disturbance—or disturbance caused by humans but unrelated to climate change—could make the impact of climate change more severe. For example, large portions of the White Mountains region were cleared for agriculture in the 19th century, leading to a young, fragmented forest. By its peak, in 1850-1880, at least two-thirds of Grafton County was cleared of forests to allow for agricultural activities.⁷⁹ Areas that have been fragmented historically may create barriers to migration of species necessitated by changing climate.⁸⁰

Fire

The White Mountains region, as well as most of northern New England, rarely experience fires today. Fires are more common in southern New England in the drier pine-oak forest types.⁸¹ Climate change could create conditions conducive for fires further north. Drier soil and fuel conditions, an increase in the occurrence of heat waves,

and an increase in fuel loading from increased morbidity and mortality would create conditions highly conducive to wildfires. In addition to direct physical damage, fires can change species distribution and productivity and will tend to favor early-successional, fast growing species.⁸²

Wind

There is no consensus yet as to whether winds will intensify or weaken in the future.⁸³ However, if storm-driven wind does increase, it could lead to increased physical damage. New England forests are subject to three major classes of destructive windstorms: tropical cyclone (hurricanes), extratropical cyclones, and more-localized intense winds associated with stormfronts and thunderstorms.⁸⁴ Northern New Hampshire and Vermont have been struck by severe hurricanes only twice, in 1815 and 1938 over the period 1492 to 1976. As a result of the 1938 hurricane, nearly 3 billion board feet of timber were blown down affecting 243,000 ha of forest land in Connecticut, Rhode Island, Massachusetts, and Vermont. Weakened trees or local wind-prone sites were most affected. There is no consensus yet on whether hurricanes will increase or decrease in intensity or frequency due to climate change. However, increased numbers of localized intense storms could increase windthrow, especially in places where trees are exposed due to clearing of neighboring forest.

Flooding

Flooding may increase in frequency and intensity as a result of climate change. This is thought to occur in general because warming would release greater amounts of water into the atmosphere's hydrological system at a global level.⁸⁵ At a local level, this could result in an increase in frequency of intense downpours⁸⁶ leading to rapid melting in the spring and/or an increase in rain-on-snow events. Warmer-than-current springs could also intensify spring snowmelt. Increased flooding in the White Mountains region could lead to increased rock and mud slides, leading to physical damage in the forest, riparian (river-side) zones, and property. Runoff can also disrupt municipal water treatment and delivery systems, wash out bridges, highways and other human infrastructure, and inundate croplands. An example of a particularly intense rainfall event occurred in October 1996 when record rainfalls

flooded homes, broke off water supplies in Portland, Maine and Exeter, New Hampshire and washed out highways and bridges throughout New England.⁸⁷

Pest and Pathogen Outbreaks

Warming in winter may allow destructive insects and pathogenic fungi to survive at higher latitudes than at present, enabling subtropical or warm-temperature pests and pathogens to invade vegetation in areas from which they are now excluded.⁸⁸ For example, one of the factors that may currently be slowing the northward spread of hemlock wooly adelgid may be the length and severity of winter.⁸⁹ Hemlock wooly adelgid attack is currently causing catastrophic loss of hemlocks in southern New England. Hemlock is a key species for deer during the winter in this region. Drought stress, which may also increase with climate change, may also lead to increased pest outbreaks. For example, in New England, periodic epidemics of spruce budworm which result in the killing of mature balsam fir and spruce stands over large areas, are related to warm, dry summers and the conditions associated with drought.⁹⁰

CLIMATE CHANGE AND THE TOURISM AND RECREATION INDUSTRIES

The White Mountains region has a large investment in maintaining the natural resources that attract so many people to take part in their varied tourist and recreational opportunities. Climate change has the potential to affect many of the key natural resources that draw visitors to the area throughout the year. The natural beauty and recreational attractions have also made the area one of the most popular locations in the country for vacation homes. The quality of fall foliage viewing, skiing and snowmobiling in the winter, and fishing and hiking in the summer are all vulnerable to the rapid climate changes predicted to occur in the coming years.

The tourism and recreation industries are critical to state economies of this region. Much of the White Mountains region is found in the state of New Hampshire. The travel and tourism sector in New Hampshire resulted in \$25 billion in direct spending and \$15 billion in indirect spending for 1994, which represented 95% of the gross state product.⁹¹ The White Mountains region accounted for

18% of that spending.⁹² In the New England area in 1991, over 58 percent of residents participated in some form of wildlife-associated recreational activity and spent approximately \$2.5 billion to do so.⁹³ Visitors to New Hampshire's ski areas spent \$139 million during the 1992-1993 ski season. This direct spending led to over \$178 million in secondary sales, including hotel and restaurant purchases.⁹⁴ The three northern New England States (Maine, New Hampshire, and Vermont) have consistently had the highest percentage of vacation homes in the United States since the census first started keeping track of this in 1940.⁹⁵ In 1990, for example, 11% of New Hampshire housing were vacation homes. If climate change alters the primary characteristics that draw people to these activities, then subsequent changes in participation rates can also be expected. Changes in participation will have direct effects on the region's economy.

The fall foliage displays

Every autumn in the White Mountains region, deciduous trees prepare for winter. During that process their leaves turn a brilliant mixture of reds, purples, oranges, yellows and browns. This fall foliage display is a popular tourist attraction bringing in so-called "leaf-peepers" from all over the world. The weekends during the fall foliage season, running between mid-September to mid-October, are often the busiest of the year for the tourism industry.⁹⁶ The fall foliage season is vulnerable to climate change because the quality of the display and colors are dependent on which tree species are present as well as individual tree health - both of which may be affected by changes in climate.

Leaves change color when temperatures grow cooler and days shorter in the fall. First, the connection which allows the leaf to exchange sugars, water, and nutrients with the rest of the tree is blocked, trapping any remaining sugars within the leaf. Next, the green pigment, chlorophyll, which allowed the leaf to produce sugars during the summer, begins to deteriorate and lose color. Other pigments that were always present in the leaf, but masked due to the abundance of the green chlorophyll, begin to show through. These pigments are typically yellow, red, or orange (carotenoids, anthocyanin and xanthophylls). Maples often display a particularly brilliant red hue due to the large amounts of sugars that are trapped or produced in



A typical New England scene, the change of seasons, may be threatened by global warming. (photography: Paul O. Boisvert).

their leaves.⁹⁷

Many factors, including soil type, site quality, soil moisture availability, and genetic characteristics, can interact with climate to produce varying qualities of color display. Because of this complexity, predicting a good foliage display is often an educated guess at best. However, certain climatic factors are known to contribute to the quality of the color display. For example, summer droughts tend to disrupt fall color displays in a number of ways. Droughts can cause leaves to dry, shrivel, and fall to the ground before producing any significant color.⁹⁸ Warmer temperatures will increase water loss from plants and soils. If rains do not increase enough to offset this, drought conditions will become more common. Even in a mild drought, fall colors can become uncoordinated when the leaves of drought-intolerant trees, like ash and birch, change color and fall earlier than the leaves of more drought tolerant trees like red maple and oaks.⁹⁹ However, higher CO₂ concentrations may lead to greater production of sugars in the spring and early summer, leading to some trees producing more intense colors when their leaves do fall.

Climate models predict that warm temperatures will continue longer into the fall than currently. This might suggest that foliage will simply change color later in the season, for example in November instead of October. But leaf fall, and therefore color change, is triggered by both temperature and day length. Some trees are more directly

influenced by day length than others.¹⁰⁰ This, too, would lead to an uncoordinated display where those trees more influenced by day length would change color and drop their leaves earlier than those trees more influenced by temperature. Because of warmer nighttime temperatures, respiration, the energy used for the tree's growth and maintenance, could increase, leading to greater loss of sugars from the tree. This may dampen the colors of some species, especially those like maples that require large amounts of sugars to produce red anthocyanins. Increased rain in the fall and cloudy warm weather would also reduce color. Clouds would lead to less production of sugars and warm weather would increase losses of sugars due to respiration. The best colors occur when falls are dry but not droughty.

Finally, climate change may lead to decreased quality of fall foliage as those trees currently found south of this region displace those currently located in the White Mountains region—as is predicted by some models of potential vegetation change as a function of temperature (for example, see Figure 3).¹⁰¹ If current northern hardwood species such as sugar maple, spruce, and fir populations decline while oak and other trees currently found in the south increase, then the unique combinations of brilliant red maples, yellow birches, and touches of dark green conifers may be replaced by the more uniform browns of the oaks, currently found south of the region (see Page 10). In addition, in the process of species shift, individual trees will sicken and die resulting in fewer

robust trees that can produce thick displays of brilliant colors.

Ski industry

The ski industry in New Hampshire plays a significant role in the state's economy and especially in the economy of the White Mountains region. The length of the ski season and therefore the success of the ski industry, is inherently tied to weather. Any significant change in climate will have a direct impact on the ski areas and the economy of the region (see Box 5).

Any significant warming in the region will most likely cause the ski season to begin later and end earlier though expanded snowmaking could mitigate this somewhat. Currently, the ski season generally lasts from December to April. Larger resorts with snowmaking capability open one to two weeks prior to Thanksgiving and close in late April. To estimate the potential impact of climate change on the winter ski season, we looked at temperature records from Pinkham Notch, New Hampshire, located within the White Mountains region near Mt. Washington. We defined the potential number of winter season days as those days with maximum temperatures below 32°F (0°C) between November 1 and April 30. Between 1956 and 1995,



The ski season in New Hampshire may be considerably shortened due to warming temperatures as a result of climate change. (photography: Paul O. Boisvert).

there was an average of 165 winter season days (Figure 4). Using two warming scenarios, one of plus 3.6°F (2°C), the other of plus 7.2°F (4°C), the season length decreased to 149 and 130 days respectively. This represents a loss of about 10 and 20 percent of the total season length. While most of the warming would serve to shorten the length of the season, some would occur as mid-season thaws, which would necessitate additional snowmaking to rebuild the snow base. Some models predict that

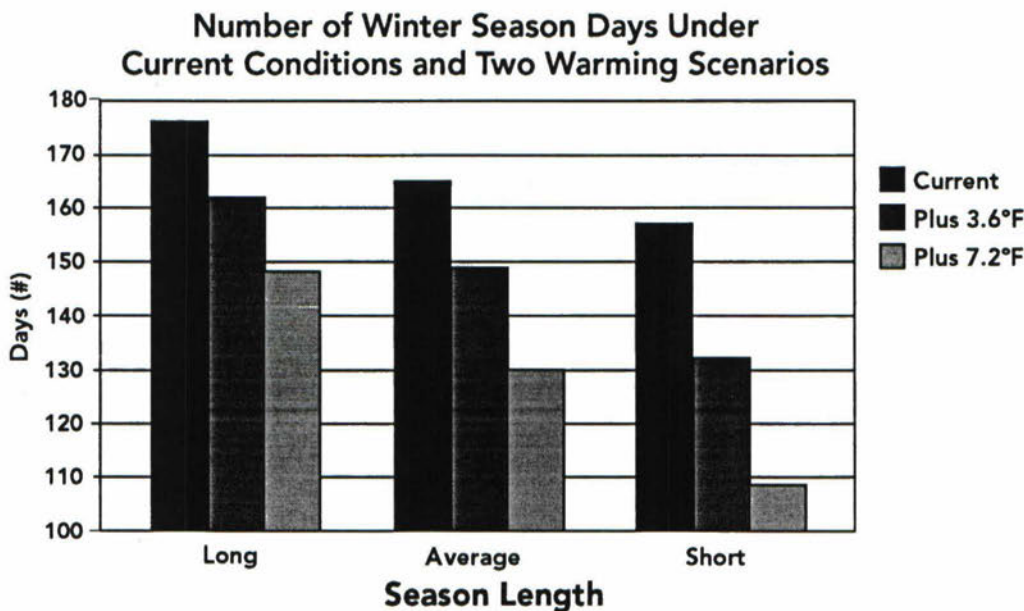


Figure 4. Number of winter season days in Pinkham Notch, New Hampshire under current climate conditions and two warming scenarios: plus 3.6°F (2°C) and plus 7.3°F (4°C). Winter season days are defined as those days whose maximum temperature is below 32°F (0°C) between November 1 and April 30 of a given year. The range of winter season lengths are represented by long, average and short length seasons between the years 1956 and 1995.

Source: Weather data obtained from the Northeast Regional Climate Center, Cornell University, Ithaca, NY.

Box 5. The Economic Importance of the Ski Industry to New Hampshire

New Hampshire has 28 alpine and nordic ski areas of which 11 are located in the White Mountains region. Since the 1983-84 ski season, skier visits to New Hampshire have risen and fallen, with peaks occurring during the 1985-86 ski season, during the 1988-89 season, and during the 1992-93 season. The greatest number of visits occurred during the 1992-93 season with 2.1 million skier visits. The low during this period occurred during the 1984-85 season, which had less than 1.5 million skier visits. Since the 1994-95 season, skier visits have again been on the rise. Direct spending by ski area visitors in New Hampshire during the 1995-96 ski season totaled nearly \$190 million. This represented 8.6 percent of the state-wide total of \$2.8 billion for direct visitor spending (for the period July 1995-June 1996) and 55 percent in the four northern and western travel regions (for the five month ski season).¹⁰² Ski areas have been offering an increasing variety of summertime activities such as alpine slides, festivals, and horseback riding. As a result, off-season visits have been increasing by an annual average of 3.3 percent over the last decade (FN Compounded 1985-1995). However, revenue generated during the off-season is considerably lower than during the ski season; the total spent in the summer of 1995 was \$53 million.¹⁰³

The ski industry also generated an estimated \$319 million in secondary sales between July 1995 and June 1996. State and local governments received \$18 million in taxes and fees from direct ski area and visitor spending in the form of property, business, profit, room, meal and other taxes. An additional \$48 million was received from taxes associated with secondary spending. Alpine and nordic ski areas employed 4,586 full- and part-time people during the ski season. An additional 12,551 people were employed in other establishments where skiers made direct purchases, or at establishments supported by secondary sales, from skier spending during the ski season. The annual payroll from these jobs totalled \$185 million. These figures represented 4.2 percent of all jobs and 2.1 percent of household payroll for the four travel regions.¹⁰⁴

precipitation will increase in the winter, while others predict similar or slight decreases.¹⁰⁵ If precipitation falls as snow, this could reduce the need for snowmaking. However, if precipitation falls as rain due to warming temperatures, this could lead to rain-on-snow events which could cause a deterioration of snow conditions required for skiing. Additional snowmaking would be necessary to recoup losses.

Ski areas already invest heavily in snowmaking equipment to extend the ski season. The two main factors influencing snowmaking are temperature and water availability, both of which may be affected by climate change. Attitash Mountain in New Hampshire spends \$750,000 per year on snowmaking, which represents 20 percent of their operating cost. Temperatures should be less than 28°F (-2.2°C) for successful snowmaking¹⁰⁶ and, generally, the colder the temperature the less costly it is to make snow. Under future climate scenarios these conditions will be met on fewer days.

Water availability could increase or decrease with climate change, depending on how precipitation is affected. If precipitation increases in the winter as rain then more water may be available for

snowmaking. Less water could be available if there is no change in precipitation or if precipitation decreases. With warmer summers, there may also be less water available in the streams and ponds during winter to make snow. It takes 150,000 to 180,000 gallons of water to cover one acre of ski trails with one foot of snow. Depending on the rate and season (fall or spring) at which water is withdrawn from the streams, this amount of water withdrawal can lead to decreased fish habitat area and increased ice formation as well as increased scouring of the river bed, leading to fish egg damage.¹⁰⁷

Current and future advances in technology, as well as other mitigation strategies, can address some of these problems. For example, technology exists that can increase the average freezing temperature of water and increase the quantity of snow made per unit of water used.¹⁰⁸ This may allow ski areas to make snow under moderately warmer conditions and allow them to save energy and energy costs. In addition, as snowmaking equipment becomes more energy efficient, ski areas will also be able to cut down on costs. These types of technology improvements could help alleviate some of the negative affects of climate change for ski areas, at least in the



Rainbow, brook and brown trout habitat may be partially or completely eliminated in the White Mountains as well as other areas in New England by the middle to the end of the next century if warming occurs as projected in current climate change models. (Photo: Charlie Fellenbaum).

short term. Increasing the size of ponds from which water can be withdrawn for snow making, as has already been started in some ski areas, would mitigate damage to fish habitat from snowmaking.

An in-depth study of the impact of global warming on downhill skiing in the Laurentians in Quebec used temperature scenarios similar to the higher temperature scenario presented for the White Mountains in this report (see Figure 1).¹⁰⁹ In addition, precipitation, snow-cover and snowmaking conditions were included as driving factors in the analysis. With warming of from 7.6 to 9.3°F and increased precipitation ranging from 0 to 16 percent, the study found a reduction of the ski season length of 40 to 89 percent with a minimum financial loss of \$10 million (Canadian) and a maximum loss of the virtual elimination of the ski industry in the area. Ski season length was little affected until the average winter temperature increased by 3.6°F (2°C).

Recreational fishing

Recreational fishing in the White Mountains region could be significantly affected by climate change. Climate change may have direct effects on fish habitat and populations, especially in cold-water rivers and streams, due to the impact of warmer temperatures and changes in precipitation on stream temperature and flow rates.¹¹⁰ Cold-water fish species common to the White Mountains region may be unable to survive a significant warming of water temperature, though species differ in their degree of

tolerance. Brook trout, for example, have strict temperature requirements and may be particularly vulnerable to climate change. Brown trout and rainbow trout can tolerate a wider temperature range than brook trout, but are still limited by temperature, especially during spawning.¹¹¹ Changes in timing or amount of precipitation may affect the quantity and quality of water in streams which could also cause deterioration of habitat for trout.

The economic impact of losses in trout habitat could be significant. Nationally, an estimated 35.6 million people spent 511 million days fishing in 1991. In New England, two million people devoted 24 million days to fishing and spent an average of \$674¹¹² each, or a total of \$1.3 billion. Of the two million people who fished in New England in 1991, 35 percent traveled from out of state to do so.¹¹³

Climate change is expected to cause a decline in cold-water fish habitat by increasing the temperature of streams to levels exceeding the thermal tolerance limit for cold-water fish, making some species, like brown and brook trout, unable to survive the warmer waters. The loss should be greater along the southern borders of a species' natural range where temperatures are already close to the thermal tolerance. According to a study by the Environmental Protection Agency, loss of habitat for cold-water fish may be significant throughout their range.¹¹⁴ Rainbow trout, brook trout, and brown trout are the most important cold-water fish for recreational fishing in the New England area and several states could potentially lose all habitat suitable for these species (Figure 5). Cool-water guilds, which include walleye, Northern Pike, and yellow perch, will probably not be affected in the New England area.

Stream flow rates could also be affected by climate change. If warmer temperatures and changes in precipitation patterns cause severe floods in spring or extreme low flows in late fall or winter, then species may be excluded from occupying sections of stream where they would otherwise be expected to occur.¹¹⁵ Low water levels and reduced flows could decrease the availability of winter habitat, decrease the reproductive success of fish, and reduce food availability.¹¹⁶ Low flows can prevent the migration of trout to their spawning grounds as well as reduce the area avail-

able for spawning. Reduced flows and ice formation in winter may result in the suffocation, desiccation, and freezing of trout eggs. When river depths are too shallow, ice formations can rip the eggs from the stream bottom. Reduction in habitat can cause crowding and stress-induced disease, and it can also lead to stranding (when a segment of stream is too shallow or frozen preventing fish from passing through to another area). Flooding scours stream bottoms and can destroy eggs as well as diminish food supply.¹¹⁷

Reproduction could also be directly affected by warmer temperatures. Temperature is one of the most important variables in reproduction. Some species will spawn only within a narrow temperature range that is lower than what they can tolerate as adults. Warming could affect this vulnerable stage in the fish life-cycle before affects to adult fish become important.¹¹⁸

Warmer stream temperatures would suggest that cool- or warm-water fish could replace cold-water fish. However, water velocity could limit what species are able to colonize these areas. For example, trout typically live near headwaters of streams where the topographic gradient is steep, water velocity is fast, and the bottom is gravelly or rocky.¹¹⁹ Many warm-water species require a medi-

um to low gradient with medium to slow water velocities in addition to appropriate water temperatures.¹²⁰ Therefore, even if water temperatures in an area become ideal for warm-water species, they may still fail to expand their habitat into the area due to streams running too quickly. In streams where water flow has been slowed because of the construction of dams or other water diversions, warm-water species have been able to expand their habitat to the detriment of trout.¹²¹

Potential benefits to fish could occur at the northern end of the range in Canada where warmer temperatures could increase growth, productivity, and maturation rates of fishes. One study estimated that productivity could increase by about 10-20 percent per 1.8°F (1°C) increase in temperature, as long as other factors that limit growth, such as nutrient and food supply, continue to be available as climate changes.¹²²

How these effects will subsequently translate into behavioral changes on the part of anglers is difficult to gauge. If the species composition of a particular stream changes from cold-water to warm-water fish, anglers may choose to fish in the same location for different species, travel further north or move to higher elevations to fish for the same species or change habits all together.

Loss of Habitat for Cold-Water Fish

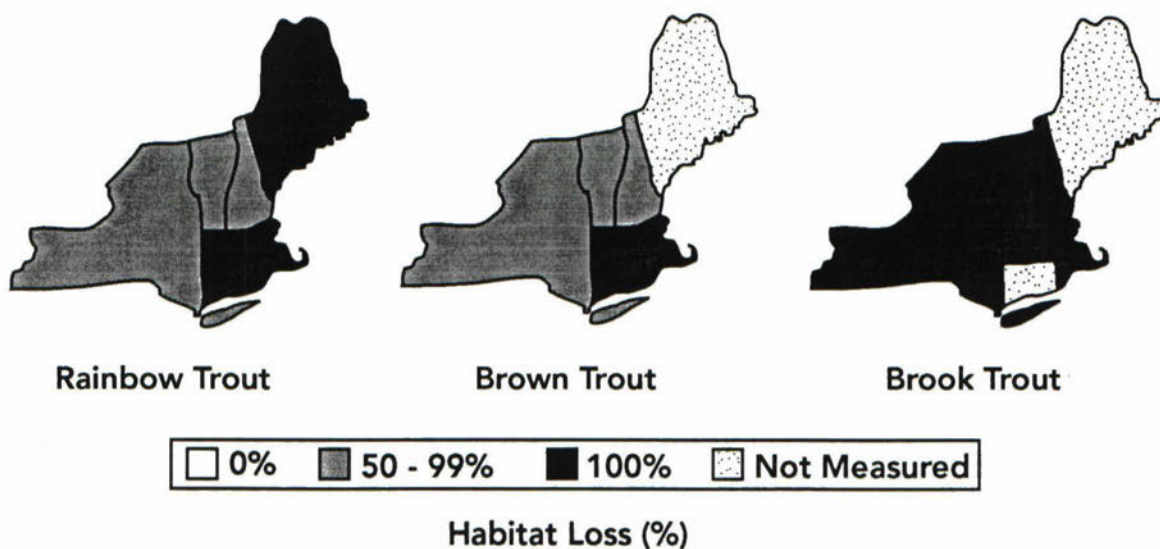


Figure 5. Percent loss of habitat for rainbow, brook and brown trout in New England according to one scenario from a 1995 EPA study on the ecological impacts of climate change on freshwater recreational fishing using the GFDL (Goddard Fluid Dynamics Laboratory) equilibrium climate model at double CO₂ concentrations as input (see Figure 1). This study did not consider brook or brown trout in their baseline information for Maine or brook trout for Connecticut.

Source: US EPA, Ecological Impacts from Climate Change: An Economic Analysis of Freshwater Recreational Fishing, EPA 220-R95-004, April, 1995.



While global warming will probably lead to a longer hiking season for the White Mountains region, it might also be much less enjoyable due to hotter, and potentially drier, smoggier summers and larger areas with dead and dying trees. (photography: Paul O. Boisvert).

Generally, cold-water fishing is more valuable than warm-water fishing, so a gain of an acre in warm-water habitat is not equal to a loss of an acre of cold-water habitat.¹²³ In the worst case result of the EPA model on the potential impact of climate change on recreational fishing,¹²⁴ the number of cold- and cool-water fishing days (defined as person-days spent fishing) nationally declined by 50 million while the number of warm-water and rough guild fishing days increased by 64 million. However, because of the greater value placed on

cool- and cold-water guilds, there was a net annual economic loss of \$320 million.

Hiking and nature walking

Hiking and camping are popular summertime activities in the White Mountains region. Climate change may significantly affect this experience. Warmer temperatures will probably lengthen the hiking season by increasing the number of snow-free days in the mountains. However, if the disturbance and declines discussed elsewhere in this report do become more common,¹²⁵ the quality of the natural experience may be significantly decreased. Numbers of dead and dying spruce and fir trees, pest and pathogen outbreaks, more frequent fires, and more frequent droughts in summer may all increase, contributing to a more open but significantly less attractive forest for recreation.

Warmer temperatures could also exacerbate already deteriorating air quality. Much of the excitement of hiking to a peak or driving to the top of Mt. Washington is derived from the sweeping panorama visible from the top. However, visibility is decreased by the particulate component of pollution. Both particulates and ozone have already become a problem in the White Mountains region and both could be exacerbated by warming temperatures in the summer (see Box 6). For example, according to an ongoing study conducted by the Appalachian Mountain Club¹²⁶ some higher elevation sites, includ-

Box 6. Ground-level Ozone

Ozone is a strong oxidant formed by reactions of nitrogen oxides (NO_x) with hydrocarbons in the presence of sunlight. Fossil fuel use, primarily from automobile engines and industry, produces most of the compounds that result in ozone formation. Ozone, formed near the "ground level," can be damaging to humans, vegetation and animals. Elevated ozone concentrations, especially common during the summer months, have become a serious problem—not only in urban areas, but in remote, high-elevation forests like the White Mountains due to long-distance transport processes. Furthermore, increases in temperature are known to enhance ozone production,¹²⁹ suggesting that climate change may exacerbate this problem. Ground-level ozone causes irritation and damage to membranes of the respiratory system and eyes in humans and other animals. High ozone concentrations can lead to damage to needles and leaves, contributing to reduced growth and seed production and increased susceptibility to other problems, such as insects and diseases.¹³⁰ As such, it is thought to be a contributor, along with acid deposition, to dieback and decline of forest species, especially conifers such as eastern white pine.¹³¹ Current monitoring of ozone-related damage to plants and trees in New England shows the greatest injury is found where ozone concentrations are highest and air quality is poor (e.g., Southern New England especially Connecticut).¹³² Air quality may improve if emissions of sulfates (SO₂), nitrates (NO_x) and volatile organic compounds (VOCs) are decreased. Reductions in SO₂ are already occurring at a national level, which should aid in haze reduction - though warming could reduce the benefit of these reductions.

ing Mt. Washington, have ozone concentrations comparable to those of urban areas far to the south¹²⁷ In 1988, a particularly hot and humid summer in New Hampshire with high ozone concentrations and lots of haze, the heat combined with poor air quality may have led to the decrease in the number of hikers and other visitors to the White Mountains National Forest that was observed that year.¹²⁸

CLIMATE CHANGE AND THE MAPLE SYRUP INDUSTRY

Sugaring, the harvesting of sugar maple sap to produce maple syrup, is a tradition in the White Mountains region and throughout New England that dates back to pre-colonial days. To residents and tourists alike, it wouldn't be spring in New England without the Maple syrup season. Yet climate change could seriously affect the maple syrup industry in the White Mountains region as well as New England as a whole, shortening the season and decreasing the profitability of the industry.

One important reason that maple syrup production could be so susceptible to climate change is that strong sap flow only occurs when there is a sharp difference between day and night temperatures: optimal sap flow in sugar maple is dependent on a prolonged early spring period with cold (less than 25°F or -3.9°C) nights and warm (more than 40°F or 4.4°C) days.¹³⁵ As discussed above (see Page 10), one impact of climate change may be that there will be less difference between day and night temperatures (diurnal range). So, while the timing of the sugaring season depends on latitude - in the White Mountains region of northern New



Maple syrup production or sugaring is a cherished tradition in New England as well as being a popular tourist attraction. Warmer nights and earlier springs may shorten the maple syrup season. In addition, sugar maple itself is susceptible to increased mortality as a result of climate change. (photography: Paul O. Boisvert).

Hampshire the season typically runs from mid March to mid April, while in southern New Hampshire the season typically runs from the end of February to the beginning of April¹³⁴ — the length of the season depends on the number of cold nights followed by warm days. With a decrease in the diurnal range of temperatures, the length, and therefore profitability, of the maple syrup season is threatened. If warming were to occur predominately at night, the number of days of optimal syrup flow will decrease considerably more than if the warming occurred by the same amount in the day as the night.

While it is essential to have optimal flow days

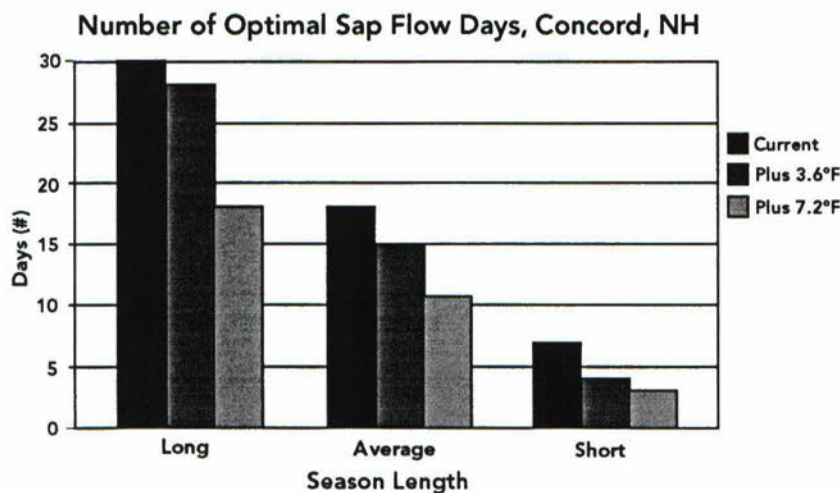


Figure 6. Number of optimal sap flow days as defined by days between January and May with maximum temperature over 40°F and minimum temperature under 25°F under current climate conditions and two predominantly nighttime warming scenarios (twice as much warming during the night as during the day). Warming scenarios are for plus 3.6°F (2°C) and 7.2°F (4°C). Values are given for historically long, average and short seasons for Concord, NH between the years 1948 and 1992.

Source: Weather data obtained from the Northeast Regional Climate Center, Cornell University, Ithaca, NY

Box 7: The economic and social value of the maple syrup industry in New Hampshire

Sugarbush operators (maple syrup producers) can be found throughout New England. Operations range in size, from those with a few trees in the backyard using traditional methods to collect and boil down the sap, to large farms with thousands of trees employing the latest in automated collection and production methods. While maple syrup production is not yet reported separately in the US Census, there are about 600-700 sugarhouses in New Hampshire plus a large number of small backyard operations (Hank Peterson, Maple Producers Association, Peterson Sugar House, personal comm.). Since maple syrup is harvested in early spring, it is important to the farmer as it provides the first source of income during the year. The value of maple syrup production in New Hampshire in 1995 was \$2,112,000 and peaked in 1992 at \$3,093,000 (North American Sugar Maple Association). Although the price of syrup and the price of production fluctuate, often depending on fuel costs, the profit margin remains about constant each season.

The maple syrup industry is increasingly important to tourism with many sugarbushes and sugarhouses open to the public during the season. Sugaring in New England is a tradition dating back to the Native Americans who boiled down the maple sap and used the syrup as an important part of their diet. Maple syrup was the most common sweetener available during the colonial period before cane or beet sugar was available. Today, maple syrup remains a symbol of New England. As Tom Slayton, editor of Vermont Life magazine, put it, "That early spring burst of activity unfailingly ties Vermonters to the land and the rhythm of the seasons. It's our particular form of alchemy, I guess, the alchemy of wood-fired arch and steaming maple sap that turns our grimmest season and the year's hardest labor into pure gold."¹⁴²

The combination of climate change, sugar maple declines, and nighttime warming driven by greenhouse gases may decrease the profitability of the maple syrup industry in much of New Hampshire. Since many operations are already small and marginal in terms of profit, as seasons worsen, the syrup industry may decline. As warming continues, the maple syrup industry will probably become more profitable further north into Canada. In fact, this trend is already apparent as maple syrup is now being produced in more northerly areas of Canada where it has never been possible before.¹⁴³

While the blow may not be severe to the economy of New Hampshire as a whole, individual towns, as well as the tourism industry in general, could feel repercussions. Beyond economic losses, maple syrup is one of the defining qualities of life in New England, its decline would be sorely felt.

for a successful maple syrup season, a typical season also includes days that would not be counted under the definition of optimal flow. A typical season lasts on average 33 days of which about 18 are optimal by the definition used in this report (see Figure 6). Because of the short season length, a loss of even one optimal flow day can be significant since there is a direct relationship between number of optimal flow days and total season length. For example, one sugarbush operator calculated a loss in production of 20 percent during one season which experienced 6 nights with above-freezing temperatures.¹³⁵ In another instance, during the 1992-1993 season, a harsh winter (cold and heavy snow) delayed the beginning of the season by about two weeks, while warm weather stopped it one week early. This resulted in a total production loss of about 50 percent. The number of optimal flow days—accord-

ing to the definition in this report—using only weather information, would have been 8, well below the average number of such days (Figure 6).¹³⁶

To find out how optimal flow days would be affected by climate change, we looked at temperature records for Concord, in south-central New Hampshire, an area where a large number of sugar maple farms operate. As a baseline, we used temperature records for the years 1948 to 1992 and applied scenarios of increased temperature occurring at a rate that was twice as much during the night as during the day. This is the ratio at which current warming is occurring in North America.¹³⁷ In this scenario, we defined optimum flow days as those with night temperatures less than 25°F (-3.9°C) and day time temperatures more than 40°F (4.4°C). As can be seen in Figure 6, under the predominantly nighttime warming scenarios, the num-

ber of optimal sap flow days would be reduced considerably, to 15 days for the 3.6°F scenario and to 11 days for the 7.2°F scenario, representing a loss of 17% and 39% in a season of average length.

While the difference between nighttime and daytime warming may decline over time, especially if emissions of sulfates decrease, overall temperature increase could still negatively affect maple syrup production. Increased temperatures could cause buds to break earlier in the season than they currently do. Once buds break, the sap collected produces syrup which is bitter and cannot be marketed.¹³⁸ If the season begins earlier as well, this would merely shift the timing of the whole season earlier. However, if warming is not uniform between seasons (e.g., a cold winter followed by a warm spring), the season could be shortened.

Maple syrup production is also threatened by tree decline.¹³⁹ As trees decline, the rate and quality of sap flow has been shown to decrease.¹⁴⁰ Because sugar maple is found primarily on moist rich soils and is not particularly tolerant to drought, sites currently suitable for sugar maple growth may become unavailable as soils become drier due to climate

change. New sites could become available further north of the White Mountains region and in Canada. Decreased snow cover is also detrimental to syrup production, since snow insulates the ground, keeping it frozen longer and keeping buds from breaking early.¹⁴¹ However, some climate models predict increased amounts of snow fall during the winter, which could counterbalance increased melting due to warmer temperatures.

CLIMATE CHANGE AND THE TIMBER INDUSTRY

Much of the White Mountains region is forested. These forests are owned and managed by private and public landholders including individuals, large timber companies, and the state and federal governments. The largest single management unit in the White Mountains region is the White Mountain National Forest, which is managed for the multiple uses of recreation, ecosystem health and biodiversity, and wood products production. Timber is harvested for use in furniture, specialty products,

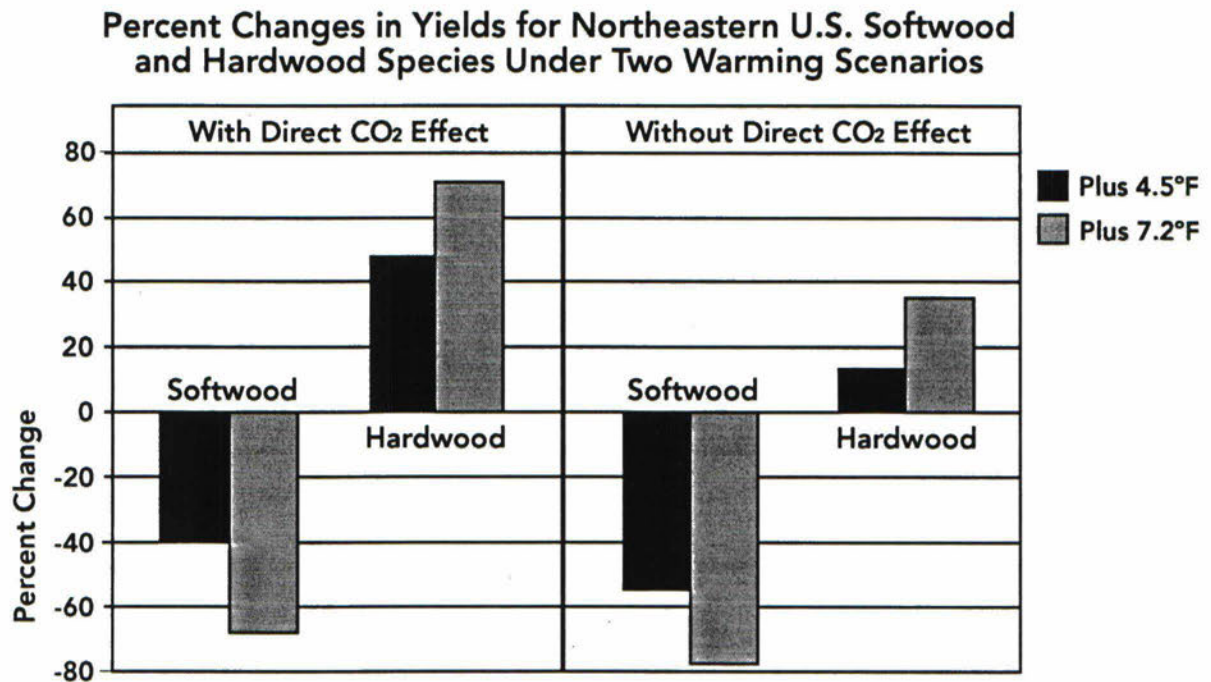


Figure 7. Change in yield under two warming scenarios, plus 4.5°F (2.5°C) and plus 7.2°F (4.0°C) with and without direct CO₂ effects in the northeastern United States using forest gap models as input to the FASOM model, a dynamic nonlinear programming model of the forest sector in the United States.

Source: Callaway, M Smith J, and Keefe, S, (1995) *The Economic Effects of Climate Change on US Forests*, RCG/Hagler Bailly, Boulder CO, Prepared for Adaptation Branch, Climate Change Division, Office of Policy, Planning and Evaluation, US EPA, Washington, DC Contract No. 68-W2-0018.

building material, fuelwood, and pulp for paper production. Major commercial forest types that occur in the White Mountain National Forest include northern hardwoods, the most abundant type in the Forest with over 200,000 acres under management, spruce-fir communities, found at higher elevations, and some hemlock. Outside of the National Forest, much of the area is former agricultural lands that have reverted to forest and are held by a variety of small and large private owners. White pine is found in many of these previously disturbed areas throughout the White Mountains region. In New England as a whole, papermaking, sawmilling, logging, and wood product fabrication employ about 250,000 individuals.¹⁴⁴ The output of these industries totals about 9 percent of the New England's manufacturing production.¹⁴⁵ The forest products industry is the third largest in New Hampshire in terms of revenues and fourth in terms of employment.¹⁴⁶

An EPA study on the economic effects of climate change on US forests by region¹⁴⁷ showed decreased softwood (which includes spruce, fir, hemlock and white pine) yields but increased hardwood yields (including northern hardwoods) with increased temperature, when applied to the northeastern United States (Figure 7). When the model included the possible direct effects of CO₂ on growth and productivity, yields were less depressed for softwoods and increased for hardwoods. However, there is evidence in the research literature that direct CO₂ effects cannot be applied equally to all forest species over the long term, and with higher than double CO₂ concentrations (see page 13).

The US Forest Service also recently performed an analysis, by forest type and by region, of the impact of climate change on forest productivity and timber supply in the United States.¹⁴⁸ Assuming that forest type would not change, productivity and timber supply increased for both softwood and hardwood forests in the Northeastern United States.

Both the EPA and the Forest Service studies looked specifically at how productivity (the amount of carbon or biomass produced by trees) could change *assuming current forests are not replaced by other species*. Neither model examined how forest species and type could change as a result of climate change. As was discussed in more detail earlier in the report (see Page 10 and Figure 3), climate change may mean that many tree species may not

be able to successfully reproduce and grow in their current locations. Increased disturbance, which may also accompany climate change - including increased risks from fire, pest and pathogen outbreaks and storm damage - could also lead to changes in forest species and type. In addition, as species shift there will be an increase in tree mortality, which would also decrease productivity, especially in the short-term.

Because we know how individual species react to climate, soil conditions and disturbances, it is possible to make some preliminary estimates on how trees important to the timber industry in the White Mountains region could be affected by climate change. White pine and red oak, currently the two most important timber species in New England as a whole, could increase in the White Mountains region in a warmer climate: oak because of warmer, drier conditions and white pine because it tends to become dominant after disturbances which may increase due to climate change. Quality northern hardwoods (sugar maple, ash and yellow birch) could decline due to changes in climate, especially extreme or unusual weather. Spruce and fir could decline as warming temperatures push the trees upward in elevation (see Box 4, page 13). Beech and red maple, which may be more tolerant of warmer drier conditions, could increase but are much less valuable as timber resources.

Because of the many uncertainties discussed, the ultimate economic impact of the various changes in forest types on the timber industry is hard to predict. The timber industry in New England has been remarkably flexible in its ability to adapt to changes in timber species harvested in the past. The industry thus may be able to adapt to potential losses of spruce and fir and some northern hardwood species, by potential increases in white pine or oak. However, during transition periods between forest species, productivity could be greatly reduced. At this point we can only suggest that there are potential risks and benefits to the timber industry of this region and that further development of forest models is necessary before more accurate economic models can be developed.

CONCLUSIONS

A scientific consensus exists that human-generated emissions of greenhouse gases to the atmosphere are probably having a discernible impact on global climate, and that influence is expected to increase in the future. If predictions from climate models become reality, many dimensions of our world will change. While there is a range of plausible outcomes for ecosystems and society, many scenarios point to significant risks to natural resources and our quality of life.

The White Mountains region provides year-round recreational opportunities for visitors and a satisfying way of life for residents, largely due to an abundance of natural resources. In turn, these natural resources are, to a great extent, dependent on climate. We are so used to climate remaining fairly constant during our lifetimes that we have little prior knowledge to guide us when it changes. For the White Mountains region there is a range of possible scenarios for the future.

The most optimistic see the region benefiting in some respects. Through a combination of long growing seasons, wet summers, and carbon dioxide fertilization, these scenarios suggest that trees and forests will become more productive, will remain healthy and will actually store more biomass as climate change proceeds. Ski seasons may shorten, but this will be compensated for by longer summer recreation seasons. Some new tree species may be established and some tree species currently occurring in the region may die off, but on balance forests would remain healthy and people will continue to live, work and enjoy the White Mountains much as they always have.

Yet there is a darker vision for this region, another potential outcome of climate change. In this scenario, as temperatures rise, weather becomes more extreme and less predictable. Winters with heavy snow are accompanied by early spring warming to produce large-scale flooding. Longer, hotter, summers lead to drought conditions by early fall increasing the susceptibility of trees to disease and forests to wildfires. Fall foliage displays are muted and ski seasons are shortened. Thawing during winter damages sugar maples and other tree species. Warmer nights and earlier springs shorten the maple syrup season making syrup production unprofitable in the region. Summer recreation is less pleasant due to increased smog and uncomfortably hot temperatures. Already existing pollution, like acid rain and ozone, combine with climate change to cause widespread forest declines leading to forest morbidity and mortality. New forests are slow to recolonize disturbed areas, leading to large areas of weeds, grasses and shrubs.

We don't know at this point whether either of these scenarios or one in between might really unfold if climate change continues as projected. Because the risks are great, the prudent course would be to try to avert a potentially disastrous result. This implies action to slow and reduce the emissions of greenhouse gases at local, national and international levels.

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- 1 The discussion of climate change science and its predictions for North America and the White Mountains for this report is drawn extensively from the Intergovernmental Panel on Climate Change (IPCC) assessments. The IPCC is an international group of thousands of scientists that was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988, to assess scientific information about climate change relevant for international and national policy formulation. Since 1988, the IPCC has published numerous reports, including the Second Assessment Report in 1995 which provided a comprehensive review and analysis of the science of climate change, the potential impacts to natural and human systems, and mitigation strategies. For more information, see *Climate Change 1995: The Science of Climate Change*. (Eds. JT Houghton, LG Meira Filho, BA Calander, N Harris, A Kattenberg and K Maskell) Cambridge University Press, Cambridge. 571p. For an overview, refer to the "Summary for Policymakers".
- 2 The climate models used to generate this range of temperature predictions are described in Kattenberg A, Giorgi F, Grassi H, Meehl GA, Mitchell JFB, Stouffer RJ, Tokioka T, Weaver AJ and Wigley TML (1995). *Climate Models - Projections of Future Climate*. In *Climate Change 1995: The Science of Climate Change*. (Eds. JT Houghton, LG Meira Filho, BA Calander, N Harris, A Kattenberg and K Maskell) Cambridge University Press, Cambridge. p. 285-357. This citation is a key chapter in the Intergovernmental Panel on Climate Change's 1995 report on the science of climate change. It is a comprehensive review of current climate models with a discussion of their reliability reflecting the work of hundreds of researchers from a diverse group of countries
- 3 Ibid.
- 4 see Technical Summary in *Climate Change 1995: The Science of Climate Change*. (Eds. JT Houghton, LG Meira Filho, BA Calander, N Harris, A Kattenberg and K Maskell) Cambridge University Press, Cambridge. p.9-49.
- 5 The following discussion on climate change science is drawn from the IPCC Second Assessment Report (1995), see note 1 above.
- 6 Ibid.
- 7 Kattenberg et al., 1995.
- 8 IPCC, 1995.
- 9 Ibid.
- 10 Emissions of sulfate aerosols may decrease, especially in developed countries, in the next 100 years if strategies to reduce acid precipitation are effective. Predictions have also been made that there will be a continuing transition away from coal use as fuel technology advances. Since sulfate aerosols are relatively short-lived in the atmosphere, if emissions are decreased, their cooling effect will decrease quickly. Ironically, reduction of this form of pollution could result in greater warming due to greenhouse gases. See "Climate Change 1994: Radiative Forcing of Climate Change and An Evaluation of the IPCC IS92 Emissions Scenarios" (Eds J.T. Houghton, et al Cambridge University Press, Cambridge, 1995 for examples of various emissions scenarios (the six IS92 scenarios) including those where sulfate aerosols are reduced. One scenario where sulfate aerosols were held constant is also included in this report.
- 11 IPCC, 1995
- 12 *Climate Change, 1994* (see note 10).
- 13 Kattenberg et al., 1995
- 14 Ibid.
- 15 See Figure 1 "Sources" for climate model references.
- 16 Kattenberg et al., 1995
- 17 Ibid.
- 18 Ibid.
- 19 In general, the effects of intense rain on the landscape include mudslides, erosion and tree falls. However, in the White Mountains region specifically, erosion is often limited to stream-banks, and mudslides are currently uncommon occurrences (personal communication, Dr. Steven Fay, Forest Soil Scientist, White Mountain National Forest, Laconia, NH)
- 20 Kattenberg et al., 1995.
- 21 For an excellent review and analysis of climate and precipitation trends in the United States for the last century based on extensive weather station data, see Karl TR, Knight RW, Easterling DR and Quayle RG (1995). Trends in U.S. climate during the twentieth century. *Consequences* 1:3-12.
- 22 Kukla G and Kar, TR (1993) Nighttime warming and the greenhouse effect. *Environment, Science and Technology*, 27(8): 1469-1474.
- 23 There is an extensive literature on the relative rapidity of climate change projected to occur with greenhouse gas warming. For a general overview, see Gates DM, (1993). *Climate Change and Its Biological Consequences*, Sinauer Associates, Inc. A more technical collection of papers can be found in Huntley B, Cramer W., Morgan AV, Prentice HC, and Allen JRM, (eds) (1997). *Past and Future Rapid Environmental Changes: The Spatial and Evolutionary Responses of Terrestrial Biota*. Springer-Verlag, Berlin. For more specific information on climate change in the White Mountains, see the review in Davis, MB (1985). History of the vegetation on the Mirror Lake watershed. pp. 53-65. In GE Likens (ed.) *An Ecosystem Approach to Aquatic Ecology: Mirror Lake and its Environment*. Springer-Verlag New York.
- 24 The historical changes in vegetation (paleoecology) in the White Mountains has been extensively studied at a variety of sites including Mirror Lake in the Hubbard Brook Experimental Forest, reviewed in Davis, 1985 and in a series of lakes and ponds in New Hampshire, reviewed in Spear, RW (1989). *Late-Quaternary History of High-Elevation Vegetation in the White Mountains of New Hampshire*. *Ecological Monographs*, 59:125-151 and Spear, R., M Davis, and LCK Shane (1994). *Late Quaternary History of Low-and Mid-Elevation Vegetation in the White Mountains of New Hampshire*, in *Ecological Monographs*, 64(1): 85-109. These studies of pollen and plant macrofossils found in bog sediments enable scientists to reconstruct the history of vegetation over the last approximately 14,000 years.
- 25 Davis, 1985.
- 26 Davis, 1985.
- 27 IPCC, 1995 and see p. 14 for a discussion of how greenhouse-gas mediated climate change could result in higher incidence and severity of disturbances.
- 28 A description of red spruce's (*Picea rubens* Sarg.) current range can be found in Burns RM and Honkala BH, tech. Coords. (1990). *Silvics of North America, Volume 1. Conifers Agriculture Handbook 654*. U.S. Department of Agriculture, Forest Service, Washington, D.C. 250pp.
- 29 This estimate is from Goldthwait RP (1976). Past climates on "the hill". *Mt. Washington Observatory Bulletin*, March and June issues, as quoted by Spear RW (1989). *Late-Quaternary History of High-Elevation Vegetation in the White Mountains of New Hampshire*. *Ecological Monographs*, 59:125-151.
- 30 These estimates are derived from model simulations for continental interiors of North America, see Davis, 1985; COHMAP Members (1988). Climatic changes of the last 18,000 years: Observations and model simulations. *Science* 241:1043-1052. Spear, RW, (1989). *Late-Quaternary History of High-Elevation Vegetation in the White Mountains of New Hampshire*, in *Ecological Monographs*, 59(2): 125-151. It is assumed that the White Mountains behaved in a consistent fashion with the results given.
- 31 Davis, 1985; Spear, 1989.
- 32 Davis, 1985; Spear et al., 1994.
- 33 The forests and ecosystems of the White Mountains region are some of the most studied and best characterized of any in the world. This is in large measure because of long-term studies of forests and ecosystems that have been performed at the Hubbard Brook Experimental Forest (HBEF) in Woodstock, New Hampshire located in the White Mountains region. The HBEF was established by the US Forest Service in 1955 and since that time has generated a continuous long-term data set that includes information on temperature, precipitation, soil, hydrology, nutrient cycling and vegetation. Studies at the watershed level have been key to our understanding of ecosystem dynamics and forest succession both in the White Mountains itself and as applied to forests the world over. In addition, if climate change occurs as has been projected by climate models, the HBEF would be an excellent site for monitoring changes in vegetation, soils, and nutrient cycling that may result due to the extensive baseline information that exists there. For more information on the vegetation, ecosystem dynamics and forests of the White Mountains and Hubbard Brook, see Bormann FH and Likens GE (1979). *Pattern and Process in a Forested Ecosystem*. Springer-Verlag, New York. 253p., G E Likens (ed.) (1985) *An Ecosystem Approach to Aquatic Ecology: Mirror Lake and its Environment*. Springer-Verlag New York, and Likens, GE and Bormann, FH, (1995). *Biogeochemistry of a Forested Ecosystem*. Second Edition. Springer-Verlag New York. 159pp. See Box 3 for more details.
- 34 For an overview of how forests and biomes are predicted to change with projected climate change, see the *Forests* chapter in the IPCC, 1995: Kirschbaum MUF, Fischlin A et al. (1995). *Climate Change Impacts on Forests*. In *Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses* (Eds. RT Wilson, MC Zinyowera, and RH Moss) Cambridge University Press, Cambridge. p. 95-130.
- 35 Bormann FH and Likens GE (1979). *Pattern and Process in a Forested Ecosystem*. Springer-Verlag, New York. 253pp.
- 36 Likens GE and Bormann FH (1995). *Biogeochemistry of a Forested Ecosystem*. Second Edition. Springer-Verlag New York. 159pp. In addition, for a listing of the hundreds of peer-reviewed publications, dissertations, and theses that have emerged from

- Hubbard Brook Ecosystem Study, see "Publications of the Hubbard Brook Ecosystem Study" compiled by Phyllis Likens in 1997 which can be obtained from the Institute of Ecosystem Studies, Millbrook, NY.
- 37 G E Likens (ed.) (1985) *An Ecosystem Approach to Aquatic Ecology: Mirror Lake and its Environment*. Springer-Verlag New York.
 - 38 Leak WB and Smith ML (1996). Sixty-years of management and natural disturbance in a New England forested landscape. *Forest Ecology and Management*, 81: 63-73.
 - 39 MAPSS is a computer model that maps biomes on the basis of climate. Thus, depending on what the pattern of temperature and precipitation in a particular location is, MAPSS determines what type of trees and other vegetation should grow there. To learn more about this model, see Neilson RP (1995). A model for predicting continental-scale vegetation distribution and water balance. *Ecological Applications* 5:362-385 and VEMAP Members (1995). Vegetation/ecosystem modeling and analysis project: Comparing biogeography and biogeochemistry models in a continental-scale study of terrestrial ecosystem responses to climate change and CO₂ doubling. *Global Biogeochemical Cycles* 9:407-437. as well as the chapter on forests in the IPCC synthesis Kirschbaum MUF, Fischlin A et al. (1995) *Climate Change Impacts on Forests*. In *Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses* (Eds. RT Wilson, MC Zinyowera, and RH Moss) Cambridge University Press, Cambridge. p. 95-130.
 - 40 Ibid.
 - 41 There is general consensus that spruce decline has occurred in New England; see Vogelmann HW, Perkins TD, Gadger GJ and Klein RM (1988). A 21-year record of forest decline on Camels Hump, Vermont. *USA Eur. J. For Path.* 18: 240-249. Vogelmann et al., 1988; Siccama TG, Bliss M and Vogelmann HW (1982). Decline of Red Spruce in the Green Mountains of Vermont. *Bulletin of the Torrey Botanical Club*. 109 (2): 162-168. Scott JT, Siccama TG Johnson AH Breisch AR (1984) Decline of Red Spruce in the Adirondacks, New York. *Bulletin of the Torrey Botanical Club* 111 (4): 438-444, for examples. A more exhaustive description can be found in the proceedings of the report of the U.S. National Acid Precipitation Assessment Program, "Acidic Deposition: State of Science and Technology, Vol. III Terrestrial, Materials, Health and Visibility Effects" (1991). PM Irving, ed., National Acid Precipitation Assessment Program, Washington, DC.
 - 42 For a review, see Johnson AH, Cook ER, Siccama TG (1988) Climate and red spruce growth and decline in the northern Appalachians *Proc. Natl. Acad. Sci., USA* 85: 5369-5373.
 - 43 For a review, see Friedland AJ and Battles JJ (1987). Red spruce (*Picea rubens* sarg.) decline in the northwestern [sic] United States: Review and recent data from Whiteface Mountain. In *Proceedings of the Workshop on Forest Decline and Reproduction: Regional and Global Consequences*. Krakow, Poland (23-27 March, 1987), Kairiukstis L, Nilsson S, and Straszak A, (Eds.), IIASA, A-2361 Luxenburg, Austria.
 - 44 Friedland and Battles, 1987; Johnson et al., 1988.
 - 45 For reviews, see Johnson AH, McLaughlin SB, Adams MB, Cook ER, DeHayes DH, Eagar C, Fernandez U, Johnson DW, Kohout RJ, Mohnen VA, Nicholas NS, Peart DR, Schier GA, and White PS (1992). Synthesis and conclusions from epidemiological and mechanistic studies of red spruce decline. In *Ecology and Decline of Red Spruce in the Eastern United States* (C Eagar and MB Adams, eds.) Springer-Verlag, New York. p.385-411. Friedland and Battles, 1987; Perkins TD, Klein RM, Badger GJ, and Easter MJ (1992). Spruce-fir decline and gap dynamics on Camels Hump, Vermont. *Canadian Journal of Forest Research* 22: 413-422 as well as the report of the U.S. National Acid Precipitation Assessment Program (1991).
 - 46 The Hubbard Brook Experimental Forest (see note 33 and Box 3) in the White Mountains has been a key site for research into how acid rain affects watersheds and forests. See Likens GE, Driscoll CT and Buso DC, (1996). Long-term effects of acid rain: Response and recovery of a forest ecosystem. *Science* 272: 244-246 and Likens GE and Bormann FH. (1974). Acid rain: A serious regional environmental problem. *Science* 184: 1176-1179 for examples.
 - 47 Data that show how increased root mortality may be caused by acidic soils due to acid precipitation can be found for sites in both Europe and the US. For examples, see Matzner E, Murach D and H Fortmann (1986). Soil acidity and its relationship to root growth in declining forest stands in Germany. *Water, Air and Soil Pollution* 31:273-282 and Joslin JD and Wolfe MH (1992). Red spruce soil solution chemistry and root distribution across a cloud water deposition gradient. *Canadian Journal of Forest Resources* 22: 893-904.
 - 48 Johnson et al., 1992; Berlyn GP, Anoruo AO, Johnson AH, Vann DR, Strimbeck GR, Boyce RL and WL Silver (1993). Effects of filtered air and misting treatments on Cuticles of Red Spruce needles on Whiteface Mountain, NY. *Journal of Sustainable Forestry* 1:25-47; Jacobson JS, Heller LJ, Yamada KE, Osmeloski JF, Bethard T and Lassoie JP (1990). Foliar injury and growth response of red spruce to sulfate and nitrate acidic mist. *Canadian Journal of Forest Resources* 20: 58-65.
 - 49 Johnson et al., 1992.
 - 50 Hamburg SP and Cogbill CV (1988). Historical decline of red spruce populations and climatic warming. *Nature* 331: 428-431.
 - 51 Ibid.
 - 52 A description of the PnET-II model and the results for New England can be found in Aber JD, Ollinger SC, Federer CA, Reich PB, Goulden ML, Kicklighter DW, Melillo JM, Lathrop RG Jr. (1995). Predicting the effects of climate change on water yield and forest production in the northeastern United States. *Climate Research* 5: 207-222.
 - 53 The TEM includes both nitrogen and carbon dynamics thus making this model particularly sensitive to the increased availability of nitrogen in the soil due to increased decomposition in warmer temperatures. For a description of the model and its application to New England, see Melillo JM, McGuire, AD, Kicklighter, DW, Moore, B, Vorosmarty, CJ, Schloss, AL (1993). Global climate change and terrestrial net primary production. *Nature* 363: 234-240.
 - 54 Aber J D, K J Nadelhoffer, P Steudler, and J M Melillo (1989). Nitrogen saturation in northern forest ecosystems. *Bioscience* 39(6):378-386; Magill AH, J D Aber, J J Hendricks, R D Bowden, J M Melillo and P A Steudler (1997). Biogeochemical response of forest ecosystems to simulated chronic nitrogen deposition. *Ecological Applications* 7(2):402-415.
 - 55 For a review, see Eamus D (1991). The interaction of rising CO₂ and temperatures with water use efficiency. *Plant Cell Environ.* 14: 843-852.
 - 56 The following article provides an up-to-date review of the relationship between elevated CO₂ and plant growth. Bazzaz FA, Bassow SL, Berntson GM and Thomas SC (1996). Elevated CO₂ and terrestrial vegetation: Implications for and beyond the global carbon budget. Pages 43-72 In B Walker and W Steffen (eds.) *Global Change and Terrestrial Ecosystems*. Cambridge University Press, Cambridge, England.
 - 57 Ibid
 - 58 Bazzaz et al., 1996; For a specific example, see Curtis PS, Klus DJ, Kalisz, S and SJ Tonsor (1996). Intraspecific variation in CO₂ responses in *Raphanus raphanistrum* and *Plantago lanceolata*: Assessing the potential for evolutionary change with rising atmospheric CO₂. In *Carbon Dioxide, Populations, and Communities* (C. Koerner and FA Bazzaz, eds.), Academic Press, New York.
 - 59 Bazzaz et al., 1996
 - 60 Bazzaz et al., 1996. See Kozlowski TT, Kramer PJ, and Pallardy SG (1991). *The Physiological Ecology of Woody Plants*, Academic Press, New York. 655 p. for additional references.
 - 61 Bazzaz et al., 1996; Weiner J (1996). Problems in predicting the ecological effects of elevated CO₂. In *Carbon Dioxide, Populations, and Communities* (C. Koerner and FA Bazzaz, eds.), Academic Press, New York. Kozlowski et al., 1991.
 - 62 Aber et al., 1995; Melillo et al., 1993; Kirschbaum et al., 1995.
 - 63 For a review of how disturbances could increase with climate change in the Pacific Northwest, see Franklin JF, Swanson FJ, Harmon ME, Perry DA, Spies TA, Dale VH, McKee A, Ferrell, WK, Means JE, Gregory SV, Lattin JD, Schowalter TD, and Larsen D (1992). Effects of Global Climatic Change on Forests in Northwestern North America. In *Global Warming and Biological Diversity*, (RL Peters and TE Lovejoy, eds.) Yale University Press, New Haven, p. 244-257. Many of these same ideas can be applied to the White Mountains, see discussion starting on p.16.
 - 64 Davis, 1985.
 - 65 The application of individual-based, gap-phase succession models, which descend from the JABOWA model, to climate change analysis is reviewed in Review and analysis of JABOWA and related forest models and their use in climate change studies. National Council of the Paper Industry for Air and Stream Improvement, Technical Bulletin No. 717, June 1996.
 - 66 For reviews and further information on the relationships between winter thaws, summer droughts and forest decline in general, see Auclair, AND, Eglinton PD and Minnemeyer SL (1997). Principal forest dieback episodes in northern hardwoods: Development of numeric indices of areal extent and severity. *Water, Air, and Soil Pollution* 93: 175-198 and Auclair AND, Lill JT, and C Revenga (1996). The role of climate variability and global warming in the dieback of northern hardwoods, *Water Air, and Soil Pollution* 91: 163-186. For a description of dieback and decline disease in North American forests in general, see Manion PD and Lachance D (eds.) "Forest Decline Concepts" (1992). American Phytopathological Society Press, St. Paul, MN

- and Little CE "The Dying of Trees: The Pandemic in America's Forests", 1995 Penguin Books, New York.
- 67 Auclair et al., 1997; Auclair et al., 1996.
 - 68 Ibid.
 - 69 Auclair, A (1987). The Climate Change Theory of Forest Decline. Presented at the IUFRO Conference on Woody Plant Growth in a Changing Physical and Chemical Environment, Vancouver, Canada.
 - 70 Ibid.
 - 71 Auclair et al., 1997; Auclair et al., 1996.
 - 72 Dr. Allan Auclair, Science and Policy Associates, Inc., Washington, DC., unpublished data.
 - 73 Nicholls N, Gruza GV, Jouzel J, Karl TR, Ogallal LA, and Parker DE (1995). Observed Climate Variability and Change. In *Climate Change 1995: The Science of Climate Change*. (Eds. JT Houghton, LG Meira Filho, BA Calander, N Harris, A Kattenberg and K Maskell) Cambridge University Press, Cambridge. p.137-192.
 - 74 Ecosystems in the Northeast exposed to a variety of air pollutants that affect basic soil characteristics like pH and nutrient levels, lead to increased levels of toxic metals in the soil (e.g., aluminum) as well as directly damaging plant structures like leaves and roots. Many studies have been done on how each individual pollutant affects the biotic resource. However, the interactive effect of these pollutants in combination with climate change is only beginning to be studied. The accumulation of stresses that the combination of air pollution and climate change represents could lead to severe declines in forest ecosystems. For more information, see Bormann FH (1985). Air pollution and forests: An ecosystem perspective, *Bioscience* 35:434-441 and Aber JD, Driscoll C, Federer CA, Lathrop R, Lovett G, Melillo JM, Steudler P and Vogelmann J (1993). A strategy for the regional analysis of the effects of physical and chemical change on biogeochemical cycles in northeastern (U.S.) forests, *Ecological Modelling* 67:37-47. Researchers at the Institute for the Study of Earth, Oceans, and Space at the University of New Hampshire including Dr. John Aber, Dr. Scott Ollinger and others are currently refining the ecosystem model PnET described above (see page 12) to include the multiple interactions that may occur between atmospheric deposition, air pollution, ozone and climate change in the northeastern United States.
 - 75 Houston, DR (1981) Stress-triggered tree diseases: The diebacks and declines. NF-INF-41-81. USDA, Forest Service, Broomall, Penn. USA.
 - 76 Likens et al., 1996.
 - 77 Sugar maple decline is an excellent example of the interaction between pollutants, soil nutrient levels, climate and insects and disease. For examples, see Adams CM and Hutchinson TC, (1992). Fine root growth and chemical composition in declining Central Ontario sugar maple stands. *Can J For Res* 22: 1489-1503; Bernier B, D Pare', and M Brazeau (1989). Natural stresses, nutrient imbalances and forest decline in Southeastern Quebec, *Water, Air and Soil Pollution* 48: 239-250, 1989 and Auclair et al., 1997; Auclair et al., 1996; as well as the discussion of sugar maple decline in this report (page 14).
 - 78 These comments on disturbance refer to forests in general. More information on disturbance and forests can be found in Waring RH and Schlesinger WH (1985). *Forest Ecosystems: Concepts and Management* Academic Press, Orlando, FL, 340p.
 - 79 Hamburg, SP (1984). Organic matter and nitrogen accumulation during 70 years of old-field succession in central New Hampshire. Ph.D. Dissertation, Yale University, New Haven, CT, 250pp.
 - 80 New England's landscape is highly dissected and fragmented due to repeated cycles of clearing for agricultural and forestry uses. However, since much of the area has regrown forests, this fragmentation is not always readily apparent. It has been hypothesized that fragmentation will limit the ability of species to respond to climate change by migration (for example, see Huntley B (1991). How plants respond to climate change: Migration rate, individualism and the consequences for plant communities. *Annals of Botany* 67: 15-22). The full significance of historical fragmentation of the landscape in places like New England as it might impact migration of species due to climate change needs to be worked out in more detail.
 - 81 Kircher, JC (1988). *A Field Guide to Eastern Forests*. Houghton Mifflin Company, Boston.
 - 82 Increased fire frequency for this region has been predicted by the MAPSS model (Neilson, 1995) and is discussed in general terms in Kirschbaum et al., 1995, the forests chapter of the IPCC, 1995 report.
 - 83 Storm frequency is predicted to increase in some climate models (IPCC, 1995). However whether this finding can be specifically applied to New England or the White Mountains in particular is not yet known. Climate modeling that would include enough topographic and site specific details to answer this question has not yet been developed for this region. There is also little consensus on whether or not hurricanes will increase in frequency or severity with climate change. Research is actively being pursued to answer these questions.
 - 84 Bormann and Likens, 1979.
 - 85 IPCC, 1995.
 - 86 See Karl et al., (1995), for an analysis of how the frequency of intense downpours has increased in the last century for the northeastern United States.
 - 87 Associated Press, October, 1996.
 - 88 For a general discussion of how pests and pathogen outbreaks could increase with global warming, see Dobson A and Carper R (1992). Global Warming and Potential Changes in Host-parasite and Disease-Vector Relationships. In *Global Warming and Biological Diversity*, (RL Peters and TE Lovejoy, eds.) Yale University Press, New Haven. p. 201-217.
 - 89 McClure MS (1995). Biology of *Adelges tsugae* and its potential for spread in the northeastern United States. *Proceedings of the First Hemlock Woolly Adelgid Review*, (SM Salom, TC Tigner, and RC Reardon, eds.), Charlottesville, Virginia, October 12, 1995, USDA Forest Service, Forest Health Technology Enterprise Team, Morgantown, West Virginia, p. 16-25. Hemlock wooly adelgid, an introduced insect species that preys on hemlock, suffered high mortality (>90%) during the severe winter of 1993-1994 in Connecticut. It is probable that the strain of hemlock wooly adelgid found in eastern North America today derives from a less cold-hardy stock than is found in general in its native Japan. For this reason, this adelgid may eventually develop sufficient cold hardiness to expand its distribution northward despite low winter temperatures. The rate of that spread could be hastened by warmer, less severe winters due to climate change.
 - 90 For a discussion of how drought could lead to pest outbreaks, see Mattson WJ and Haack RA (1987). The role of drought in outbreaks of plant-eating insects. *Bioscience* 37:110-118. For a general discussion of how global warming could affect plant-parasite interactions, see Rubinstein DI (1992). The greenhouse effect and changes in animal behavior: effects on social structure and life-history strategies. In Peters and Lovejoy, 1992.
 - 91 Goss, LE (1995). Fiscal Year 1994 Travel Economics Report, The Institute for New Hampshire Studies, Plymouth State College.
 - 92 Ibid
 - 93 U.S. Department of the Interior, Fish and Wildlife Service and U.S. Department of Commerce, Bureau of the Census (1993), 1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, U.S. Government Printing Office, Washington, DC, 1993.
 - 94 New Hampshire Department of Resources and Economic Development (1993). *The New Hampshire Ski Industry 1992-1993, Its Contribution to the State's Economy*, prepared by The Institute for New Hampshire Studies, Plymouth State College, (1993).
 - 95 U.S. Census Bureau, Census of Housing, "Vacation Homes," (1997).
 - 96 Dr. Laurence Goss, personal communication, Institute for New Hampshire Studies, Plymouth State College
 - 97 For general descriptions of fall coloring and leaf abscission, see Raven PH, Evert RF, and Curtis H (1981). *The Biology of Plants*, 3rd Edition, Worth Publishers, Inc., New York.686p. and Kozlowski et al., 1991.
 - 98 Kozlowski et al., 1991.
 - 99 The drought tolerance characteristics of these trees are described in Burns RM and Honkala BH, Tech. Coord. (1990). *Silvics of North America, Volume 2. Hardwoods Agriculture Handbook* 654. U.S. Department of Agriculture, Forest Service, Washington, D.C. 877p.
 - 100 For a review, see Kozlowski et al., 1991
 - 101 See p. 10 in this report and Kirschbaum et al., 1995.
 - 102 Data on the New Hampshire ski industry is from The New Hampshire Ski Industry, 1992-1993: Its Contribution to the State's Economy. (1993). Prepared for the New Hampshire Department of Resources and Economic Development in cooperation with Ski New Hampshire, Inc. and The U.S. Forest Service, WMNF. Prepared by The Institute for New Hampshire Studies, Plymouth State College and The New Hampshire Ski Industry, 1995-1996: Its Contribution to the State's Economy. 1996. Prepared for Ski NH, Inc. by The Institute for New Hampshire Studies, Plymouth State College.
 - 103 Ibid.
 - 104 Ibid.
 - 105 Predictions are for central North America, see Kattenberg et al., 1995.
 - 106 This is the figure used in the study of climate change and skiing in the Laurentians in Canada described in McBoyle G and Wall G (1987) The impact of CO₂ - induced warming on downhill skiing in the Laurentians" *Cahiers de Géographie du Québec* 31:39-50.
 - 107 U.S. Environmental Protection Agency(1995). *Ecological Impacts*

- from Climate Change: An Economic Analysis of Freshwater Recreational Fishing, EPA-230-R-95-004.
- 108 Rich Brown, General Manager, Snomax Technologies, Personal Communication.
 - 109 McBoyle and Wall, 1987.
 - 110 The main factors influencing fish species distribution in streams in general are stream temperature, gradient, stream order (size of stream), and flow rate. See Moyle PB and JJ Cech Jr, (1996). *Fishes, An Introduction to Ichthyology*, Third Edition, Prentice-Hall, New Jersey.
 - 111 See Sternberg (1996) *Freshwater Gamefish of North America* Cy Decosse Inc. Minnetonka, MN 160pp. for description of trout habitat requirements.
 - 112 Based on national average expenditures.
 - 113 U.S. Department of the Interior, Fish and Wildlife Service and U.S. Department of Commerce, Bureau of the Census (1993). 1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, U.S. Government Printing Office, Washington, DC.
 - 114 EPA, 1995.
 - 115 See Moyle and Cech, 1996 for a general review of the effects of low flow on fish habitat.
 - 116 Low flows and their impact to trout populations in New England are described in U.S. Department of Agriculture, Forest Service, Final Environmental Impact Statement, Loon Mountain Ski Area, South Mountain Expansion Project, FS-6200-28 (7-82), October, 1992.
 - 117 See Moyle and Cech (1996) and W B Willers (1981) *Trout Biology: An Angler's Guide*. University of Wisconsin Press for descriptions of the effects of floods on fish habitat.
 - 118 See Sternberg, 1996 for description of habitat and thermal requirements of brown, brook and rainbow trout.
 - 119 Ibid.
 - 120 Ibid.
 - 121 See Willers, 1981 and Sternberg, 1996 for descriptions of trout requirements for fast moving water.
 - 122 Regier H A and J D Meisner, (1990). Anticipated effects of climate change on freshwater fishes and their habitat, *Fisheries*, 15(6): 10-15.
 - 123 Value is defined as "... the dollar amount individuals are willing to pay over and above their current expenditures to ensure the continued availability of the opportunity to use recreational fishing resources" and were calculated as part of an empirical review of recreational fishing day values. (EPA, 1995; p. 3-16).
 - 124 EPA 1995. This particular result used the GFDL Transient 2050 climate model. The recreational fishing model assumes that the loss in cold-water acreage translates directly into an equal expansion of cool (e.g., Northern Pike, Walleye, Yellow Perch), warm (e.g., Bass Crappie), and rough guild (e.g., carp, catfish, suckers) fishing opportunities. An equal exchange of habitats, however, is unlikely, because of other limiting factors such as stream velocity as described in the text. For the entire set of 6 climate models that were used as inputs to the recreational fishing model in the report, the change in economic value nationally ranged from a gain of \$80 million to a loss of \$320 million. The recreational fishing model includes assumptions about fishing-day values, fish thermal tolerance limits, warm-water fishing behavior, delineation of fish habitats, substitutability of cool- or warm-water habitat for cold-water habitat, and runoff. While these assumptions were considered by the authors to be their most conservative and best estimates, a sensitivity analysis of how varying these assumptions would affect the model output resulted in a wide range of national economic losses (\$1.6 billion) or benefits (\$1.0 billion). Incorporating additional potential runoff changes alone, such as the potential for low stream flows during the summer as a result of lowered precipitation and increased evaporation, resulted in an increase in the estimated losses by \$0.4 to \$1.0 billion per year.
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A Climate Change Partnership for America

September 5, 1997

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II. The Proposal and Its Unveiling: Strategic and Policy Benefits

At the October 6 event, the President and a set of CEOs could, together, announce a new ***Climate Change Partnership for America*** that recognizes and rewards the commitments of companies to undertake greenhouse gas emissions reductions in advance of legally binding targets. The "real tons on the table now" focus of this announcement, whether framed in terms of a binding commitment to reduce tons of CO₂-equivalent, to obtain offsets for emissions above a specified level, to spend a specified amount of money on procuring emissions reductions, or some blend of these, would capture the attention of the international community, demonstrate the seriousness of the President's commitment to environmental success on the climate issue, and lock in a core of constituent companies in favor of a Kyoto Protocol that contains the flexibility tools the Administration has proposed.

The "quid pro quo" for this set of commitments by industry would be a commitment by the President that any company participating in the Partnership would have the opportunity to earn early reduction credits that could be transacted in an emissions trading market or used to comply with future domestic GHG emissions limitation requirements that might be imposed after the mandatory compliance period of the Kyoto Protocol began. The partnership would provide a forum for the President to formally recognize that many of the industries that will be called upon to reduce greenhouse gas emissions are capital stock-intensive and would benefit from a cushion against economic bumps in the emissions reduction road. Similarly, for fossil-fuel-intensive firms, the availability of a "bank" of early reduction credits already available to them *at the beginning* of the first compliance period would enhance their ability to continue their economic activity while complying with any GHG emissions obligations.

That these credits would be earned by the companies' achievement of actual emissions reductions prior to the first compliance period is essential to ensuring the environmental integrity of the initiative and to the subsequent compliance regime. At the same time, the emissions reductions achieved during the pre-compliance period to earn such credits would lower the "business as usual" GHG emissions trajectories, at least of the participating firms. It is the lowering of these emission trajectories prior to the first budget period that would be instrumental to avoiding the significant economic disruption that many now fear emissions limits could later entail.

In addition, these emissions reductions would yield a direct environmental benefit. *Announcement of such an initiative would put the President and the United States on the environmental and economic high ground on the climate change issue.*

IV. Using a Private GHG Emissions Pool: Assuring Performance; Guarantees and Remedies

A. The Contours of the Corporate Commitments. The Climate Change Partnership for America initiative envisions that a group of companies would commit, during the period from 1998 up until the start of a first greenhouse gas emissions budget period (the "early banking" period), to:

- ◆ Limit their cumulative emissions over the early banking period to a specified emissions budget level, or spend a specified amount of money (e.g. \$10 million per company) on reducing greenhouse gas emissions during that period, or limit their emissions to a specified emissions budget level and obtain offsets for any emissions above that level during the early banking period; and
- ◆ Join an emissions trading "pool" in which each pool participant reports its emissions performance to the pool during the early banking period, and the pool reports the pool's emissions performance to the federal government.
 - ◇ The emissions trading pool would be a voluntary agreement legally enforceable among members, with pool members rewarded in relation to pool emissions performance.
 - ◇ Pool participation would make members eligible to meet their annual emissions milestones through their own reductions, investing in reduction projects, trading within the pool, purchasing options, banking, and (if certified) trading outside the pool.
 - ◇ The pool as an entity would provide services to members, including verification, accounting, and liquidity; vetting off-pool reductions and logging off-pool sales; and providing an independent channel to government for reporting purposes.
- ◆ Provide, directly or through the pool, a guarantee, insurance mechanism or backstop for the emissions commitments of the members.

Because the pool mechanism's legal enforceability would provide both environmental and financial credibility, pool membership would provide a new revenue stream to members through the sale of reductions and options on reductions. The pool would also assist members in meeting their insurance/guarantee/backstop obligations. And, pool membership would afford member companies "green" product and service differentiation.

V. Meshing the Early Banking Partnership with Domestic Implementation of Legally Binding Emissions Budget Obligations.

Because the Climate Change Partnership for America initiative contemplates that one or more pools would commence operation well before either domestic or international legal constraints on GHG emissions took effect, questions will arise (as they have with Climate Challenge) as to the relationship between pool operations and eventual domestic regulation of GHG. Typical questions might include:

- * If allowances or permits are allocated on the basis of historic emissions, will pool participants' baselines be set so as not to penalize them for early reductions?
- * Can pool compliance obligation be substituted for individual company compliance obligations under whatever domestic regulatory system eventually is established?

These and similar questions would need to be explored by pool candidates and the Administration as negotiations on a partnership move toward a more fully detailed conclusion. The fact that these arise as questions that both sides of the partnership would need to grapple with, however, illustrates how the Climate Change Partnership for America approach of banking and crediting for early reductions transforms the relationship between industry and government into one of negotiation toward a mutual goal.

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