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HEARINGS

before the

SUBCOMMITTEE ON ENVIRONMENTAL PROTECTION
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
UNITED STATES SENATE

HEARING ON RECENT DEVELOPMENTS IN INTERNATIONAL NEGOTIATIONS ON GLOBAL CLIMATE CHANGE AND STRATOSPHERIC OZONE DEPLETION

TUESDAY, JULY 30, 1991



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1 #09STATEMENT OF MR. ROBERT REINSTEIN, DEPUTY ASSISTANT
2 SECRETARY OF STATE FOR ENVIRONMENT, HEALTH AND NATURAL
3 RESOURCES, DEPARTMENT OF STATE

4 Mr. Reinstein: Thank you, Mr. Chairman. I appreciate
5 the opportunity to come up here and brief you on the most
6 recent negotiating session. I feel a little lonely here;
7 there were four of them and only two of us, but I guess we'll
8 manage.

9 The last time I came up here to brief this committee was
10 after the first negotiating session here in Chantilly, outside
11 of Washington. We were frankly rather disappointed at the
12 progress made in Chantilly.

13 I am pleased to report that at the recent session in
14 Geneva in June, we made a good deal more progress in moving
15 forward. There were more countries: 127 countries in Geneva,
16 94 developing countries, and a larger number of experts from
17 capitals rather than diplomats from New York and Washington.

18 It was clear that the developing countries are engaging in
19 the process in a much more active and substantive way. In
20 fact, many brought suggestions and a few brought specific te^Xat
21 proposals and so forth, so it was clear that the large number
22 of countries who came to Geneva came to engage substantively
23 in the negotiating process.

24 We did resolve the remaining procedural issue, which was
25 the election of chairs of the two working groups that had been

1 established in February. We settled on co-chairs for each of
2 the two groups and were able to begin substantive work early
3 in the Geneva session in the working groups.

4 During the week-plus that we were able to work, we
5 established an atmosphere of cooperation and forward momentum
6 among the countries there. In Working Group I, which deals
7 with commitments, we had a rather extended discussion of
8 principles which are believed by some countries to be what
9 should guide the negotiations.

10 We had some difficulty with that approach. We felt that
11 it would possibly lead us into endless debate about abstract
12 principles and felt that we should get into more specific
13 discussion of appropriate commitments, actions, to respond to
14 possible global climate change rather than a debate over
15 general principles which could get us into philosophical
16 issues and waste a lot of time.

17 However, to the degree that countries said that they
18 would want to take up principles, we did submit some
19 principles for consideration. They are included in my written
20 testimony.

21 The second working group, dealing with mechanisms, made
22 considerable progress. They had fewer texts to work with,
23 fewer differences among those texts, and were able to produce,
24 at least in the area of scientific cooperation, some bracketed
25 text. We will be working in the next session, which ~~we~~ will



1 be in Nairobi, toward further development of bracketed text on
2 the institutional aspects of the convention. So we were quite
3 pleased with the progress in Working Group II.

4 A number of interesting proposals were put on the table
5 by several countries. Perhaps the most interesting one, which
6 was proposed by Japan and supported by the U.K. and France,
7 was something called Pledge and Review. Pledge and Review
8 encourages countries to put forward their own national action
9 plans for responding to climate change. These action plans
10 would then be reviewed by the other parties to the convention.

11 The concept has not really been well developed yet, but I
12 anticipate a good deal more discussion about it in the
13 September session in Nairobi and in the future negotiating
14 sessions. The next one following is in Geneva in December.

15 In some informal meetings, the U.S. put forward what is
16 called a non-paper, an unofficial paper on technology
17 cooperation which would focus on country studies and a
18 technology cooperation resources inventory. In doing so, the
19 U.S. advocated a partnership among sovereign countries to
20 facilitate this cooperation, recognizing that technology
21 transfer to developing countries and to countries with
22 economies in transition on a priority basis must be a central
23 aspect of the cooperative effort. Financial resources to
24 support this effort should, in our view, make maximum use of
25 existing bilateral and multilateral institutions and should be

X 1 integrated in such a way that support for ~~the~~ general
2 development purposes is in no way diminished.

3 The plenary also addressed the role of the IPCC. The
4 IPCC will be taking up some of the requests from the INC in
5 its future meetings. There is a meeting of Working Group III
6 on response strategies next week in Geneva. I will be there
7 to chair that.

8 Since returning to Washington, we have briefed
9 environmental groups and industry groups and we are very
10 pleased to have the opportunity to brief you here today. I
11 would be happy to try to answer any questions. I see that I
12 did not exceed my time.

13 [The prepared statement of Mr. Reinstein follows:]
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1 Senator Baucus: Thank you, Mr. Mott.

2 Mr. Reinstein, what about it? Mr. Mott says that the
3 United States is lagging behind; we're laggards. While other
4 countries are doing the right thing, the United States isn't.
5 We are kicking and screaming at the table.

6 Mr. Reinstein: Mr. Chairman, I'm afraid I cannot agree
7 with all those statements. We, in fact, have participated
8 actively in the negotiations from the beginning as we
9 participated actively in the IPCC from 1988.

10 In fact, we have worked actively and constructively with
11 a large number of other delegations, including European
12 delegations, to try to find ways to move the process forward.
13 Frankly, our position on targets and timetables is not the
14 only issue that needs to be resolved through negotiation. And
15 that need not block a meaningful agreement.

16 We have favored a bottom-up approach of commitments to
17 specific actions.

18 Senator Baucus: What kind of approach?

19 Mr. Reinstein: A bottom-up as opposed to a top-down.
20 Targets and timetables are essentially a top-down approach.
21 You fix the result and then you go and try to find out how to
22 achieve it. We have favored a bottom-up approach.

23 Both top-down and bottom-up can produce meaningful
24 results. I think the important thing here is that we need to
25 find a way that will engage in commitments from as many

1 countries as possible, because over the long term, it is quite
2 clear that it is not the OECD countries but the developing
3 countries' projected emissions that will grow the most rapidly
4 and will essentially offset all of the efforts by all the OECD
5 countries, including the United States, if we do not involve
6 them early in the process.

7 We are engaged in trying to find a solution that will
8 commit the largest number of countries to meaningful actions
9 to reduce greenhouse gas emissions.

10 Senator Baucus: It is the conclusion of the IPCC that
11 the global warming phenomenon is real and also -- well, first,
12 the greenhouse gas phenomenon is real -- that is not disputed.
13 Also, it is the conclusion of the IPCC that global warming is
14 occurring as a consequence of the greenhouse phenomenon.

15 Mr. Reinstein: That was not the conclusion exactly of
16 Working Group I of the IPCC. First, there is no question
17 about the science of the greenhouse effect. There is also no
18 question about the buildup of greenhouse gas concentrations in
19 the atmosphere.

X 20 There is measured ^{global}~~greenhouse~~ warming. It differs from
21 one location to another on the earth, but on average, there is
22 a measured global warming. What was not the conclusion of the
23 IPCC scientists was that there was a clear causal link between
24 human greenhouse gas emissions and the observed warming over
25 the last 100 years.

1 The IPCC scientists said that, while on the one hand, the
2 magnitude of the observed warming is roughly consistent with
3 some of the model projections, it is also consistent with
4 historical fluctuations prior to the industrial age caused by
5 natural causes. The IPCC scientists said that it was not
6 possible at this time to determine whether human causes or
7 natural causes were clearly the cause of the observed warming
8 over the last 100 years.

9 I think we can provide the text of the relevant part of
10 the policy-makers' summary of the IPCC report to clarify that
11 for you.

12 Senator Baucus: It is true that other countries do want
13 specific deadlines, certain dates, and certain limitations of
14 greenhouse gas emissions.

15 Mr. Reinstein: Yes, they do. Some other countries do,
16 yes; some don't.

17 Senator Baucus: Specific dates and amounts are certainly
18 included in the CFC Montreal Protocol. That seems to have
19 some effect. Don't you need dates to accomplish something? I
20 am not getting into the question of what developing countries
21 have to do. I agree that's a major problem, but why not data
22 and dates for everyone?

23 Mr. Reinstein: The effect of a particular global date
24 affects different countries differently. The economic
25 consequences of those proposed dates --

1 Senator Baucus: You can have different dates for
2 different data for different countries.

3 Mr. Reinstein: Mr. Chairman, I think when you look at
4 this problem, you see that it is not only an environmental
5 problem. It is also a major economic issue.

6 Senator Baucus: As with CFCs.

7 Mr. Reinstein: The economic consequences -- well, as
8 with CFCs, yes. I was involved very much in the CFC work in
9 1987 and since then.

10 However, there are some differences here, particularly in
11 the energy sector. The situation in the United States with
12 respect to energy policy is somewhat different from the
13 situation in Europe. We are a very large economy and our
14 population density is quite different here than in Western
15 Europe. The public transportation options in Montana, I think
16 you will agree, are rather different from The Netherlands.
17 These things affect our ability to respond in the same way as
18 some of the European countries.

19 Senator Baucus: Does the Administration believe, Mr.
20 Reinstein, that global warming can be addressed by United
21 States actions which only include tree planting, CFC phase-
22 outs, Clean Air Act amendments and several pilot energy
23 efficiency demonstration programs, without addressing CO2?

24 Mr. Reinstein: Mr. Chairman, this question about whether
25 the United States is proposing to do anything about CO2 -- and

1 I'll put aside the Clean Air Act amendments which are already
2 on the books, and those commitments that have already been
3 made and will affect CO2 emissions -- but in the National
4 Energy Strategy, there are a number of proposals that would
5 result in limiting CO2 emissions.

6 I have here a five-page summary of comparison between
7 proposals in the National Academy of Sciences study for
8 actions in the energy sector and National Energy Strategy
9 proposals related to the NAS proposals. In fact, there are a
10 number of things that have been proposed by the Administration
11 that will result in CO2 emissions reductions. In fact, we are
12 out there proposing to do things.

13 Senator Baucus: My time is up. I'll get back a little
14 later.

15 Senator Simpson has walked in and wondered if he could
16 give a statement.

17 Senator Simpson: Mr. Chairman and Senator Lieberman, I
18 promise to be just three minutes or four. You've heard that
19 stuff before, haven't you? Well, watch.

20 Senator Lieberman: Go for five.

21 Senator Simpson: No, I'm not going to take five. You
22 are all very generous, but I'm not going to do it.

23 Obviously, this is a continuing and tough issue. There
24 is always speculation. The new one is that this summer's hot
25 weather, which has been absolutely extraordinary in the last

1 few days -- it's like Wyoming out here the last few days --
2 but when it was hot, why this was all due to this singular
3 cause.

4 There is no proof to support that hypothesis.
5 Climatologists agree that reading too much significance into
6 any particular year's temperature is just absolutely silly.

7 I know where I'm headed with this one. I've had my head
8 mashed on this, but it is fun to try to portray the
9 Administration as a bunch of stumbling boobs who don't care
10 about global warming or the environment or anything else --
11 very simplistic hurrah in my mind.

12 It is difficult to prove a trend in climate change using
13 temperature records. I've been interested in watching the
14 "Washington Post" reporting in these last months. If there
15 is a warming trend, it has not shown up in records of the
16 average annual temperature in the U.S. since 1895. In fact,
17 the one study conducted by the Agriculture Department that
18 involved 1,000 official weather stations showed that the
19 Nation had cooled by one-third of one degree Fahrenheit since
20 1920.

21 The scientific proof for global climate change is just
22 not available, but the speculation is extraordinary and
23 prolific. It is very fashionable now for environmental groups
24 and some in the media to oversimplify in extraordinary ways or
25 to exaggerate anecdotal evidence concerning possible climate

1 change.

2 It is obviously a vastly complex system, the earth's
3 climate. It is not fully understood. Those who suggest we
4 take action before the evidence is in, I think, are
5 shortsighted or have their own agenda, open or hidden.

6 Of course I believe we should foster accelerated research
7 on this issue and then take action as it is warranted. But we
8 should not just proceed willy-nilly with requirements to
9 control carbon dioxide emissions after we just passed -- and
10 it wouldn't have been done without the gentleman who chairs
11 this subcommittee -- a comprehensive Clean Air Bill that is
12 going to cost industry and consumers in the country a lot of
13 money. At least that's what they said. Some of that was, I
14 think, hysterically portrayed, but it's going to cost bucks.

15 A recent study concluded by scientists at the University
16 of Illinois at Urbana, indicates that any measures to deal
17 with any possible global warming could be postponed for up to
18 a decade without having an effect on the things that we are
19 speaking of. We do have time to study the problem sensibly,
20 rationally, without emotion, fear, hype, hurrah, and all the
21 stuff that drives everything around here, and then get serious
22 and take action.

23 I find it extraordinarily ironic that countries such as
24 Germany demand that the U.S. make firm commitments to reduce
25 emissions of carbon dioxide and adopt specific targets and

1 timetables for doing so. Germany may be a country with a
2 different agenda. It is, I think, easy for the Germans to
3 comply with specific timetables since they are going to be
4 able to retire many of the old polluting facilities in East
5 Germany with little or no cost to their government or
6 consumers.

7 I will be visiting with my lovely friend, Urgas Rufus,
8 the Ambassador on that issue, and I'm sure that, in his very
9 forthcoming and professional way, we can discuss that. So, I
10 do say, Mr. Chairman, that I think the Administration is
11 taking the correct approach -- and has been harshly criticized
12 for it, as if they were doing nothing or enjoyed polluting the
13 earth. That is absurd. Some of the harsh criticism I have
14 heard leveled against the Administration, I just think is
15 unwarranted.

16 If we're going to talk about global warming, let's talk
17 about the role of the Third World. We have discussed that
18 briefly here this morning. Tropical deforestation, slash and
19 burn farming techniques -- go look at Thailand and see what's
20 happening there. Those are just as significant as activities
21 in the industrialized world.

22 Again, if we are going to talk about the industrialized
23 world taking action, we should talk about the Soviet Union,
24 Eastern Europe, and China making the same commitments as the
25 Western countries. It is very interesting to me that some of

1 the people who would have cut China off through the MFN are
2 the very people who are most concerned about global warming.
3 How do you do it? How do you get these things done when you
4 just cut the cords with one-fifth of the world's population?
5 How absurd. How dizzy.

6 So, that's our problem. I don't think it makes sense to
7 commit the U.S. to a strategy that is not necessary but makes
8 good PR, or at least something that looks like we're dealing
9 with a bunch of neanderthals, or to penalize U.S.
10 competitiveness when we already have a significant trade
11 deficit -- and, indeed, economics does enter the fray.

12 I just hope that during this, what was originally quite a
13 hot summer but has now turned quite cool for some strange
14 perilous reason that I am unable to determine but I'll think
15 about, when it all comes to global climate change, cooler
16 heads will prevail rather than just the same old heat.

17 Thank you.

18 Senator Baucus: Thank you very much, Senator, for those
19 thoughtful comments.

20 Senator Lieberman?

21 Senator Lieberman: Thank you, Mr. Chairman.

22 Mr. Reinstein, let me begin with a couple of baseline
23 questions. The first really goes to the question of who is
24 responsible for the formation of global climate change policy
25 in the Administration? I gather that the Secretary of State

1 has recused himself from these questions because of his oil
2 and gas holdings. Of course, I understand that.

3 I have read of an interagency task force headed by the
4 Justice Department. Needless to say, there are always
5 suggestions that everybody's favorite Darth Vader, Governor
6 Sununu, is lurking actively in these policy judgments. Who is
7 in charge here?

8 Mr. Reinstein: The interagency process at my level is
9 chaired by the State Department under the auspices of the
10 Policy Coordinating Committee on Oceans, Environment, and
11 Science of the National Security Council.

12 Senator Lieberman: Who is represented on that?

13 Mr. Reinstein: That interagency group --

14 Senator Lieberman: Is it a large group?

15 Mr. Reinstein: It's 50 or 60 representing close to 20
16 agencies, I would say.

17 Ms. Jacobson: Is that the central policy-making body?

18 Mr. Reinstein: That is the central working-level group.
19 That group reports to a group chaired by the President's
20 Science Advisor, Dr. Bromley. Again, that group includes a
21 large number of agencies at the Assistant Secretary and Deputy
22 Secretary level.

23 That group in turn reports to the Domestic Policy Council
24 of the Cabinet, so there is a direct interagency line to the
25 Cabinet and, through the Cabinet, to the President.

1 Senator Lieberman: Okay. Of course, as always, the
2 President is ultimately the decision-maker and responsible.

3 Mr. Reinstein: That's correct.

4 Senator Lieberman: What is Governor Sununu's role?

5 Mr. Reinstein: The Governor is the President's Chief of
6 Staff and he oversees the day to day operations of the White
7 House. That includes Cabinet affairs and the work of the DPC.

8 Senator Lieberman: Has he been actively involved in
9 these global change issues?

10 Mr. Reinstein: He has been following the progress of the
11 negotiations, yes.

12 Senator Lieberman: I take it that our policy is
13 consistent with his attitude on this issue?

14 Mr. Reinstein: I haven't heard that it is not, and I
15 think I probably would, so I take it that it is.

16 Senator Lieberman: Let me clearly understand, if I can,
17 what you said before to try to summarize the current state of
18 Administration thinking on this and where there is a problem,
19 now that we understand who is in charge.

20 I believe I understood you to say that there has been
21 global warming, but it is not clear yet whether that is the
22 result of natural ^{or} ~~of~~ manmade phenomena. Is that correct?

23 Mr. Reinstein: That is my understanding of what the
24 scientists have concluded in the IPCC, yes.

25 Senator Lieberman: Let me just cite from our own Office

1 of Technology. It says the atmospheric concentration of CO2
2 has increased 25 percent during the last century, currently
3 increasing about .5 percent every year. Can that possibly all
4 be from natural phenomena? Why would natural phenomena have
5 changed so dramatically in the last century?

6 Mr. Reinstein: The buildup of CO2 concentrations in the
7 atmosphere is clearly attributable to the consumption of
8 fossil fuels and to such other things as deforestation. I
9 think that some of the confusion arises because the overall
10 greenhouse effect, that is to say the natural greenhouse
11 effect, is a much larger phenomenon than the human
12 contribution to CO2 even. In fact, the largest single
13 greenhouse gas is water vapor.

14 The problem is that the natural phenomena, which are very
15 large and very powerful, tend to be orders of magnitude larger
16 than some of the human factors. The natural phenomena are
17 very complex.

18 Senator Lieberman: But is there any reason to believe
19 that the natural phenomena would have changed so dramatically
20 in the last century?

21 Mr. Reinstein: Are you speaking of the CO2
22 concentrations? Not of the climate itself, but of the
23 composition of the atmosphere?

24 Senator Lieberman: Yes.

25 Mr. Reinstein: The buildup in CO2 in the atmosphere is

1 attributable to human activities.

2 Senator Lieberman: Right.

3 Mr. Reinstein: I think scientists agree on that.

4 Senator Lieberman: And in that sense, the Administration
5 agrees on that?

6 Mr. Reinstein: Yes, we do.

7 Senator Lieberman: So then -- I'm coming to the end of
8 my time -- but why not more aggressively pursue, if I can put
9 it this way, an anti-CO2 policy or a CO2 reduction policy?

10 Mr. Reinstein: Senator, I think we are engaged in a
11 policy that will limit over the longer term emissions of CO2,
12 so I would say that we are engaged in such a policy.

13 Senator Lieberman: So we agree -- I am just trying to
14 clarify so that I understand -- the Administration accepts
15 that fossil fuel consumption is a critical part of the problem
16 and that we ought to reduce these CO2 emissions, but has in
17 that sense a longer term approach to doing than what others
18 have called for. Is that correct?

19 Mr. Reinstein: I would say it is certainly a longer
20 term, and indeed, it is essential that you look not only at
21 what we have today but at the technology development aspect
22 which is going to be critical to the long-term response. We
23 are also doing so in an integrated way. That is to say that
24 this problem cannot be divorced from other environmental
25 problems, from questions like energy security, industrial

1 competitiveness, trade, and so forth. What we are trying to
2 do is look at in the broader context as it affects the entire
3 economy over the longer term.

4 Senator Lieberman: Thank you. My time is up on this
5 round.

6 Senator Baucus: Thank you, Senator.

7 Obviously, there is a dynamic here between environmental
8 damage and economics. No one disputes that. But let's put
9 the economics aside for just a second.

10 What models and/or empirical data did you at the State
11 Department use in determining the U.S. position, apart from
12 international, the IPCC? The United States of America --
13 we've got the EPA and lots of different agencies here, as well
14 as some private contractors.

15 Mr. Reinstein: Senator, the State Department does not
16 engage in atmospheric modeling. We are an agency conducting
17 U.S. foreign policy. We draw on a number of technical
18 agencies: EPA, NASA, NOAA, DOE, and others, for input into the
19 interagency process of formulating an understanding of the
20 science and an appropriate policy response.

21 Senator Baucus: You are the coordinator/negotiator with
22 these other countries.

23 Mr. Reinstein: Yes.

24 Senator Baucus: Therefore, you get your marching orders
25 from somebody somewhere. Someone tells the State Department:

1 this is what the U.S. position is. Who, and what body of
2 information makes that determination?

3 Mr. Reinstein: The understanding of the issue, which is
4 shared among all of the agencies, is drawn from technical
5 expertise throughout the Executive Branch of the Government.
6 We don't get marching orders from technical agencies. We
7 don't get policy guidance from computers.

8 What we do get is an understanding of the factors that
9 are involved in the scientific situation as well as the
10 economic implications of policy proposals.

11 Senator Baucus: Let me ask this question. Is there some
12 person or some group of people or some agency that basically
13 says to Mr. Reinstein: this is what our position should be at
14 these various meetings?

15 Mr. Reinstein: The policy is developed --

16 Senator Baucus: Or do you, Mr. Reinstein, yourself
17 develop that policy?

18 Mr. Reinstein: There are some proposals relative to the
19 policy that come up from the working level. That is people
20 who are involved in the substance of the issue come up with
21 understandings and proposals, and those move up the policy
22 review chain that I described earlier.

23 There are policy views, also, that come from the top
24 down.

25 Senator Baucus: If I may generalize, where, primarily,

1 does the U.S. negotiating position come from? Who makes the
2 decision, basically? I know it's complicated and this and
3 that, but just basically, who calls you up and says: this is
4 what it is?

5 Mr. Reinstein: I think it evolves rather from a
6 discussion among a number of agencies and a number of
7 individuals at all levels. I don't get single phone calls
8 from single individuals sort of dictating the U.S. negotiating
9 position. It is a position that has evolved through an
10 interagency process. It is a position that is the shared
11 position of all the agencies involved when we come to it.

12 Senator Baucus: What group, primarily? I think you
13 answered this already.

14 Mr. Reinstein: Yes, I did answer it already. The
15 primary group that reviews from a policy point of view the
16 U.S. negotiating position is the group that is chaired by Dr.
17 Bromley and reports to the Domestic Policy Council. It is a
18 sub-Cabinet-level group.

19 Senator Baucus: The next question is: do you know
20 whether they have themselves developed or contracted any
21 modeling which shows the degree to which global warming is a
22 man-caused phenomenon through greenhouse gases?

23 Mr. Reinstein: No. At that level, they don't do that
24 kind of modeling, ~~or~~ independent modeling. They draw on the
25 technical work that is produced by all of the agencies that I

1 mentioned in the U.S. Government.

2 Senator Baucus: Have those agencies done any modeling?

3 Mr. Reinstein: Those agencies have done a lot of
4 modeling.

5 Senator Baucus: And what does that show?

6 Mr. Reinstein: It is generally consistent with the IPCC
7 results. In fact, the United States was probably the single
8 largest contributor to the science portion of the IPCC's first
9 interim report.

10 Senator Baucus: That reconfirms that greenhouse gases
11 are increasing, that they are manmade, and that the planet is
12 getting warmer, which is caused significantly by greenhouse
13 gas buildup?

14 Mr. Reinstein: As I pointed out, there is agreement that
15 there is a buildup of greenhouse gas concentrations in the
16 atmosphere. The United States, more than any other country,
17 through its observations, has contributed to confirming that,
18 through NASA and NOAA research.

19 There is also some agreement of some global warming. As
20 I explained, the causal link between that observed warming and
21 the change in the concentration of CO2 and other human
22 greenhouse gases in the atmosphere was not made by the
23 scientists. It is possible, but it is not yet confirmed.

24 Senator Baucus: Why do other countries apparently take a
25 different view? Other countries do want limits, and that

1 logically implies that those countries do believe that global
2 warming is occurring and that it is significantly caused by
3 manmade increases in greenhouse gases?

4 Mr. Reinstein: Mr. Chairman, I don't think that science
5 is the only reason why certain other countries made such
6 proposals. I think it also has to do with domestic politics
7 in some of those countries. I think it has to do in some
8 cases with the relative comparative advantage that may be
9 gained by some of those countries in the industrial
10 competitiveness and trade areas based on some analysis I've
11 seen.

12 I think there are a number of factors that enter into
13 decisions by individual countries to make such commitments.

14 Senator Baucus: I don't mean to get picky. I really
15 don't. I am just trying to establish a commonality of
16 understanding so that we know where to go next.

17 I have in front of me the IPCC June 1990 statement and it
18 says on page two: based on current model results, we predict,
19 under the IPCC business as usual emissions of greenhouse
20 gases, a rate of increase of global mean temperature during
21 the next century of about .3 percent Centigrade per decade.
22 This is greater than that seen over the past 10,000 years and
23 will result in a likely increase of global mean temperature of
24 about one degree Centigrade over the present value by 2025 and
25 three degrees Centigrade before the end of the next century.

1 The rise will not be steady because of the influence of other
2 factors. So they do predict an increase under the business as
3 usual scenario. That's the conclusion of IPCC.

4 Mr. Reinstein: That is the model output and the
5 scientists agree that, in fact, that is the model projection
6 based upon the business as usual assumptions, which are quite
7 conservative assumptions.

8 Senator Baucus: That is pretty clear. They are saying
9 right there that there is a direct tie between greenhouse
10 emissions and increase in the global mean temperature.

11 Mr. Reinstein: They are saying that in the future, the
12 models indeed predict that there will be a warming due to the
13 human contribution. That's is what they are saying.

14 That is a different question from the question you asked
15 as to whether the observed warming to date has been caused by
16 emissions to date. This is where we're heading in the future
17 versus where we've been in that past. It can be different. I
18 think it certainly is a reason for caution.

19 Senator Baucus: Let me rephrase the question. Do you
20 agree that in the future, if greenhouse gas emissions occur
21 worldwide at the current rate under a business as usual
22 scenario, then the earth is likely to warm to about this
23 degree? Do you agree?

24 Mr. Reinstein: I would say yes. I could agree with
25 that.

1 Senator Baucus: My time is up. Let me go to Senator
2 Lieberman.

3 Senator Lieberman: Do you want to pursue that?

4 Senator Baucus: If that's the case, then why in the
5 world aren't we trying to address this more aggressively?

6 Mr. Reinstein: I think we are trying to address it.

7 Senator Baucus: Why are other countries moving more
8 aggressively than we are?

9 *Mr. Thomas. For a number of reasons.

10 Senator Baucus: What are they?

11 Mr. Reinstein: I think that some of them have to do with
12 their domestic politics and some of them have to do with their
13 relative situations. For some of these countries, as was
14 pointed out, it is easier for them to achieve those results
15 than it is for the United States.

16 Senator Baucus: And you're saying -- why?

17 Mr. Reinstein: Population density is one factor. The
18 relative abundance and cost of coal versus natural gas at some
19 of those places.

20 Germany, for example, has a heavily subsidized,
21 inefficient coal industry. They can save a huge amount of
22 money by eliminating the production of that subsidized coal
23 and replacing it with natural gas. Natural gas is readily
24 available with three sources very near Western Europe: from
25 the North Sea, from the Soviet Union, and from North Africa by

1 pipeline, which is the cheapest way to deliver it. From their
2 point of view, it is economically more favorable than it is --

3 Senator Baucus: I am going to have to give Senator
4 Lieberman a lot more time here.

5 Mr. Mott, do you have a reaction to this?

6 Mr. Mott: I just wanted to interject that one frequently
7 hears that population density, and the State of Montana and
8 the State of Wyoming are somehow behind fossil fuel
9 consumption patterns in this country. The Environmental Law
10 Institute here in Washington did a short study of fossil fuel
11 combustion for automobile travel and they excluded all the
12 States like Montana and Alaska and Wyoming and took basically
13 the Northeast and California, comparably densely populated
14 States to the EC countries.

15 Vehicle miles traveled in those densely populated areas,
16 where we can't use as a scapegoat the wide-open spaces, still
17 ran something like twice those in Europe, pointing the finger
18 to urban settlement patterns, the lack of infrastructure for
19 public transportation, and I think, discrediting the idea that
20 our relatively more extravagant fossil fuel combustion has to
21 do primarily, at least in the transportation sector, with the
22 greater distances of the American West.

23 Senator Baucus: I guess the point is similar to the
24 point I was wondering about. America's per capita energy use
25 is quite high compared with other countries with living

1 standards higher than ours. I mean if another country has a
2 higher living standard than the United States and uses much
3 less energy per capita than the United States, that implies
4 something.

5 Senator Lieberman?

6 Senator Lieberman: Thank you, Mr. Chairman.

7 Mr. Reinstein, is the problem here that we are concerned
8 about the economic effect of a targets and timetables approach
9 to CO2 reduction? Are we concerned about that, or are we
10 concerned about a political reaction if we ask people to do
11 too much to changed their ways in the ways that they will have
12 to in order to achieve some of these CO2 reductions?

13 Mr. Reinstein: Senator, we are concerned about some of
14 the possible economic effects, but I think that if you look at
15 the political question, you can appreciate -- for example, our
X 16 Western European friends frequently point^{out} as the single
17 largest example of U.S. energy policy difference with Western
X 18 European energy policy, the price of gasoline in this country.

19 We had a debate last summer over whether to raise the
20 price of gasoline through, I think originally, what was
21 proposed as a 10 cent increase in the tax.

22 Senator Lieberman: Right.

23 Mr. Reinstein: Well, the Congress, responding to what it
X 24 perceived to be the politics of a gasoline price increase, ~~and~~
25 reduced that 10 cents to a 5 cent increase in the end. I

1 think that some perceptions about the willingness of the
2 American public to pay more for fuel, to perhaps consume less,
3 are shared by Members of the Congress. That would be my
4 conclusion.

5 There is an issue here about lifestyle and about what the
6 American public is willing to do in relation to questions like
7 this. I think we are going to have to have that debate here.

8 Senator Lieberman: Indeed. Don't we, therefore, if we
9 accept the fact that American CO2 emissions are a substantial
10 part of the problem, have to show some leadership on this and
11 also do some education?

12 Mr. Reinstein: I would agree that we should be showing
13 leadership and doing education. I think there is a good deal
14 that we need to do in both those areas.

15 Senator Lieberman: Let me ask you about your bottom-up
16 approach as opposed to the targets and timetables. What does
17 that mean or how does that bottom-up work?

18 Mr. Reinstein: It means commitment to specific actions
19 and quantifying what the results of those actions will be in
20 terms of net greenhouse gas emissions.

21 Senator Lieberman: But don't those specific actions
22 require some governmental setting of targets and timetables?
23 In other words, the bottom-up approach does not just leave it
24 to happen, does it, or leave it to volunteerism?

25 Mr. Reinstein: It is not just voluntary necessarily. I

1 think there are a number of things we do that produce actions,
2 produce results, that reduce in greenhouse gas emissions. A
3 large number of them are done not just for reasons associated
4 with climate change, but for other reasons.

X 5 I think it is very important -- it's essential -- that we
6 look at possible actions in the broad context. That is, to
7 take actions not solely for reasons of avoiding climate
X 8 change, which at this point ^{is} is still debated in terms of how
9 serious it is and how quickly it may occur, but things which
10 will produce benefits for other reasons. I think a large
11 number of countries are coming to agree with such a position;
12 that we need to take all these things in context; that we do
13 them for a large number of reasons: environmental, economic,
14 and security.

15 Senator Lieberman: Well, I think we are going around the
16 same tree here. To some extent, I think you've acknowledged
17 that there needs to be government leadership; that indeed in
18 some ways, there needs to be government targets or whatever
19 you want to call them, but not quite as explicitly or as high
20 as the European and others are, for whatever their reasons.
21 Some of the reasons you've cited are probably valid, so not as
22 high as they have set them.

23 I think that unless we have that kind of government
24 leadership through either targets or incentives, we are not
25 going to get very far.

1 Have you perchance looked at this market incentive
2 approach to CO2 reduction that is part of the bill that
3 Senator Chafee and I and the Congressmen have introduced?

4 Mr. Reinstein: Senator, I have not had a chance to look
5 at that yet. I'm sorry.

6 Senator Lieberman: Therefore, I cannot ask for your
7 reaction. But I would invite you to take a look at it, and I
8 would welcome your responses in writing as to whether you
9 think that might fit into a bottom-up approach to CO3
10 reduction.

11 Thank you, Mr. Chairman.

12 [The material to be supplied follows:]

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1 Senator Baucus: Thank you, Senator.

2 I am just curious about your reaction, Mr. Reinstein, in
3 the degree to which you can respond to these points. There
4 are various agencies -- the National Academy of Sciences asked
5 the Office of Technology Assessment to identify a number of
6 economically efficient and cost-effective actions that will
7 limit CO2 emissions. I will list what they are and would like
8 your reaction to them, to the degree that you can.

9 One is lighting, lights. According to the Office of
10 Technology Assessment, lighting efficiency can reduce CO2
11 emissions by three to five percent and save actually \$16
12 billion. That is according to EPA's Green Lights Program.

13 Mr. Reinstein: Exactly that kind of an issue is also in
14 the National Energy Strategy and I believe that the
15 Administration supports improvements in this area.

16 As I mentioned earlier, I do have a summary of sort of
17 the crosswalk between the National Academy of Sciences'
18 options and proposed actions in the National Energy Strategy.
19 I would like to submit that for the record.

20 Senator Baucus: It would be helpful.

21 [The material to be supplied follows:]

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1 Mr. Reinstein: Also, the EPA Green Lights Program has
2 promoted significant savings. I am not sure if you are aware
3 of that, but we can provide information on that program.

4 Senator Baucus: Right.

5 [The material to be supplied follows:]
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1 Senator Baucus: Second is energy-efficient buildings.
2 OTA believes that if all new buildings are required to be
3 energy efficient, CO2 emissions will be ^cput from roughly four
4 to six percent annually, and we could save as much as \$53
5 billion. I wonder if you are familiar with that?

6 Mr. Reinstein: That is an area that has also been
7 identified by the Administration as having significant
8 potential savings, which we would support. There is a
9 question of how you would go about achieving that at the
10 Federal level, but it is an area that we agree has significant
11 potential.

12 Senator Baucus: Increased vehicle efficiency -- OTA
13 reports that this could lower CO2 emissions by nearly 10
14 percent. The National Academy of Sciences reports the cost to
15 be a net benefit.

16 Mr. Reinstein: There are also, obviously, potential
17 savings in this area, and the Administration agrees with that.
18 There are sections of the National Energy Strategy that
19 address that area.

20 Senator Baucus: Do you support the CAFE standards, the
21 Bryan Bill?

22 Mr. Reinstein: I don't believe that is a current
23 Administration position. The State Department is not involved
24 in the domestic energy policy debate directly.

25 Senator Baucus: Which of those that we have just

1 discussed: lighting, energy-efficient buildings, and increased
2 vehicle efficiency are just suggestions by the Administration
3 and which, in the Administrations' energy program, would be
4 mandatory actions?

5 Mr. Reinstein: Mr. Chairman, I have not been directly
6 involved in the development of the National Energy Strategy
7 and the legislation which would implement it, so I would have
8 to ask to provide some follow-up on that. It is not the State
9 Department's area of responsibility, but I would point out
10 that there are a large number of areas where the
11 Administration sees potential savings, reductions of CO2
12 emissions, and has made proposals to carry them out. The
13 manner in which those proposals would be carried out, I think,
14 is something that is under debate in other committees of this
15 Congress.

16 Senator Baucus: You're right. It is not the State
17 Department's responsibility to develop these, but it is the
18 State Department's responsibility to negotiate the climate
19 change agreement. I would assume, therefore, that that
20 assumes knowledge of the U.S.' actual efforts to reduce CO2
21 emissions. So it very much is an integral part of the
22 development of the U.S. position so that the United States
23 Government can state its position authoritatively at those
24 negotiations.

25 Mr. Reinstein: The question of how this would be carried

1 out -- mandatory or voluntary, using economic incentives and
2 market incentives rather than command and control and so on --
3 is not a State Department function. We do agree with the
4 general Administration position to use market incentives as
5 opposed to command and control.

6 Senator Baucus: I appreciate that. I don't want to drag
7 this out any farther unless Senator Lieberman has more.

8 Senator Lieberman: Just a final question, if you will
9 submit a response in writing. That is: we have talked around
10 the question of the understandable economic impact of some of
11 the CO2 emission reduction programs.

12 If you have any more detailed analysis of that, of the
13 economic impact of some of these CO2 reduction programs, I
14 would be interested in seeing that.

15 Mr. Reinstein: We would be happy to share it with you.

16 [The material to be supplied follows:]
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1 Senator Baucus: Along the same lines, I think that there
2 are probably -- I guess the main point is that the United
3 States Government, with a little bit more aggressive action,
4 could find ways to significantly reduce CO2 emissions in a way
5 that does not cause economic havoc. For example, coal
6 production in this country. There are lots of new
7 technologies that are being developed to burn coal much more
8 efficiently.

9 What we're really getting at is all the fuel efficiency
10 provisions, building efficiency provisions, lighting
11 provisions -- there are a whole host of efforts that can be
12 taken with a little more energy or enthusiasm -- by the
13 Administration, I might add -- so that we could address the
14 problem in a way that is implied and actually expressly stated
15 by the Senator's point. That is in a way that does not cause
16 economic harm to this country. In fact, in many cases,
17 according to National Academy of Sciences and OTA that would
18 provide net economic benefit to this country.

19 I just think that there is a perception of the United
20 States as being a little slow in this area, not working as
21 hard as it should, and we're dragging our feet. So I just
22 urge you, Mr. Reinstein, to take the message back to the State
23 Department, or more particularly, all the way up to the
24 President, that there is at least one subcommittee here that
25 would like to see the Administration be much more aggressive

1 than it has thus far. Thank you.

2 The hearing is adjourned.

3 [Whereupon, at 11:37 a.m., the subcommittee adjourned, to
4 reconvene at the call of the Chair.]

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OZONE & GREENHOUSE : RECENT FINDINGS

A SUMMARY

30 OCT 1991

DAN ALBRITTON (NOAA) & BOB WATSON (NASA)

● BASIS: "SCIENTIFIC ASSESSMENT OF OZONE DEPLETION: 1991"

- PREPARED FOR U.N. MONTREAL PROTOCOL UPDATE.
- WRITTEN BY ~40 SCIENTISTS WORLDWIDE.
- MAIL PEER REVIEWED BY ~50.
- WORKSHOP REVIEW/COMPLETION 14-19 OCT, SWITZERLAND.
~80 SCIENTISTS, 25 COUNTRIES.
- TO BE PRINTED ~ 15 NOV - 1 DEC
- PRESENTED TO THE UNEP ~ SPRING '92
- MEETING OF PROTOCOL SIGNATORIES ~ JUL '92.

● TODAY'S SUMMARY: TWO MAIN TOPICS...

① OZONE LAYER DEPLETION

WHAT IS NEW IN THIS "OLD" STORY?

② OZONE DEPLETION & GREENHOUSE EFFECT

HOW ARE THESE TWO INTERRELATED?

(FOR ① AND ② : THE RELATION TO POLICY)

① STRATOSPHERIC OZONE DEPLETION

● WHAT WE ALREADY KNEW:

- POLAR REGIONS:
- THE ANTARCTIC OZONE HOLE IS MAN-MADE ✓
 - CFCs, HALONS, AND OTHER EMISSIONS
 - THEIR EFFECT IS ENHANCED THERE BECAUSE OF ICE PARTICLES
 - THE HOLE WILL BE THERE A LONG TIME: ~75 YRS.
 - NO "HOLE" IN ARCTIC, BUT LONG, COLD WINTERS COULD YIELD LARGE OZONE LOSSES.

GLOBALLY:

● 1989 UNEP/WMO REPORT:

- "DOBSON" NETWORK - DOWNWARD TRENDS MID-TO-HIGH LATS NH
 - WORSE IN WINTER
 - LARGER THAN PREDICTED WITH GAS-PHASE MODELS

● 1991 SATELLITE STUDY (STOLARSKI - NASA)

- "TOMS" DATA - BOTH HEMISPHERES
 - FASTER LOSS IN 1980s THAN IN 1970s

● WHAT IS NEW? ("1991 UNEP/WMO REPORT")

POLAR REGIONS:

- THE "CAUSE & EFFECT" PICTURE IN ANTARCTICA IS NOW EVEN STRONGER (LAB, FIELD, THEORY)

- THE ODD/EVEN-YEAR FLUCTUATIONS IN THE HOLE'S SEVERITY HAS NOT OCCURRED THE PAST 3 YEARS:

STRONG → ... 1986 1987 1988 1989 1990 1991
WEAK →

(REASON? NOT CLEAR - MAYBE CHEMISTRY HAS SWAMPED THE DYNAMICAL FLUXUATIONS NOW?)

(WHAT'S NEW? CON'T)

GLOBAL OZONE:

- THE DOWNWARD TRENDS IN BOTH HEMISPHERES ARE NOW IN FALL, SPRING, & SUMMER.

• "DOBSON" DATA ANALYSIS: (BISHOP, 1991)

• EXAMPLE: BETWEEN $26^{\circ}\text{N} - 64^{\circ}\text{N}$ -

1979-1991

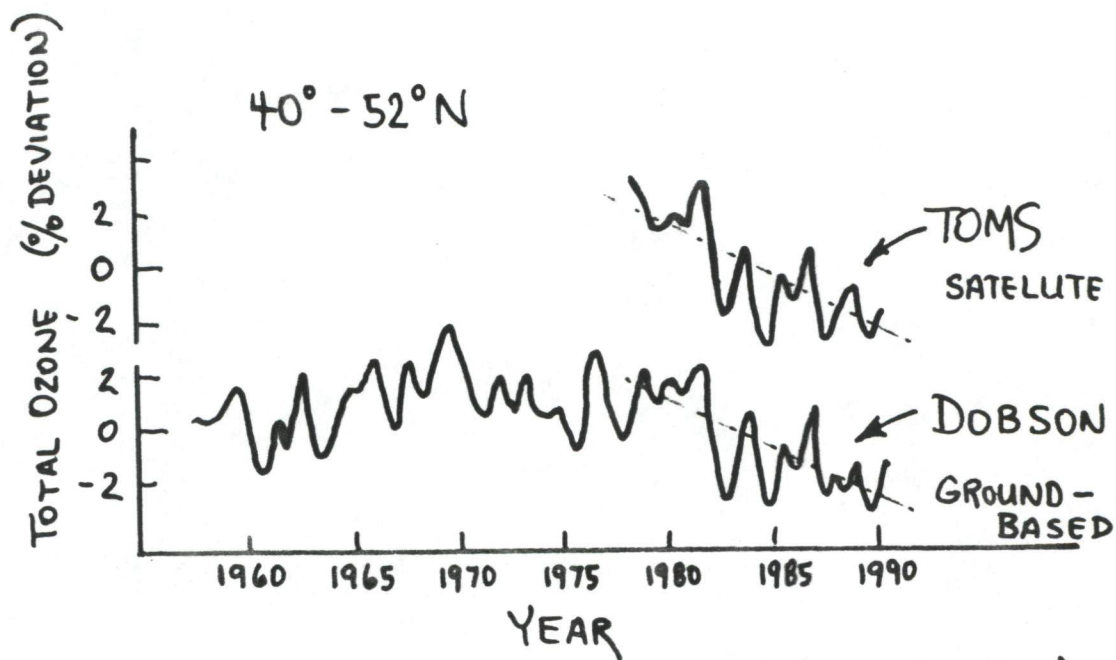
-3.3 ± 1.2

1970-1991

-1.3 ± 0.4

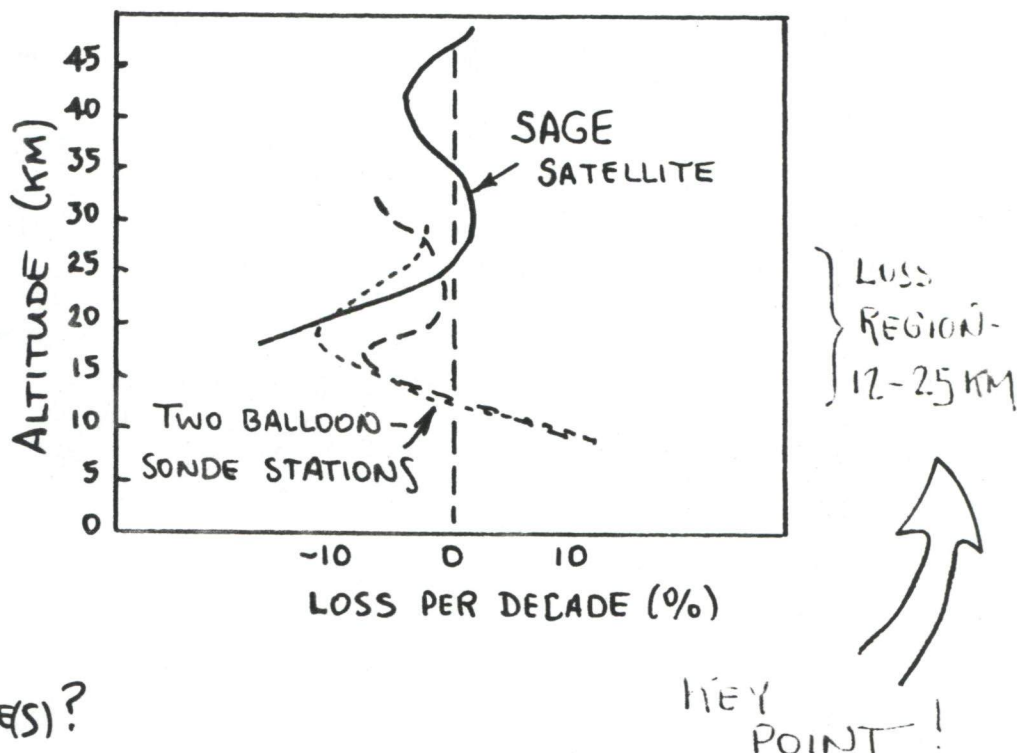
% PER DECADE

- SEEN IN 2 INDEPENDENT DATA SETS.
(CONFIDENCE BUILDING!)



(ANGELL, 1991)

- THE LOSSES ARE CLEARLY IN THE LOWER STRATOSPHERE.



- CAUSE(S)?

- NOT COMPLETELY CLEAR YET
- BUT WEIGHT OF EVIDENCE INDICATES...
 - > ACCELERATED CHLORINE/OZONE CHEMISTRY DUE TO SULFATE AEROSOL LAYER (EVER-PRESENT)
 - ITS AT THIS ALTITUDE
 - LAB DATA SHOW SPEEDING-UP REACTIONS
 - MODELS WITH THIS CHEMISTRY SIMULATE MUCH (BUT NOT ALL) OF THE OBSERVATIONS
 - > NO NON-CHLORINE EXPLANATIONS ARE SUPPORTED BY OBSERVATIONS.

● IMPLICATIONS OF OZONE LOSSES

- WITHOUT MONTREAL PROTOCOL (1987, 1990) CHLORINE WOULD RISE INDEFINITELY. LARGE OZONE LOSSES!
- CURRENT SITUATION:
 - CHLORINE MAY PEAK AT ~ 4.1 PPBV AT ~ 2000 OR LATER. (3.4 PPBV NOW)
 - ADDITIONAL OZONE LOSSES - 1990's?

AT LEAST THOSE OF 1980's - 3-8% MORE
(ASSUMING NO SURPRISES!)

> FOCUS OF POLICY DEBATE:

1. How HIGH SHOULD WE LET IT GO?
2. How LONG SHOULD PEAK LEVEL BE ALLOWED?

SPECIFICS -

- SPEED UP PHASE OUTS: CFCs, HALONS, ...?
- SELECTIVE USE OF SUBSTITUTES?
- METHYL BROMIDE - A "HIGH-PAYOFF"!

NATURAL VIS-A-VIS MAN-MADE SOURCE?

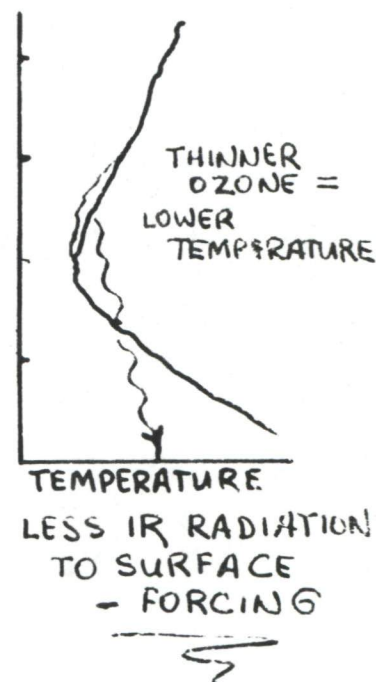
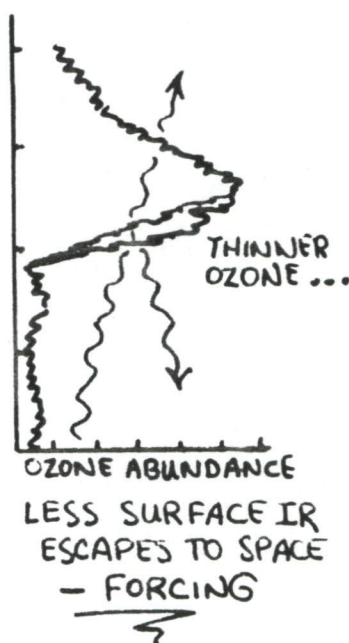
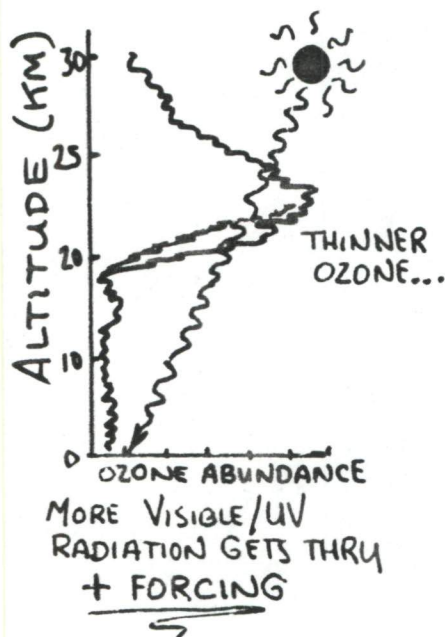
THE WMO/UNEP 1991 REPORT LAYS OUT
OPTION/CHLORINE SCENARIOS

② OZONE LOSS & GREENHOUSE FORCING

(A FIRST LOOK AT THE RADIATIVE EFFECTS OF LOWER-STRATOSPHERIC OZONE LOSSES.)

● MECHANISMS:

THREE COMPONENTS...

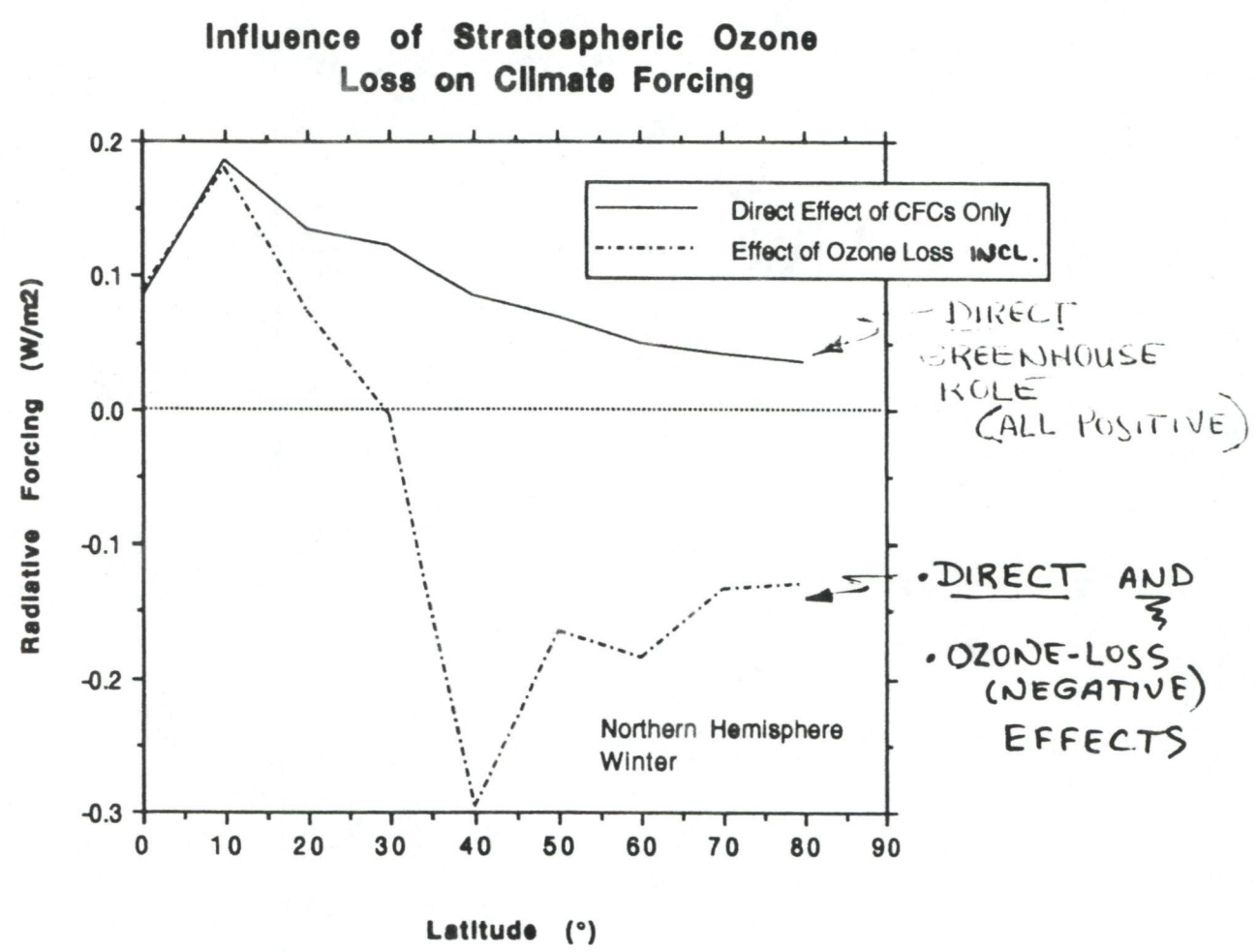


NET EFFECT: DECREASE IN RADIATIVE FORCING (I.E., A TENDENCY TOWARD COOLING)

A FEW POINTS:

- THE EFFECTS "TRACK" LOWER-STRATOSPHERIC OZONE LOSS
 - SEASONAL VARIATION (LARGER IN WINTER)
 - LATITUDINAL DEPENDENCE (LARGER AT HI LATs)

PRELIMINARY CALCULATIONS:



POSITIVE (WARMING)
NEGATIVE (COOLING)

THAT IS: GLOBALLY INTEGRATED } RADIATIVE EFFECT OF CFCs MAY BE ~0!

BOTH : • AS THEY WERE ADDED (1945 - NOW)
 TO THE ATMOSPHERE

• AS THEY ARE REMOVED (NOW - 2100)

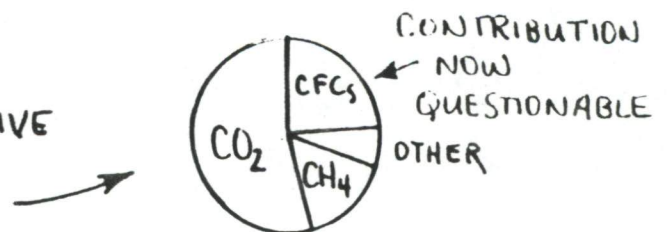
● PERSPECTIVE:

- CALCULATIONS DONE WITH SEVERAL RADIATIVE MODELS
 - E.G., NOAA, STATE UNIV. NEW YORK, UK-READING UNIV,
 - GENERAL AGREEMENT ON OVERALL PATTERNS
- IMPLIED TEMPERATURE COOLING OBSERVED
 - ABOUT -0.3°C PER DECADE
 - MORE IN ANTARCTICA
- BUT THERE ARE SOME PRESSING FURTHER RESEARCH TASKS:
 - PUT OZONE LOSSES IN GCM'S (CLIMATE MODELS)
 - RADIATIVE/DYNAMICAL COUPLINGS
 - EFFECTS OF LATITUDINAL GRADIENTS
 - ROLE OF CLOUDINESS

● IMPLICATIONS TO POLICY FORMULATION:

- THE CFCs MAY WELL BE CLOSE TO "GREENHOUSE NEUTRAL".
- THE PICTURE THAT CFC ELIMINATION WILL REDUCE RADIATIVE FORCING HAS CHANGED.

- THE GREENHOUSE RADIATIVE FORCING "LIST" HAS CHANGED.



- THE TOTAL PREDICTED RADIATIVE FORCING FOR THE 1980s MAY HAVE BEEN OVERESTIMATED. (10%)
(WHICH IS "GOOD NEWS"!))

APPENDIX:

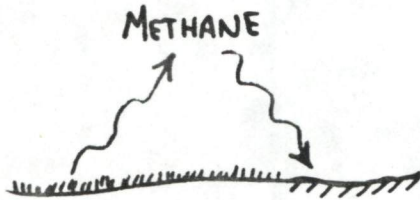
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GLOBAL WARMING POTENTIALS: NEW RESULTS

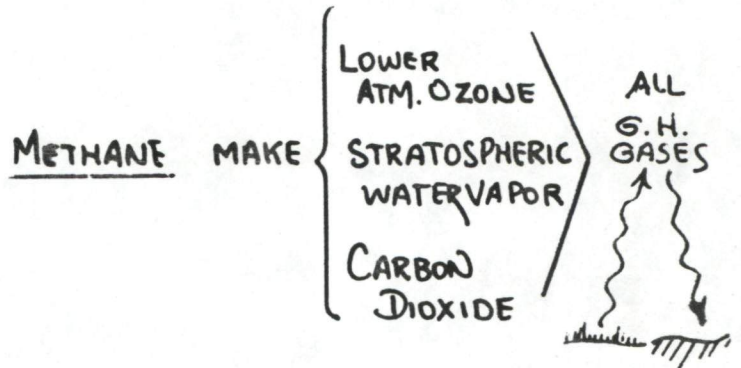
● BACKGROUND:

◦ TRACE GASES CONTRIBUTE TO GREENHOUSE FORCING IN 2 ways...

DIRECT EFFECT



INDIRECT EFFECT



◦ GLOBAL WARMING POTENTIALS (GWPs) ARE USED TO INTERCOMPARE GASES

$$\text{GWP} = \text{DIRECT} + \text{INDIRECT}$$

CARBON DIOXIDE	1	(REFERENCE)		} IPCC, SCIENCE ASSESSMENT, 1990
METHANE	21	6	15	
NITROGEN OXIDES	40	-	40*	
CFC-11	3500	3500	-*	

* BUT THIS IPCC (1990) PICTURE HAS CHANGED...

● RESULTS OF RECENT STUDIES:

- DIRECT EFFECTS OF WELL-MIXED GASES : ☒ WELL-UNDERSTOOD
EXAMPLES : CARBON DIOXIDE, CFCs, NITROUS OXIDE,...

- INDIRECT EFFECTS : HARDER THAN ORIGINALLY REALIZED!

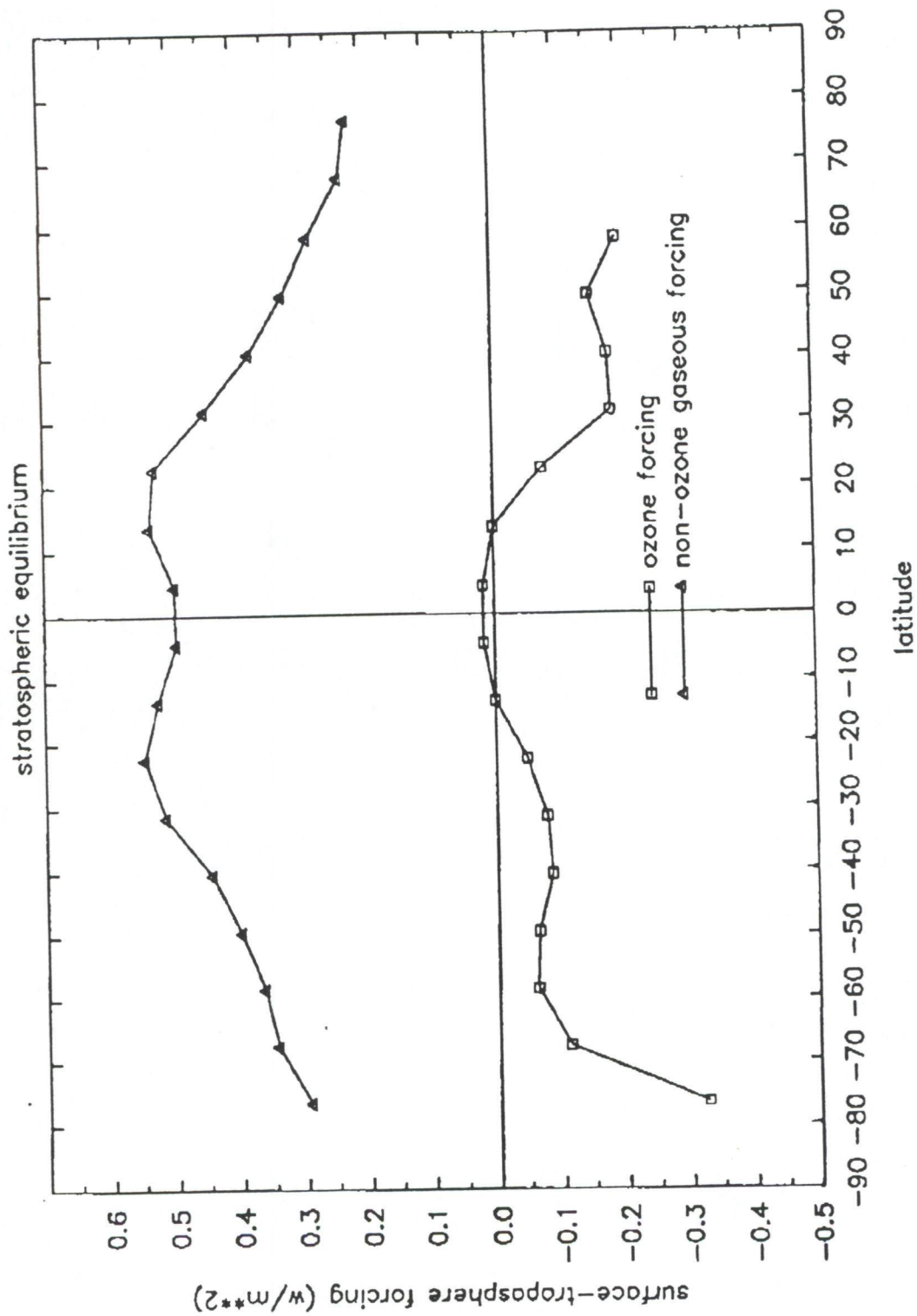
- DIFFERENT RESULTS AMONG VARIOUS MODELS
E.G., METHANE - 50%
NITROGEN OXIDES - FACTORS OF 3
- IPCC USED ONLY 1 MODEL (DIDN'T SEE THIS)
- SCRUTINY SHOWS MANY PROCESSES ARE UNCERTAIN
- PARTICULARLY FOR "POLLUTION" GASES
E.G., NITROGEN OXIDES: INFLUENCE $\begin{matrix} + \text{LOWER ATM. OZONE} \\ - \text{METHANE} \end{matrix}$
NET: TOO CLOSE TO CALL

● IMPLICATIONS FOR POLICY DECISIONS:

- THE INTELLECTUAL FRAMEWORK OF A COMPREHENSIVE SET OF INDICES (GWPs) IS STILL SOUND.
- DIRECT GWP'S OF LONG-LIVED GASES: SOLID ☒
- BUT INDIRECT GWP'S ARE RECOGNIZED AS BEING MUCH HARDER TO CALCULATE.
- METHANE INDIRECT GWP LIKELY TO BE ESTIMATED WITHIN 6 MO.
- GWPs FOR SHORT-LIVED GASES (E.G., NITROGEN OXIDES) WILL REQUIRE THE DEVELOPMENT OF NEW TOOLS.

THEREFORE, QUANTIFYING A COMPREHENSIVE APPROACH IS NOW DEEMED TO BE MORE DIFFICULT.

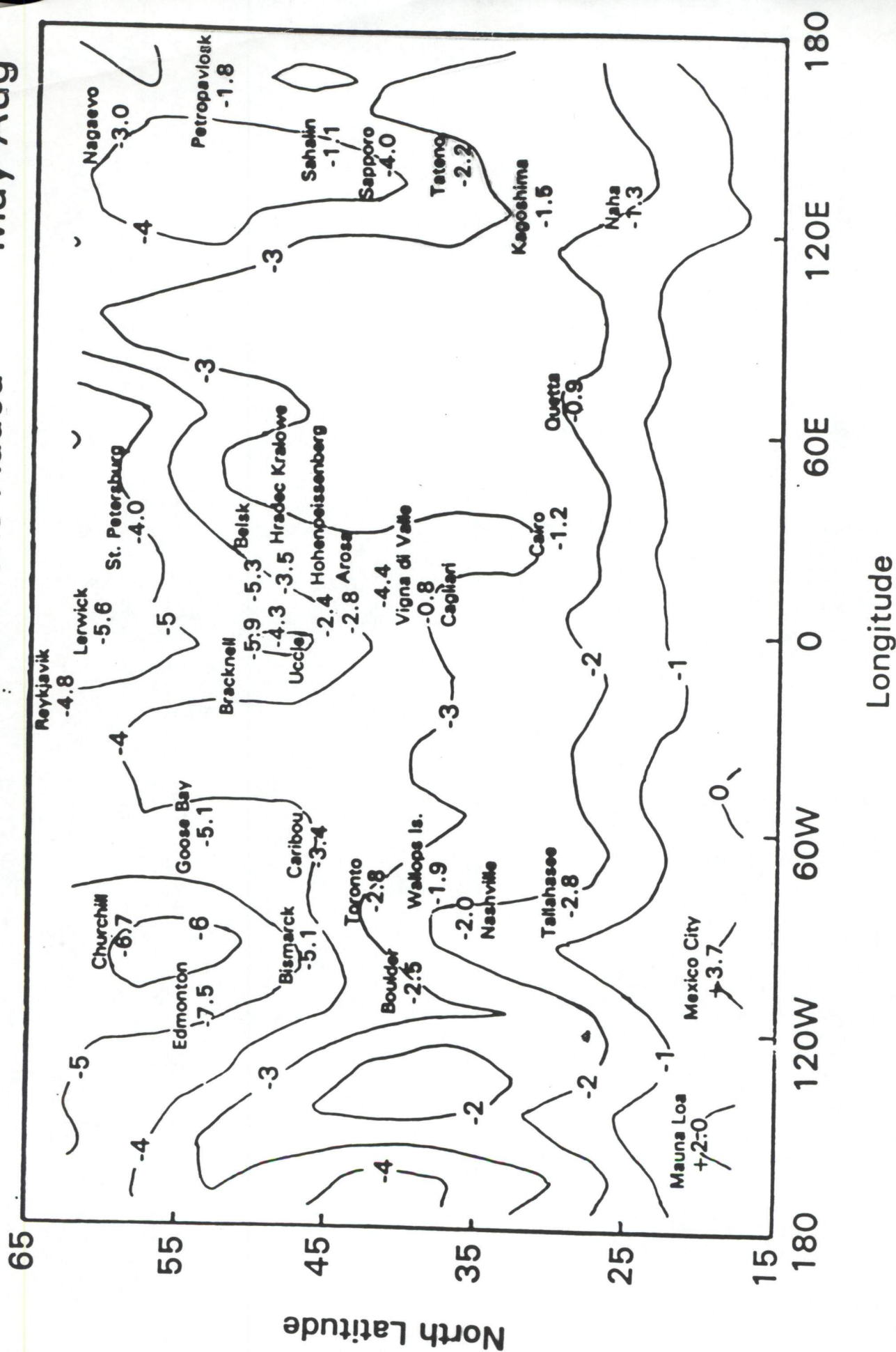
january radiative forcings



TOMS Total Ozone Trends (%/decade)

Ground-Based Stations Added

May-Aug



ARTICLES

Global Warming: Legal Implications for the Arctic*

DR. EDITH BROWN WEISS**

I. INTRODUCTION

We are now conducting the largest experiment with our planet ever undertaken: the emission of greenhouse gases which are expected to warm the temperature of the earth beyond any level previously known to human civilization. These gases are the result of the burning of fossil fuels, deforestation, cattle ranching and nitrogen fertilizers, among other sources.¹ There is still considerable scientific uncertainty about the greenhouse problem:² how many degrees the temperature will rise, the rate of the rise and most importantly, the geographical distribution of the effects of the rise.³

Scientists in the United States and the Soviet Union have established a computer mediated dialogue, the Greenhouse/Glasnost Teleconference, to identify and understand the effects of likely climate changes in the Arctic.⁴ The climate scenario used in their exercise assumes that the mean temperature of the earth will increase by 2.4 degrees centigrade by the year 2025 and

* Copyright 1989, Edith Brown Weiss. This article is intended as an introduction to the issues. An earlier version was prepared for the US-USSR Greenhouse-Glasnost Teleconference, June 1989, Aspen Institute, Berlin.

** Professor of Law, Georgetown University Law Center, A.B., Stanford University; LL.B., Harvard Law School; Ph.D., University of California, Berkeley. The author thanks Timothy Enneking for his valuable research assistance.

1. See generally, Conference Statement, International Assessment of the Role of Carbon Dioxide and of other Greenhouse Gases in Climate Variations and Associated Impacts (UNEP, WMO, ICSV, 1985) (Villach, Austria); U.S. National Research Council, CARBON DIOXIDE AND CLIMATE: A SCIENTIFIC ASSESSMENT (1979).

2. Some scientists question whether on the basis of present scientific knowledge we even need to be concerned about global warming. See, e.g., Michaels, *The Greenhouse Climate of Fear*, Wash. Post, Jan. 8, 1989 (Outposts), at C3.

3. See, e.g., *Developing Policies For Responding to Climatic Change* (WMO/TD-No. 225, April 1988) (summarizing of the discussions and recommendations of the scientific workshops held in Villach, Austria, Sept. 28 - Oct. 2, 1987, and in Bellagio, Italy, Nov. 9-13, 1987, under the auspices of the Beijer Foundation, World Meteorological Organization and the United Nations Environment Programme). The Report provides regional scenarios for climate change. *Id.* at 9-18. The scenario for the high latitudes, which includes the Arctic, predicts that the region will have larger temperature changes in winter than will regions in lower latitudes and will have more precipitation. *Id.* at 9-15-16.

4. W. Kellogg, Summary of Greenhouse-Glasnost Climate Scenario (Feb. 14, 1989) (prepared for Greenhouse-Glasnost Teleconference).

3-4 degrees by 2050.⁵ This is consistent with the upper limit of the projections of the 1987 Villach international scientific conference on global change.⁶ The changes in the Arctic are assumed to be 2 to 2.4 times the global average changes, with smaller changes at lower latitudes.⁷

Using the above assumptions, the Teleconference projects a possible scenario in which the Arctic Ocean and its perimeter ports would be free of ice for half the year and could be quite readily navigable year-round with minimal ice-breaking.⁸ This change could come gradually over the next six decades.⁹

If the climate scenario developed for the Greenhouse-Glasnost Teleconference occurs, the development of the Arctic region could be comparable to the settlement of a new continent. There could be vast, important changes in the use of the Arctic: widespread exploitation of oil, natural gas and coal resources; routine use of the Arctic ocean and the use of the Northwest and Northeast Passages for transportation; further development of commercial fisheries; changes in military strategy in the region; serious pollution problems; increased scientific research to understand and monitor the environmental system and to facilitate resource exploitation; destruction of the way of life of native peoples such as the Inuit and Aleut; intensified border and jurisdictional disputes; and perhaps change in the political status of Greenland.

Many of these changes would likely occur anyway in response to technological advances and the growing demand for resources which are found in the Arctic. The greenhouse effect significantly accelerates the rate of Arctic development and change. This poses a major challenge for the international community.

The challenge for our generation and the next is to ensure that the rate of change in the Arctic is slow enough so that environmental and social systems have time to adapt to the new conditions. The challenge for future communities is to take advantage of the changed conditions without ruining the environmental integrity of the region. This will require controlling pollution, minimizing transport accidents, preventing military build-ups, controlling resource disputes, undertaking necessary scientific research and environmental monitoring, and engaging in other actions necessary to maintain sustainable economic development of the region.

II. ALTERNATIVE ARCTIC LEGAL REGIMES

The Arctic has always been distinguished from other areas of the world:

5. *Id.*

6. See *Developing Policies*, *supra* note 3.

7. W. Kellogg, *supra* note 3.

8. Letter from Walter Orr Roberts to author (Feb. 6, 1989) (available from author).

9. *Id.*

much of the ocean is covered with ice year-round and it is almost fully enclosed by the five countries bordering it—the Soviet Union, Canada, United States, Norway and Denmark.¹⁰ Much of the world has tended to view the region as a big wall of ice, where international commerce ends.

If there is the settlement and commercialization of the region, it will be urgent to develop and clarify the legal and institutional regimes that govern activities there. At least three basic juridical regimes are possible: the sector regime, the law of the sea regime, and a new regime designed specifically for the unique features of the Arctic. The latter may be composed primarily of Arctic countries or may be a broadly multilateral regime.

A. THE SECTOR THEORY

Under the sector theory, the five countries bordering the Arctic would be entitled to control it by extending their national boundaries in straight lines to form sectors ending in the center of the Arctic.¹¹ It is unclear whether the sector theory would necessarily give a country control over all waters as well as land areas (and resources) within each sector or whether it could be limited to land areas.¹² Both the Soviet Union and Canada have subscribed to the sector theory in the past.¹³ Canada, however, has now abandoned it;¹⁴ currently, the Soviet Union's position is unclear.¹⁵

B. THE LAW OF THE SEA REGIME

The primary alternative regime for the Arctic is the law governing the oceans. In the past there has been controversy about whether the Arctic Ocean should be treated as an ocean or as land-fast ice, which is virtually

10. These five countries have direct borders on the Arctic Ocean. Reference is also made to *eight* Arctic countries. This would include those countries with any land area above the Arctic Circle, namely Sweden, Finland, and Iceland in addition to the five already mentioned. See, e.g., MacKenzie and Pearce, *A Sudden Thaw in the Arctic*, NEW SCIENTIST, April 16, 1989, at 25-26.

11. See W. BUTLER, NORTHEAST ARCTIC PASSAGE 71; Shusterich, *International Jurisdictional Issues in the Arctic Ocean*, 14 OCEAN DEV. & INT'L L. 235, 253 (1984).

12. See W. BUTLER, *supra* note 11, at 72-76.

13. The sector theory was first invoked by the Imperial Russian government in 1916. W. BUTLER, *supra* note 11, at 72. The Russian government declared the following islands off the Siberian coast to be an integral part of Russian territory: Vilil'kitskii, Severnaia Zemlia, Maliy, Taimyr, Starokadomskii, Novopashennyi, Henrietta, Jeanette, Bennet, Herald, and Uedinenie Islands. *Id.*

The Soviet government formally declared its claim to Arctic *lands* on the basis of the sector theory in a Decree of the Presidium of the Central Executive Committee of the Union of Soviet Socialist Republics, *Territorial Rights of the Soviet Union in the Arctic*, April 15, 1926, 124 State Papers, Part II, 1064-65, quoted in Head, *Canadian Claims to Territorial Sovereignty in the Arctic Regions*, 9 MCGILL L.J. 200, 206 n. 32 (1963). Canada has asserted certain rights within its sector since 1907. Shusterich, *supra* note 11, at 246-48.

14. See W. BUTLER, *supra* note 11, at 72.

15. See A. Kolodkin, Annual Meeting of the American Society of International Law, Panel on the Arctic (1988) (available from American Society of International Law).

permanent ice attached to a land mass and forming a natural extension thereof.¹⁶ However, if the Arctic Ocean is ice-free for at least three months during the summer, it can hardly be treated as land-fast ice.

The 1982 Law of the Sea Convention is the most recent treaty applicable to the Arctic.¹⁷ It provides coastal countries with exclusive economic resource zones (EEZ) of 200 nautical miles, in which they have jurisdiction over the exploitation of living and non-living resources¹⁸ and with jurisdiction over continental margins out to 350 miles.¹⁹ This means that countries such as Canada and the Soviet Union have exclusive jurisdiction to control the exploitation of oil and gas resources up to 350 miles from their coastline.²⁰ Under the Convention, countries must agree to any scientific research conducted within their 200 mile exclusive economic resource zone.²¹

The Law of the Sea Convention also provides for transit through straits,²² rather than only innocent passage,²³ which gives greater protection for unimpeded access through straits and permits submarines to navigate through the straits underwater. The only provision explicitly addressed to the Arctic

16. See W. BUTLER, *supra* note 11, at 75-77.

17. United Nations Convention on the Law of The Sea, opened for signature, Dec 10 1982, U.N. Doc. A/ CONF. 62/ 122 (1982), reprinted in 21 I.L.M. 1261 (1982) [hereinafter Law of the Sea Convention].

18. *Id.* at Part V, art. 56(1) and art. 57 which state:

In the exclusive economic zone, the coastal state has: (a) sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or non-living, of the waters superjacent to the sea-bed and of the sea-bed and its sub-soil, and with regard to other activities for the economic exploitation of the zone, such as the production of energy from the water, currents and winds; (b) jurisdiction as provided for in the relevant provisions of this Convention with regard to: (i) the establishment and use of artificial islands, installations and structures; (ii) marine scientific research; (iii) the protection and preservation of the marine environment; (c) other rights and duties provided for on this Convention.

The exclusive economic zone shall not extend beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured.

19. *Id.* at Part VI, art. 76(6).

20. See *id.*

21. *Id.* at Part V, art. 56(1)(b)(ii).

22. *Id.* at Part III, § 2, arts. 37-44.

23. *Id.* at Part II, arts. 17-26. Innocent passage means:

navigation through the territorial sea for the purpose of (a) traversing that sea without entering internal waters or calling at a roadstead or port facility outside internal waters; or (b) proceeding to or from internal waters or a call at such roadstead or port facility. . . . Passage shall be continuous and expeditious. However, passage includes stopping and anchoring, but only in so far as the same are incidental to ordinary navigation or are rendered necessary by *force majeure* or distress or for the purpose of rendering assistance to persons, ships or aircraft in danger or distress. . . . Passage is innocent so long as it is not prejudicial to the peace, good order or security of the coastal State. Such passage shall take place in conformity with this Convention and with other rules of international law.

Id. at arts. 18-19(1).

is Article 234, which gives countries special rights to control pollution in the 200 mile zone.²⁴

The 1982 Law of the Sea Convention has, however, never gone into effect. While the requisite number of countries have signed it, not enough have ratified it.²⁵ The United States has never signed the Convention. In the absence of an effective Convention, a controversial legal issue arises as to whether the Law of the Sea Convention, or portions of it, represent customary international law and, as such, are binding upon countries notwithstanding the lack of the requisite ratifications.²⁶ Certainly the important provisions for the Arctic—Article 234, the 350 mile jurisdiction for continental margins, and transit through straits—did not exist as rules of customary international law prior to negotiation of the Convention. The issue is whether they have since become rules of customary international law as a result of the negotiations and subsequent practice. There is no agreement among countries on this point.

In the absence of the comprehensive Law of the Sea Convention, the previous Geneva Conventions on the High Seas,²⁷ Territorial Seas,²⁸ Fisheries,²⁹ and Continental Shelf³⁰ are still in effect between those states parties to them and are authoritative to the extent they have not been overruled by superseding rules of customary international law. In brief, the determination of the applicable legal rules governing the oceans is complex and potentially controversial, particularly as to which rules represent customary international law.

24. *Id.* at Part VII, § 8, art. 234 which states:

Coastal states have the right to adopt and enforce non-discriminatory laws and regulations for the prevention, reduction and control of marine pollution from vessels in ice-covered areas within the limits of the exclusive economic zone, where particularly severe climate conditions and the presence of ice covering such areas for most of the year create obstructions or exceptional hazards to navigation, and pollution of the marine environment could cause major harm to or irreversible disturbance of the ecological balance. Such laws and regulations shall have due regard to navigation and the protection and preservation of the marine environment based on the best available scientific evidence.

25. The Law of the Sea Convention was approved on April 30, 1982, by 130 votes in favor, 4 against (including the United States), with 17 absentions (including the Soviet Union and several Eastern and Western European states). UN Doc. A/CONF.62/SR.182 at 10 (1982), cited in Sohn, *The Law of the Sea: Customary International Law Developments*, 34 AM. U.L. REV. 271 n.2 (1985).

While by March 1984, 134 countries had signed the Convention, by October 1984, only 14 had ratified it, thereby falling short of the requisite 60 ratifications necessary for the Convention to take force. *Id.* at 271, nn. 3-4.

26. See *id.* at 276-77 (1985). See contra C. SANGER, ORDERING THE OCEANS: THE MAKING OF THE LAW OF THE SEA 106-7 (1986) (citing those who hold contrary views).

27. Convention on the High Seas, 29 April 1958, 450 U.N.T.S. 82.

28. Convention of the Territorial Sea and the Contiguous Zone, 29 April 1958, 516 U.N.T.S. 205.

29. Convention on Fishing and Conservation of the Living Resources of the High Seas, 29 April 1958, 559 U.N.T.S. 285.

30. Convention on the Continental Shelf, 20 April 1958, 499 U.N.T.S. 311.

If the 1982 Law of the Sea Convention were to take effect, many of the jurisdictional issues would become clearer. However, the regime may still be inadequate for managing the projected development of the Arctic under the global warming scenario, particularly the environmental problems that would likely arise.

C. NEW INTERNATIONAL REGIMES

A third juridical approach is to develop a new international regime for the Arctic, which could, of course, be made consistent with existing oceans law. An analogy may be made to other areas of the globe—Antarctica, the oceans, outer space, even regional seas—in which increasing industrial, transport, commercial and other uses of these areas necessitated the negotiation of new regimes to handle the complex new problems that arose.³¹ Whether such a regime should be a series of agreements addressed to specific problems, such as pollution or transport, or a more comprehensive regime is a question that should be explored. If we were to follow the Outer Space Treaty,³² we would draft a general framework convention for the Arctic, which would be followed by agreements directed to specific functions, such as pollution control, arms control, transport, etc. If we were to adopt the Law of the Sea approach,³³ there would be one comprehensive agreement for the Arctic which would encompass all uses. But, this latter approach is not likely to be acceptable to the Arctic countries if it would require them to legitimate the claims of other States in every aspect of managing the Arctic.

Considerable attention and perhaps some innovation will be required to solve the problem of what institutional form the management of the Arctic should take. If there were, for example, a Council for the Arctic, it is not clear who the appropriate participants would be. Countries bordering the region would participate, but what rights should other countries have to participate in the Council? As the Arctic develops, the international community is likely to have an increasingly greater interest in the area; this, in turn, will bring about a greater need for protection of international interests in the Arctic.³⁴

31. See, e.g., Antarctic Treaty of 1959, *opened for signature*, Dec. 1, 1959, 402 U.N.T.S. 71; Convention on the Conservation of Antarctic Marine Living Resources, *opened for signature*, Aug. 1, 1980, 33 U.S.T. 3476, T.I.A.S. 10240; Convention on the Regulation of Antarctic Mineral Resource Activities, *opened for signature*, Nov. 25, 1988, 27 I.L.M. 868; Law of the Sea Convention, *supra* note 17.

32. Treaty on Principles Governing the Actions of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies, *opened for signature*, Jan. 27, 1967, 610 U.N.T.S. 205.

33. See *supra* notes 16-30, and accompanying text.

34. See generally Young, *Arctic Waters: The Politics of Regime Formation*, 18 OCEAN DEV. & INT'L L. 101 (1987) and Young, "The Politics of International Regime Formation: Managing Nat-

If global warming were to make the Arctic region suitable for large-scale commercial development and use, the question arises as to who would develop it. If we assume that the Arctic countries will assert primary authority, then we must ask about the availability of long-term financing for environmentally conscious development in the region. Sustainable economic development in the Arctic will be costly. The international community may want to consider the establishment of an international long-term financing facility or an international fund for the Arctic.

III. THE FUNCTIONAL LEGAL PROBLEMS

In addition to the overarching issues concerned with legal regimes and institutions, more discrete legal issues are raised by the projected warming scenario. These relate to border demarcations, exploitation of non-living resources, commercialization of living resources, transport, military uses, pollution control, status of the native peoples, and the political status of Greenland.

A. BORDER DISPUTES

There are already many border disputes in the Arctic. While there are none concerning the two land boundaries between countries in the Arctic (U.S./Canada and USSR/Norway), there are five significant marine boundary disputes, and also many smaller ones associated with these, as indicated below. With global warming and advances in technologies for exploiting the resource rich Arctic, these boundary disputes are likely to intensify.

Norway and the Soviet Union are in dispute over 60,000 square miles of Arctic continental shelf associated with the archipelago of Spitsbergen (or Svalbard). This area is believed to be rich in oil and minerals.³⁵

The United States and the Soviet Union are still negotiating the precise boundaries established in the 1867 Treaty ceding Alaska to the United States.³⁶ Several areas are in dispute: the Navarin Basin, the Norton Basin,

ural Resources and the Environment, 43 INT'L ORG 349 (1989), for insightful analysis on the politics of forming new regimes.

35. See W. BUTLER, *supra* note 11, at 111-13; see also Shusterich, *supra* note 11, at 253-55. This dispute is related to the Treaty Concerning the Archipelago of Spitsbergen, done Feb. 9, 1920, T.S. 686, 2 L.N.T.S. 7. Norway and the Soviet Union have been negotiating over the area for 23 years. Norway would like the boundary to be at an equal distance between the two countries, while the Soviet Union would like to preserve the line established by the Treaty.

36. Shusterich, *supra* note 11, at 246-47. Shusterich states:

Although both countries agree that the 1867 boundary line delimits continental shelf areas, there has been some disagreement on how to actually draw the line. The Soviets favor using rhumb lines, a traditional technique used at the time the Treaty was signed, in which a line on a map is shown as crossing all meridians at the same angle. The United States believes that the more modern great circle method of calculation be used to determine the

and the Barrow Arch.³⁷ There is also a potential dispute between these two countries over Wrangle Island, a 2,000 square mile island in the Chukchi Sea north of the Bering Strait.³⁸ The method used to demarcate these boundaries will determine the ownership of more than 15,000 square miles believed by some to be rich in oil.³⁹

Canada and the United States dispute the boundary in the Beaufort Sea. Canada claims that the line which established the border on land in 1825 forms both a land border and an extension of that border.⁴⁰ On the other hand, the United States claims that the boundary runs northeasterly along an equidistant line between the United States and Canadian coasts.⁴¹ Again, there is substantial mineral wealth in the area.

Canada and the Soviet Union also have potential claims to very large areas as continental shelves, which other countries could dispute. If the undersea Alpha Ridge, a mountain range larger than the Alps, is linked under the ocean to Canada's Ellesmere Island, Canada would be able to claim rights under Article 76 of the Law of the Sea Convention to resources on a continental shelf extending to 350 miles.⁴² Similarly, the Soviet Union, which has determined that the Alpha ridge connects to the Soviet Union, could claim a continental shelf out to 350 miles.⁴³ If these claims were to be upheld, they

location of the line. An area of more than 15,000 square miles in a promising petroleum area would be at issue depending on the methods used to determine the line. The issue of what method to use in actually drawing a line to delimit a marine boundary could have importance in a large number of boundary issues throughout the world.

Id. at 246-47. Since 1981, the United States and the Soviet Union have held a number of negotiating sessions to establish the definite boundary between Alaska and Siberia.

37. W. WESTERMEYER & K. SHUSHTERICH, UNITED STATES ARCTIC INTERESTS 249 (1984).

38. See *Teacher Fights U.S. "Giveaway" of Island*, Chicago Tribune, Mar. 3, 1989, at 1, col. 1. There is some sentiment in the U.S. to push the border toward the Soviet Union to include Wrangle and five other small islands, but this is not the official position of the United States. *Id.* at 1.

Part of the difficulty in this boundary dispute concerns the definition of the term "Frozen Ocean" which is used in Article I of the 1867 Convention. See W. WESTERMEYER & K. SHUSHTERICH, *supra* note 37, at 244 n. 6. There is a long, convoluted history regarding the two countries' relations on the island, which includes invasion and disputed landings.

39. W. WESTERMEYER & K. SHUSHTERICH, *supra* note 37, at 250.

40. *Id.*

41. *Id.*

42. See Law of the Sea Convention, *supra* note 17, Part VI, Art. 76(6).

Canada is pursuing the origins of the Alpha Ridge. *Ice Station CESAR, Near the North Pole*, Reuters, April 15, 1983, at 1 ("the giant undersea mountain range is bigger than the Alps, could be attached to Canada's continental shelf and might provide a bonanza of mineral and energy resources"). If the ridge is linked under the Arctic Ocean to Canada's Ellesmere Island, then Canada has 10 years under the Law of the Sea Convention to file a claim over the 200,000 square mile ridge. The study, "The Canadian Expedition to Study the Alpha Ridge" ("CESAR"), which was completed in March, 1983 is an attempt to obtain geologic and geomorphologic data on the structure of the Alpha Ridge. W. WESTERMEYER & K. SHUSHTERICH, *supra* note 37, at 243.

43. See W. WESTERMEYER & K. SHUSHTERICH, *supra* note 37, at 244; Law of the Sea Convention, *supra* note 17, at Part VI, Art. 76(6).

would greatly reduce the international area of the Arctic Ocean in which resources fall outside national jurisdiction and could be contested by other countries. As noted earlier, the Law of the Sea Convention has not gone into effect, and it is unsettled whether Article 76 would be binding nonetheless as a rule of customary international law.

As we become more able to develop the mineral resources of the Arctic, it is likely that there will be considerable controversy over how to treat the Arctic archipelagoes for purposes of determining exclusive economic resource zone boundaries under the Law of the Sea Convention⁴⁴ or rules of customary international law. This issue will need urgent attention.

As the Arctic Ocean warms and becomes accessible, we can anticipate that countries will be increasingly forceful in asserting their jurisdictional claims to disputed areas.

B. NON-LIVING RESOURCES

The Arctic is rich in oil and natural gas.⁴⁵ Lands in or near the Arctic are rich in coal.⁴⁶ Recent discoveries indicate that 50% of world oil deposits may lie above the Arctic Circle.⁴⁷ For example, it is estimated that the coastal plain portion of the U.S. Arctic National Wildlife Refuge contains between 600 million to 9.2 billion barrels of recoverable oil.⁴⁸ Canada's Drake Point field contains proven reserves of natural gas of 6 trillion cubic feet.⁴⁹ Up to 40% of the mineral wealth of the Soviet Union is said to be located near the Arctic Circle.⁵⁰ Moreover, more than half of its total coal reserves may lie north of the 60th parallel, and potential reserves in Soviet circumpolar seas have been estimated at 45 billion barrels of oil and 700 trillion cubic feet of natural gas.⁵¹

As the Arctic warms, exploitation of these resources will become progressively more feasible and commercially viable. Such exploitation will raise important jurisdictional issues about how far the continental shelf extends from the Arctic countries, about continental shelf boundary demarcations

⁴⁴ See Law of the Sea Convention, *supra* note 17, Part IV, Arts. 46-54. See generally PHARAND, CANADA'S ARCTIC WATERS IN INTERNATIONAL LAW (1988).

⁴⁵ D. SUGDEN, ARCTIC AND ANTARCTIC (1982). While no one disputes this statement, it is not possible to state exactly *how much* of various oil, gas, and mineral resources exist in the Arctic. *Id.* Current technology and the extremely harsh climate make accurate assessments impossible. *Id.*

⁴⁶ *Id.* at 384-85.

⁴⁷ S. OLLIVANT, ARCTIC CHALLENGE TO NATO 2 (1984) (Institute for the Study of Conflict, Conflict Studies No. 172).

⁴⁸ *Hodel Recommends Alaskan Oil Exploration*, Reuters, April 21, 1987, at 1.

⁴⁹ *Project to Ship Gas from Arctic Nears Approval in Canada*, N.Y. Times, Feb. 13, 1982, at 33, col. 1.

⁵⁰ Willbow and Duniloff, *Can U.S. Hold Its Lead Over Soviets in Science Race?*, U.S. NEWS & WORLD REPORT, Oct. 1, 1984, at 52.

⁵¹ B. THEUTENBERG, THE EVOLUTION OF THE LAW OF THE SEA 59 (1984).

between the Arctic countries, and about prevention of environmental disasters and oil pollution resulting from transport of the resources.

Resources could be transported from within the region either by sea or by land. If by land, they would go south through Alaska, Canada, and the Soviet Union. If by sea, they would go through the Northwest and Northeast Passages, through the Northern Sea Route, through the Bering Strait or through passages near Greenland. If we assume that there will be large-scale development of oil, gas, coal, and other mineral resources, we will greatly increase the risks of tanker collisions or other accidents in marine environments, of oil spills during exploitation, of routine oil discharges as vessels move through the Arctic waters, of land-based sources of marine pollution from resource exploitation, and of ocean pollution from the disposal of wastes. These effects in turn raise legal issues of responsibility and liability for damage. A number of international agreements apply to such incidents, but they do not comprehensively address the range of the potential problems nor are all the relevant parties signatories to these conventions.⁵²

C. LIVING RESOURCES

Warming of the Arctic will also affect fishery stocks and increase industrial fishing. Non-Arctic countries may demand access to Arctic fisheries outside the 200 mile exclusive economic resource zone.

Current international law provides an inadequate framework to ensure sustainable fishing if fishing levels are greatly increased in the area. If the Law of the Sea Convention takes effect and countries accept that it applies to the Arctic, it will give the five bordering countries rights to exploit the fishing rights within their exclusive economic resource zone of 200 miles.⁵³ Fishing outside the EEZs would be on a first-come-first-served basis, except for harvesting of anadromous fish, which is governed by separate measures.⁵⁴ Given the semi-enclosed nature of the ocean, this may well be insufficient to protect fishing stocks.

There are at least two fisheries treaties relevant to increased fisheries ex-

52. The applicable existing international law includes the following conventions: International Regulations for Preventing Collisions at Sea, *entry into force*, Sept. 1, 1965, T.I.A.S. 5813; Convention on the Prevention of Marine Pollution from Land-Based Sources, *opened for signature*, June 14, 1974, 13 I.L.M. 352 (1974) [hereinafter Paris Convention]; Convention for the Prevention of Marine Pollution by Dumping From Ships and Aircraft, 26 U.S.T. 2403, 932 U.N.T.S. 3, *reprinted in* 11 I.L.M. 262 [hereinafter Oslo Convention]; International Convention on Civil Liability for Oil Pollution Damage, *done*, Nov. 29, 1963, 9 I.L.M. 45 [hereinafter Civil Liability Convention]; International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, Nov. 18, 1971 - Dec. 18, 1971, 11 I.L.M. 284 [hereinafter International Fund Convention].

53. See Law of the Sea Convention, *supra* note 17, Part V, arts. 56(1) and 57.

54. See *id.* at Part V, art. 66.

exploitation in the Arctic: the International Convention for the Northwest Atlantic Fisheries⁵⁵ and the International Convention for the High Seas Fisheries of the North Pacific Ocean.⁵⁶ Both govern fishing in areas *near* the Arctic, the North Pacific, and the North Atlantic.⁵⁷ The adequacy of both would need to be reviewed in light of new climatic conditions.

There are already several disputes over fishing rights in or near the Arctic. On August 16, 1988, Denmark filed suit against Norway in the International Court of Justice and asked the Court to draw a single line of delimitation between Denmark's and Norway's fishing zones and continental shelf areas in the waters between Greenland and Norway's Jan Mayen Islands.⁵⁸ The case is pending before the Court. Other Arctic fisheries conflicts include Spain's dispute with Norway over fishing rights in fishing grounds claimed by Norway,⁵⁹ and Greenland's dispute with Denmark over fishing rights near Greenland, which arose during negotiations for Greenland's departure from the European Economic Community (EEC).⁶⁰

If global warming occurs, we can expect fishery disputes to increase because of easier accessibility to fishing grounds and enhanced value of the Arctic fisheries.

D. TRANSPORTATION

One of the most significant implications of global warming will be an increase in the use of the Arctic for marine transportation. The warmer climate will enable the Arctic to be used routinely for transport between Europe and Asia and between the North Atlantic and the North Pacific. Both the Northwest and Northeast Passages as well as the Northern Sea Route could become major transportation routes.⁶¹

This raises important jurisdictional issues about the legal status of these

55. Feb. 8, 1949, T.I.A.S. 2089 [hereinafter *Atlantic Fisheries Treaty*].

56. May 9, 1952, T.I.A.S. 2786 [hereinafter *Pacific Fisheries Treaty*].

57. The *Atlantic Treaty* designates the area to which it applies by longitude and latitude points. It extends to 78 degrees, 10 minutes north latitude along the west coast of Greenland and skirts the edge of the Arctic. *Atlantic Fisheries Treaty*, *supra* note 55, at art. I(1). The *Pacific Treaty* is less precise about its coverage. It provides that the area under its control applies to "all waters, other than territorial waters, of the North Pacific Ocean which for the purposes hereof shall include the adjacent seas." *Pacific Fisheries Treaty*, *supra* note 56, at art. I(1).

58. *Maritime Delimitation in the Area between Greenland and Jan Mayen (Denmark v. Norway)*, 1988 I.C.J. 66 (Order of Oct. 14).

59. See *Cod War Looms in North Atlantic Over Dispute Fishing Zone*, Reuters N. Eur. Service, Aug. 1, 1986, at 1. *Spain, Norway at Odds over Arctic Fishing Rights*, Reuters N. Eur. Service, Aug. 1, 1986, at 1.

60. See *European Community Fails to Agree [sic] Greenland Exit Terms*, Reuters N. Eur. Service, Dec. 17, 1984, at 1 [hereinafter *European Community Fails*].

61. Opening of the Northwest Passage, for example, would mean

not merely an oil route, but an international trade route that will have a profound influence on the rate of Arctic development and the patterns of worldwide trade. It will mean

passages. Both the Soviet Union and Canada have claimed them as internal waters.⁶² Whether they are internal waters or part of the territorial sea has important legal consequences. If they are part of the territorial sea, the provisions of the Law of the Sea Convention, including those concerning freedom of transit through straits, would apply.⁶³ If they are internal waters, they are under the full control of the host countries, which means that states must get the consent of these countries before using the passages.⁶⁴

One of the greatest dangers from greater transport in the Arctic will be the increased risk of collisions at sea. Collisions involving military transport are of particular concern. The Regulations for Preventing Collisions at Sea, which were approved by the International Conference on Safety of Life at Sea,⁶⁵ apply to the Arctic, but these will need to be reviewed in light of the increased dangers.

E. MILITARY IMPLICATIONS

The Arctic has military importance, primarily because of the submarines navigating under the Arctic ice and of missile, cruise and ballistic, overflights. Both the United States and the Soviet Union have submarines operating in the Arctic;⁶⁶ Canada also plans to operate submarines there in the

the fulfillment of the need felt centuries ago for a shorter and more direct route from Europe to the Far East.

W. WESTERMEYER & K. SHUSHTERICH, *supra* note 37, at 112 (quoting Dr. Charles F. Jones, President, Humble Oil and Refining Co., "Future Implications," speech presented on Jun. 3, 1969).

With regard to the Northeast passage, "[t]he shortest sea route from Europe to the Far East and the Pacific Ocean passes through the Arctic." Tass, Oct. 1, 1987, at 10. A vessel sailing from London to Yokohama would save thirteen days. W. BUTLER, *supra* note 11, at 68.

62. Use of the Northeast Passage is virtually monopolized by the Soviet Union. See W. BUTLER, *supra* note 11, at 61. The last known crossing of the entire Northwest Passage by a non-Soviet vessel was in 1940. *Id.*

Though not all portions of the Northwest Passage pass through waters claimed by Canada, it is impossible for ships to use the passage and not at some time pass through waters claimed by Canada as territorial. See Pharand, *Canada's Sovereignty over the Newly Enclosed Arctic Waters*, 25 CAN. Y.B. INT'L L. 325, 335 (1987).

63. See Law of the Sea Convention, *supra* note 17, Part X, arts. 124-32.

64. The United States has contested Canada's treatment of the Northwest Passage as internal waters. However, in a 1988 bilateral agreement, the United States agreed to obtain the consent of Canada before proceeding through the Northwest Passage, although it did not acknowledge the legality of Canada's claim of internal waters. Agreement between the Government of the United States of America and the Government of Canada on Arctic Cooperation, Jan. 11, 1988, United States-Canada, *reprinted in* 28 I.L.M. 142, 143.

In October, 1988, when the U.S. Coast Guard icebreaker, "Polar Star," needed to navigate the Passage, the United States notified Canada and obtained her consent, in accordance with the agreement. See Exchange of Notes Concerning the Transit of the Northwest Passage, Text to U.S. Note No. 425, Oct. 10, 1988, 28 I.L.M. 144; Text of Canadian Response to U.S. Note 425, Oct. 10 1988, 28 I.L.M. 145.

65. June 17, 1960, 536 U.N.T.S. 27.

66. See S. OLLIVANT, *supra* note 47, at 17.

near future.⁶⁷ With the Arctic covered by ice, submarine detection is difficult.⁶⁸ Absence of the icebergs for even several months a year will leave the submarines vulnerable for that period of time, thus significantly reducing the importance of the Arctic as a submarine refuge.

Countries should be concerned about whether such a change in climatic conditions could alter the strategic balance and precipitate an arms build-up in the area. The Soviet Union, for example, has land-based weapons and an associated infrastructure facing the Arctic which is greater than that of other countries in the region. The United States relies on a substantial submarine capability in the region. If submarines could be readily detected, both Canada and the United States could turn to land-based military build-ups in the region and in areas adjacent to the Arctic. This may make it necessary to consider new arms control initiatives for the Arctic.

Secretary Gorbachev recently proposed a Nuclear Free Zone in northern Europe and the Arctic.⁶⁹ Somewhat similar proposals have been made in the past, such as that by former U.S. President Eisenhower in 1955.⁷⁰ If we accept the global warming scenario, Arctic countries may find it prudent to begin discussions about potential arms control agreements before the climate changes occur.

A change in the political status of Greenland could also raise strategic concerns. If Greenland were to become independent of Denmark (a process which would be encouraged by improved economic conditions from global warming), the question would arise as to whether Greenland would join NATO or would choose to become neutral. It is likely that she would join NATO, but this is not assured. If she did not join NATO, it would have important strategic implications for existing military alliances and military strategy.

F. POLLUTION

The Arctic is a fragile environment. The fauna and flora are highly vulnerable to change. Pollution in the region is not easily cleansed, and recovery from environmental damage requires a long time. If the Arctic warms according to the projected scenario, serious pollution threats will arise from energy resource development, transportation, increased settlements and urbanization, and tourism. There is also likely to be an increased flow of pollution coming from outside the Arctic. Water flowing into the Arctic from the

67. See *Nuclear Subs Plans Certain to Go Ahead*, The Daily Telegraph, Nov. 23, 1988, at 15.

68. The sounds generated by moving ice, as well as the depth and complexity (in terms of temperature, pressure, and salinity gradients) of the waters beneath the ice pack, makes the detection of submarines nearly impossible in the Arctic. See S. OLLIVANT, *supra* note 47, at 5.

69. Tass, Oct. 1, 1987, at 7.

70. See J. HONDERICH, *ARCTIC IMPERATIVE* 188 (1987).

Atlantic and Pacific carries millions of tons of industrial and agrochemical wastes.⁷¹

Thus, one of the top priorities must be the negotiation of a pollution control regime for the Arctic. This could be modeled after the regional seas pollution agreements, with the establishment of an Arctic Council and a protocol designating protected areas, or could be part of a larger, more comprehensive regime for the Arctic. Some areas of the Arctic may well deserve special protection as international ecological sites.

While warming of the Arctic will bring uses which will pollute the area, the natural capacity of the Arctic to handle pollution may improve, thus mitigating, but not eliminating, pollution problems. At present, the Arctic environment is ill-equipped to handle pollution *because* its climate is so extreme. It is important to build mechanisms into an Arctic agreement for controlling pollution that will foster scientific research and provide for revisions of the agreement in light of changing scientific findings.

In response to concerns about pollution, both Canada and the Soviet Union have passed national legislation to control pollution from transport off their shores. Because of particular concern about the passage of supertankers through the Arctic, Canada unilaterally passed the Arctic Waters Pollution Prevention Act in 1970 (proclaimed in 1972), which set forth Canadian control over shipping to 100 nautical miles.⁷² The Act also prohibits "deposit[s] of waste of any type in the arctic waters."⁷³ The Soviet Statute on the Administration of the Northern Sea Route⁷⁴ empowers the Soviet government to "prevent and eliminate the consequences of pollution" and to control vessel traffic in the Arctic region near the northern coast of the USSR.⁷⁵

There is also an existing body of international law applicable to Arctic pollution. The Law of the Sea Convention explicitly addresses pollution of polar areas. Article 234 provides that "[c]oastal States have the right to adopt and enforce non-discriminatory laws and regulations for the prevention, reduction and control of marine pollution from vessels in ice-covered

71. For instance, the inflow of water from the Atlantic "coming along the coast of America, collects the exhaust waters from there and from western Europe and threatens to become a formidable pollution pipe, pumping millions of tons of agro-chemical and industrial waste into the Arctic." *Call to Prevent Arctic Pollution*, Xinhua General Overseas News Service, Mar. 14, 1980, at 1.

72. Arctic Waters Pollution Prevention Act, CAN. REV. STAT. ch. A-12 § 2 (1985), *reprinted* in 9 I.L.M. 543 [hereinafter Arctic Waters Act].

73. *Id.* at § 4(1), *reprinted* in 9 I.L.M. 544. See generally Note, *International Law and Canadian Arctic Pollution Control*, 38 ALB. L. REV. 921 (1974) (authored by J. Sherrin) (provides analysis of the issues concerning the Arctic Waters Act).

74. Statute on the Administration of the Northern Sea Route Attached to the Ministry of the Maritime Fleet, 1971, *reprinted* in W. BUTLER, *supra* note 11, at 177.

75. *Id.* at arts. 1 and 3.

areas within the limits of the exclusive economic zone,"⁷⁶ which is 200 nautical miles.⁷⁷ Part XII of the Convention addresses marine pollution generally, including areas beyond 200 miles.

Other multilateral conventions also apply to the Arctic. Some only address certain kinds of pollution; others only extend to part of the Arctic region. These conventions include two conventions associated with the International Maritime Organization: the 1969 International Convention on Civil Liability for Oil Pollution Damage⁷⁸ and the 1971 International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage.⁷⁹

Conventions which extend only to part of the Arctic region include the 1974 Paris Convention for the Prevention of Marine Pollution from Land-Based Sources⁸⁰ and the 1986 Protocol,⁸¹ and the Oslo Convention for the Prevention of Marine Pollution by Dumping From Ships and Aircraft.⁸²

Because the Arctic is such a fragile system, it is important to develop a coordinated regime for monitoring and controlling pollution there. The projected global warming scenario accelerates the time table for when such a regime is needed. Because of the long lead times in negotiating new legal regimes, it is urgent for at least the countries bordering the Arctic to begin discussions about such a regime.

G. NATIVE PEOPLES

Native peoples inhabit all countries bordering the Arctic. These people are often referred to as Eskimos, although they consist of the Aleuts in the Bering Sea area and the Inuits, who inhabit Alaska, the Canadian area, and Greenland. The presence of these unique native peoples raises important legal and equitable questions concerning rights to economic development and to cultural protection. For example, what rights do the Inuit people in Canada have to offshore living and non-living resources? What jurisdictional

⁷⁶ Law of the Sea Convention, *supra* note 17, at Part XII, art. 234.

⁷⁷ *Id.* at Part V, art. 57.

⁷⁸ Civil Liability Convention, *supra* note 52.

⁷⁹ International Fund Convention, *supra* note 52. Three of the five Arctic countries, the USSR, Norway, and Denmark are parties to the Civil Liability and International Fund Conventions; Canada and the United States have never joined. See *supra* note 52. Japan, whose vessels will likely transport oil from the Arctic, belongs to both Conventions. See *supra* note 52.

⁸⁰ Paris Convention, *supra* note 52.

⁸¹ Convention for the Prevention of Marine Pollution from Land-Based Sources: Protocol Amending the Convention, March 26, 1986, 27 I.L.M. 625 [hereinafter Protocol]. The Paris Convention and the Protocol extend to a sector encompassing western Europe, part of Greenland, part of the Soviet Union, the Baltic and Mediterranean Seas and adjacent seas. Paris Convention, *supra* note 52; Protocol, *supra*.

⁸² Oslo Convention, *supra* note 52. This convention extends to parts of the Atlantic and Arctic Oceans, the Baltic Sea, and the Mediterranean Sea. *Id.*

rights do the Inuit have to areas of the Beaufort and Chukchi Seas? Some of these rights have already generated conflicts.⁸³

Global warming could destroy the traditional way of life of these peoples, raising profound issues of equity. Through our global consumption of fossil fuels and other practices which generate greenhouse gases, we will have caused this loss. International human rights law obligates states to respect the economic and cultural rights of its peoples. The International Covenant on Civil and Political Rights⁸⁴ provides in Article 1(2) that "[i]n no case may a people be deprived of its own means of subsistence,"⁸⁵ and in Article 27 on culture that "in those States in which ethnic, religious or linguistic minorities exist, persons belonging to such minorities shall not be denied the right, in community with the other members of their group, to enjoy their own culture, to profess and practice their own religion, or to use their own language."⁸⁶ The International Covenant on Economic, Social and Cultural Rights⁸⁷ also protects a right to culture.⁸⁸ All countries bordering the Arctic, except the United States, are party to the Covenants.

As in the case of the Indians in the Amazon and of tribal peoples elsewhere, international efforts may be made to try to enforce these human rights. In the scenario projected under global warming, it is unlikely that we can salvage the environmental conditions necessary for these people to maintain their way of life. But, the international community may have a legal obligation to ensure the protection of the human rights of native peoples in the Arctic to the extent possible. This may require special assistance to give them opportunities for sustainable economic development, to ensure the protection of their culture insofar as possible, and to ease their transition into a different society.

H. GREENLAND

Greenland is a part of Denmark: she has been granted home rule. While Greenland controls its own domestic policies, Denmark is responsible for her foreign policy and military security. In the early 1980's Greenland successfully negotiated with Denmark for the right to withdraw from the European

83. See, e.g., K. KRUSE, *THE INUPIAT AND DEVELOPMENT: HOW DO THEY MIX?* cited in W. WESTERMEYER & K. SHUSHTERICH, *supra* note 11, at 134-57.

84. International Covenant on Civil and Political Rights, adopted, Dec. 16, 1966, 999 U.N.T.S. 171.

85. *Id.* at Part I, art. 1(2).

86. *Id.* at Part III, art. 27.

87. International Covenant on Economic, Social and Cultural Rights, adopted, Dec. 16, 1966, 993 U.N.T.S. 3.

88. See *id.* at Part I, art. 1(1); Part II, art. 3; Part III, art. 2.

Economic Community. Seventy percent of Greenland's population voted against EEC membership when Denmark voted to join.⁸⁹ The major factor preventing Greenland from becoming completely independent is her economic dependency on Denmark.⁹⁰

At the moment Greenland is sparsely populated with only 54,000 and has barely begun to develop economically.⁹¹ However, under certain scenarios of global warming, her economic status might improve. It is worth considering whether an independent Greenland would then be economically viable. Studies have indicated that the area may prove to be rich in oil and gas.⁹² Should Greenland become independent, an option which is not presently under discussion, there could be major implications for any Arctic regime. One important variable would be the extent to which an independent Greenland would assume the international obligations entered into by Denmark.

IV. CONCLUSION

Depending upon the rate of change, global warming could bring unprecedented opportunities to develop and use the Arctic, which would make the region an integral part of the world's commerce. But it would also carry many attendant risks of economic and political mismanagement, enhanced conflict, and most importantly, ecological destruction. These will be aggravated to the extent that the changes occur too rapidly to allow countries and environmental systems to adapt.

Even without the global warming scenario developed in the Greenhouse-Glasnost Teleconference, it is likely that in time, we will need to develop a new international legal regime for the Arctic. Several independent factors push in this direction. First, technological advances are easing the burdens which the severe conditions of the Arctic place on human activities. Secondly, the diminishing world supply of critical minerals, fuels, and other products is likely to raise the prices of these products. Resources previously too expensive to be exploited with a given technology will become profitable to exploit. Alternatively, technological advances may lower the price of exploitation of resources to the point where it becomes profitable. Similar developments can be foreseen for other uses of the Arctic, such as for transportation and tourism. Thus, one does not need to posit any change in the

89. *European Community Fails*, *supra* note 60, at 1.

90. T. ARMSTRONG ET AL., *THE CIRCUMPOLAR NORTH* 202-5 (1978).

91. *Id.* at 182, 202-5.

92. *Id.* at 183-89. "Discovered coal deposits in Svalbard, Greenland, northern Canada and Alaska amount to some 15,000 billion tons; undiscovered deposits have been estimated at 3,300,000 billion tons. [citation omitted] And both Greenland and northern Canada also contain important quantities of uranium." S. OLLIVANT, *supra* note 47, at 9

world's climate to justify a serious examination of the growing importance of the Arctic to the international community. Global warming significantly accelerates this need.

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AGORA: WHAT OBLIGATION DOES OUR GENERATION OWE TO THE NEXT? AN APPROACH TO GLOBAL ENVIRONMENTAL RESPONSIBILITY

DO WE OWE A DUTY TO FUTURE GENERATIONS TO PRESERVE THE GLOBAL ENVIRONMENT?

A common assumption underlying nearly every book or essay on the global environment is that the present generation owes a duty to generations yet unborn to preserve the diversity and quality of our planet's life-sustaining environmental resources. This duty is sometimes said to be an emerging norm of customary international law,¹ including the more recently treaty-generated custom of the "common heritage of mankind."² Professor Edith Brown Weiss lists three different approaches one might take in response to an asserted environmental obligation to future generations: the "opulent" model, which denies any such obligation and permits present extravagance and waste; the "preservationist" model at the other extreme, which requires the present generation to make substantial sacrifices of denial so as to enhance the environmental legacy; and the "equality" model—favored by Professor Weiss—which says we owe to future generations a global environment in no worse condition than the one we enjoy.³

I. PARFIT'S PARADOX OF FUTURE INDIVIDUALS

International law scholars appear to have overlooked the startling thesis put forth by Derek Parfit in 1976.⁴ I will state his thesis in a somewhat stronger form than he did.⁵ Let us picture the people who will be living 100 years from now;⁶ they will be specific, identifiable persons. We can claim that we currently owe an environment-preserving obligation to those particular as-yet-unborn persons. Parfit's paradox arises when we seek to dis-

¹ Professor Weiss regards it as an obligation *erga omnes* that has some support in customary international law. See Weiss, *The Planetary Trust: Conservation and Intergenerational Equity*, 11 *ECOLOGICAL Q.* 495, 540-44 (1984).

² See D'Amato, *An Alternative to the Law of the Sea Convention*, 77 *AJIL* 281, 282-83 (1983).

³ E. BROWN WEISS, *IN FAIRNESS TO FUTURE GENERATIONS: INTERNATIONAL LAW, COMMON PATRIMONY AND INTERGENERATIONAL EQUITY* (1989).

⁴ Parfit, *On Doing the Best for Our Children*, in *ETHICS AND POPULATION* 100 (M. Bayles ed. 1976); Parfit, *Overpopulation*, Part One (ms. 1976), referred to in Parfit, *Future Generations: Further Problems*, 11 *PHIL. & PUB. AFF.* 113 (1982) [hereinafter *Future Generations*].

⁵ My restatement takes into account chaos theory; see *infra* text at notes 9-11. Parfit originally assumed large-scale environmental interventions, yet his thesis is in fact applicable to any environmental intervention.

⁶ In saying this, I do not assume that the human race will necessarily survive the next 100 years. Acts of cosmic stupidity are always possible: self-obliteration by nuclear war, depletion of the ozone layer, and so on.

charge that postulated obligation. Suppose that we undertake a specific environmental act of conservation. For example, we help to pass a law requiring catalytic converters on all automobiles in our state. We will thus have succeeded in intervening in the environment—making the environment slightly different from the way it would have been but for our action. Our intervention will reduce the amount of air pollution that otherwise would have taken place, and increase the utilization of energy and resources in the manufacture of catalytic converters.

Yet this slight difference resulting from our intervention in the environment will affect the ecosphere in the years subsequent to our intervention. In particular, it will affect the conditions under which human procreation takes place. The particular sperm and egg cells from which any human being develops is a highly precarious fact; the slightest difference in the conditions of conception will probably result in fertilization of the egg by a different sperm. Hence, when the environment is disrupted even a slight amount, a different future person will probably be conceived. According to Parfit's thesis, our intervention in the environment will make a sufficient impact to assure that different sperm cells will probably fertilize the egg cells in all procreations that take place subsequent to our environmental intervention. Different people will be born from those who would have been born if we had not intervened in the environment.

To be sure, in the first few years following our environmental intervention, there is very low probability that many subsequent human conceptions will be affected. But as years go by, the effect of our single environmental intervention increases exponentially⁷ until it is a virtual certainty that 100 years from now all human conceptions will have been affected a little bit from our single act of environmental intervention, and that this little effect will actually result in fertilization of egg cells by sperm cells different from those that would have fertilized those egg cells in the absence of our act. Parfit's conclusion is that every single person alive 100 years from now will be an entirely different individual from the person he or she would have been had we not intervened in the environment.

This fact creates a paradox in our attempt to discharge our moral obligation to future generations. How can we owe a duty to future persons if the very act of discharging that duty wipes out the very individuals to whom we allegedly owed that duty? Our attempted environmental altruism will prevent the birth of the precise beneficiaries of our altruism.

It is no answer to argue that the entirely new set of individuals who will replace those we wipe out will themselves greatly benefit from our intervention. For although they may be the beneficiaries of our environmental intervention, we could not have owed a *duty* to them because they were not possible persons at the time we claimed that we had a duty. Any present duty that we have to future generations can only be a duty to particular future persons who are awaiting their turn to be born. If in exercise of such an alleged duty we commit an act of environmental intervention that denies

⁷According to chaos theory. See *infra* text at note 10.

the opportunity to be born to those very individuals, we cannot possibly be making *them* better off by virtue of our intervention. Thus, we find that any attempted altruism on our part to intervene in the environment to help future persons will make those persons incomparably worse off than if we had not intervened. They would be better off living in a degraded environment 100 years from now—that is, in an environment we did not act to preserve—than not living at all.⁸

Parfit's paradox is uncomfortable and counterintuitive. Is it somehow fallacious? If not, is there any way we can accept Parfit's thesis and still make sense of the notion of "obligation to preserve the environment"?

II. IS PARFIT'S REASONING FAULTY?

People encountering Parfit's thesis for the first time are properly skeptical that a minor intervention in the environment can actually result in entirely different individuals in 100 years from those who would have existed then had there been no such intervention. But the result is scientifically accurate, stemming from the discovery in recent years of chaos theory. In the 1950s, Edward Lorenz, a meteorologist at the Massachusetts Institute of Technology, discovered that a very slight shift in the initial data about weather conditions fed into a computer will result in drastic differences in simulated weather conditions after a number of iterations.⁹ The differences, or perturbations, grow exponentially, doubling every 4 days. Lorenz called this the "butterfly effect." An environmental intervention as slight as a butterfly flapping its wings near a weather station will change long-term weather predictions. Although 2 weeks after the butterfly's capricious flight the effect will hardly be felt outside an area 16 times the path of the butterfly, after 1 or 2 years the butterfly's flight could actually be the cause of a major storm that otherwise would not have taken place.¹⁰ A weekly quadrupling rate means that an initial perturbation will increase by 4 to the 52d power after just 1 year—enough to make itself felt anywhere on the planet. By my own rough calculations, after 3 years the number of perturbations will have increased by more than the total number of atoms in the universe. Thus, applying chaos theory in support of Parfit's thesis makes clear that any action we take will affect the environment in such a way as to change the conditions of all acts of human procreation several decades hence. Even minor acts in the present can substantially affect which particular sperm cells succeed in fertilizing human ova 60 years from now.

If there is no valid scientific objection to Parfit's thesis, can we argue that it proves too much? Can we argue that *any* act that we do, not just acts of environmental preservation, will have a similar exponentially increasing

⁸ What if the environment is so bad that even the act of living is a curse? Would any person choose not to have lived at all rather than to be born into a miserable and degraded situation? We can perhaps choose for ourselves, but I doubt that we have a moral right to make that choice for others yet unborn.

⁹ See, e.g., J. PETERSON, *THE MATHEMATICAL TOURIST* 144–49 (1988); J. GLEICK, *CHAOS: THE MAKING OF A NEW SCIENCE* (1987).

¹⁰ J. FRIEDLAND, *MATHEMATICS AND THE UNEXPECTED* 66 (1988).

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future effect.¹¹ For instance, a jogger will have this effect on the future, just as will the air-polluting automobile that drives by her as she jogs. Can we thus contend that since acts of environmental degradation as well as acts of environmental preservation equally change the composition of future populations, Parfit's thesis is vacuous?

No, because Parfit's thesis is aimed at moral considerations. It is premised on the generally accepted moral obligation not to act in any situation where our action would make others worse off.¹² Hence if we engage in an act of environmental preservation for the reason that we feel an obligation to future persons, our very act will make those persons worse off than if we had not acted at all: indeed, our act will make them totally worse off—they will be deprived of their existence. To be sure, the same is true of any environmentally *degrading* act that we might take—except that no one claims that we owe an obligation to future generations to degrade the environment! Parfit's thesis is thus pinpointed at only one claim of obligation: that if we act to *preserve* the environment out of a sense of obligation to future persons, that obligation is nonsensical because in so acting we destroy the obligees.

Indeed, this theme could be embellished by pointing out that all environment-preserving actions are supererogatory in contrast to all *selfish* uses that we might make of the environment. The argument would proceed as follows. Imagine that we could have a conversation with a lawyer who represents the class of actual persons who will be alive 100 years from now. She tells us that she is prepared to accept just our selfishly motivated environmental acts. For when we act to use up environmental resources just to gratify our immediate desires, we are at least motivated by an understand-

¹¹ Both Professor Weiss and Dr. Gündling, in their replies to my essay, chide me for failing to make the argument that I have just made. Professor Weiss says that I did not make my own case as strongly as I might, because "[v]irtually every policy decision of government and business affects the composition of future generations." See p. 206 *infra*. Dr. Gündling says I have "overlooked" the point that "man always interferes with history, even when he is not aware of, and taking care of, future generations." See p. 210 *infra*. But my argument is that although every policy decision of government and business surely affects the composition of future generations, we are nevertheless entitled to examine each and every one of those policy decisions from a moral point of view. If some are immoral, we reject them for that reason alone. But some policy decisions are asserted to be morally required solely because they will benefit future generations. It is just these policy decisions that are subject to the Parfit rejoinder: if you undertake a policy decision only to benefit future generations, and that is its only "moral" justification, it is not morally justifiable at all because it destroys the very persons you claim to protect.

Both Professor Weiss and Dr. Gündling suggest that they are talking about group rights, not individual rights, when they talk about future generations, and hence the composition of the group does not matter too much. The reader can decide whether, if every single member of group A is wiped out and replaced by someone else, we are still entitled to call it group A and insist that at least the group has been preserved.

With appropriate caveats. For example, if we bar the establishment of a McDonald's hamburger shop directly next to the geyser Old Faithful in Yellowstone National Park, we are making a McDonald's franchisee worse off. As with any moral consideration, we have to balance that against the aesthetic sensibilities of numerous tourists who want to view Old Faithful without updated reminders of how many billions of hamburgers have so far been made out of how many millions of cows.

able *reason*—the reason of self-interest. True, she adds, those acts will operate to change the conditions of future human procreation in such a way that the class of persons she represents will change its members' identities each time we act. But she accepts this result as inevitable. On the other hand, she strenuously objects to any of our acts of environmental intervention that are motivated solely by a sense of obligation to her clients. That is not a good reason to act, she argues, because in so acting we will gratuitously destroy her clients. Our attempt to be altruistic to her clients will result in their destruction. "We don't need friends like you," she might conclude. "My clients would rather live in whatever environment is left to them than not be born at all."

Perhaps we can shift the ground of contention to argue that Parfit's thesis should be disregarded because our obligation to act to preserve the environment stems from a generic notion of "future generations" and not because we have any particular future individuals in mind. In other words, can we say that we do not care which persons inherit the earth so long as whoever inherits it inherits a habitable planet in no worse condition than the one we enjoy? Of course we can say all this, and in a rather rough way we probably think it and act upon it. But the argument, upon inspection, simply glosses over the problem. Future generations are not an abstraction; they consist of individuals. The particularity of the individuals is apparent when we consider how lucky it is for anyone to be born. The odds of your being born instead of one of your many potential siblings are comparable to the odds of winning the Pennsylvania Lottery in the recent drawing when the first prize was over \$100 million. The point is that the winner of the lottery would not be equally content to have any other person win the lottery; similarly, you and I would not be content if a different person had been born instead of us. We may have been lucky to have been born at all, but we are not ready to relinquish that luck simply on the ground that large numbers and vanishingly small probabilities are involved. The fact that *somebody* will be born does not mean that the person lucky enough to be born is indifferent about who it is.¹³ Future generations cannot be indifferent about whether it is *they* or other persons who will enjoy the fruits of the earth. If we feel we owe an obligation to *them*, we, too, cannot be indifferent about the question. We cannot discharge our obligation to them if in the process of doing so we deprive them of life.

III. GIVEN PARFIT'S PARADOX, DO WE HAVE ENVIRONMENTAL OBLIGATIONS?

At first blush, Parfit's thesis appears to set us back. It seems to justify Professor Weiss's "opulent" model in a way that most of us would instinctively find morally repulsive. Although I believe that Parfit's thesis is unsailable, I do not think it is retrogressive. Instead, it may help us to clear the ground of unnecessary conceptual confusion and proceed on a firmer footing.

¹³ Cf. Leslie, *No Inverse Gambler's Fallacy in Cosmology*, 97 MIND 269 (1988).

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I suggest that we begin by noticing that the notion of obligation to future generations is typically located within the developing concept of international human rights. The general argument starts with the claim that human rights are more important than any other value in international law, including the rights of states. And it continues by claiming that future generations also have a human right—the right to inherit an environment no worse than the one we enjoy.

The foregoing are relatively uncontroversial assertions. But if we look closely, we see that the entire concept of "human rights" is species chauvinistic. This form of chauvinism is illustrated by the following quotation from Judge Richard Posner: "Animals count, but only insofar as they enhance wealth. The optimal population of sheep is determined not by speculation on their capacity for contentment relative to people, but by the intersection of the marginal product and marginal cost of keeping sheep."¹⁴ Posner purports to derive these conclusions from his principle of wealth maximization, which for him constitutes the bedrock *moral* justification for all law.¹⁵ He characterizes "wealth" solely in human terms; the sheep's own wealth, of course, is not to be maximized or even taken into account. Since a sheep's own capacity for enjoying life has *by definition* nothing to do with maximizing human wealth, it becomes for Posner *morally and legally irrelevant*.

One of the most articulate opponents of "animal rights" is R. G. Frey, whose species chauvinism is explicit when he writes:

[I]t is the sheer richness of human life, and in what this richness consists, which gives it its superior quality. Some of the things which give life its richness we share with animals; there are other things, however, which can fill our lives but not theirs. For example, falling in love, marrying, and experiencing with someone what life has to offer; having children and watching and helping them to grow up; working and experiencing satisfaction in one's job; listening to music, looking at pictures, reading books By comparison with animals, our lives are of an incomparably greater texture and richness¹⁶

Few persons would quarrel with this statement if Professor Frey has in mind the lowest forms of animal life such as insects and mollusks. But what about whales or chimpanzees? Some whales possess a brain six times bigger than the human brain; Dr. John Lilly has claimed that they are more intelligent than any man or woman.¹⁷ According to Dr. Kenneth Norris, whales see and taste through sounds, and possess many other faculties of which we are only vaguely aware.¹⁸ Chimpanzees, monkeys and gorillas take obvious pleasure in raising their young, and exhibit the same gamut of emotions in the process as do humans. They seem to understand human sign language

¹⁴ R. A. POSNER, *THE ECONOMICS OF JUSTICE* 76 (1983).

¹⁵ "Wealth maximization provides a foundation not only for a theory of rights and of remedies but for the concept of law itself." *Id.* at 74.

¹⁶ R. G. FREY, *RIGHTS, KILLING, AND SUFFERING* 109-10 (1983).

¹⁷ J. LILLY, *MAN AND DOLPHIN* (1961).

¹⁸ *See* D. DAY, *THE WHALE WAR* 154 (1987).

and, indeed, their "language ability" seems to increase the more researchers take pains to teach them our language.¹⁹

Are we bound by a notion of "human rights" to consider that the only things that are valuable in the world are those that directly benefit ourselves? Consider the following thought experiment. Suppose Robinson is the last person on earth. When he dies, the human species will have come to an end. During his lifetime, would he have a moral right to kill animals for sport, even knowing that some of those he would kill are the last survivors of their own species? Posner's principle of maximizing wealth would still apply in Robinson's case; it is not dependent upon the existence of other humans. Under that principle, Robinson has a moral right to do whatever would contribute to his own wealth, including the hunting and termination of various animal species for no other reason than the "sport" of it. And under Frey's view, Robinson can do anything he pleases because his life is incomparably richer than any lives of the animals or animal species that he destroys.

Note, however, that the same result obtains under the traditional international conception, mentioned at the outset of this discussion, of preserving the environment for the benefit of future generations. Since there will be no future generations, Robinson has a moral license under this conception—as well as under Posner's and Frey's views—to engage in hunting for sport even if in so doing he terminates entire animal species.²⁰

If this result is uncomfortable, it points to the shortcomings of the species chauvinism that underlies the theories of Posner, Frey and "fairness to future generations." All three are impoverished accounts of our actual sense of moral obligation. They are too dependent upon finding an articulate link to the improvement of the *human* condition.

It is important to recall that Parfit's thesis only deconstructs the notion of obligation to *future generations*, and not environmental obligations generally. If we have a choice between committing a wasteful act (such as killing a whale) or committing an environmentally preserving act (such as planting a tree), either act, under Parfit's thesis, will change the identity of future generations. Hence, we cannot assert a moral obligation to *future generations* to commit or refrain from committing either the wasteful or the conserving act. But that does not necessarily mean that we have no moral obligation at all.

¹⁹ See LANGUAGE LEARNING BY A CHIMPANZEE: THE LANA PROJECT (D. M. Rumbaugh ed. 1977).

²⁰ To be sure, we can argue that an "enlightened" Robinson might calculate that Darwinian evolution might result, 100 million years after his death, in the creation of a new human species. Hence, by not killing off various animal species, an enlightened Robinson might help speed up the evolutionary development of humans from those very animal species. Perhaps in that sense Robinson has a kind of obligation to a future to-be-evolved generation of humans. However, I would contend that this argument slyly begs the question. We can always define an "enlightened" human rights policy as including the preservation of nonhuman species. But then the same debate is reproduced as we argue about what is and what is not "enlightened."

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Is there a different sense of moral obligation that could yield a duty to present generations to preserve the environment? Consider Parfit's own thoughts on the subject:

We need some new principle of beneficence, which is acceptable in all kinds of case. Though we have not yet found this principle, we know that it cannot take a person-affecting form. It will be about human well-being, and the quality of life, but it will not claim that what is morally most important is whether our acts will affect people for good or bad, better or worse. . . . [N]on-religious moral philosophy is a very young subject. We should not be surprised that much of it is still puzzling.²¹

I agree with the sentiment of these thoughts but take slight exception to Parfit's search for a moral principle. In fact, I think the search for moral principles and precepts can indirectly support much immoral conduct, because no matter how a principle is stated, it may be interpreted and construed in such a way as apparently to justify immoral behavior.²² In my view, it is better to begin with our preverbal *sense of morality*. That sense, I would suggest, tells us that it is somehow wrong to despoil the environment, to act in ways that waste natural resources and wildlife, and to gratify pleasures of the moment at the expense of living creatures who are no threat to us.²³

What George F. Will said about whales in a sense is true of all acts of environmental preservation: "The campaign to save whales is a rare and refreshing example of intelligence in the service of something other than self-interest."²⁴ Natural evolution has produced some prey-specific predatory animals that will hunt their prey to extinction, at which point they will become extinct themselves. Presumably if they had developed a greater intelligence, they would exercise restraint. Humans are lucky in that we are

²¹ Parfit, *Future Generations*, *supra* note 4, at 171-72.

²² In brief, any stated moral principle may be deconstructed. Contexts always exist in which a given moral principle, if strictly applied, would lead to an immoral result. See J. FLETCHER, *SITUATION ETHICS: THE NEW MORALITY* (n.d.); J. FLETCHER & J. W. MONTGOMERY, *SITUATION ETHICS: TRUE OR FALSE* (1972).

²³ Consider the most morally repugnant behavior of recent times: Hitler's policy of extermination of minority groups. This was "justified" at the time in terms of moral utilitarianism—the need to "purify" the human race. Yet even entering into the "debate" about the immorality of "Aryan supremacy" was to compromise one's moral position—for it amounted to giving some degree of intellectual credence to the Nazi position! In other words, it wasn't the *principle* of utilitarianism that was "misapplied" by the Nazis; rather, *any* attempt to apply a "principle" to their acts was itself perverse.

²⁴ Professor Weiss interprets this passage as calling for a return to "our natural instincts." See J. WEISS, *supra* note 20, at 277-78. But not everything that is preverbal is instinctual. Our sense of similarity (judging

that subjects are similar to others) is something we develop prior to learning the language—and must be a prerequisite to language learning—without being a matter of instinct. See R. M. HARE, *THE LOGICAL STRUCTURE OF THE WORLD* §§87-109 (George tr. 1967). I suspect much of the grounding of our developed sense of morality comes from thousands of situations that we analyze morally on the grounds of their similarity to other situations.

²⁵ J. D. DAY, *supra* note 18, at 9 (from Wash. Post).

blessed with the intelligence to figure out how to survive in an environment where we are not physically the strongest, fastest or best-protected animals. That same intelligence can be stretched to include a world-based empathy for the environment, "beneficent" in Parfit's sense.

We should not limit our actions to those we are able to determine now as directly or indirectly benefiting ourselves or our descendants. Rather, we should cultivate our natural sense of obligation not to act wastefully or wantonly even when we cannot calculate how such acts would make the present or future persons worse off.²⁵ There is good evidence that customary international law—with various fits and starts and setbacks—is moving generally in this direction, perhaps responding to a deep and inarticulate sense that human beings are not in confrontation with, but rather belong to, their natural environment. That such law is currently given the label "human rights" should not constrict our understanding of what it is or where it is going.

ANTHONY D'AMATO*

OUR RIGHTS AND OBLIGATIONS TO FUTURE GENERATIONS FOR THE ENVIRONMENT

This we know: the earth does not belong to man; man belongs to the earth. . . . Whatever befalls the earth, befalls the sons of the earth. Man did not weave the web of life; he is merely a strand in it. Whatever he does to the web, he does to himself.

Chief Seattle†

We read every day about the desecration of our environment and the mismanagement of our natural resources. We have always had the capacity to wreck the environment on a small or even regional scale. Centuries of irrigation without adequate drainage in ancient times converted large areas of the fertile Tigris-Euphrates valley into barren desert. What is new is that we now have the power to change our global environment irreversibly, with profoundly damaging effects on the robustness and integrity of the planet and the heritage that we pass to future generations.

In Fairness to Future Generations argues that we, the human species, hold the natural environment of our planet in common with all members of our

²⁵ This would be a pure example of deontological ethics in Kant's sense. For a brief discussion and references, see D'Amato & Eberle, *Three Models of Legal Ethics*, 27 ST. LOUIS U.L.J. 761, 772-73 (1983) ("a deontological theory of ethics says that some acts are morally obligatory regardless of their consequences for human happiness").

* Of the Board of Editors.

† Letter from Chief Seattle, patriarch of the Duwamish and Squamish Indians of Puget Sound, to U.S. President Franklin Pierce (1855). Although the letter appears in numerous anthologies, the original has never been located.

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species: past generations, the present generation, and future generations.¹ As members of the present generation, we hold the earth in trust for future generations. At the same time, we are beneficiaries entitled to use and benefit from it.

There are two relationships that must shape any theory of intergenerational equity in the context of our natural environment: our relationship to other generations of our own species and our relationship to the natural system of which we are a part.²

The human species is integrally linked with other parts of the natural system: we both affect and are affected by what happens in the system. The natural system, contrary to popular belief, is in many ways a hostile one. Deserts, glaciers, volcanoes, tsunamis can bring havoc to our species. Moreover, the natural environment can be toxic to our species, as through the natural toxicity of some plants and animals or the dramatic release of toxic clouds of carbon dioxide from Lake Nyos in the Cameroon, which killed 1,700 people. On the other hand, the natural system makes life possible for us. It gives us the resources with which to survive and to improve human welfare.

Our actions affect the natural system. We alone among all living creatures have the capacity to shape significantly our relationship to the environment. We can use it on a sustainable basis or we can degrade environmental quality and the natural resource base. As part of the natural system, we have no right to destroy its integrity; nor is it in our interest to do so. Rather, as the most sentient of living creatures, we have a special responsibility to care for the planet.

The second fundamental relationship is that between different generations of the human species. All generations are inherently linked to other generations, past and future, in using the common patrimony of earth.³

To define intergenerational equity, it is useful to view the human community as a partnership among all generations. In describing a state as a partnership, Edmund Burke observed that "as the ends of such a partnership cannot be obtained in many generations, it becomes a partnership not only between those who are living but between those who are living, those who

E. BROWN WEISS, IN *FAIRNESS TO FUTURE GENERATIONS: INTERNATIONAL LAW, COMMON PATRIMONY AND INTERGENERATIONAL EQUITY* (1989).

² The field of human ecology studies this relationship. See *READINGS IN MAN, THE ENVIRONMENT, AND HUMAN ECOLOGY* (A. S. Bougehev ed. 1973) (good selection of readings in human ecology); R. & P. WATSON, *MAN AND NATURE* (1969) (thoughtful essay).

³ Professor D'Amato criticizes existing theories of equity for depending on "an articulate link to the improvement of the human condition" (i.e., as anthropocentric), rather than on a "natural relationship with nature itself. It is certainly true that *In Fairness to Future Generations* is concerned with equity among generations of the human species. But it is equity with regard to the rate and use of the planet, which is explicitly rooted in the recognition that the human species is part of the natural system. This implies great respect for the natural system of which we are a part, but it does not imply that all other living creatures are or should be treated equally. Rather, the human species, as a part of this natural system, has a special obligation to maintain the integrity of the planet, so that all generations will be able to enjoy its fruits.

are dead, and those who are to be born."⁴ The purpose of human society must be to realize and protect the welfare and well-being of every generation. This requires sustaining the life-support systems of the planet, the ecological processes and the environmental conditions necessary for a healthy and decent human environment.

In this partnership, no generation knows beforehand when it will be the living generation, how many members it will have, or even how many generations there will ultimately be. It is useful, then, to take the perspective of a generation that is placed somewhere along the spectrum of time, but does not know in advance where it will be located.⁵ Such a generation would want to inherit the earth in at least as good condition as it has been in for any previous generation and to have as good access to it as previous generations. This requires each generation to pass the planet on in no worse condition than it received it in⁶ and to provide equitable access to its resources and benefits. Each generation is thus both a trustee for the planet with obligations to care for it and a beneficiary with rights to use it.

Intergenerational equity calls for equality among generations in the sense that each generation is entitled to inherit a robust planet that on balance is at least as good as that of previous generations. This means all generations are entitled to at least the planetary health that the first generation had.⁷ In practice, some generations may improve the environment, with the result that later generations will inherit a richer and more diverse natural resource base. In this case, they would be treated better than previous generations. But this extra benefit would be consistent with intergenerational equity, because the minimum level of planetary robustness would be sustained and later generations would not be worse off than previous generations. The converse is also possible, that later generations would receive a badly degraded environment with major loss of species diversity, in which case they would be treated worse than previous generations. This latter case would be contrary to principles of intergenerational equity. Equity among generations provides for a minimum floor for all generations and ensures that each generation has at least that level of planetary resource base as its ancestors. This concept is consistent with the implicit premises of trusteeship, stewardship and tenancy, in which the assets must be conserved, not dissipated, so that they are equally available to those who come after.

The theory of intergenerational equity finds deep roots in international law.⁸ The Preamble to the Universal Declaration of Human Rights begins, "Whereas recognition of the inherent dignity and of the equal and inalienable rights of all members of the human family is the foundation of freedom, justice and peace in the world." The reference to all members of the human

⁴ E. BURKE, *Reflections on the Revolution in France* 139-40 (1790), in 2 WORKS OF EDMUND BURKE 368 (London 1854).

⁵ See J. RAWLS, *A THEORY OF JUSTICE* (1971).

⁶ See Callahan, *What Obligations Do We Have to Future Generations?*, in *RESPONSIBILITIES TO FUTURE GENERATIONS* 73 (E. Partridge ed. 1981).

⁷ See B. ACKERMAN, *SOCIAL JUSTICE IN THE LIBERAL STATE* (1980).

⁸ E. BROWN WEISS, *supra* note 1, at 25-26.

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family has a temporal dimension, which brings all generations within its scope. The reference to equal and inalienable rights affirms the basic equality of these generations in the human family.

The United Nations Charter, the International Covenant on Civil and Political Rights, the Convention on the Prevention and Punishment of the Crime of Genocide, the American Declaration on the Rights and Duties of Man, the Declaration on the Elimination of Discrimination against Women, the Declaration on the Rights of the Child and many other human rights documents protect the dignity of all people and the equality of their rights. The Declaration of the Principles of International Cultural Co-operation provides in Article 1 that "each culture has a dignity and value which must be respected and preserved," and that "all cultures form part of the common heritage belonging to mankind." These instruments reveal a fundamental belief in the dignity of all members of human society and in an equality of rights that extends in time as well as space. Indeed, if we were to license the present generation to exploit our natural and cultural resources at the expense of the well-being of future generations, we would contradict the purposes of the United Nations Charter and international human rights documents.

It is not enough, however, to apply a theory of intergenerational equity only among generations. It also carries an intragenerational dimension. When future generations become living generations, they have certain rights and obligations to use and care for the planet that they can enforce against one another. Were it otherwise, members of one generation could allocate the benefits of the world's resources to some communities and the burdens of caring for it to others and still potentially claim on balance to have satisfied principles of equity among generations.

Moreover, the fulfillment of intergenerational obligations requires attention to certain aspects of intragenerational equity. As is well-known, poverty is a primary cause of ecological degradation. Poverty-stricken communities, which by definition have unequal access to resources, are forced to overexploit the resources they do have so as to satisfy their own basic needs. As an ecosystem begins to deteriorate, the poor communities suffer most, because they cannot afford to take the measures necessary to control or adapt to the degradation, or to move to pristine areas.

Thus, to implement intergenerational equity, countries need to help poor communities to use the natural environment on a sustainable basis, to assist them in gaining equitable access to the economic benefits from our planet, such as potable water, and to help protect them from degraded environmental quality. As beneficiaries of the planetary legacy, all members of the present generation are entitled to equitable access to and use of the legacy. The future nationals of all countries will benefit from efforts of the present generation to protect the general planetary environment for future generations. Conversely, all will suffer if the present generation does not make such efforts.

I have proposed three basic principles of intergenerational equity. First, each generation should be required to conserve the diversity of the natural

and cultural resource base, so that it does not unduly restrict the options available to future generations in solving their problems and satisfying their own values, and should also be entitled to diversity comparable to that enjoyed by previous generations. This principle is called "conservation of options." Second, each generation should be required to maintain the quality of the planet so that it is passed on in no worse condition than that in which it was received, and should also be entitled to planetary quality comparable to that enjoyed by previous generations. This is the principle of "conservation of quality." Third, each generation should provide its members with equitable rights of access to the legacy of past generations and should conserve this access for future generations. This is the principle of "conservation of access."

These proposed principles constrain the actions of the present generation in developing and using the planet, but within these constraints do not dictate how each generation should manage its resources.

These principles of intergenerational equity form the basis of a set of intergenerational obligations and rights, or planetary rights and obligations, that are held by each generation. These rights and obligations derive from each generation's position as part of the intertemporal entity of human society.

Planetary rights and obligations are integrally linked. The rights are always associated with obligations. They are rights of each generation to receive the planet in no worse condition than did the previous generation, to inherit comparable diversity in the natural and cultural resource bases, and to have equitable access to the use and benefits of the legacy. They represent in the first instance a moral protection of interests, which must be transformed into legal rights and obligations.

Planetary rights and obligations coexist in each generation. In the *intergenerational* dimension, the generations to which the obligations are owed are future generations, while the generations with which the rights are linked are past generations. Thus, the rights of future generations are linked to the obligations of the present generation. In the *intragenerational* context, planetary obligations and rights exist between members of the present generation. They derive from the *intergenerational* relationship that each generation shares with those who have come before and those yet to come. Thus, intergenerational obligations to conserve the planet flow from the present generation both to future generations as generations and to members of the present generation, who have the right to use and enjoy the planetary legacy.

Intergenerational rights of necessity inhere in all generations, whether these be immediately successive generations or ones more distant. There is no theoretical basis for limiting such rights to immediately successive generations. If we were to do so, we would often provide little or no protection to more distant future generations. Nuclear and hazardous waste disposal, the loss of biological diversity and ozone depletion, for example, have significant effects on the natural heritage of more distant generations.

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Intergenerational planetary rights may be regarded as group rights, as distinct from individual rights, in the sense that generations hold these rights as groups in relation to other generations—past, present and future.⁹ They exist regardless of the number and identity of individuals making up each generation. When held by members of the present generation, they acquire attributes of individual rights in the sense that there are identifiable interests of individuals that the rights protect. However, those interests derive from the fact that those living now are members of the present generation and have rights in relation to other generations to use and benefit from the planet. The remedies for violations of these rights will benefit other members of the generation, not only the individual.¹⁰

Developments in international law outside the field of the environment make acceptance of intergenerational rights a natural and desirable evolution. Indeed, international human rights law—the genocide convention, and the prohibition against racial discrimination, to cite two examples—are arguably directed as much to the protection of future, as to present, generations. The extinction of, for example, an entire people is more odious in law than the murder of an equal number of people constituting a minority of each of several groups. Similarly, discrimination denies an "equal place at the starting gate" not only to the generation of the suppressed group but (by implication) also to future generations. Provisions in other human rights agreements refer to rights of children and of the elderly, and to education and training, which are implicitly temporally oriented.

One might still ask whether it is not preferable to speak only of planetary obligations toward future generations without corresponding intergenerational rights. Can intergenerational obligations exist without rights?¹¹ While rights are always connected to obligations, the reverse is not always true. Theoretically, an obligation need not always entail a right. For example, a moral obligation of charity does not give those who benefit a right to charity. The legal positivist Hans Kelsen hesitated to find a legal right connected to certain legal obligations.

⁹ For a thoughtful analysis of group rights in relation to goods that are enjoyed together, see J. Waldron, *Can Communal Goods Be Human Rights?* (paper delivered at Conference on Development, Environment and Peace as New Human Rights, Oxford University, Oxford, England, May 28-31, 1987).

¹⁰ The temporal dimension may offer a theoretical basis for unifying those human rights that we now consider to be group or social rights and for so-called new human rights. Group rights, such as cultural rights, have a temporal dimension since the community inherently extends over time. Theoretically, rights to development, to food, to health, and to the environment can be seen as intergenerational, or intertemporal, in that they are rights of access of each generation to use and benefit from our natural and cultural resources. See E. BROWN WEISS, *supra* note 1, at 114-15.

¹¹ Bryan Norton, a philosopher, argues that if one accepts the conceptual model of rights as limited to individual rights (which he does), it is preferable to recognize general obligations toward the integrity of environmental systems rather than to discuss environmental protection in the framework of rights, since this framework cannot encompass such categories as future generations, whose individual members are still contingent. Norton, *Environmental Ethics and the Right of Future Generations*, 7 *SOC. THEORY & PRAC.* 319, 337 (1981).

If the obligated behavior of one individual does not refer to a specifically designated other individual . . . but refers only to the legal community as such, then . . . one is satisfied . . . to assume a legal obligation without a corresponding reflex right: for example in case of the legal norms that prescribe a certain human behavior toward some animals, plants, or inanimate objects by pain of punishment. It is forbidden to kill certain animals at certain times (or altogether), to pick certain flowers, to cut certain trees or to destroy certain historical monuments. These are obligations which—indirectly—exist toward the legal community interested in these objects.¹²

John Austin described some obligations as absolute duties, which exist independently of any correlative right. He defined absolute duties as those prescribing actions toward parties other than the one obliged, who are not determinate persons, such as members generally of an independent society and mankind at large.¹³

If we were to follow this analysis, we would contend that the obligations of the present generation to future generations constitute obligations or duties for which there are no correlative rights, because there are no determinate persons to whom the right attaches. Similarly, in the intragenerational context, obligations to conserve diversity, quality and access would be viewed as absolute duties for which there is no correlative right.

While this approach may be attractive, it ignores the fundamental temporal relationship that each generation has to all other generations and that gives rise to the rights of each generation to share equitably in the use of the planet and its natural resources. These rights focus discussion on the welfare of generations, what each generation is able to have and to enjoy, in a way that obligations cannot. If obligations of the present generation are not linked with rights, the present generation has a strong incentive to bias the definition of these obligations in favor of itself at the expense of future generations. Intergenerational rights have greater moral force than do obligations. They provide a basis for protecting the interests of all generations in a healthy and robust planet.

Professor D'Amato in his essay takes issue with the notion of rights of future generations to the planet by invoking Derek Parfit's famous paradox and combining it with the new theory of chaos. He argues that future generations cannot have rights because they are composed of individuals who do not exist yet and every intervention we take today to protect the environment affects the composition of these future individuals, robbing some potential members of future generations of their existence.

It is important to parse this analysis into its two component parts: that future generations cannot have rights because the individuals do not exist yet, and that actions to protect the environment for future generations will destroy the rights of some future individuals because different people will be born as a result of the intervention. The first is that future generations

¹² H. KEISEN, *PURE THEORY OF LAW* 62 (M. Knight trans. 1969).

¹³ J. AUSTIN, *AUSTIN'S JURISPRUDENCE, LECTURES ON JURISPRUDENCE* 413-15 (1873).

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cannot have rights, because rights exist only when there are identifiable interests, which can only happen if we can identify the individuals who have interests to protect. Since we cannot know who the individuals in the future will be, it is not possible for future generations to have rights.

This paradox assumes the traditional conceptual framework of rights as rights of identifiable individuals. The planetary, or intergenerational, rights proposed in *In Fairness to Future Generations* are not rights possessed by individuals. They are, instead, *generational* rights, which must be conceived of in the temporal context of generations. Generations hold these rights as groups in relation to other generations—past, present and future. This is consistent with other approaches to rights, including the Islamic approach, which treats human rights not only as individual rights, but as “rights of the community of believers as a whole.”¹¹ They can be evaluated by objective criteria and indices applied to the planet from one generation to the next. To evaluate whether the interests represented in planetary rights are being adequately protected does not depend upon knowing the number or kinds of individuals that may ultimately exist in any given future generation.

Enforcement of these intergenerational rights is appropriately done by a guardian or representative of future generations as a *group*, not of future individuals, who are of necessity indeterminate. While the holder of the right may lack the capacity to bring grievances forward and hence depends upon the representative’s decision to do so, this inability does not affect the existence of the right or the obligation associated with it.

Now it may be argued that such rights do depend upon knowing at least the number of individuals in the future, because if the earth’s population continues to grow rapidly, the amount of diversity and degree of quality that must be passed on will be higher than if the population in the future were at the same level or less than it is today.

But, if anything, the existence of these generational rights to the planet may constrain the population policies of present and future generations. Whether a generation chooses to meet its obligations by curtailing exploitation, consumption and waste or by constraining population growth is a decision it must make. The fact that future generations have a generational right to receive the planet in a certain condition puts constraints on the extent to which a present generation can ignore this choice.

The second part to Professor D’Amato’s argument is that if we intervene to conserve the environment to protect future generations, we cannot succeed in protecting them because our intervention will cause a different group of individuals to emerge. But since the rights of future generations exist only as generational rights, it does not matter who the individuals are or how many they may be. Only at the point where the individuals are born do they by definition become members of the present generation do the generational rights attach to individuals.

Professor D’Amato’s response is that “[f]uture generations are not an abstraction; they consist of individuals.” But they do not consist of individ-

uals until they are born, and hence it is necessary and appropriate to speak of future generations qua generations as having rights in relation to the planet.

Professor D'Amato correctly points out that the composition of future generations cannot be known in advance, in part because it is affected by actions of the present generation. Indeed, he does not make his own case as strongly as he might. For example, we do not need to limit ourselves to ascribing these effects to subtle changes in the biochemistry of conception as Professor D'Amato does in his amusing excursion into the dynamics of egg and sperm.

Virtually every policy decision of government and business affects the composition of future generations, whether or not they are taken to ensure their rights under the guidelines enunciated above. Decisions regarding war and peace, economic policy, the relative prosperity of different regions and social groups, transportation, health, education—all influence the demographics and the composition of future generations by affecting the lives and fortunes of the present generation: who will succeed and prosper, who will marry whom, who will have children, and even who will emigrate.

In Fairness to Future Generations takes the view that our planetary obligations to future generations are owed to all the earth's future human inhabitants, whoever they may be. This opens the possibility that these decisions, too, deserve to be scrutinized from the point of view of their impact on future generations. Professor D'Amato's approach reflects an unnecessarily constrained view of human rights law that would shut off a useful and broadly acceptable theoretical underpinning to sustainable resource development. The possibility that intergenerational equity may place limits on our actions is an important new area of human rights research.

Such limitations should be applied very narrowly, lest the rights of future generations develop into an all-purpose club to beat down any and all proposals for change. But surely long-term environmental damage is a good place to begin. Future generations really do have the right to be assured that we will not pollute ground water, load lake bottoms with toxic wastes, extinguish habitats and species or change the world's climate dramatically—all long-term effects that are difficult or impossible to reverse—unless there are extremely compelling reasons to do so, reasons that go beyond mere profitability.

Professor D'Amato invokes chaos theory to justify his contention that any environmental intervention will produce different individuals in the future than would otherwise have been produced. But he overlooks the most important implication of chaos theory for the environment and for future generations: namely, that systems do not proceed on orderly, linear paths of change, but rather that they will abruptly change.¹⁵ This can be demonstrated on a home computer, using a very simple program. It has been

¹⁵ For catastrophe theory, see R. THOM, *MATHEMATICAL MODELS OF MORPHOGENESIS* (1983); for the theory of complex systems, see I. PRIGOGINE & I. STENGERS, *ORDER OUT OF CHAOS: MAN'S NEW DIALOGUE WITH NATURE* (1984). For a concise review of the influence of chaos theory, see *Chaos Theory: How Big an Advance?*, 245 SCIENCE 26 (1989).

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suggested that there may be key breaking points in our global environmental system, beyond which systems will reorganize and substantially change their properties.¹⁶ If we are concerned about future generations, it is important to try to predict these breaking points. More importantly, the best tool that we could give future generations to respond to abrupt changes and reorganizations is a robust planet, which requires conserving a diversity of resources so that future generations have greater flexibility in designing responses.

Professor D'Amato proposes that there is a "preverbal sense of morality" that tells us not to waste resources, degrade the environment or wantonly kill animals. But, if anything, history in the last few centuries suggests that our natural instincts are self-indulgent. We have desecrated environments, wasted resources and slaughtered animals purely for pleasure or for modest personal gain. It may be that the human species carries both a selfish gene and an altruistic one, as the sociobiologists tell us,¹⁷ but it is hardly sufficient to rely on the generous gene to build a theory of morality to overcome the selfish genes, without more.

In Fairness to Future Generations relies on a fundamental norm of equality among generations of the human species in relation to the care and use of the natural system. But it recognizes that we are part of the natural system and that we, as all other generations, must respect this system. We have a right to use and enjoy the system but no right to destroy its robustness and integrity for those who come after us.

Whether we rely on a beneficent "preverbal sense of morality" toward the planet and its resources or on theories rooted in the welfare of the human condition and the ecological system of which people are a part, there is a shared recognition that the present generation has an obligation to care for the planet and to ensure that all peoples can enjoy its services.

EDITH BROWN WEISS*

OUR RESPONSIBILITY TO FUTURE GENERATIONS

In recent years, lawyers have begun to join ecologists in debating whether there are—or should be—obligations to protect the interests of future generations.¹ This legal debate was preceded by a philosophical one, dating back to the early 1970s, on the emergence of a new or "ecological" ethic

* G. Gallopini, President, Fundación Bariloche, discussion with author, June 1986. This is consistent with the scientific paradigms in the theories of catastrophe and of the dynamics of complex systems far from equilibrium.

¹ See S. J. & J. BALDWIN, *BEYOND SOCIOBIOLOGY* (1981). Sociobiologists assert that there are two types of inherent behavior that explain all our social behavior: selfish, altruistic, cooperative and spiteful. Humans act so as to try to ensure that their genes will be carried forward into succeeding generations. *Id.* at 49-50.

* On the Board of Editors.

For the German-speaking context, see P. SALADIN & C. A. ZENGER, *RECHTE KUNFTIGER GENERATIONEN* (1988).

redefining the relationship between man and nature in such a way as to ensure the survival of the human species on earth.² The background to these various ethical approaches has been the indisputable fact that humanity has accumulated a monstrous potential to destroy life on earth, and that it is using natural resources and the environment in a way that threatens the survival of future generations—at least, at a standard that we today consider worthy of human beings.

There is good reason to deal with our responsibility to future generations not only as a moral postulate, but also as a legal principle; I will return to that below.³ As to international law, one can state that the debate no longer is merely an academic one, but rather has found its way into international politics, which may mean that it has crossed the threshold of the law-creating process. The protection of future generations is mentioned specifically in various international instruments.⁴ In addition, responsibility to future generations is the implied subject of several recent developments: I am referring to the various efforts at the international level to reach a consensus on paths toward "sustainable development." In this context, "sustainable development" is to be understood as development that takes into account not only the needs and interests of the present generation, but also those of generations to come.

A major achievement of these efforts has been the report *Our Common Future*⁵ of the World Commission on Environment and Development (WCED). The WCED—generally referred to as the "Brundtland Commission," after its chairperson, Prime Minister Gro Harlem Brundtland of Norway—had been asked by the Secretary-General of the United Nations "to propose long-term environmental strategies for achieving sustainable development by the year 2000 and beyond." The WCED defined "sustainable development" as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."⁶ This definition clearly shows that the debate on "sustainable development" is, in fact, a discourse on our responsibility to future generations. The WCED proposed a set of legal principles for "sustainable development,"⁷ and suggested that a global convention on "environment and development" be prepared on the basis of those principles.⁸ The date envisaged

² H. JONAS, DAS PRINZIP VERANTWORTUNG (1979); ÖKOLOGIE UND ETHIK (D. Birnbacher ed. 1980); RESPONSIBILITIES TO FUTURE GENERATIONS: ENVIRONMENTAL ETHICS (E. Partridge ed. 1980).

³ See part III *infra*.

⁴ See Weiss, *The Planetary Trust: Conservation and Intergenerational Equity*, 11 *ECOLOGY L.Q.* 495, 540 ff. (1984).

⁵ WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT, *OUR COMMON FUTURE* (1987) [hereinafter *OUR COMMON FUTURE*].

⁶ *Id.* at 43.

⁷ *Id.* at 348 (Ann. I); see also EXPERTS GROUP ON ENVIRONMENTAL LAW OF THE WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT, *ENVIRONMENTAL PROTECTION AND SUSTAINABLE DEVELOPMENT* (1987).

⁸ *OUR COMMON FUTURE*, *supra* note 5, at 332.

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⁹ *Id.*¹⁰ *S.*¹¹ *Id.*

by the Commission for the adoption of the convention (1988)⁹ has already passed, but there is some hope that such a convention could be adopted by 1992.

That protecting future generations raises some basic conceptual problems is demonstrated by the preceding articles by Anthony D'Amato and Edith Brown Weiss. Although it is difficult to accept all his arguments,¹⁰ Professor D'Amato is right in saying that duties of protecting future generations can be disputed and need to be justified. Duties toward future generations—or rights of future generations¹¹—ultimately rest on a value judgment: the fundamental assumptions that the human species (and all other species, since man is an inseparable part of nature) should survive, and that future generations are entitled to live in dignity. Professor Weiss shows in her article, as she has done previously,¹² that there is good reason to make this value judgment and to define its implications. According to Professor Weiss, future generations have rights and duties: rights flowing from preceding generations, duties toward the generations to follow. "Intergenerational equity," she continues, requires observance of three basic principles: conservation of options, conservation of quality, and conservation of access.

Both contributors deal with different dimensions of the subject, but both argue at a relatively abstract level. For this reason, I would like to add a view to the debate that may be a little more pragmatic. Given the limitations of an *Agora* contribution, my remarks will necessarily be abbreviated.

I. WHY A RESPONSIBILITY TO FUTURE GENERATIONS?

The starting point for all considerations concerning a responsibility to future generations has already been mentioned above. It is this: the way we currently deal with nature and the environment clearly threatens the survival of humankind under conditions worthy of human beings. If we are not prepared fundamentally to change our life style, i.e., our way of producing and consuming, we will plunder and irreversibly damage our bases of life in a very short time. However, even if we accept this proposition as true, there remains the additional question whether we are obliged to prevent the disaster from occurring to our posterity. This question involves both morals and the law. The responsibility to act does not result solely from the fact that posterity is threatened. It must also be manifest that it is our will that humankind should survive.

In my view, there can be no doubt that this will exists, and that it is based on a worldwide consensus. As Professor Weiss has shown in her previous work,¹³ the interest in survival is deeply rooted in the thinking of all peoples. And whenever we find different attitudes as to a responsibility of future generations, the reason is certainly not that the consensus I mentioned does not exist. More likely, the threat to posterity is considered less dramatic ("It will certainly not be that bad"), or future generations are given more credit

⁹ *Id.* at 333.

¹⁰ See part II *infra*.

¹¹ *Id.* at 499 ff.

¹² See part I *infra*.

¹³ Weiss, *supra* note 4.

for being able to cope with the problems ("People have always found a way; they'll make it this time, too").

Even if there is global consensus that the human species is to survive, do Parfit's paradox and, or chaos theory compel a different approach to that objective, as Professor D'Amato tells us? Professor D'Amato's argument seems to be that if we act in the interest of future generations, we will deprive the concrete individuals to be born of their identity, which, as suggests, is the most serious infringement of the interests of future generations.

Professor D'Amato is right in saying that if we care for, and act in the interest of, future generations, the individuals who will be born will not be the same as they would have been if we had not done so. They will certainly have a different identity. However, it is neither logically compelling nor acceptable that identity, as defined by Parfit (and Professor D'Amato), be the sole and decisive criterion for our behavior toward future generations.

The reasoning behind the identity and chaos arguments seems to be that man should not interfere with historic events so as to preserve all options for posterity. What is overlooked is that man always interferes with history, even when he is not aware of, and taking care of, future generations. "Identity" in Parfit's (and Professor D'Amato's) sense in any event results from what man is doing today. The identity of future individuals is always constituted by the behavior of the preceding generations. Intervention is an inescapable fact of life. The only question is whether the interventions are conscious, deliberate and concerned, or not.

If we follow the identity/chaos arguments, future persons will have an identity we need not envy. And for many, the problems will not be raised because they will not be born at all.

II. RIGHTS OF OR DUTIES TOWARD FUTURE GENERATIONS?

If we accept that there is a responsibility to future generations, the question arises whether there are—should be—"only" duties of present generations. Professor Weiss, like others,¹¹ argues strongly in favor of rights of future generations, for which she offers a theoretical rationale; she also believes that rights of future generations would have "greater moral force" than obligations of present ones.

I do not have any difficulty in following Professor Weiss's concept of rights of future generations, though it transcends the traditional understanding of rights, which ordinarily has reference to the individual. I also share the view that rights of future generations have "greater moral force" than mere obligations of present generations. However, I should like to suggest that the whole controversy should not be concentrated on the issue of rights of, or duties toward, future generations. This is really not the major problem, and it should therefore not consume all our time, energy and imagination. The major problem is what we have to do today to meet our responsibility to future generations—what the concrete obligations are—and how we can fulfill these obligations under the present circumstances

¹¹ P. SALADIN & C. A. ZENGER, *supra* note 1.

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of the international community. This remains the major problem even if we recognize rights of future generations because, as Professor Weiss rightly observes, rights are always connected to obligations.

Consequently, I prefer to emphasize the need to work, now, toward a global consensus on what those obligations entail. Specifically, the consensus should encompass a duty of our present generation to preserve nature and the environment so as to enable future generations to live on the same standard as we claim today. As soon as we reach this consensus—which should not really be difficult—we should apply all our powers of reasoning to define its fundamental implications. What we need are basic principles for acting in the interest of future generations.

We cannot simply rely on the assumption that our way of dealing with nature and the environment will turn out to be harmless. Nor can we expect that future generations will develop the knowledge and technology necessary to cope with all the problems they inherit from us. Therefore, today we must take true preventive action, or more precisely, precautionary action,¹⁵ which will ensure that natural resources are used sparingly and that degradation of the environment is reduced to a minimum. After two decades of experience with environmental protection, we know that we will not be successful if we only make marginal corrections or take sporadic protective measures. The objective of true preventive environmental protection will only be achieved if we change, fundamentally and on a global level, our way of running the economy. This, in turn, will be achieved only if we change our basic system of values. Economic growth is not per se an indicator of progress, nor is wealth necessarily an indicator of prosperity.

The most difficult challenge to all efforts to define and achieve "inter-generational equity" will turn out to be that we have failed to achieve equity within our own generation. The economic development of states continues to be fiercely unequal. Inequality of development is also reflected in the state of the environment; the environmental problems of many developing countries are far more serious than those of industrialized countries. Thus, we face a twofold challenge: we have to meet the "old" responsibility to achieve equity within the present generation and we have to be concerned about the future of humankind. These duties are linked to each other: poverty in the countries of Africa, Asia and Latin America is one of the most serious threats to future generations. One could also put it this way: without equity within the present generation, we will not be able to achieve equity among generations.

The inequities of the present imply that we cannot solve the problems of the future simply by postulating a global collective sacrifice. For many countries, restrictions would not be possible and would even deteriorate the economy and, thus, the environment. Many countries need development for the very reason that it is an essential prelude to finding long-term solutions to environmental problems. As a result, we also require a new order for the use of nature and the environment by the members of the

¹⁵ See Gundling, *The Status of International Law and the Principle of Precautionary Action*, INT'L J. ESTUARINE & COASTAL E. (forthcoming).

present generation, and any catalog of principles for our behavior toward future generations must take into account the unequal development that exists today and must provide for principles of allocation designed to overcome that inequality. I do not know whether we will be able to solve this tremendous problem, or how; but I am convinced that we have to work on it if the idea of equity really means something to us.

III. THE ROLE OF INTERNATIONAL LAW

Protecting the environment is primarily a duty of the state. It is the state that has to direct societal life in a way that ensures that the natural bases of life are preserved. Therefore, the postulate that we are responsible to future generations is, first of all, directed at the state and requires that the state adopt a policy, at both the national and international levels, that meets this responsibility.

Responsibility to future generations should entail not only moral duties but also duties of law. The threat to future generations is too serious, and the task of warding off this threat too complex, to be left to the informal and often uncertain domain of morals. Law should provide for the fundamental duty to preserve the environment for the benefit of future generations, and it should also provide the basic principles that states must observe in fulfilling this duty. The fundamental duty and basic principles should be part of both national and international law; without doubt, the responsibility to future generations is the common task of all states.

As has been demonstrated by Professor Weiss,¹⁶ the idea of protecting the interests of future generations has already been introduced into international politics and international law. However, this introduction is no more than a point of departure. We need universal and unequivocal recognition of the duty to protect the interests of future generations, as well as of the principles necessary to implement that duty. This recognition cannot be left to the development of customary law but, rather, has to be achieved on the basis of a treaty. I would therefore like to join all those who argue for a universal convention on the basic obligations of states to protect the environment; the duty to future generations should have a prominent place in the framework of this convention.

Among the basic principles provided for in the convention should be, to name only a few: the obligation to pursue a preventive (precautionary) environmental policy; the obligation to reduce environmental pollution to a minimum; and the obligation to develop technologies that do not harm the environment. In addition, the convention would have to allow for the economic development of the states of Africa, Asia and Latin America so as to meet the requirement of equity within our present generation and to solve the problems of poverty-based environmental degradation.

LOTHAR GÜNDLING*

¹⁶ Weiss, *supra* note 4, at 540 ff.

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by Barbara Wells

Natural Resources Policy Studies
Center for Policy Research

National Governors' Association

The National Governors' Association, founded in 1908 as the National Governors' Conference, is the instrument through which the nation's Governors collectively influence the development and implementation of national policy and apply creative leadership to state issues. The association's members are the Governors of the fifty states, the commonwealths of the Northern Mariana Islands and Puerto Rico, and the territories of American Samoa, Guam, and the Virgin Islands. The association has seven standing committees on major issues: Agriculture and Rural Development; Economic Development and Technological Innovation; Energy and Environment; Human Resources; International Trade and Foreign Relations; Justice and Public Safety; and Transportation, Commerce, and Communications. Subcommittees and task forces that focus on principal concerns of the Governors operate within this framework.

The association works closely with the administration and Congress on state-federal policy issues through its offices in the Hall of the States in Washington, D.C. The association serves as a vehicle for sharing knowledge of innovative programs among the states and provides technical assistance and consultant services to Governors on a wide range of management and policy issues.

The Center for Policy Research is the research and development arm of NGA. The center is a vehicle for sharing knowledge about innovative state activities, exploring the impact of federal initiatives on state government, and providing technical assistance to states. The center works in a number of policy fields, including agriculture, economic development, education, environment, health, social services, training and employment, trade, and transportation.

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Preface

Despite uncertainties about the timing, rate, and magnitude of global climate change, its potentially devastating consequences cannot be ignored. The Governors acknowledged the urgency of this challenge by adopting a comprehensive climate change policy at their 1990 annual meeting. The policy recommends measures that provide a reasonable return on investment and offer social and economic benefits beyond stabilizing or reducing greenhouse gas concentrations.

This report expands upon the NGA policy by presenting examples of state programs that reduce or offset greenhouse gas emissions while achieving other important objectives. The project was administered by NGA's Environment, Health, and Safety Program under the direction of Jim Solyst, with funding provided through a cooperative agreement with the U.S. Environmental Protection Agency's Office of Research and Development.

NGA obtained information on the state programs with the assistance and cooperation of numerous state officials. The author wishes to thank Carol Dee Angel, MetroPool, Inc.; Larry Bean, Iowa Department of Natural Resources; Jonathan Colman, The Rideshare Company; Senator Robert Cowles, Wisconsin State Senate; Jerry Dion, Arizona Energy Office; Lloyd Eagan, Wisconsin Department of Natural Resources; Bryan Forbis, Missouri Department of Natural Resources; Bea Friedman, MetroPool, Inc.; Lance Green, Wisconsin Department of Natural Resources; Paul Hibbard, Massachusetts Department of Public Utilities; Julian Jones, U.S. Environmental Protection Agency, Air and Energy Engineering Research Laboratory; Elizabeth Robertson, Georgia Office of Energy Resources; Sam Sadler, Oregon Department of Energy; Roya Stanley, Iowa Department of Natural Resources; Jean Stimolo, Rideworks of Greater New Haven; and Henry Yoshimura, Massachusetts Department of Public Utilities.

Special thanks to Mary Houghton who edited the report.

John Thomasian
Director
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Executive Summary

Global climate change threatens to have potentially devastating consequences that have only begun to be explored, understood, and addressed. Yet countless well-established state programs already are chipping away at the nation's greenhouse gas emissions. By integrating and building upon these efforts, each state can make a significant contribution to preventing climate change.

In July 1990, the National Governors' Association (NGA) adopted a strong policy on curbing the greenhouse effect. The policy acknowledges the compelling findings of the NGA Task Force on Global Climate Change, which reported the following:

- Carbon dioxide, carbon monoxide, methane, nitrous oxide, chlorofluorocarbons (CFCs), and other greenhouse gases trap heat in the earth's atmosphere.
- Atmospheric concentrations of greenhouse gases are rapidly increasing due to human activities.
- There is a scientific consensus that within decades this increase will raise the average global temperature by 3 degrees to 10 degrees Fahrenheit.
- Such a temperature change will alter the global climate, potentially increasing the frequency and severity of droughts, storms, beach erosion, and flooding, and causing desertification and the migration of agricultural and forest zones.
- Controlling greenhouse gas emissions, primarily through energy policy, is central to mitigating potential climate change.
- States can have a major influence over greenhouse gas emissions through their utility, land-use, transportation, taxation, and other authorities.

The NGA policy recommends measures that provide a reasonable return on investment and offer social and economic benefits beyond stabilizing or reducing greenhouse gas concentrations. It calls on states to encourage energy efficiency through utility regulation and transportation management; to stop the production of chlorofluorocarbons and recycle those in use; to develop and commercialize alternative and renewable energy sources; and to implement forestry programs to increase carbon storage.

Many states already have instituted the kinds of programs that the policy recommends. These programs illustrate the multiple benefits of emissions reduction strategies. For example:

- Utility regulations in Massachusetts and solar energy demonstration projects in Arizona are designed to discourage use of energy sources that emit greenhouse gases, and also to reduce pollution, energy production costs, and dependence on foreign oil.
- Iowa's Building Energy Management Program cuts emissions from electricity-generating plants while lowering the energy costs of schools and state agencies. In 1990, carbon dioxide emission reductions averaged 125 tons per building.
- A ride sharing program in Connecticut helps commuters organize car pools and better utilize mass transit, resulting in lower vehicular greenhouse gas emissions as well as reduced highway maintenance and construction costs, improved traffic flow and parking access, and cleaner air. The state's 12,000 car pools and 180 van pools eliminate an estimated 83,000 tons of carbon dioxide emissions per year.
- Energy-efficient agricultural practices promoted in Georgia reduce greenhouse gas emissions and increase profit margins for farmers and processors. For example, energy saving techniques for the state's broiler industry could eliminate 31,030 tons of carbon dioxide each year.
- A new Wisconsin law requiring control and recycling of chlorofluorocarbons will help curb the effects of this gas on both climate and the stratospheric ozone layer that protects the earth from ultraviolet radiation.
- Trees planted as part of a program in Missouri will absorb and store carbon while shading and cooling urban areas, reclaiming mining lands, preventing soil erosion, purifying water runoff, and beautifying the state. One reforestation project will produce 2 million trees, which will annually displace almost 200,000 tons of carbon dioxide.

Several states are integrating such multipurpose programs into state global climate change strategies. These comprehensive approaches have helped states like Oregon first identify the ways state agencies can cut greenhouse gas emissions and then coordinate and encourage their implementation. Because no single state agency has authority to influence every source of greenhouse gas emissions, statewide strategies may prove to be the best tool for achieving and measuring significant reductions.

1.

Introduction

The term “greenhouse effect” refers to the capacity of certain gases to permit solar radiation to reach the earth’s surface and then limit its escape back into space, causing warming of the atmosphere. Greenhouse gases include carbon dioxide, carbon monoxide, volatile organic compounds, nitrous oxide, methane, and chlorofluorocarbons (CFCs). Over the past 100,000 years, periods of high levels of atmospheric carbon dioxide, the predominant greenhouse gas, have roughly corresponded with periods of high average global temperature, lending credence to the greenhouse theory.

However, scientists have found there is no simple correlation between greenhouse gas levels and temperature because various factors, such as the interaction of the atmosphere with land masses and oceans, alter the greenhouse effect. Existing mathematical models do not predict with certainty the extent, rate, and timing of global temperature change, but they do indicate that some warming due to increased greenhouse gas concentrations in the atmosphere is likely.

Since 1958, annual measurements of carbon dioxide and other greenhouse gases in the atmosphere have shown that concentrations of these gases are rapidly increasing. The U.S. Environmental Protection Agency (EPA) and others have estimated that at current emission rates, atmospheric concentrations of carbon dioxide will have doubled from pre-industrial levels by the middle of the next century. Because carbon dioxide has a life span of 100 years and some other greenhouse gases remain in the atmosphere and stratosphere even longer, their effects on global climate will continue long after emissions are stabilized or reduced.

Atmospheric Greenhouse Gas Concentrations and Their Sources

Calculating total greenhouse gas emissions and identifying their sources to establish baseline information for measuring reductions is a monumental task. EPA’s Air and Energy Engineering Research Laboratory published preliminary estimates in an October 1990 report, *National- and State-Level Emissions Estimates of Radiatively Important Trace Gases (RITGs) From Anthropogenic Sources*. The report estimated annual emissions of carbon dioxide, carbon monoxide, methane, volatile organic compounds, nitrous oxide, and chlorofluorocarbons in the contiguous United States. These estimates did not reflect emissions from all possible sources; they covered only the major source categories for which emissions data were readily available.

Emissions of carbon dioxide were by far the greatest—an estimated 5.52 billion tons. According to the report, 35 percent of these emissions came from

utilities, 26 percent from industrial combustion, 24 percent from transportation, and 15 percent from residential and commercial sources (see Figure 1). Emissions of carbon monoxide, an ozone precursor, were the next highest at 60.9 million tons. Transportation sources accounted for 70 percent of the carbon monoxide emissions, with 11 percent attributed to residential sources, 7 percent to industrial processes, and the rest to utilities, industrial combustion, and other sources (see Figure 2).

The report estimated annual emissions of another ozone precursor, volatile organic compounds (VOCs), at 22 million tons. Transportation sources produced 40 percent of the VOC emissions, while 21 percent were attributed to solvent evaporation, 10 percent to industrial processes and combustion, 7 percent to residential wood burning, 4 percent to gasoline marketing, and 18 percent to other sources (see Figure 3). Emissions of the third ozone precursor, nitrous oxide, were estimated at 20.5 million tons per year. Forty-three percent were attributed to transportation sources, 33 percent to utilities, 16 percent to industrial combustion, and 8 percent to residential, industrial, and other sources (see Figure 4).

By contrast, 46 percent of the 33 million tons of methane emissions were produced by a different source, municipal solid waste landfills. Ruminants (cattle, sheep, and swine) produced 21 percent; natural gas distribution accounted for 14 percent; 10 percent were caused by underground coal mines; and 9 percent came from industrial and other sources (see Figure 5). (The methane estimates did not include emissions from several significant sources, including surface mines and manure piles.)

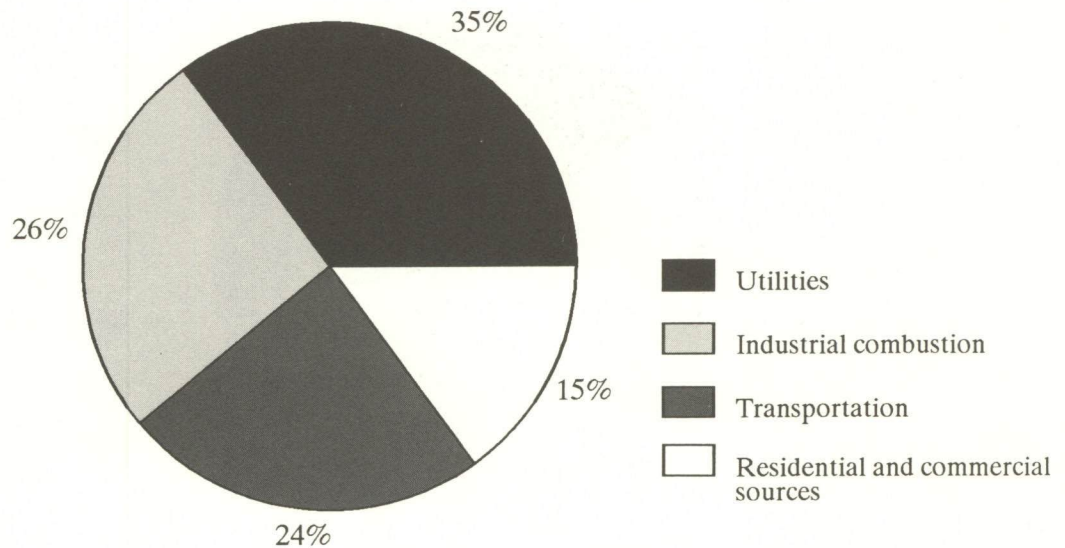
The estimate for annual emissions of chlorofluorocarbons was just 400,000 tons, but the report cautioned that this relatively small volume has a disproportionate impact on climate. This is in part because CFCs have very long life spans. Furthermore, in addition to acting as a greenhouse gas, CFCs break down the stratospheric ozone layer that protects the earth from the sun's harmful rays. Thus, as an ozone depleter CFCs enable more radiation to reach the atmosphere, while as a greenhouse gas they help prevent heat from escaping. CFC emissions are exclusively man-made, with 34 percent attributed to air conditioning, 20 percent to blowing agents, 19 percent to refrigeration, 16 percent to solvents, and 11 percent to aerosols and other sources (see Figure 6).

State Influence on Greenhouse Gas Emissions

EPA's preliminary estimates point to the great potential for states to affect the level of greenhouse gas emissions. All the identified sources of greenhouse gases, including utilities, industry, homes and businesses, transportation, and solid waste landfills, are influenced by state policies. For that reason, NGA's task force identified a wide range of state actions that could reduce emissions from the major sources.

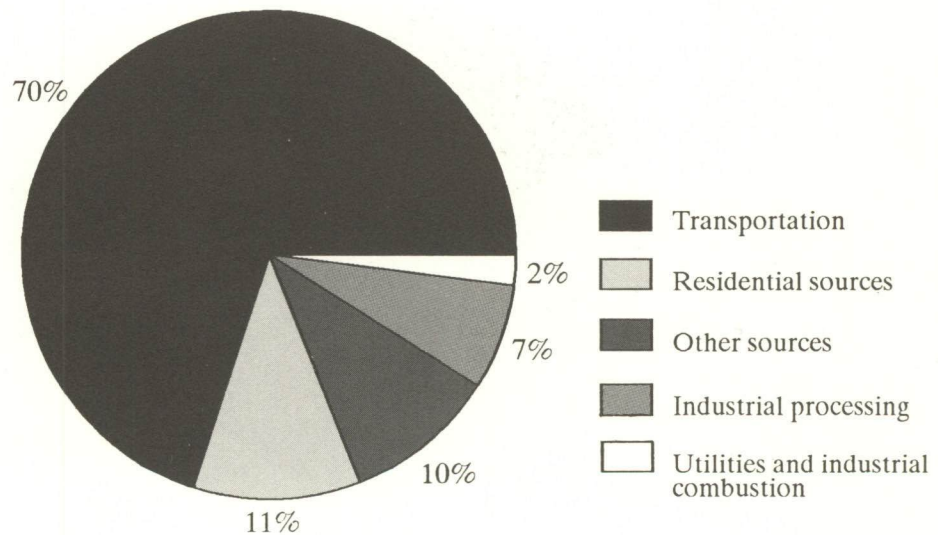
For example, utility rate reform and promotion of energy alternatives to fossil fuels could reduce the nearly 2 billion tons of carbon dioxide, 320,000 tons of carbon monoxide, and more than 6 million tons of nitrous oxide estimated to be emitted by utilities each year. States also could help cut the estimated 800 million tons of carbon dioxide, 7 billion tons of carbon monoxide, and 700,000 tons of nitrous oxide emitted by residential and commercial sources by adopting more stringent energy-efficiency

Figure 1
Carbon Dioxide Emissions by Sector



SOURCE: U.S. Environmental Protection Agency, Air and Energy Engineering Research Laboratory, *National- and State-Level Emissions of Radiatively Important Trace Gases (RITGs) From Anthropogenic Sources* (EPA-600/8-90-073), October 1990.

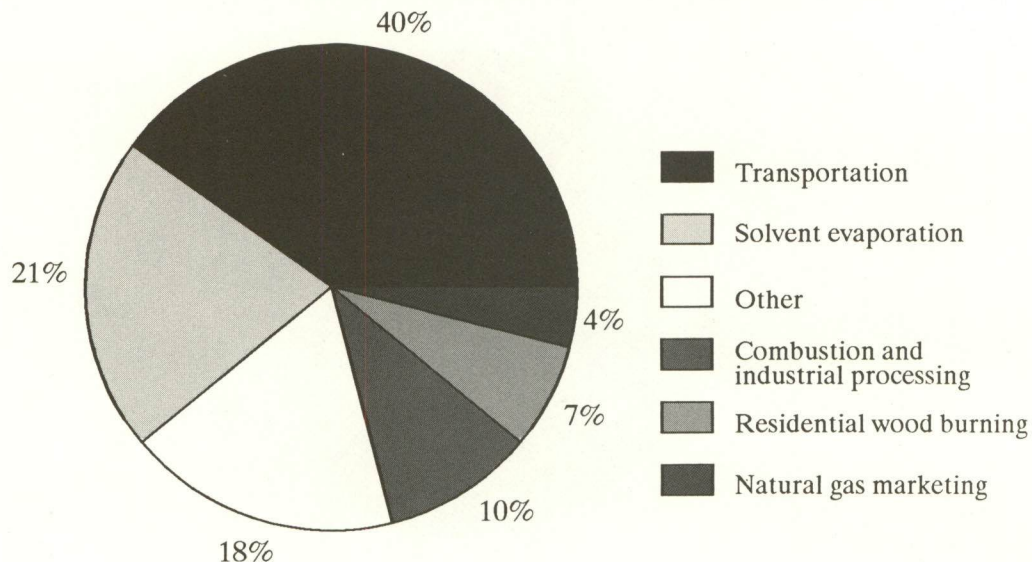
Figure 2
Carbon Monoxide Emissions by Sector



SOURCE: U.S. Environmental Protection Agency, Air and Energy Engineering Research Laboratory, *National- and State-Level Emissions of Radiatively Important Trace Gases (RITGs) From Anthropogenic Sources* (EPA-600/8-90-073), October 1990.

Figure 3

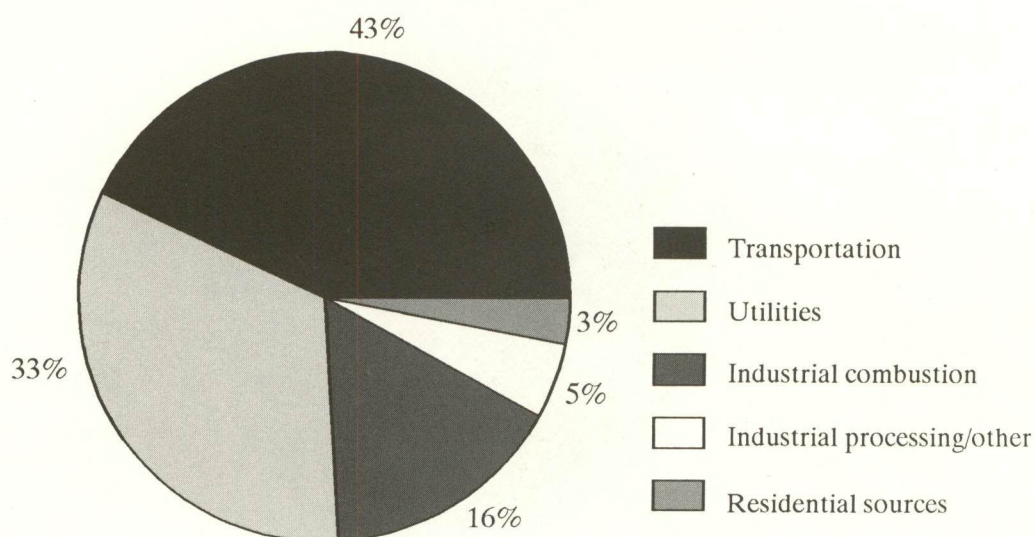
Volatile Organic Compound (VOC) Emissions by Sector



SOURCE: U.S. Environmental Protection Agency, Air and Energy Engineering Research Laboratory, *National- and State-Level Emissions of Radiatively Important Trace Gases (RITGs) From Anthropogenic Sources* (EPA-600/8-90-073), October 1990.

Figure 4

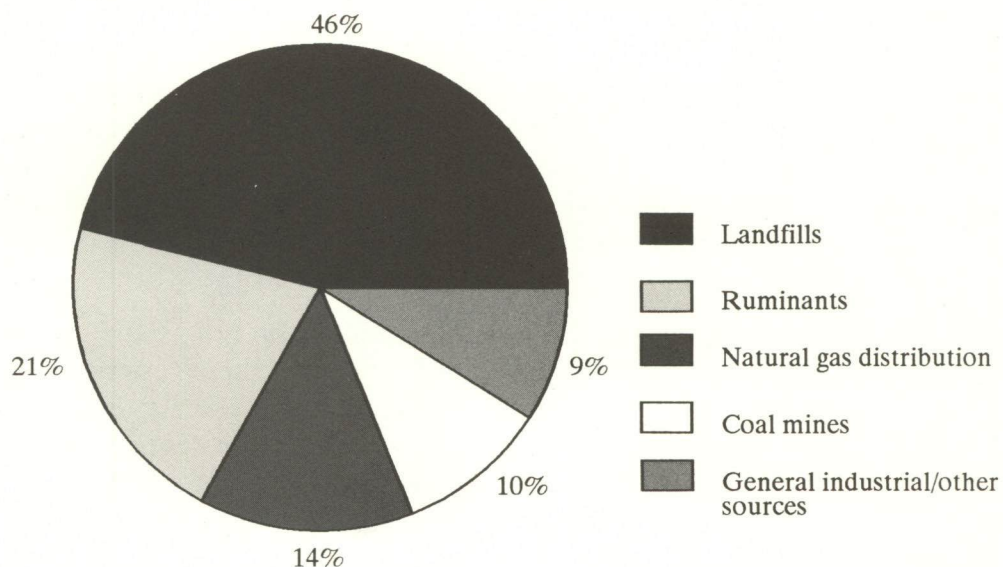
Nitrous Oxide Emissions by Sector



SOURCE: U.S. Environmental Protection Agency, Air and Energy Engineering Research Laboratory, *National- and State-Level Emissions of Radiatively Important Trace Gases (RITGs) From Anthropogenic Sources* (EPA-600/8-90-073), October 1990.

Figure 5

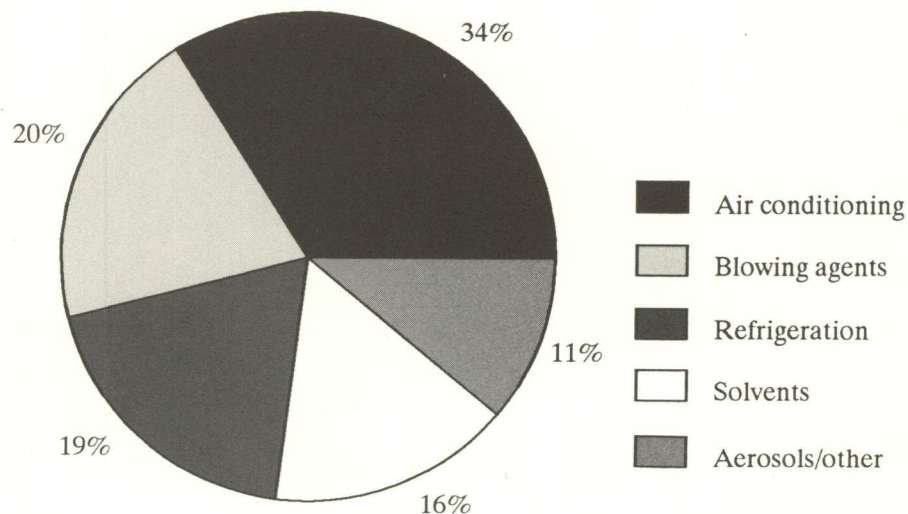
Methane Emissions by Sector



SOURCE: U.S. Environmental Protection Agency, Air and Energy Engineering Research Laboratory, *National- and State-Level Emissions of Radiatively Important Trace Gases (RITGs) From Anthropogenic Sources* (EPA-600/8-90-073), October 1990.

Figure 6

Chlorofluorocarbon Emissions by Sector



SOURCE: U.S. Environmental Protection Agency, Air and Energy Engineering Research Laboratory, *National- and State-Level Emissions of Radiatively Important Trace Gases (RITGs) From Anthropogenic Sources* (EPA-600/8-90-073), October 1990.

standards for buildings and instituting other energy efficiency programs. In addition, gas guzzler taxes on cars, car pool requirements, and mass transit improvements could reduce the 1.3 billion tons of carbon dioxide, 42 million tons of carbon monoxide, and nearly 17 million tons of nitrous oxide and VOCs emitted from transportation sources annually.

As state governments work to reduce greenhouse gas emissions, they also can plan to displace increasing atmospheric concentrations of these gases. For example, tree planting programs and sensible management of forests can increase the volume of carbon absorbed and stored by trees, creating carbon “sinks.” In urban areas, trees not only sequester carbon, but also create a cooling effect through photosynthesis and shading.

Many states have longstanding programs that already are helping to curb greenhouse gas emissions. In many cases, these programs were developed to reduce conventional forms of pollution and to conserve natural resources, but in the process they may slow the progress of global climate change as well. This report illustrates how some states are using their far-reaching authorities to reduce greenhouse gas emissions while achieving other environmental and economic goals.

2.

Massachusetts: Selecting New Energy Sources That Make Environmental Sense

The Massachusetts Department of Public Utilities has taken on the challenge of providing electricity at the lowest possible financial, social, and environmental cost. To that end, the department's regulations governing competitive bidding for new energy sources assign a dollar-per-ton figure to eight air pollutants, including the greenhouse gases carbon dioxide, carbon monoxide, methane, and nitrous oxide (see Table 1). These assigned environmental costs, known as "externalities," are added to the direct costs of operating proposed power plant technologies.

The department spent four years developing the regulations that govern how all Massachusetts electric companies plan, solicit, procure, and estimate the costs of new utility resources. These resources include electricity-generating facilities, conservation incentives, and demand management programs. The department's system for ranking proposals is based on the environmental costs of the energy source and a variety of other factors, such as price, energy savings, prospects of success, fuel diversity, and compliance with emission standards.

The new regulatory process could result in an overall reduction of greenhouse gas emissions from Massachusetts plants. The inclusion of environmental externalities in the bidding process favors energy resource projects that lower total system pollutant emissions. For example, because natural gas facilities emit one-fourth as much carbon per kilowatt-hour generated as coal-fired facilities, their environmental externality cost associated with carbon would be lower than that of coal-fired plants.

Table 1
Environmental Externality Values Assigned to Emissions of Greenhouse Gases
(in 1989 constant dollars)

The Massachusetts Department of Public Utilities has directed utility companies to use the following estimated costs of greenhouse gas emissions to evaluate the environmental impacts of proposed energy generation or conservation projects. Emissions of carbon monoxide are assigned an additional \$820 per ton, or \$0.41 per pound, for their effect on ambient air quality.

carbon dioxide	\$22 per ton, \$0.011 per pound
carbon monoxide	\$50 per ton, \$0.02 per pound
methane	\$220 per ton, \$0.11 per pound
nitrous oxide	\$3,960 per ton, \$1.98 per pound

SOURCE: Massachusetts Department of Public Utilities.

In addition, new generation facilities may displace older, dirtier power plants and thereby further reduce total system emissions. Consequently, the competitive advantage given to cleaner facilities through the inclusion of externality values in the bidding process could lead to a resource mix with lower total emissions of greenhouse gases like carbon dioxide.

Development of the Regulations

The Department of Public Utilities proposed integrated resource management regulations in December 1989 and met with public interest groups, electric companies, and government agencies over a six-month period to refine them. During the deliberations, the issue was not whether to factor the environmental costs of new sources into the selection process, but rather to determine how those costs should be quantified and incorporated into the resource selection process.

Under the final regulations, published in August 1990, the department decided to assign a dollar amount to each ton of emissions. The department found that, ideally, the externality value for each of the eight pollutants should be based on the damages caused by residual emissions that escape into the atmosphere even though the facilities causing pollution comply with state and federal pollution regulations. To this end, the department decided that actual damage values, such as health care costs, loss of natural resources, and reduction in the quality of life, should be used when known. However, since damage costs are difficult to determine with certainty, the cost of emission control is used as a proxy for damage costs.

Emission control costs are determined through the implied valuation method, which equates the value to society of pollution abatement with the marginal costs to industry of meeting current emissions limits. For example, if the federal government's emissions standards require measures with a marginal cost of four dollars to reduce one pound of emissions, the implicit value society places on reducing emissions of that pollutant is four dollars per pound. This creates an incentive for energy resource developers to design pollution control systems that can do the job for less.

The department also had to decide how to weigh the price and environmental cost categories against other criteria, such as the reliability, compatibility, and fuel diversity offered by different project proposals. The department determined that a fixed weighting system would not reflect the particular requirements of individual utilities. For example, a company with heavy dependence on oil-fired generation might favor other types of generation in order to diversify its fuel mix. However, another company with a wide variety of fuel sources might place little emphasis on fuel diversity. For that reason, the department allows each electric company to propose a ranking system, subject to the department's review, that weighs various categories of criteria according to the specific needs of the company.

The department began applying the regulations in September 1990. Although it will take some time before the regulations' full impact is felt given the lengthy resource selection process, they promise to significantly reduce utility emissions of greenhouse gases.

3.

Iowa: Instituting Energy Management In Buildings

The Iowa State Energy Bureau's Building Energy Management Program has an ambitious goal: State buildings, public schools, education agencies, hospitals, non-profit organizations, and local government facilities will be equipped with all available, cost-effective energy management improvements by 1995. The program's benefits so far are twofold. By cutting energy use, it keeps dollars in a state that imports 98 percent of its energy. At the same time, the program reduces greenhouse gas emissions by lowering demand for electricity from generating plants that burn fossil fuels.

Moreover, these energy improvements pay for themselves. For state facilities, the State of Iowa Facilities Improvement Corporation issues bonds to raise capital for energy investments and install the equipment identified in an engineering analysis. Other facilities finance the improvements through third-party private agreements. The agencies then repay the loans using money saved as a result of lower energy costs. Cash flow neutrality is key to the program's success; the payments are sufficient to retire principal and interest within six years.

The program covers energy improvements such as replacement of lights and ballasts; boiler replacement and controls; heating and ventilation controls; improved insulation of roofs, walls, and pipes; installation of storm windows, weatherstripping, or heat recovery units; and improved load management.

Several of the participating state agencies were guaranteed a specified level of energy savings by the contractor who installed the improvements. The guarantee assured the agencies that the value of their energy savings would cover the cost of lease payments. When actual savings fall short of the guaranteed levels, the agencies can use an energy guarantee fund—created with contributions from the contractor and the state corporation—to make up the difference.

The Iowa School Energy Bank

Under a 1987 law, every school in Iowa must receive an energy audit once every five years. The audit examines the facility's fuel bills, energy use, occupancy rates, electrical equipment, operation, and maintenance procedures. The Iowa School Energy Bank program offers audits and engineering analysis, finances energy management improvements in school buildings, and assists schools in obtaining energy savings insurance. As with the state buildings program, the improvements must pay for themselves through energy savings within six years.

In 1990 the program reduced carbon dioxide emissions by an estimated 86,167 tons—an average of 125 tons per building—through energy improvements in 691 participating school buildings. Ultimately 2,500 school buildings will receive the improvements, as well as thousands of buildings in other branches of the program.

When the Iowa School Energy Bank has completed the audit of a school, an engineering analysis of the building is performed to evaluate heating, ventilation, and air conditioning equipment; create simulations of building energy use; estimate the costs of improvements; and determine the time needed to repay the costs. The Department of Natural Resources then may issue a six-month interest-free loan to the school district to cover the cost of the engineering analysis. Schools may obtain the needed equipment and pay for engineering design work by entering into a lease-purchase agreement, which is under an umbrella “master lease agreement” negotiated by the department with a regional lending institution.

The Building Energy Management Program has exceeded expectations, accelerating installation of energy improvements and branching out from state agencies and schools to nonprofit organizations and local government agencies. Because of the program’s numerous benefits and ability to pay for itself, its continued success is all but guaranteed.

4.

Connecticut: Improving Transportation Efficiency

Over the last decade, the Connecticut Department of Transportation has helped pioneer programs to increase use of car pools, van pools, and public transportation. The programs reduce traffic congestion, pollution, and greenhouse gas emissions by helping commuters find alternatives to driving alone. Through the services of three ride sharing organizations, the state currently has nearly 12,000 car pools and 180 van pools on the road. They annually save almost 9 million gallons of gasoline and reduce carbon dioxide emissions by an estimated 83,000 tons.

Years ago, the state recognized some harsh realities of motor vehicle transportation that are even more apparent today. If present trends continue, the nation's road congestion could triple in fifteen years, even if capacity were increased by 20 percent. Americans already spend 1 billion hours a year detained in traffic, wasting 2 billion gallons of gasoline. Nationwide, more land is devoted to automobiles than to housing. And cars emit their weight in carbon dioxide each year, at a rate of roughly nineteen pounds for every gallon of gasoline burned.

Carbon dioxide emissions from automobiles could increase by as much as 50 percent by 2010. This is because U.S. fuel efficiency standards that reduce the volume of gasoline each automobile consumes are more than offset by Americans' increasing dependence on personal cars, usually driven with a single occupant. As an illustration, between 1980 and 1988 Connecticut gained 125,000 residents; during the same period 513,936 additional cars were registered. This translates into rapidly increasing emissions of air pollutants and greenhouse gases. The only way to lower these vehicle emissions is to cut the number of miles people drive.

A Public-Private Partnership

In 1980, the late Ella Grasso, Governor of Connecticut, joined Bob Kilpatrick, the chief executive officer of CIGNA Corporation, in establishing The Rideshare Company. The nonprofit corporation began operating in June of that year with a \$75,000 CIGNA grant. Through The Rideshare Company and two other regional brokerages, MetroPool, Inc., and Rideworks, Connecticut has become a partner with private corporations to promote ride sharing and disseminate information on public transportation services. Together they cover every town in the state, as well as parts of New York.

The brokerages offer ride-matching services and mass transit information; arrange low-interest loans and leases for vans used for pooling; work with employers to develop commuter assistance programs; distribute information on highway construction; and evaluate potential ridership for proposed bus and rail improvements.

They are supported by an award-winning program to increase public awareness of alternatives to riding alone: "Ride Together Connecticut—It's the Best Way to Work!"

Today the brokerages receive approximately 70 percent of their funding from federal highway funds administered by the state, and 30 percent from corporate sponsors and private sources. Much of their work is accomplished through *The Commuters' Register*, a free statewide newspaper that lists commuters interested in sharing a ride to work. Developed by The Rideshare Company, the monthly newspaper publicizes ride sharing programs and provides useful commuter information. It includes bus and rail schedules, with fares and routes listed by town; the locations of park-and-ride lots; feature articles; and surveys for the potential ridership of proposed mass transit projects. More than 90,000 copies of the newspaper are distributed each month at workplaces, courthouses, state agencies, town halls, banks, and retail outlets.

Working through *The Commuters' Register*, the brokerages match riders with car and van pools. The ride sharing organizations typically are able to match 30 percent of the individuals listed in the publication with rides, consistently beating the match rate of 12 to 15 percent achieved by similar programs nationwide. In addition, clients can call the brokerages and receive assistance from a customer service representative, who can enter their information into a computerized database of potential van poolers and car poolers to find a match, or provide them with updated mass transit routes and schedules.

As an additional service to clients, The Rideshare Company developed an innovative financing program for purchases of vans used for pooling. With the cooperation of private banks and the Connecticut Department of Transportation, The Rideshare Company helps commuters who want to start van pools obtain low-interest loans to purchase vans at near wholesale prices. Federal funds finance up to 75 percent of the price of full-size vans and 60 percent of mini-vans. The Rideshare Company provides an additional 15 percent and 20 percent, respectively, through a bank line of credit.

The program also helps approved drivers find passengers, determine fares, monitor routine maintenance, and obtain insurance. Passenger fares may cover the van loan, insurance payments, maintenance costs, and gasoline, and the owners are exempt from property and state sales taxes on the vans. For full-size vans, drivers may recover any taxes they pay on gasoline used for commuting. In the event of a breakdown, the Connecticut ride sharing groups provide backup vans. In addition, drivers may use the vans as their personal vehicles at night and on weekends.

Employer-Sponsored Commuter Programs

The ride sharing organizations also work with employers to promote alternatives to driving alone. Employers receive numerous benefits from facilitating their employees' commute, including attracting a labor pool that normally would not have access to their locations, saving money on expensive new parking facilities, reducing congestion around their locations, and providing a low-cost fringe benefit.

Many suburban and rural employers located far from bus and rail routes have difficulty recruiting qualified employees; a commuter program helps make their work site accessible to a wider labor pool. Rideworks provides vans and helps these companies arrange car pools. Rideworks also helps employers survey travel costs and conditions for employees; analyze commuting options in relation to current working hours, policies, and procedures; develop commuter policies and ride sharing programs that meet those conditions; and evaluate the possible need for staggered work hours, flextime, a shortened work week, and similar alternatives.

Employer-provided ride sharing incentives may include monthly bus and rail passes, free parking for car and van poolers, free peripheral lot parking with shuttle service, and guaranteed rides home for ride sharers with emergencies. Even with no expenditures, companies at no cost may have the brokerages prepare commuter and transportation maps, establish ride sharing procedures, develop commuter tips for employees, conduct transportation briefings to outline available commuter programs, and convene meetings with key officials or agencies to change traffic patterns or transportation schedules.

Challenge Grants

Beginning in 1989, each brokerage received a \$500,000 Employer Challenge Initiative Grant from the state's fuel oil overcharge funds. Over a two-year period, the grants are being used to increase employer commitments to promoting ride sharing, providing an alternative to free employee parking. The grants have had great success. Once a program has proven itself, it is not unusual for an employer to go far beyond just matching the grant. In southwestern Connecticut, for example, in the first eighteen months of the program the average public contribution to a company was \$2,500, but the average employer contribution was \$6,000. The grant in effect establishes a demonstration program that is perpetuated independently by the employer.

For Rideworks, an appealing feature of the challenge grant program is its ability to return funds to the community. The public sector provides the original grant money, which the employer matches and returns to the employees in the form of bus and rail fare subsidies. The employees in turn put the money back into the public coffers through public transportation fares.

Each small success can have impressive results. For example, an early promotion at Blue Cross/Blue Shield led to the creation of two van pools and eleven car pools within three months. This saved fifty-three parking spaces, for a 5 percent decrease in parking lot use. With the cost of providing new parking averaging \$10,000 per space, these relatively modest results could save the company more than a half million dollars.

Nevertheless, educating employers about the benefits of ride sharing is an ongoing challenge. Federal tax policies present a major stumbling block: A company's employee allowance of \$15 per month toward public transportation is taxable, but a \$100 allowance for parking is not. This creates a strong incentive for employers to pay for parking rather than undertake the recordkeeping, reporting, and tax burdens of transportation subsidies.

As an alternative to employer-sponsored programs, The Rideshare Company has proposed using challenge grant funds for another program it has operated since 1988. This program identifies specific transit routes that are underutilized and then contacts residents along those routes to identify commuters who drive to the downtown Hartford area alone. Those drivers are offered a free two-week bus pass as an incentive to find out if public transportation can meet their commuting needs. The Rideshare Company also is exploring the possibility of offering low-cost van insurance by piggybacking onto the state's insurance plan, and is negotiating a "frequent pooler" program with airlines that would enable poolers to earn miles toward free airline tickets.

The ride sharing programs will most likely prosper, despite dwindling federal and state funds, because they solve congestion problems and provide a substantial return on a small investment—all for a fraction of the cost of new highway development. Moreover, the highly visible programs enjoy strong community and political support that grows each year.

5.

Georgia: Promoting Energy-Efficient Agricultural Practices

The Georgia Governor's Office of Energy Resources has long been an advocate for energy conservation in the agriculture sector. Agriculture is Georgia's economic base, accounting for \$30 billion in annual sales and employing more than 33 percent of the workforce. By facilitating six programs targeted to crop, poultry, and livestock producers, the office has helped increase energy and agricultural efficiency. These efforts not only conserve energy and save money, but also result in significant reductions in carbon dioxide emissions.

Since the early 1980s, the Office of Energy Resources has worked through the Cooperative Extension Service at the University of Georgia to assist individual farmers. County extension service representatives are extensively involved in site work. With the receipt of oil overcharge funds in 1987, the office began working through the Georgia Institute of Technology as well to lend technical assistance to agricultural processors. Georgia Tech staff engineers analyze systems of all types and recommend energy-saving measures. For a relatively small investment of \$200,000 a year, the projects under these two programs achieve impressive results and indicate even greater potential.

Cutting Energy Use at Dairy Farms and Poultry Houses

One project of the Cooperative Extension Service could reduce annual carbon dioxide emissions from Georgia dairy farms by 5,000 tons. The project involves energy analysis of Georgia's dairy farms, with an emphasis on more efficient heating of wash water and cooling of milk. As of January 1991, 250 such analyses had been completed. The average dairy farm in Georgia, with 150 cows and producing 7,000 pounds of milk per day, can save \$63 per month by using the milk heat to warm wash water through the use of a heat exchanger. The farm can save an additional \$50 by using well water to partially cool the milk as it comes from the cow through another type of heat exchanger. It takes approximately two years for energy savings to recoup the cost of the equipment, which lasts for approximately twenty years. To promote these simple adaptations, a new Dairy Grant Program will offer up to \$2,000 per dairy farmer for the purchase and installation of the heat exchangers.

In a program directed at poultry houses, extension service staff visited 345 sites over a two-year period. They evaluated energy consumption and demonstrated energy-saving methods such as building insulation improvements, cleaning and maintaining fans, and using fluorescent lighting. Based on these evaluations and recommendations, the Office of Energy Resources estimates that carbon dioxide emissions from the state's broiler industry could be slashed by as much as 31,030 tons while

saving \$2.5 million annually. Visits are being made to an additional 221 broiler houses and 137 laying houses, and a demonstration project is underway.

Saving Fuel

Two other programs help farmers save energy in pesticide applications. In general, simple adjustments such as making fewer trips across fields to spread the pesticides, applying smaller amounts of chemicals, and regularly calibrating equipment can save farmers an estimated \$3 per acre. This would cut their total annual consumption of diesel fuel by 391,000 gallons, with a reduction in carbon dioxide emissions of 196 tons.

The Resource Conservation and Development Council of Georgia also contributes to the Office of Energy Resources' efforts, administering a program that promotes the "no tillage" method of planting. The Georgia No Tillage Assistance Program is helping farmers restore drought-stricken pasture land to life. Annual funding of \$700,000 from the Office of Energy Resources enables the Georgia Soil and Water Conservation Commission to purchase no-tillage agriculture equipment and make it accessible to farmers through local soil and water conservation districts. No-tillage drills are used to place new seeds into soil without destroying existing vegetation, not only saving fuel but also reducing soil erosion by eliminating the need to plow the land.

No-tillage techniques save oil by reducing tractor fuel consumption from five gallons per acre to a half gallon per acre. Through June 1990, more than 36,000 acres had been planted using the no-tillage method, saving 151,200 gallons of gasoline and eliminating 1,701 tons of carbon dioxide emissions.

6.

Arizona: Developing and Commercializing Renewable Energy Sources

Arizona's Energy Office promotes solar energy development and demonstration projects, advocating full, creative utilization of the state's most abundant natural resource—the sun. The solar programs staff provides information on cost analysis, projected energy savings, and products and technologies for residential, commercial, industrial, and government projects. These projects replace traditional electricity resources with electricity generated from solar radiation, which emits no greenhouse gas.

Harnessing Solar Radiation

One project was to build a twenty-four-home residential development powered by a 220-kilowatt (peak) central photovoltaic grid-tied system. The system cost \$1.75 million and saves 350,000 kilowatt-hours annually. The energy office helped the homeowners negotiate with the local utility company for a favorable buy-back rate on excess electricity generated by the system. The office also will retrieve data on the system's operation and use so that future projects may benefit from the results of this demonstration. While conserving energy, reducing costs, and producing valuable data, the photovoltaic system displaces an estimated 455 tons of carbon dioxide emissions each year.

The energy office also has provided funding to purchase equipment and has offered technical assistance for the construction of individual custom photovoltaic homes. One 3,600-square foot solar-powered home in Tucson was built at a lower cost and uses less energy than comparable non-solar custom homes in the area. All of its power is generated by a 1.6-kilowatt (peak) photovoltaic array with battery storage, supplemented by a 5-kilowatt propane generator in the summer when cooling loads exceed the photovoltaic system's capacity. The system cost \$22,000 to install and saves 6,100 kilowatt-hours annually. Estimated annual displacement of carbon dioxide emissions is eight tons.

A major demonstration project funded by the state placed six solar street-lights in each of six rural Arizona cities and towns. They were installed at a total cost of \$99,000. Each 35-watt solar light replaced a conventional 150-watt lamp; operating for six hours per night each light saves 328.5 kilowatt-hours of electricity annually. The energy office estimates that each year the thirty-six lights displace 15 tons of carbon dioxide emissions.

An Energy-Efficient Planned Community

One of the state's most futuristic projects, called Civano Tucson Solar Village, will incorporate the most innovative solar devices, solar-designed buildings, and comprehensive planning techniques. The Tucson-Pima County Metropolitan Energy Commission is managing the development of this planned community with funding from the state energy office and the urban consortium of the U.S. Department of Energy. The solar village will combine solar technology, resource conservation, and innovative transportation systems. It will concentrate housing and workplaces in the same area, with energy-efficient homes and multifamily dwellings clustered around a community activity center. Construction of the community is scheduled to begin in 1993.

7.

Wisconsin: Recycling and Controlling Chlorofluorocarbons

The Wisconsin state legislature in 1989 decided to control emissions of chlorofluorocarbons for two important reasons. First, CFCs deplete the stratospheric ozone layer that protects the earth's surface from solar ultraviolet radiation. They also contribute to the greenhouse effect by trapping heat in the atmosphere. On April 21, 1990, the state enacted legislation to reduce CFC releases from three major sources: vehicle (or "mobile") air conditioners, building air conditioners and refrigeration systems, and discarded or salvaged refrigeration equipment.

The law (1989 Wisconsin Act 284) notes that more than 25 percent of CFCs used in the United States every year are lost to the atmosphere because of poor maintenance, inappropriate servicing practices, and leaking mobile air conditioners. It mandates regulation of CFC handling, requires CFC recovery and recycling where possible, and encourages development of nontoxic CFC substitutes that neither harm the environment nor contribute to the greenhouse effect. Registration fees from affected facilities will cover the cost of additional agency staff and resources needed to implement the law.

Mobile Air Conditioners

Under the law, from January 1 to December 31, 1994, a manufacturer or distributor may not sell in Wisconsin any motor vehicle with an air conditioner containing ozone-depleting refrigerants unless at least 25 percent of the company's new motor vehicles sold in the nation during November and December 1993 do not have air conditioners containing ozone-depleting CFCs. In 1995 this minimum percentage of U.S.-marketed vehicles without CFCs goes up to 50 percent. After 1995, sales of mobile air conditioners containing CFCs will be prohibited altogether in Wisconsin.

As of December 31, 1990, the law prohibited the sale of ozone-depleting refrigerants in containers holding less than fifteen pounds. After March 31, 1991, businesses wishing to sell CFCs that were recovered from mobile air conditioners must certify that the refrigerant is going to be recycled with approved equipment and that the individuals operating the equipment meet specific qualifications. At the same time, businesses that service mobile air conditioners have to certify that they do not use CFCs to clean the exteriors of the units; that they pump the ozone-depleting refrigerant into a storage tank; that they use approved refrigerant recycling equipment; and that those who use the equipment are qualified.

New Regulations

The Wisconsin Department of Agriculture, Trade, and Consumer Protection already has promulgated regulations governing the granting of one-year waivers for auto manufacturers who for certain reasons are unable to equip the required percentage of their new cars with non-ozone-depleting air conditioners.

The regulations also require those who sell or distribute used refrigerant to record the names of purchasers. Purchasers in turn must keep records of CFC suppliers' names. The regulations set standards of purity for recycled refrigerant, and require clear labeling for used refrigerant destined for recycling and for recycled refrigerant meeting the national recognized purity standards for reuse.

Under the agriculture department rules, businesses that recycle CFCs are required to hold and display a certificate of annual registration with the department. Registrations are granted to applicants who certify that recycling is conducted with approved equipment and procedures, that the recyclers have completed an approved training program, and that the recycled product is properly labeled and sold in quantities greater than fifteen pounds. Businesses that perform motor vehicle repairs that may release ozone-depleting refrigerant from mobile air conditioners also must obtain a registration certifying that the operator does not use CFCs for exterior cleaning, that the refrigerant is pumped into a storage tank that meets federal standards, and that the operator recycles the used refrigerant with approved equipment and procedures.

Under the regulations, an independent testing organization certifies recycling equipment using standards at least as stringent as those specified in the Society of Automotive Engineers document *Extraction and Recycle Equipment for Mobile Automotive Air-Conditioning Systems* (SAE J1990, October 1989). At least two hours of training is required for individuals who operate approved refrigerant recycling equipment. The training must cover environmental concerns of CFC emissions, applicable state and federal laws, safety precautions, industry standards, and hands-on instruction in equipment use. Individuals are evaluated and receive certificates upon successful completion of the course.

Refrigeration Equipment

The Wisconsin Department of Industry, Labor, and Human Relations is responsible for promulgating additional regulations for refrigerants and refrigeration equipment. Under the law, after December 31, 1991, businesses that install or service refrigeration equipment that contains five pounds or more of ozone-depleting refrigerant must meet minimum registration requirements. They will be required to certify to the department that they do not use CFCs to clean exterior surfaces, that CFCs are transferred from the equipment to storage containers using approved equipment, and that qualified employees use the transfer equipment. Only registered businesses will be allowed to sell recycled refrigerant after December 31, 1991. As of December 31, 1992, these requirements will be extended to businesses that install or service refrigeration equipment containing any CFCs at all.

Salvaging Regulations

The Department of Natural Resources must promulgate regulations, to become effective by June 30, 1992, governing the third source of CFC emissions, the salvaging and dismantling of mechanical vapor compression refrigeration equipment. After that date, the law requires businesses and municipalities to certify that only qualified individuals use approved equipment to recover ozone-depleting refrigerants during salvaging and dismantling of any mechanical vapor compression refrigeration equipment. At the same time, anyone who sells refrigeration equipment to a scrap metal processor will have to certify that CFCs have been properly removed to a tank.

Follow-up legislation is being considered in Wisconsin to deal with nonessential uses of CFCs and to provide technical amendments to the current CFC control law.

8.

Missouri: Promoting Urban Tree Planting and Reforestation

Forestry and tree planting programs offer numerous environmental benefits. Trees provide one of the best defenses against soil erosion because they increase water infiltration into the soil, enhance the soil's capacity to hold water, protect soil from the wind, and provide root systems that hold soil in place. In addition, water that flows through forests is cleaner than water running off other land areas because tree roots take water out of the ground and purify it, and fallen leaves and twigs produce a natural water filter.

Moreover, state agencies are discovering that trees can reduce atmospheric concentrations of greenhouse gases. They assimilate carbon dioxide through photosynthesis and store carbon as roots, wood, and foliage. According to the American Forestry Association, a tree absorbs at least thirteen pounds of carbon each year, acting as a carbon sink. Two acres of trees will annually absorb the carbon dioxide produced by the energy-related activities of one average American.

Trees also can offset the temperature increases associated with the greenhouse effect. In the flatlands of the Great Plains, trees slow the wind and thereby alter the micro-climate near the ground. This leads to more favorable plant-growth conditions, such as less evaporation of soil moisture, reduced plant transpiration, and higher humidity. In urban areas, a typical shade tree can match the evaporation rate of five room air conditioners, thus creating a cooling effect while cutting energy use for electric air conditioning.

Operation TREE

The Missouri Department of Natural Resources has created a reforestation program that will tap trees for every environmental benefit they can produce. In October 1989, Director G. Tracy Mehan announced Operation TREE (Trees Renew Energy and the Environment). The program's goals are to reduce demand for heating and cooling with strategic landscaping, to arrest soil erosion, to enhance natural water filtration, and to remove carbon dioxide from the atmosphere. Operation TREE is multifaceted, with a program coordinator working to involve every division of the Department of Natural Resources and encourage cooperation with other state agencies.

In 1989, one of Operation TREE's major projects used \$500,000 in oil over-charge funds for urban tree planting grants to local governments and not-for-profit groups. The grants were used to plant 6,100 trees and 4,000 shrubs to demonstrate the direct effect of shading buildings and the indirect evapotranspiration effect of

shade trees on streets and parks within the urban environment. When fully grown, the trees alone will store about forty tons of carbon every year.

Grant applicants submitted plans detailing landscaping schemes, species to be planted, and maintenance of the plantings. Applicants selected trees according to canopy size, because maximum shading translates into the greatest energy savings; maturation rate, which determines the speed at which savings are realized; and disease resistance. The Department of Natural Resources estimates that optimal savings in energy costs—10 to 50 percent—will be realized in about fifteen years when the trees are fully grown. Nineteen agencies and school districts received the grants in February 1990.

Another grant funded a school's innovative energy monitoring system that links temperature sensors with a central computer and adjusts the heating or cooling in specific zones. Each year fuel consumption and relative temperature differences will be compared with the same day on the year before, documenting the energy savings of well-placed trees and shrubs.

“Used Paper to Trees” Project

In 1991 the Department of Natural Resources' energy division fashioned a new way to use \$400,000 in oil overcharge funds, purchasing 16,000 six- to eight-foot saplings for the “Used Paper to Trees” project. In seven cities, people received a coupon for a tree in exchange for every three-foot stack of newspaper brought in for recycling during January and February. In April they redeemed the coupons for trees and received a guide on how and where to plant them to maximize energy conservation.

This program builds on the link between tree planting, recycling, and energy conservation. The division informed the public that each ton of 100 percent recycled paper produced saves seventeen trees. Producing a ton of recycled paper uses 4,000 fewer kilowatt-hours of energy, consumes 7,000 fewer gallons of water, and emits sixty fewer pounds of air pollutants than does producing a ton of virgin paper. The program also is helping to create a market for recycled paper. The division sold much of the newspaper to Weatherguard, Inc., for conversion to high-efficiency home insulation.

Reforestation Projects

The Department of Natural Resources' Division of Parks, Recreation, and Historic Preservation is responsible for the Operation TREE reforestation program. In 1989 the division identified 5,000 acres to reforest through regeneration or reseeded. The following year, it added 3,000 acres, mostly abandoned fields filled with young saplings, to be protected for natural regrowth of an estimated 750,000 to 1 million trees. In total, the program will produce 2 million trees filling twelve square miles in state parks—enough to displace almost 200,000 tons of carbon dioxide emissions per year.

In another project aimed at recreating forests at three sites totalling 200 acres, the Division of Parks worked with the Department of Conservation to plant 50,000 trees. Volunteers and staff collected thousands of seeds from nearby forests that

matched those missing from potential planting sites. The seeds were cultivated at the Department of Conservation's nursery, and the seedlings will be planted to replicate the old growth systems that dominated the sites 200 years ago. In 1991 the project will plant 73,000 seeds to achieve 17,000 trees at three sites, and future work will add wildflowers, shrubs, wild grasses, and vines to the sites. The project will be monitored by researchers from the University of Missouri.

Soil Conservation and Land Reclamation

More trees also mean more soil conservation. The Department of Natural Resources' Division of Environmental Quality is working with the Soil and Water Commission to develop a pilot Special Area Land Treatment (SALT) site. SALT sites help soil and water districts and landowners apply conservation measures to small watersheds where soil erosion damages surrounding farms, crops, and streams. The average size of a SALT site is 7,000 to 8,000 acres, with about 4,000 acres requiring treatment. Currently, landowners plant forage cover so they can return to cropping and obtain a quick return on their investment. If only 5 percent of the 3,133,100 acres of crop and pasture lands that are not well-suited to cultivation were forested, 150,000 acres would be placed into trees and annually displace almost 4 million tons of carbon dioxide.

A new educational campaign called "Odd Corner Out" will encourage landowners to use a special cost share program to plant trees on soil highly susceptible to erosion. Funded through the voter-approved parks and soils sales tax, the program uses trees to address very difficult soil conservation problems more economically than applying expensive erosion control practices to these areas. On large fields that have less difficult problems, these conversions may help landowners comply with the conservation provisions of the 1985 Food Security Act.

The Division of Environmental Quality also has incorporated a land reclamation program for mine sites into Operation TREE. Because the side slopes typical of mine sites are too steep to lime and seed and the soil quality is poor, they are more amenable to trees than other types of cover. Forestation also helps restore the habitat of animals that disappeared when mining took over the sites.

The program encourages coal operators to plant trees and reclaim as many acres as possible; continues annual tree planting on Abandoned Mine Land (AML) projects; and plants additional trees at previously reclaimed AML sites. For example, at the program's Germantown site, a 1,200-acre area earlier reclaimed with grasses is being planted with 50,000 seedlings. Another 50,000 to 70,000 will be planted in 1991, and thousands more will be planted at other sites. In addition, mine operators independently have planted as many as 500,000 trees on their active mine reclamation sites.

From energy conservation to recreation, from land reclamation to soil and water protection, trees produce myriad benefits as they displace carbon dioxide.

9.

Oregon: Developing A Comprehensive State Program To Reduce Greenhouse Gas Emissions

There are two compelling reasons for states to establish comprehensive strategies to reduce greenhouse gas emissions and prevent global climate change. The first is that no single state agency bears responsibility for the myriad issues related to climate change or has the authority to implement every type of emissions reduction policy. Only the combined efforts of numerous agencies can significantly reduce greenhouse gas emissions.

Second, emissions reductions require interagency coordination so that agency policies enhance one another. For example, a transportation agency's promotion of nonpolluting electric vehicles will produce a net reduction in greenhouse gas emissions only if the public utilities agency promotes clean alternatives to coal-fired electricity generation. Furthermore, without a unifying strategy, one policy directed at a specific objective might inadvertently undermine another.

Several states have begun developing comprehensive emissions reduction strategies that will integrate and build upon existing environmental and energy programs to foster a coordinated approach to climate change prevention. Sometimes it takes the initiative of a Governor to start the planning process or establish a forum for cooperation among interested agencies. This is because in a time of growing demands on shrinking state budgets, it is difficult to generate enthusiasm within individual agencies for developing climate change policies, especially when no single agency has a mandate to prevent climate change.

Oregon's Global Warming Task Force

Oregon has one of the nation's most advanced comprehensive strategies to reduce greenhouse gas emissions. The process that led to the strategy began in 1988 when then-Governor Neil Goldschmidt established a Task Force on Global Warming. He charged the task force, representing twelve state agencies, with reviewing the scientific basis for predicting climate change, the impact it would have on the state, and ways of responding to the problem.

The task force made broad agency participation a top priority, but active cooperation was not easily maintained. Interest in developing a climate change report was strong among some agencies but limited in others. Fortunately, the eighteen-month process of collecting agency input allowed sufficient time for reluctant participants to realize the value and importance of becoming involved. In addition, each agency was responsible for writing a section of the report presenting its recommendations. This helped motivate agencies to contribute to the report, especially after the public had reviewed a draft of it.

The task force found that in the event of global climate change, the state economy could suffer from rapid changes in the natural resource base of forests, agriculture, fisheries, and recreational sites. Water supply would be a chief concern, with lower snowfall and higher evaporation from soil, lakes, and streams reducing an already strained resource. Hydroelectric power, which depends on the state's snow-pack for water storage and provides 70 percent of the region's electricity, could be significantly reduced as well. Climate change also could increase the frequency of extreme weather events in the state, such as flooding, landslides, and droughts.

The report also examined the sources of greenhouse gas emissions in the state. According to the Oregon Department of Energy, 63 percent of the state's carbon dioxide emissions comes from petroleum products, which are used primarily for transportation. Seventeen percent comes from the cutting of old-growth forests. (Replanting these forests does not fully recapture the lost carbon dioxide unless the trees are allowed to again become old growth.) Another 12 percent comes from natural gas used for heating. Electricity generation from coal, natural gas, and cogeneration plants accounts for 7 percent of the state's carbon dioxide emissions.

The major source of methane emissions associated with human activity in Oregon is cattle and other ruminants. Sources of nitrous oxide emissions include automobiles, biomass burning, sewage treatment, and agriculture. CFC emissions in Oregon come from refrigerators and air conditioning units, aerosols, and the electronics industry, which uses CFCs as solvents.

The task force report also included each participating agency's proposed actions for reducing greenhouse gas emissions. The Department of Energy established four priorities for responding to global warming: constructing energy-efficient buildings; improving energy efficiency in existing buildings and manufacturing processes; ensuring development of renewable resources; and assisting utilities in establishing least-cost plans—those that meet energy requirements at the lowest possible cost. In addition to promoting these priorities, the department suggested working with the Oregon delegation to the U.S. Congress to support a federal carbon tax and increased funding for low-income weatherization programs. The department also would urge the U.S. Department of Energy to base its federal energy policy on energy conservation and renewable resources.

The Oregon Department of Transportation proposed encouraging transit improvements, park-and-ride facilities, ride share programs, telecommunications, and pedestrian and bikeway improvements. The department also would improve the transportation system through congestion-reduction strategies, signal synchronization, and ramp metering to control the flow of traffic entering highways.

For its part, the Department of Environmental Quality would consider maintaining a greenhouse gas emissions inventory, adding a check for air conditioner leaks to the auto inspection program, linking air quality permits with energy efficiency, and instituting a range of recycling incentives and requirements.

Proposals offered by the Oregon Department of Forestry would maintain high standards of reforestation, increase tree planting at unstocked and understocked sites, and encourage ecologically sound forest management practices to increase carbon uptake and storage.

Emission Reduction Strategy

In 1989, the Oregon state legislature went one step beyond the task force's mandate by enacting a law (S.B. 576) that requires development of a greenhouse gas emissions reduction strategy. The Oregon Department of Energy and other agencies were directed to develop a strategy for reducing the state's greenhouse gas emissions to 20 percent below 1988 levels by 2005, with an emphasis on conservation, renewable resources, and alternative fuels. The department produced the strategy with assistance from a sixty-member public advisory group that included representatives of environmental organizations, industry, local governments, utilities, and other affected parties.

The resulting Oregon Global Warming Strategy, published in 1991 as part of the Fourth Biennial Energy Plan, presents policy options for reducing greenhouse gas emissions, targeting each gas separately. Many of the suggestions echo the proposals in the Global Warming Task Force Report, but expand upon them to achieve further emissions reductions. This document is a study; it is not an implementation plan.

The most complex and far-reaching of the strategies addresses carbon dioxide emissions, involving a wide range of sources and their respective regulatory agencies. First, it suggests expanding public transit and park-and-ride facilities, while encouraging telecommuting, flextime, bicycling, and car pooling to reduce the number of single-occupancy vehicle trips in the Portland metropolitan area. This would prevent an estimated 20,000 tons of carbon dioxide emissions each year. The strategy suggests that funding for integrated mass transit systems could come from gasoline taxes if the state constitution were amended to allow these revenues to be applied to transit development.

To further reduce automotive greenhouse gas emissions, the strategy suggests a strictly enforced state speed limit of fifty-five miles per hour—a reduction of ten miles per hour from current average car speeds and five miles per hour from truck speeds on rural interstate highways. The lower speed limit would cut carbon dioxide emissions by 210,000 tons a year. In addition, the strategy estimates that about half the 37,000 vehicles in public and private fleets, as well as all intra-city buses, could be converted to operate on compressed natural gas, preventing an additional 57,000 tons of carbon dioxide emissions every year.

Other carbon dioxide emission reduction measures proposed by the strategy include ceasing construction of new coal plants in the northwestern United States and reducing output from regional coal plants after 1997. This would reduce annual carbon dioxide emissions by 2.42 million tons. The loss of electricity generated by these plants would be made up by geothermal and wind sources of electricity, as well as by doubling the amount of conservation in current least-cost plans. Another effort would require replacing 80,000 electric water heaters in the state with natural gas heaters as they wear out, preventing an estimated 220,000 tons of carbon dioxide emissions annually.

The strategy also calls for a doubling of solid waste recycling. Oregon law already requires curbside recycling in cities with populations over 4,000, and the state

has numerous recycling depots as well. The strategy recommends improving the effectiveness of this program, primarily through rate incentives, to increase recycling from the current 22 percent to 50 percent. This would reduce carbon dioxide emissions by an estimated 350,000 tons per year. In addition, standards requiring a percentage of recycled content by weight in packaging could prevent another 870,000 tons of carbon dioxide emissions yearly. Finally, the strategy suggests that the state require that glass bottles collected under the state's bottle bill be washed and refilled a number of times before being remelted in cases where reuse would save more energy than recycling. This would reduce carbon dioxide emissions by 50,000 tons.

In the area of forest management, the strategy suggests building on both state and federal policies. Planting more trees increases the level of carbon taken up and stored in forests. Oregon law already requires replanting cut forests, and an estimated 98 percent of nonfederal forest lands are replanted. However, many acres of land cut before the enactment of the state reforestation laws remain unstocked. The strategy calls for planting 250,000 acres of unstocked nonfederal timberlands and 712,000 acres of underproductive nonfederal timberlands in the state, which would annually displace 1.61 million tons of carbon dioxide.

The Federal Role

At the federal level, protection of the spotted owl will dramatically curtail the cutting of old-growth forest in Oregon, reducing the timber harvest by 26 percent by 2005. This drop is expected to reduce carbon dioxide emissions produced by the roots and wood of harvested trees by 59 percent, or almost 4 million tons a year.

The strategy acknowledges that significant reductions in carbon dioxide emissions will require federal action, because there are some steps individual states cannot afford to take unilaterally if they hope to remain economically competitive. The Oregon strategy relies on the enactment of a federal tax of \$40 per ton on carbon dioxide emissions from fossil fuels, electricity, and natural gas, which would promote conservation in a variety of sectors. The agency estimates that this tax would reduce the state's long-term gasoline use by about 10 percent, helping to stimulate increased demand for more energy-efficient vehicles. At the same time, the tax revenues could be used to develop alternative forms of transportation and shipping. Similarly, in residential and commercial heating, the tax would encourage more homes and businesses to switch from oil to natural gas and adopt conservation measures.

The strategy suggests an increase in the federal car and light truck fuel efficiency standards to 45 and 35 miles per gallon, respectively (the 1990 standards were 27.5 and 20.2, respectively). In addition, it recommends an increase in the federal "gas guzzler" tax based on vehicle carbon dioxide emissions. At the same time, a federal "gas sipper" rebate—funded by the gas guzzler tax—could create an added incentive to purchase more fuel-efficient cars. These measures combined

could reduce Oregon's annual carbon dioxide emissions by an estimated 3.45 million tons.

Provisions for reducing emissions of two other greenhouse gases are relatively simple.* The CFC strategy relies on the 1990 Federal Clean Air Act Amendments, which will ban CFCs by the year 2000. Oregon will work in the interim to recycle CFCs from refrigerators, freezers, heat pumps, and air conditioners, and promote tax incentives for CFC recycling. The Oregon Department of Energy also proposes adding CFCs to the list of chemicals requiring reduction plans under the state Toxics Use Reduction Act of 1989, and having the Department of Environmental Quality reduce CFC emissions through industrial air permitting. An additional 200 tons of CFC-12 emissions could be eliminated annually by stopping the direct immersion method of freezing of berries.

To reduce methane emissions from cattle production, the strategy suggests low-methane diets for cattle; increasing the reproductive efficiency of beef brood cows so that fewer brood cows would be needed; and capturing methane from cattle manure. Methane emissions from landfills could be captured as well. These measures would annually save 35,000 tons of methane emissions.

Oregon's work continues. The next step will be to create a state global warming action plan for adoption by the state legislature in 1993. Under the guidance of the climate change strategy, the action plan would specify legal, economic, and administrative tactics for a strategy to hold the state's carbon dioxide emissions at 1988 levels.

* Because it was impossible to develop an accurate state-specific budget for sources of nitrous oxide without further study, the Department of Energy did not develop a strategy for this gas.

Appendix A

U.S. Environmental Protection Agency Support for State Activities

EPA programs account for a major portion of the federal government's billion-dollar commitment to studying the greenhouse effect and devising ways to prevent global warming. The agency supports state efforts to prevent global climate change by sharing the results of scientific research, promoting information exchange, and funding state initiatives.

EPA's Office of Research and Development (ORD) and Office of Policy, Planning, and Evaluation (OPPE) are helping state decisionmakers find answers to fundamental questions about the greenhouse effect, including the following:

- How is the climate changing and what effect will these changes have on natural resources, human health, and infrastructure?
- What levels of greenhouse gases are emitted by anthropogenic sources?
- Are cost-effective technologies available to reduce emissions from these sources?

The Office of Research and Development plans to spend \$3.5 million in fiscal 1991 to identify and quantify greenhouse gas emissions and their sources; develop techniques for utilizing biomass (e.g., dry organic matter such as wood and plant residues); explore ways to stabilize atmospheric methane concentrations and mitigate ozone in the upper troposphere; and conduct technology evaluation and transfer.

An October 1990 report by ORD, *National- and State-Level Emissions Estimates of Radiatively Important Trace Gases (RITGs) From Anthropogenic Sources* (EPA-600/8-90-073), presented emissions estimates for carbon dioxide, carbon monoxide, methane, volatile organic compounds, and chlorofluorocarbons in the contiguous forty-eight states. While EPA considers the estimates to be preliminary, the report offers the most comprehensive data available on the sources and volumes of greenhouse gas emissions nationwide. ORD plans to improve the estimates of methane emitted from coal mines, natural gas systems, landfills, and waste disposal sites, and also to better characterize the carbon dioxide, methane, nitrous oxide, and other emissions from biomass burning and wood stoves.

Other ORD projects will focus on technologies that reduce greenhouse gas emissions. For example, the office will develop methods of preventing carbon dioxide releases by utilizing biomass instead of allowing it to burn or decay. Biomass such as wood may be used directly as fuel, gasified for power generation, converted to liquid transportation fuel with low carbon dioxide emissions, or made into durable products that store its carbon content.

Exploring Policy Options

The ORD climate change programs are designed to support the work of EPA's Office of Policy, Planning, and Evaluation. OPPE's Climate Change Division uses the results of ORD research to develop and evaluate domestic and international climate change policies. OPPE studies options for enhancing energy efficiency, reducing greenhouse gas emissions from forest and agricultural lands, increasing carbon se-

questration by trees through improved forest management and tree planting, and adapting natural resources management to the potential effects of climate change.

Many OPPE activities directly assist states in grappling with climate change issues. OPPE supports state agency and association studies of climate change responses and effects, and provides technical assistance for state evaluations of response strategies. In addition, the office maintains summaries of state climate change activities and operates a climate change information exchange for states.

Working with EPA's regional offices, OPPE also helps states incorporate climate change considerations in their environment, energy, and natural resources management policies.

At the international level, OPPE is involved in the development of a convention on climate change, as well as international protocols to address energy, forestry, technology transfer, and other topics. OPPE also is conducting international research on climate change mitigation through energy efficiency and reforestation and on the potential impact of climate change on global resources. This research concentrates on developing and Eastern European countries.

Appendix B

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CONSENSUS

FOR CHANGE

A WORLD OF DIFFERENCE

REPORT OF THE
TASK FORCE ON GLOBAL
CLIMATE CHANGE



NATIONAL GOVERNORS' ASSOCIATION

A WORLD OF DIFFERENCE

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NATIONAL GOVERNORS' ASSOCIATION

The National Governors' Association, founded in 1908 as the National Governors' Conference, is the instrument through which the nation's Governors collectively influence the development and implementation of national policy and apply creative leadership to state issues. The association's members are the Governors of the fifty states, the commonwealths of the Northern Mariana Islands and Puerto Rico, and the territories of American Samoa, Guam, and the Virgin Islands.

The association has seven standing committees on major issues: Agriculture and Rural Development, Economic Development and Technological Innovation, Energy and Environment, Human Resources, International Trade and Foreign Relations, Justice and Public Safety, and Transportation, Commerce, and Communications. Subcommittees and task forces that focus on principal concerns of the Governors operate within this framework.

The association works closely with the administration and Congress on state-federal policy issues from its offices in the Hall of the States in Washington, D.C. The association serves as a vehicle for sharing knowledge of innovative programs among the states and provides technical assistance and consultant services to Governors on a wide range of management and policy issues. The Center for Policy Research serves the Governors by undertaking demonstration projects and providing anticipatory research on important policy issues.

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CHAIRMAN'S

FOREWORD

As events in Eastern Europe unfold daily and affirm the values and principles of a democratic and free enterprise system, we look optimistically toward the twenty-first century. Today in the United States we have an unprecedented opportunity to set standards of excellence for ourselves and for the world.

A safe and clean environment and an effective educational system are essential to achieving and maintaining a high standard of living in every democratic nation. That is why this year I challenged the Governors to address these important issues. Meaningful change, accompanied by long-term commitment, is critically needed in both areas.

To meet this challenge, the National Governors' Association established three task forces this year—on Global Climate Change, Solid Waste Management, and Education. Each task force was charged with identifying reasonable and achievable national goals and practical ways to achieve them. Equally important, the task forces have focused on the things states can do in each area.

Over the past several months we have sought to build a national consensus on the environment and education and establish ambitious goals that can direct our actions in these areas during the decade ahead.

Together the Governors have sought a Consensus for Change—a consensus on the steps that must be taken to ensure that our children have the skills they need to compete in the world marketplace, that they understand the privileges and responsibilities of living in a democracy, and that they can fulfill the responsibilities of citizenship. The ability of our citizens to meet the challenges of the next century is directly related to the quality of our schools.

However, it is not enough to focus solely on education; we must also concentrate on the world in which we live. Our quality of life is affected by the air we breathe, the water we drink, and the food we eat. To protect our environment and ensure that the world we leave to future generations is healthy and safe, we must address our most pressing environmental

problems with insight and wisdom. The decisions we as a nation make on these issues today will determine the quality of life for our children and grandchildren tomorrow.

To be sure, our efforts have been comprehensive. Each task force has worked with government and business leaders and other interested parties. We have gathered information from citizens and experts from virtually every walk of life. This process has reminded me of the strength, diversity, and ingenuity of the people in this land.

When the Governors and President Bush met in Charlottesville, Virginia, in September 1989 for the historic education summit, we were bound together by a common concern and a shared commitment. Despite the diversity of our states and our citizens, all Governors share the belief that education is the cornerstone of the future.

That spirit of cooperation led the Task Force on Education through its work with the President to develop bold education goals for the nation. Adopted by the Governors and embraced by the President in February, the nation's goals for education will chart the course for education reform in this decade. The task force has also developed state strategies to achieve the goals, and a mechanism for measuring progress toward achieving those goals.

The Task Force on Solid Waste Management studied innovations in waste disposal management from coast to coast. The recommendations and report of this task force will provide states with a valuable resource as states assess and redirect their efforts in this area.

This is the report of the Task Force on Global Climate Change. Few issues demonstrate more clearly the delicate balance between human beings and the natural environment. Although there is considerable uncertainty about the rate, magnitude, and effects of global climate change, and the costs of prevention could be substantial, we must take action. For the sake of future generations, we must take the issue of global climate change with the utmost seriousness.

To build consensus on an appropriate course for the 1990s, Task Force Chairman Governor James R. Thompson of Illinois and Vice Chair Governor Madeleine M. Kunin of

Vermont convened meetings in Charlottesville, New York City, Sacramento, Washington, D.C., New Orleans, and Burlington to discuss the issues with distinguished scientists and government officials from the United States and other countries. The task force heard from experts and advisers drawn from the academic community and from a wide range of business and environmental groups. The task force reviewed and analyzed research from all available sources. The result is a consensus on goals for dealing with global climate change and an action plan to realize those goals.

Some of the goals identified by the Task Force on Global Climate Change will not be easily or quickly achieved. But working together we *can* begin. Governors are well positioned to lead the effort and serve as catalysts for change. We *can* and *will* make a difference. Together we will make the world a better place for tomorrow's children.



Governor Terry E. Branstad, Iowa
Chairman, National Governors' Association

EXECUTIVE SUMMARY AND STATEMENT OF GOALS

The atmosphere acts like a greenhouse around the earth. Certain gases, most of which naturally occur in the atmosphere in minute quantities, trap the sun's heat and warm the planet. Without this natural occurrence, the planet would be some 60 degrees Fahrenheit colder than it is now, the seas would be permanently frozen, and life as we know it could not exist.¹ We literally owe the habitability of our planet to the phenomenon commonly known as "the greenhouse effect."

In recent years, evidence that human activities are changing the composition of the atmosphere has caused increasing concern. The world energy system, industrial and land-use practices, agriculture, and population growth are adding certain greenhouse gases to the atmosphere faster than they can be removed by natural processes. As concentrations of greenhouse gases increase, the heat trapping properties of the atmosphere also increase, like a more efficient blanket around the globe. Almost all scientists believe that this increase in greenhouse gases results in a theoretical increase in average global temperature. However, there is debate about the extent, rate, and timing of future temperature and climate changes. The U.S. Environmental Protection Agency and others have predicted that a doubling of atmospheric carbon dioxide or its equivalent in some combination of greenhouse gases—expected by the middle of the next century—could raise the earth's average temperature by 3 to 10 degrees Fahrenheit (1.5 to 4.5 degrees Celsius).² In January 1990, the National Academy of Sciences estimated that 4 degrees Fahrenheit (2 degrees Celsius) is the most likely temperature rise.³

Although the implications of such a temperature increase are not well understood, they could include an increase in the frequency and severity of climate extremes such as droughts and storms; changes in rainfall patterns; rising sea level with consequent shoreline and beach erosion, flooding of estuaries, and loss of wetlands; desertification; and migration of

agricultural and forest zones, among others. Some scientists believe that a warmer world could bring some benefits, such as lengthening the growing season in northern regions.

For several reasons, global climate change may be the most complex environmental and economic problem humankind has ever faced. First, there is substantial scientific uncertainty about the rate, magnitude, and regional effects of future climate change, and this uncertainty is likely to persist for some time. This scientific uncertainty and the difficulty in accurately predicting climate change are compounded by the existing natural variability of meteorological and biological systems. Second, the social and economic costs of the measures that might reduce the threat are not yet well understood, and a comprehensive assessment of the available options has only recently begun. Finally, mitigation and adaptation to climate change is an issue that can be effectively addressed only with the cooperation of all nations. It is likely that unilateral measures by any one country will be quickly overwhelmed by events elsewhere if other nations do not cooperate in a coordinated response. Some maintain that unilateral actions now could reduce American bargaining power in future international negotiations.

To address this important issue, NGA Chairman Governor Terry E. Branstad created the Task Force on Global Climate Change, chaired by Governor James R. Thompson of Illinois and vice chaired by Governor Madeleine M. Kunin of Vermont. The task force was charged with developing recommendations for the nation for the 1990s, and illuminating the role that states can play in addressing the problem of global climate change. To accomplish this mission, the task force held hearings across the nation, met with senior scientists and policymakers from several nations, and engaged in constructive dialogue with business and environmental leaders, whose support is crucial in any response to this problem.

After careful deliberation, the task force makes the following findings:

First, atmospheric concentrations of greenhouse gases are increasing due to human activities. Over the last 100 years, atmospheric concentrations of carbon dioxide have increased by about 25 percent.⁴ Concentrations of methane have increased by approximately 140 percent since the middle of the nineteenth

century, and there have been significant increases in concentrations of other greenhouse gases, including chlorofluorocarbons (CFCs) and nitrous oxide.⁵

Second, a broad scientific consensus has developed that increasing the concentration of carbon dioxide and other greenhouse gases will increase the atmosphere's heat-trapping ability and warm the climate to some degree. There is debate and uncertainty, however, about the magnitude and timing of the warming and the implications of that warming for the earth's climate system, environment, and economies.

Third, controlling emissions is central to reducing potential climate change. For carbon dioxide, change in energy policy is the primary strategy for stabilizing or reducing emissions. Other measures, such as slowing the loss of forests, are also critical.

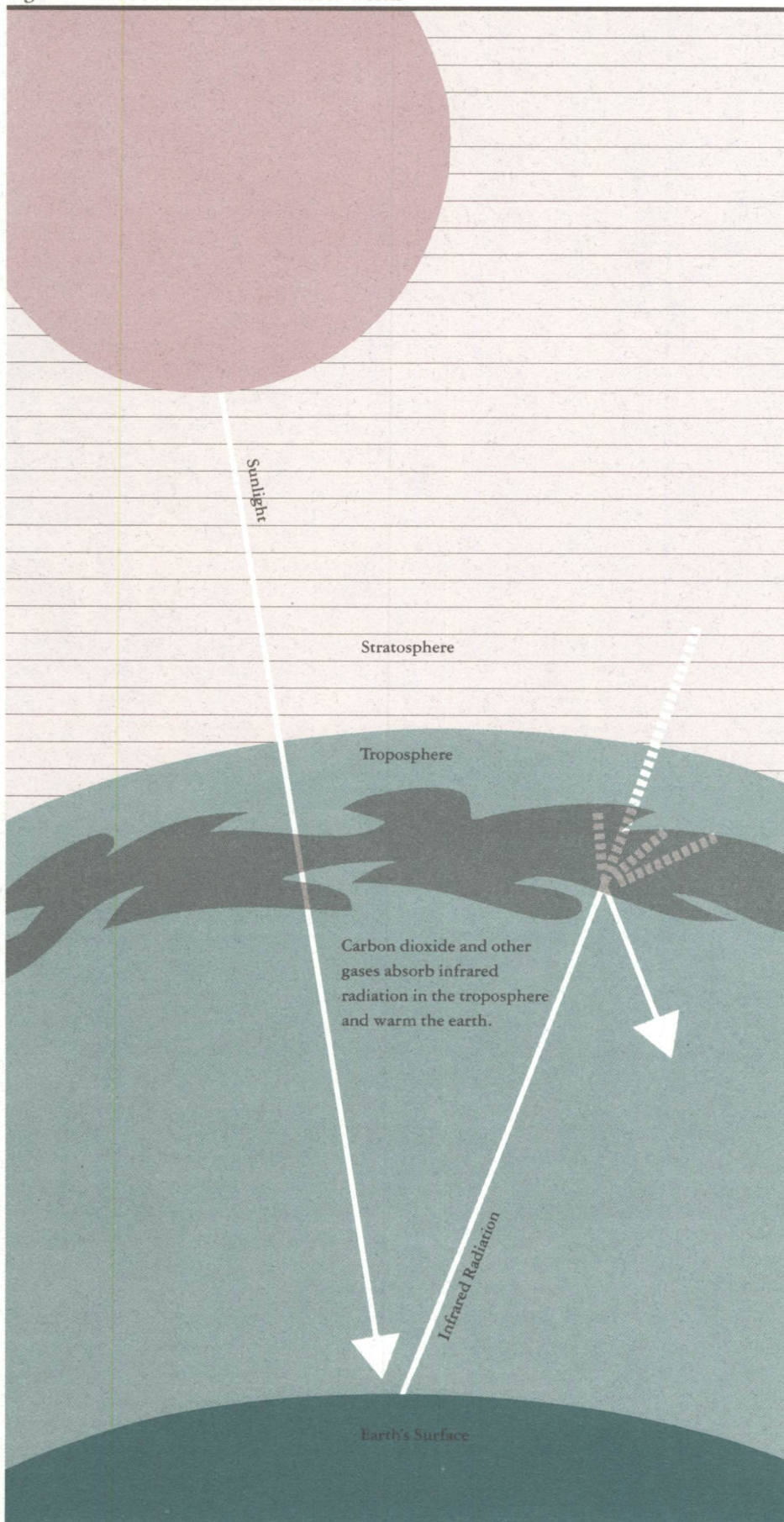
Fourth, states have an important role to play in addressing this problem because of their authority over utilities, land-use, transportation, taxation, and other means of affecting change in the environment.

Fifth, any effective solution or response to global climate change must necessarily include sustained action by the federal government and the international community. Developing nations, whose emissions may grow rapidly in the future, must be full partners in the international negotiations.

The central question facing policymakers—and the primary issue facing the task force—is whether enough is known about global climate change to warrant taking action now to reduce it. Although considerable uncertainties must be acknowledged, some scientists and government agencies in several countries have predicted that significant global climate change could be evident within the next several decades.⁶

The social and economic costs of the measures that may be necessary to reduce greenhouse emissions are still being evaluated. Economists have estimated these costs for the United States to range from virtually nothing to 5 to 6 percent of gross national product.⁷ Overreaction could have serious effects on the economic well-being of the nation, depending on the actual cost. The next generation deserves to inherit the healthiest possible economy as well as the healthiest possible environment.

Figure 1 How the Greenhouse Effect Works



Source: U.S. Environmental Protection Agency, *EPA Journal*, vol. 15, no. 1 (January/February 1989), p. 5.

The costs of responding to the threat of climate change must be weighed against the possibly severe environmental and economic consequences associated with global warming and the risks associated with delay. Because greenhouse gases can remain in the atmosphere for centuries, emissions have a cumulative impact on the climate. Although the magnitude and timing are uncertain, today's emissions are likely to "commit" the planet to some degree of warming. In its 1989 report on global warming policy options, EPA found that early governmental response to global climate change would result in less severe problems in the next century. Starting a policy response in 1990 could reduce the severity of the problem by 40 percent more than if the same policies were initiated in 2010.⁸

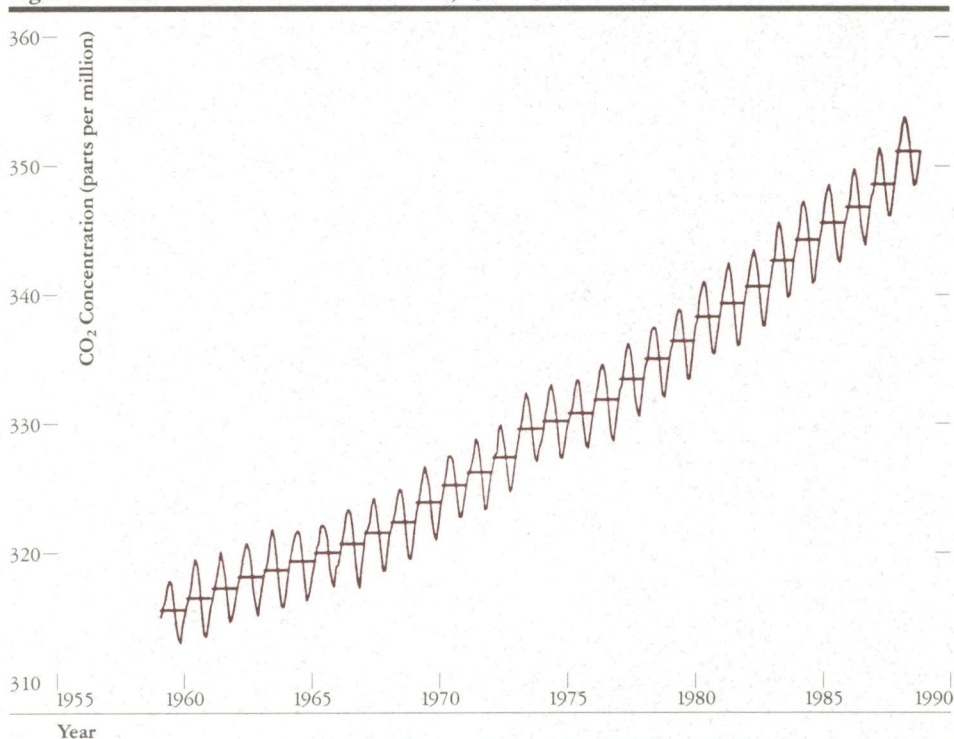
Considering the evidence and the risks of both overreaction and underreaction, the task force recommends taking steps now that provide a reasonable return on investment and offer other social and economic benefits. These prudent measures should be undertaken even in the presence of scientific uncertainty.

If the following goals are achieved for reasons apart from the challenge of global climate change, such as reduction in pollution, greater energy efficiency, or greater economic competitiveness in the global market, they will have been worthwhile even if later scientific evidence diminishes concerns over global climate change.

In view of these findings, the task force embraces seven key goals for the United States in the 1990s. They include the following:

- 1** **Develop an international agreement to protect the atmosphere.** The United States cannot significantly reduce the rate or magnitude of global climate change through unilateral action; the cooperation of all nations is required. It is particularly important that U.S. reductions in carbon dioxide emissions are not offset by a net increase in other countries. America should use its pre-eminent position to lead the development of appropriate agreements as soon as possible to assure a coordinated international approach to the threat of climate change.

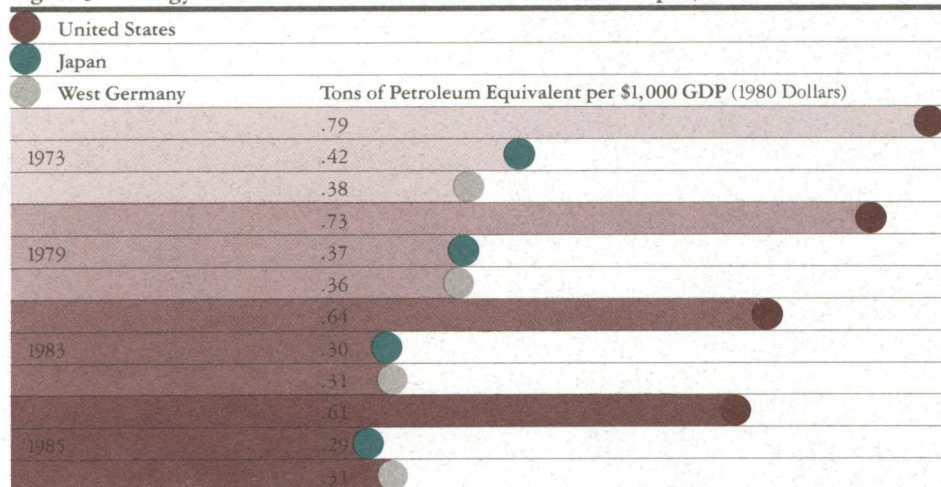
Figure 2 Carbon Dioxide Concentrations, 1958-1988



Note: This figure depicts monthly concentrations of atmospheric carbon dioxide at Mauna Loa Observatory in Hawaii. The yearly oscillation is explained mainly by the annual cycle of photosynthesis and respiration of plants in the northern hemisphere. Horizontal bars indicate average annual concentrations.

Source: U.S. Department of Energy, Multi-Laboratory Climate Change Committee, *Energy and Climate Change* (Chelsea, Mich.: Lewis Publishers, Inc., 1990), p. 35.

Figure 3 Energy Used Per Dollar of Domestic Economic Output, 1973-1985



Note: Energy demand has increased little since the early 1970s, while GNP has grown by 40 percent. Energy-efficiency improvements now save the U.S. economy \$160 billion annually. Nevertheless, Japan and West Germany use half as much energy per unit of economic output as the United States.

Source: William U. Chandler, Howard S. Geller, and Marc R. Ledbetter, *Energy Efficiency: A New Agenda* (Washington, D.C.: American Council for an Energy-Efficient Economy, 1988), p. 2.

2 Utilize cost-effective energy conservation and efficiency measures to stabilize U.S. emissions of carbon dioxide. Between 1973 and 1986, the U.S. economy grew by more than one-third with no significant increase in carbon dioxide emissions, due largely to increases in energy efficiency. The United States should take cost-effective steps to extend that record by improving the efficiency of energy generation and use sufficiently to allow economic growth while stabilizing carbon dioxide emissions. States have numerous opportunities to reduce their carbon emissions through utility regulation reform that encourages efficiency. Building, lighting, appliance, and transportation efficiency measures also can yield substantial reductions in carbon emissions by reducing the amount of fuel we use.

3 Stop production of and recycle chlorofluorocarbons, and use cost-effective strategies to stabilize or reduce other greenhouse gases. The Montreal Protocol should be amended to eliminate the production of chlorofluorocarbons and to require that those already in use be recycled so they are not released into the environment. In addition, steps should be taken wherever possible and cost-effective to stabilize or reduce U.S. emissions of methane, nitrous oxide, ozone, and other greenhouse gases. Methane recovery from waste should be encouraged. Research in agriculture and animal diets has discovered ways to reduce greenhouse gases from these sources. Implementation of these discoveries should be encouraged.

4 Develop and commercialize alternative energy systems, including clean fossil, renewable energy sources, and safe nuclear power. Federal and state governments should take steps to ensure that clean and renewable energy sources make the maximum possible contribution to the nation's energy needs. A wide array of energy sources that would reduce carbon emissions from current levels is available, including clean fossil technologies, cogeneration, solar energy, wind power, geothermal energy, biomass fuels, hydroelectricity, and a new generation of safe nuclear power. These alternative

energy systems should be further developed and marketed so that the energy needs of the nation can be met without increasing greenhouse gas emissions.

5 Implement forestry programs to reduce the effects of global climate change. The severity of climate change can be reduced by taking steps to remove greenhouse gases from the atmosphere. Planting trees, particularly in urban areas, can help reduce the severity of climate change because they take up carbon dioxide as well as provide shade. Responsible management and expansion of our existing forest resources can improve the quality of forest ecosystems, increase our production of wood, and reduce atmospheric carbon dioxide.

6 Plan and act now to adapt to a changing climate. Some degree of future climate change due to human activities or natural phenomena appears likely. A planned response to this change should be developed promptly. Particular attention should be given to problems related to water resources, sea level rise, and agricultural and forestry practices. The task force recommends that programs in these areas consider the possibility for future global climate change.

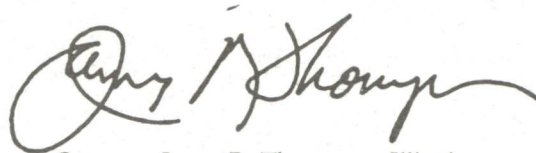
7 Pursue an aggressive research program to reduce key uncertainties about global climate change. The world's response to the threat of global climate change must be based on the best possible science. We must enhance our ability to understand, monitor, and predict the forces that are shaping the climate. It is imperative that the United States, as the world's leader in scientific research, support a program of research to better define the potential magnitude and timing of future climatic changes; the possible ecological effects of such changes; and the cost and effectiveness of various response options, including changes in energy sources.

In embracing these goals, the task force believes the federal government bears a special responsibility for assisting states or industries that may be adversely affected by a move to a less energy- and carbon-intensive economy. The

federal government must plan for and provide a transition so that our national goals do not become unreasonable limitations on the growth and development of particular states or industries.

Finally, the task force recognizes that our lifestyles, the actions we take as consumers, and our attitudes toward the natural world directly affect the planet. Continued economic growth must occur within a framework that recognizes the long-term need for sustainability. The task force supports the development of environmental education programs and other efforts to provide greater insight into the ways in which our actions knowingly or unknowingly affect the environment. We must foster an environmental ethic promoting stewardship of the earth for present and future generations.

The following chapters examine these goals in greater detail and suggest strategies that could be used to achieve them.

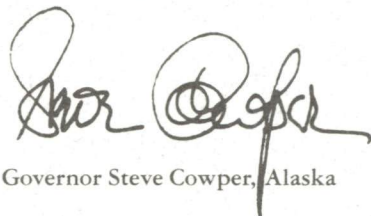


Governor James R. Thompson, Illinois
Task Force Chairman



Governor Madeleine M. Kunin, Vermont
Task Force Vice Chair

Members of the Task Force



Governor Steve Cowper, Alaska



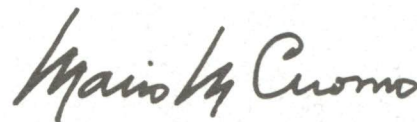
Governor Michael N. Castle, Delaware



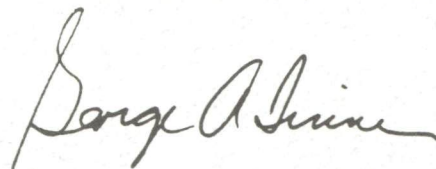
Governor Buddy Roemer, Louisiana



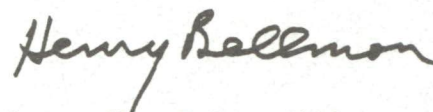
Governor Stan Stephens, Montana



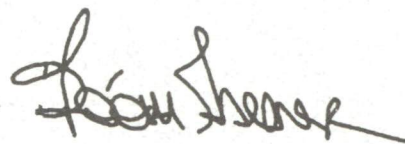
Governor Mario M. Cuomo, New York



Governor George A. Sinner, North Dakota



Governor Henry Bellmon, Oklahoma



Governor Booth Gardner, Washington



Governor Tommy G. Thompson,
Wisconsin

STATEMENT OF THE PROBLEM

Through the millennia, the earth has been changing. Great ice sheets have developed and disappeared, forests and grasslands have migrated across the globe, even the oceans have advanced and retreated in response to global forces unknown to the primitive humans who witnessed these changes. Now, human forces may be changing the earth. There is great concern among some scientists around the world that human activities may be altering the atmosphere enough to cause "global warming" and serious changes in climate.

The phenomenon of greenhouse warming was first described in 1827 by the French mathematician and physicist Jean Fourier, who suggested that the earth's temperature is the result of certain greenhouse-like properties of the atmosphere. These properties permit solar radiation to reach the earth's surface and limit its escape again into space, thus warming the planet. Without the greenhouse effect, as these properties have come to be known, the earth would be cold and lifeless.

By 1896 global warming was understood well enough that the great Swedish chemist Svante Arrhenius was able to demonstrate that the traces of certain gases found naturally in the atmosphere—principally carbon dioxide and water vapor—account for the greenhouse effect. Moreover, Arrhenius was able to calculate the temperature increase that could be expected if the combustion of fossil fuels doubled concentrations of carbon dioxide in the atmosphere. He predicted that such a doubling would raise the global average temperature by about 10 degrees Fahrenheit, consistent with several recent predictions of 3 to 10 degrees Fahrenheit. In the ensuing decades, however, little thought was given to Arrhenius's prediction, not because scientists doubted the nature of the greenhouse effect, but because few expected that human activity could appreciably raise concentrations of atmospheric carbon dioxide. Then, in the International Geophysical Year of 1958, American scientists began to take highly accurate annual measurements of atmospheric carbon dioxide at Mauna Loa, Hawaii. Since then, annual measurements have shown that carbon dioxide and other greenhouse gas concentrations are

increasing rapidly. Other gases in the atmosphere, such as methane, nitrous oxide, and chlorofluorocarbons, also have greenhouse properties and are increasing. These gases differ in their concentration, atmospheric lifetime, and climate effect.

The Greenhouse Effect

The total effect of all the known greenhouse gases has already brought the atmosphere halfway toward the doubling of atmospheric carbon dioxide that Arrhenius used as the benchmark for his calculations. The growth of global emissions of greenhouse gases is directly related to human activities and is dependent upon population growth, the level of economic activity, and other factors impossible to predict with confidence. EPA and others have estimated that, at current rates of emissions, atmospheric concentrations of carbon dioxide will have doubled from preindustrial levels by around the middle of the next century.⁹ Because carbon dioxide is the predominant greenhouse gas, a doubling of carbon dioxide from preindustrial concentrations has become the benchmark for estimating changes in temperature and climate.

Although in the earth's distant past there were periods of high atmospheric carbon dioxide corresponding with high global temperature, neither the historical record nor direct observation can tell scientists exactly what effect such a doubling in carbon dioxide concentrations will have on global temperature. To estimate future temperature, scientists must use complicated mathematical models that reflect the physical laws governing the behavior of gases, and formulas expressing the interaction of the atmospheric system with the oceans and land masses. Many of these interactions are not well understood. Among other uncertainties, the role of clouds—which both reflect sunlight back into space, cooling the earth, and trap infrared energy, warming the atmosphere—is a major source of uncertainty in mathematical climate models. Modeling ocean currents, a crucial part of the climate system, also has proven difficult.

Another limitation is the incomplete understanding of the interaction of various greenhouse and non-greenhouse gases. For example, sulfur dioxide in the atmosphere brightens clouds and causes acid precipitation. Brighter clouds reflect more of the sun's radiation and may cool the earth. Temperature records for the northern hemisphere over the last fifty years show little change, a fact that some scientists

attribute to increasing sulfur dioxide emissions. They hypothesize that sulfur dioxide, a principal cause of acid rain, may be delaying global warming.¹⁰

In addition, there is uncertainty about other various effects that counteract or reinforce increases in the global temperature. For instance, it is possible that carbon dioxide fertilization, which makes plants grow faster, increases their uptake of carbon dioxide and removes more carbon from the atmosphere. Similarly, increased activity by soil microbes in response to higher temperatures may increase natural emissions of nitrous oxides. There may be hundreds or thousands of such feedbacks, each acting to enhance or reduce the magnitude of global climate change; their number and the net effect on the climate are unknown.¹¹ Because these relationships and the overall sensitivity of the world's climate system are not well understood, the magnitude of climate change as the result of doubled carbon dioxide remains subject to considerable uncertainty.

The timing of any change in global temperature is also highly uncertain. Models can predict a new average global temperature for the climate in equilibrium, but cannot estimate how long it will take to realize that new temperature or whether the climate will change smoothly or abruptly. The atmospheric system and the oceans take a long time to warm up due to thermal inertia. There is an unknown lag time that occurs between a change in the atmospheric composition and a change in surface temperature. Thus scientists speak of increased levels of greenhouse gases resulting in a "commitment" to higher temperature without certainty about when it will actually occur.¹²

Finally, current models necessarily focus on a large geographic scale, while regional or local effects remain uncertain. Scientists expect that temperatures will increase more at higher latitudes than closer to the equator. Even a modest increase in global average temperature can include dramatic and economically important regional events, some positive and some negative, such as increased growing seasons, changes in rainfall patterns, heat waves, or storms.¹³

Increases in atmospheric concentrations of certain greenhouse gases during the last century are known, so it should be possible to directly test the models—if the global average temperature in the last century can be

Table 1 Summary Table of Greenhouse Gasses

Greenhouse Gas	Current Contributions to Warming (%)	Major Global Sources (%)	Atmospheric Concentration (parts per million)	Annual Increase (% per year)	Life Span (yrs.)	Climate Effect (CO ₂ = 1)
Carbon Dioxide	49		351.3	0.4	100	1
Fossil Fuels	35-45	75-90				
Deforestation	4-15	10-25				
Methane	18		1.675	1.0	11	25
Natural Wetlands		20-40				
Rice Paddies		12-35				
Ruminant Animals		12-20				
Landfills		6-15				
Natural Gas Drilling		5-10				
Coal Mining		3-9				
Chlorofluorocarbons	14		.000225	5.0	75-111	15,000
CFC-11			.000226	4.0	75	
Foams		55				
Aerosols		31				
Refrigerators		8				
CFC-12			.000392	4.0	111	
Refrigerators		49				
Aerosols		32				
Foams		13				
Nitrous Oxide	6		.31	0.2-0.3	150	230
Natural Soil and Ocean Releases		50-60				
Fossil Fuels		7-20				
Deforestation		7-15				
Fertilizer Use		2-17				
Tropospheric Ozone	?		.02-.1	?, but increasing	hours	2,000
Carbon Monoxide	?		.20	2	.4	NA
Fossil Fuels		10-25				
Deforestation		8-35				
Oxides of Nitrogen	?		.01-1.0	?	1-7	NA
Fossil Fuels		28-55				
Deforestation		16-25				

Sources: Christopher Flavin, *Slowing Global Warming: A Worldwide Strategy*, Worldwatch Paper 91 (Washington, D.C.: Worldwatch Institute, 1989), p. 13; Daniel A. Lashoff and Dennis A. Tirpak, eds., *Policy Options for Stabilizing Global Climate Change—Draft Report to Congress* (Washington, D.C.: U.S. Environmental Protection Agency, 1989), pp. II.51-58; Florentin Krause et al., *Energy Policy in the Greenhouse* (El Cerrito, Calif.: International Project for Sustainable Energy Paths, 1989), pp. I.1.9-11.

established to provide a base line. Two scientific groups—one in the United States and one in England—have independently surveyed the historical record and found a temperature increase of about 0.9 degrees Fahrenheit (0.5 degrees Celsius) over the last 100 years.¹⁴ This increase is about half the levels predicted by most models, based on observed increases in greenhouse gases. The discrepancy between observed and predicted temperature increases over the last 100 years keeps most scientists from stating with confidence that global warming has been observed.

Despite these uncertainties, scientists do not dispute the increase in atmospheric concentrations of greenhouse gases or the basic physics of the greenhouse effect. Several climate models developed and used independently in different countries have resulted in roughly similar estimates of future global temperature increases, in the range of 3 to 10 degrees Fahrenheit, assuming the greenhouse gas equivalent of doubling preindustrial levels of carbon dioxide. Such a warming would be unprecedented in human history. At the upper end of this range, it would approximate the temperature increase since the depths of the last ice age and would occur several hundred times faster.

Global Climate Change

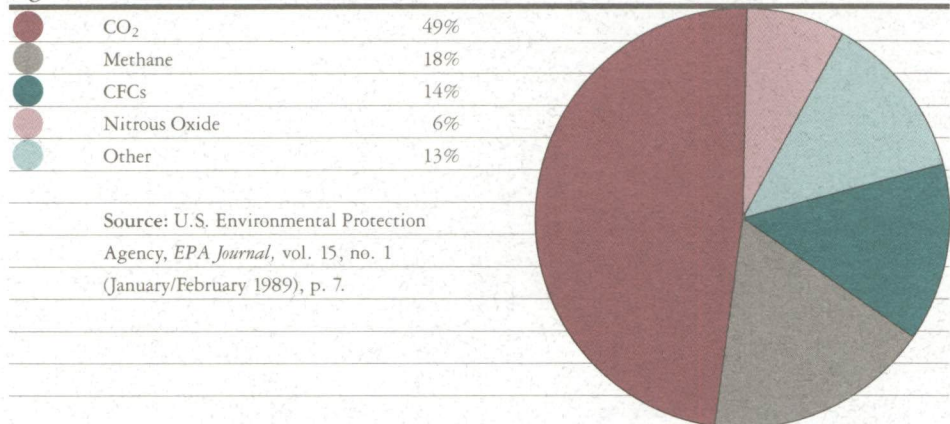
Policymakers worldwide have noted these predictions and the severe consequences of a global warming of this magnitude. The principal concern is not global temperature increase alone, but rather the fact that the global temperature governs the earth's weather and climate in fundamental ways. Climate is determined largely by ocean and atmospheric currents, which in turn are driven by differences in temperature between warmer and cooler parts of the oceans, land masses, and atmosphere. The complex interactions of the earth's climate system are directly fueled by the planet's energy balance. If global temperature changes, so too must the climate.

Table 2 Global Carbon Dioxide Balance

Carbon Dioxide Released Source	Amount per Year (in 10 ⁹ tons)	Percentage
Natural Sources		
Oceans (Ocean-atmosphere interactions, upwelling from deep oceans)	381	60
Land (Biological decomposition releases from soils, forest fires)	216	36
Total Natural Sources	597	96
Human Sources		
Fossil fuel use (Utilities, automobiles, heating, etc.)	18	3
Land use (Deforestation)	7	1
Total Human Sources	25	4
Total from all Sources	622	100
Carbon Dioxide Removed Source		
Ocean (Ocean-atmosphere interactions, photosynthesis, biological activity)	392	63
Land (Photosynthesis)	220	35
Total	612	98
Carbon Dioxide Accumulated in Atmosphere		
Total	10	1

Source: Florentin Krause et al., *Energy Policy in the Greenhouse* (El Cerrito, Calif.: International Project for Sustainable Energy Paths, 1989), p. 1.3-28.

Figure 4 Manmade Contributions to the Greenhouse Effect in the 1980s



While the science of global climate change is relatively new, studies have been conducted to examine the potential effects of a global temperature increase. These studies indicate that a doubling of atmospheric carbon dioxide could result in far-reaching—even disastrous—changes in the earth's climate. EPA's report to Congress, *The Potential Effects of Global Climate Change on the United States*, compiles data from numerous studies and analyzes the results region by region and sector by sector. The numerous

effects described in the report suggest that global climate change may be among the greatest threats humanity has ever faced.

Water Resources

Significant global temperature increases could cause more frequent and more severe droughts and floods. It is not yet known whether an increase or decrease in average rainfall is likely to result from the greenhouse effect, but most

predictions point to increases in extreme weather events such as droughts and floods.¹⁵ The regional and seasonal distribution of rainfall may also shift. Several studies suggest that mid-continental areas—such as the American Midwest—will become drier.

Other effects could include:

- Greater demand for water and decreasing supply. Irrigation and electric power production could be adversely affected in many areas.
- Lower river flows, negatively affecting hydropower, navigation, aquatic ecosystems, wildlife, and recreation.
- Earlier winter melts and the replacement of snow with rain, exacerbating seasonal flooding problems.
- Greater variability in the levels of rivers and lakes between months and years, which greatly complicates water management.
- Decreased water quality due to lower river flows and lake levels.

As mentioned earlier, today's state-of-the-art climate models cannot confidently predict regional climate change effects. The regional data that exists indicates that areas that currently experience water supply difficulties would face even greater problems associated with global warming.

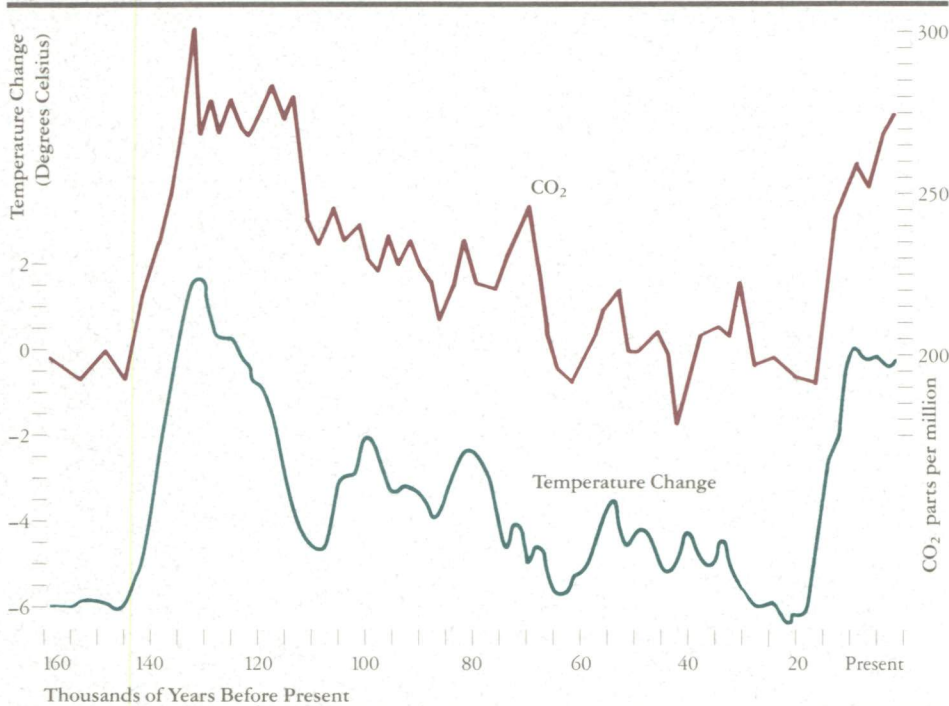
Agricultural Changes

The effects of global warming on agriculture are uncertain but potentially serious.¹⁶ The stress from increased heat, lower moisture, irrigation pressures, and expanded pest ranges must be balanced against any potential improvements in plant growth that result from increased concentrations of carbon dioxide and

"Global climate change poses a wide-ranging threat to the entire world. We must take reasonable steps now to reduce this threat and at the same time achieve other benefits such as increased energy efficiency and cleaner air."

- Governor James R. Thompson
Illinois

Figure 5 Atmospheric CO₂ and Temperature for Past 160,000 Years



Source: U.S. Department of Energy, Multi-Laboratory Climate Change Committee, *Energy and Climate Change* (Chelsea, Mich.: Lewis Publishers, Inc., 1990), p. 35.

longer growing seasons. EPA studies suggest that:

- Yields of corn, soybeans, and wheat would probably be reduced in all but the northernmost regions of the United States, which could have a longer growing season. If the "fertilization benefits" of carbon dioxide on crop yields are significant, some areas might overcome the negative effects of climate change. However, these fertilization benefits under field conditions are still uncertain.
- There may be a small to moderate aggregate reduction in agricultural output. This reduction should not threaten domestic food supplies, but it could negatively affect world food supplies and the U.S. trade balance.
- Farmland dependent upon natural rainfall could become less reliable, and the demand for irrigated acreage is likely to increase. This could put stress on regional water demand and lead to further degradation of surface and groundwater.

- Higher temperatures probably would increase the range and survivability of agricultural pests. More pests would survive winter, produce more than one generation per year, and affect crops earlier in the growing season. Pesticide usage probably would increase to combat the growing pest population.

In the aggregate, EPA studies suggest that the United States would probably not suffer a large net loss in agricultural production as the result of climate change. Any benefits of climate change, however, would not be uniform. Severe changes would necessitate continued technological improvements in agriculture. The shift of growing regions northward may be impeded

"I inherited this farm from my parents, and will pass it on to my children. I know there are uncertainties, but no scientist has told me the pollution is good for my trees."

• David Marvin
Vermont Maple Sugar Producer
Burlington Regional Hearing

by different soil conditions. The shifts in agriculture necessary to accommodate a change in climate would burden many farmers and threaten the economies and ecosystems of some agricultural regions.

At the task force's regional hearing in Burlington, Vermont, speakers expressed serious concerns over the ability of local agricultural economies to adapt to fundamentally different climates. The Vermont maple syrup industry, for example, has suffered from the combined effects of acid rain, ozone pollution, and heat stress. According to industry representatives, areas in Canada that produced no maple syrup twenty years ago are now enjoying bumper crops. It is likely that the predicted climate change will push the southern boundary of sugar maples and many other crops further northward, causing further economic disruption in northeastern agricultural communities.

Sea Level Rise

As water warms, its volume increases. Global warming in the range of most predictions could raise the ocean level from one and one-half to six feet over present levels by the year 2100, though recent estimates suggest the probable actual increase would be one to two feet.¹⁷ During the last ice age, when global temperatures were about 9 degrees Fahrenheit lower than today, sea level was more than 300 feet lower than it is now. Conversely, during the last interglacial period (100,000 years ago), when temperatures were about 2 degrees warmer than today, sea level was approximately twenty feet higher.¹⁸ Land-based glaciers, which store huge amounts of water, also influence sea level by slowly growing and shrinking. While most global warming predictions include declining glaciers, recent satellite data indicates that some glaciers are growing.

More frequent tropical storms and higher storm surges would exacerbate any increase in average sea level. While predictions suggest global warming could cause the loss of several hundred feet of shore or more, most U.S. recreational beaches are already less than 100 feet wide at high tide.

Many beaches and barrier islands could require massive adaptive efforts or face complete destruction. Flooding could increase along the

Table 3 Effect of a One-Foot Sea Level Rise

Area	Beach Erosion
Northeast to Maryland	50-100 feet
Carolinas	200 feet
Florida Coast	100-1,000 feet
Louisiana	several miles
California	200-400 feet

Note: These numbers represent averages for the coastal regions listed; local beach erosion could be considerably higher where it coincides with other erosion problems.

Source: Joel B. Smith and Dennis Tirpak, eds., *The Potential Effects of Global Climate Change on the United States*, Report to Congress (Washington, D.C.: U.S. Environmental Protection Agency, 1989), pp. 126-127.

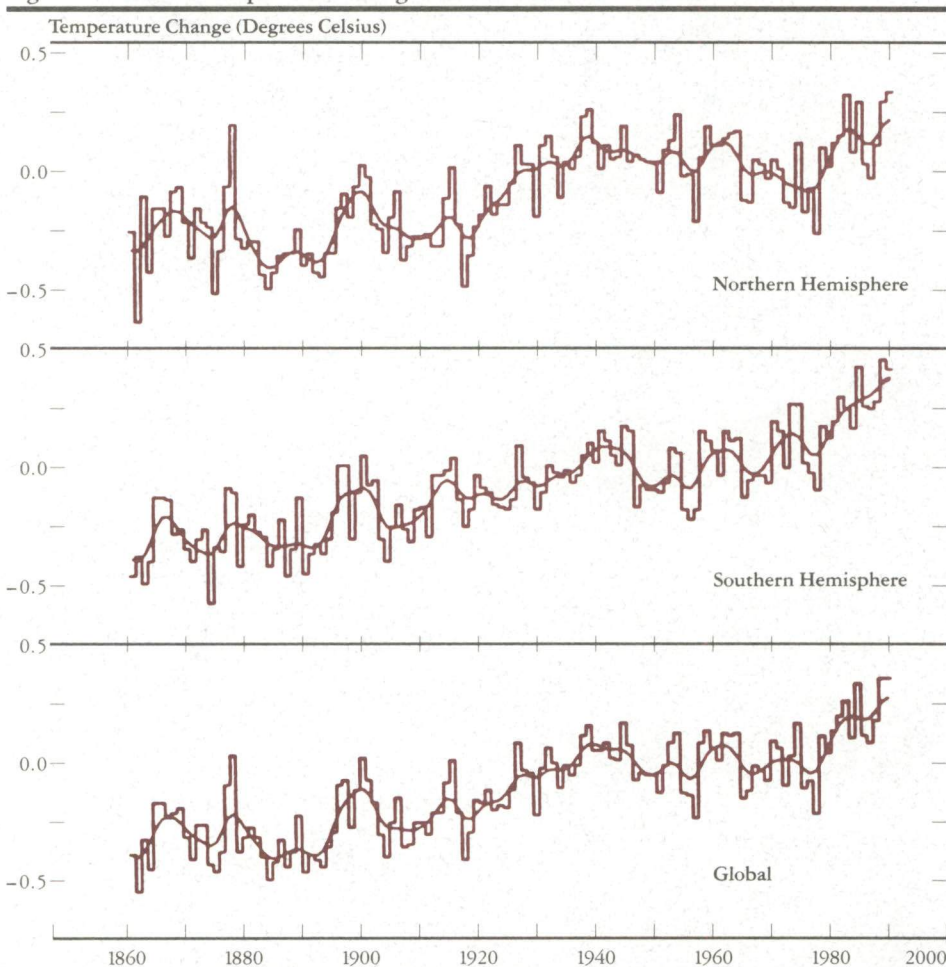
coast as higher sea levels boost storm surges, reduce coastal drainage, and raise the water table. In the face of a three-foot sea level rise, EPA estimates it would cost \$73 billion to \$111 billion to protect barrier islands and developed mainlands through 2100.¹⁹ This estimate measures only the cost of shore protection. The financial losses of coastal industries such as tourism and fishing could be much higher.

A rise in sea level also would allow saltwater to infiltrate farther into rivers, bays, wetlands, and aquifers. Increased salinity has already damaged oyster harvest in the Chesapeake Bay and pressured water supplies in Florida and

New Jersey. According to EPA, a three-foot rise in sea level could eliminate up to 82 percent of continental U.S. wetlands, a crucial ecological resource.²⁰ In addition to changes in the level of the sea, some scientists predict that major changes could occur in ocean currents such as the Gulf Stream, with virtually unpredictable effects on fishing or local weather.

At a regional hearing in New Orleans, Louisiana, the task force Governors heard evidence from experts on the potential climate-related devastation in the region. In Louisiana, shorelines are already retreating at a rapid pace; climate-induced sea level rise is expected to intensify this destruction.

Figure 6 Annual Temperature Changes for Land and Ocean Areas



Source: U.S. Department of Energy, Multi-Laboratory Climate Change Committee, *Energy and Climate Change* (Chelsea, Mich.: Lewis Publishers, Inc., 1990), p. 89.

Impact on Forests

Forests are particularly sensitive to climate and rainfall. Climate change could force the southern ranges of many forests northward by hundreds of miles. Unfortunately, forest migration will probably occur too slowly to keep up with favored climate conditions, and large areas of forest could die. Temperature increases of the magnitude predicted would make forests more susceptible to fires, pest attacks, and replacement with low-value trees, grasslands, and shrubs. In addition, changes in forests could reduce their biological diversity, aquifer recharge, wildlife habitat, and recreational uses. Precipitation runoff and soil erosion could increase in many areas.²¹

Scientists at the task force meeting in Burlington discussed the implication of climate change for forest ecosystems. The intricate relationships between climate and forest growth, insect ranges, and diseases complicate predictions of forest impacts. But several scientists feared that the multitude of pressures on forests, including climate change, could cause a widespread loss of whole ranges of tree species. According to the U.S. Forest Service, valuable commercial forests stretching from Texas to Virginia have experienced declining growth in recent years. Trees have the unique ability to absorb carbon dioxide from the atmosphere as they grow. This benefit to the climate could be reduced by heat stress, which stunts tree growth and reduces carbon dioxide uptake.

"One of the most tragic consequences of global climate change will be the rise of sea level. This can be expected to cause widespread erosion and flooding of coastal areas, loss of wetlands and estuaries, and incalculable damage to buildings and structures."

• Governor Buddy Roemer
Louisiana

Effects on Biological Diversity

Unlike most other effects, the loss of a species is irreversible. Many species of plants and animals live within narrowly prescribed climate bands and may not be able to migrate or adapt quickly enough to adjust to climate changes. Reduced biological diversity could have serious implications, and untapped resources for research in agriculture, medicine, genetics, and industry could be irretrievably lost. Changes in habitat, location of wintering ground for migratory birds, and breaks in the food chain could cause ecological devastation.²²

Changes in Air Quality

Higher temperatures speed the reaction rates among chemicals in the atmosphere. As a result, the formation of ground-level ozone, which is the result of reactions of oxides of nitrogen and volatile organic compounds, would increase in many areas. Emissions of hydrocarbons, nitrogen, and sulfur oxides from human and natural sources also would increase with temperature. Under higher temperatures, sulfur and nitrogen oxides would oxidize more rapidly, increasing the formation of acid rain and snow in the atmosphere. EPA estimates that in the Midwest and Southeast, a 7 degree Fahrenheit temperature increase could triple the number of areas exceeding the National Ambient Air Quality Standards for ozone.²³

Human Health Effects

It is possible that deaths related to extreme temperatures could be increased in the summer and decreased in the winter. At present, the United States experiences more weather-related deaths during summer than in the winter months. Increases in temperature may be linked to higher infant mortality, outbreaks of malaria and Dengue fever, heart attacks, strokes, and respiratory diseases. In addition, populations and ranges of disease-spreading vectors such as mosquitoes and ticks may increase. Lung

cancer has been linked to increases in ozone levels, which are likely to increase as temperatures increase. In general, EPA reports that "unless the U.S. population becomes fully acclimated to higher temperatures, climate change will be associated with a rising number of summer deaths."²⁴

Changes in Climate Extremes

The most common prediction of global climate change is expressed in terms of average temperature, but the global average masks great variation from place to place and from season to season. In particular, summer heat waves could intensify considerably. The number of days in which an area reaches a certain temperature threshold would be greatly increased in some areas. Some predict these changes will be enough to become noticeable to the population within the next decade. For example, one study speculates that the average number of days in a year when the temperature exceeds 100 degrees could increase from three to twenty-one in Omaha, assuming a doubling of atmospheric carbon dioxide.²⁵ Furthermore, the changes may come in the form of sudden climate jumps rather than following a smooth curve. One study of U.S. temperatures since 1900 has shown an increase in average nighttime temperatures and little change in average daytime temperatures. The study suggests that if global climate change takes place in the form of higher nighttime temperatures, some of the biological effects would be reduced.²⁶

Meteorological Events

One of the first effects likely to be felt is an increase in weather variability from season to season and from year to year. This change could bring more frequent and intense droughts and floods. Many sectors of the economy, particularly those relying on water resources, depend on reasonably predictable rainfall patterns. In addition, the warmth of ocean water is a determinant of the strength of hurricanes. Under the global warming scenarios studied, hurricanes would become more frequent, violent, and widespread. Winter snow melts would occur earlier and rain would replace snow in some areas.²⁷

Environmental Refugees

These effects may make some parts of the world much less hospitable than at present. Increased desertification, sea level rise, or flooding could require evacuation of some areas. America's

Pacific Trust Territories, for example, could be hard pressed to support their current population due to low elevation and susceptibility to damage from tropical storms. Indeed, some nations, especially low-lying or island countries, could cease to exist if sea level rises as much as some have predicted. These changes could result in an international flood of environmental refugees—people fleeing not from political or economic systems, but from ecological disaster.

Other Effects

Urban infrastructures may well be affected by increasing temperatures. The net effect is difficult to predict; some cities might have lower snow removal and street repair costs but higher air conditioning costs, for example. During the heat wave of 1988, Amtrak was forced to close major sections of track as a result of heat damage that warped the rails.²⁸ Annual costs of new electric facilities needed to meet increased demand from climatic changes could reach \$3 billion to \$6 billion by 2010. Climatic change could add between \$33 billion and \$73 billion to capital costs in this sector by 2055, depending on GNP growth, according to EPA.²⁹

In addition to these effects, many other unanticipated effects could take place. The predictions outlined above cannot be considered immutable; they indicate the adaptation and displacement that may be necessary to cope with significant climate change. In some cases, such as species loss, the damage would be permanent. Other changes, such as agricultural effects, could require a massive restructuring.

Climate change in the range predicted by most models would place the earth's temperature at its highest point since humans appeared on earth.³⁰ The effects on climate-sensitive ecosystems and human activities would be unprecedented.

"Every generation owes a sacred trust to the future that requires us to pass to succeeding generations the planet itself, unbroken and unspoiled. We do not own the earth; rather, we are its stewards."

• Governor Madeleine M. Kunin
Vermont

DEVELOP AN INTERNATIONAL AGREEMENT TO PROTECT THE ATMOSPHERE

All nations will be affected by global climate change, and the challenge it poses cannot be met by the United States alone. Indeed, unilateral American efforts to respond to the threat of climate change will be seriously devalued if other countries do not also take action. Projections of population growth, energy use, and land-use indicate that emissions from developing countries are likely to increase rapidly and to overshadow America's emissions in the future. According to EPA predictions, energy consumption in developing nations could increase by a factor of 2.5 to 4 by the year 2025, and it could account for the bulk of the carbon dioxide emitted to the atmosphere by the year 2050.³¹ At the same time, many developing nations lack the capacity to adapt to climate change and to minimize their contribution to greenhouse gas buildup because they lack the resources and technologies they need for "clean" economic growth. Affluent nations will need to make financial and technological assistance available to developing countries in return for specific commitments to an environmentally sustainable development path. There are several necessary steps:

- The United States must assert its leadership within the international community to negotiate at the earliest possible date an international framework convention that ensures

"All nations are implicated in the prospect of global climate change, and the United States should not act alone to address the problem. The United States as a major market must require equal efforts in alleviating global warming from countries with which it trades. A coordinated international effort is needed, so that all nations contribute equitably."

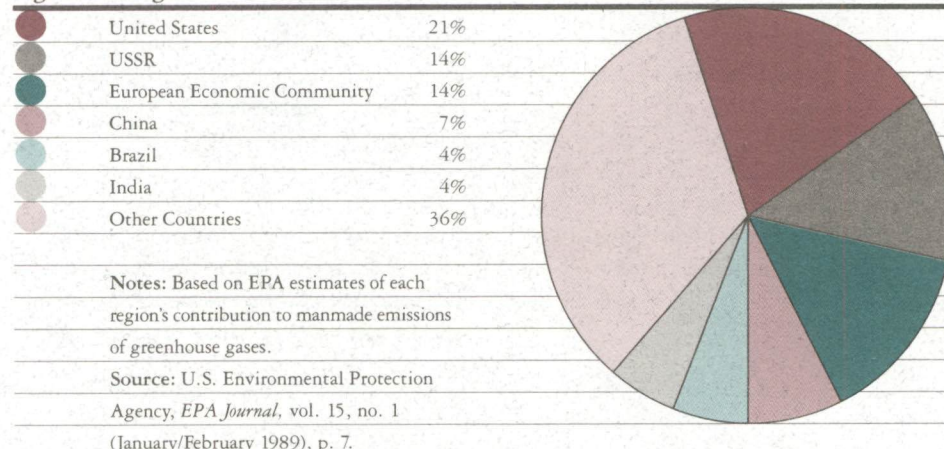
• Governor George A. Sinner
North Dakota

international cooperation to protect the atmosphere.

- Individual protocols or treaties containing specific commitments from all nations on greenhouse gases, energy efficiency, population growth, and other items should be negotiated as soon as possible.
- Agreements to stop deforestation of the earth's tropical belt should be given high priority.

While forestry programs are promising for the United States' response to global climate change, they are particularly applicable to the developing world. Numerous interrelated social and economic pressures have led to widescale deforestation in Latin American, Africa, and Asia. Population growth has required more land for agriculture and livestock. In debt-strained nations, the valuable agricultural commodities and forest products derived from cleared tropical forests provide much-needed foreign currency. In some countries, the need for fuel wood, often the primary energy source, has required the population to exploit every possible wood source. These pressures have led to widespread clearing of forests in the tropics: each year at least 27.3 million acres are lost, an area roughly the size of Illinois.³²

Figure 7 Regional Contributions to the Greenhouse Effect in the 1980s



UTILIZE COST-EFFECTIVE ENERGY CONSERVATION AND EFFICIENCY MEASURES TO STABILIZE U.S. EMISSIONS OF CARBON DIOXIDE

Meeting the challenge of global climate change will require cooperative action by the states, the federal government, and the private sector. A number of steps that would help minimize the rate and magnitude of global climate change are cost-effective and meritorious regardless of their climate benefits, and should be taken now. These steps include:

- reforming the regulation of electric utilities;
- improving building energy efficiency standards;
- improving appliance efficiency standards;
- improving transportation energy efficiency; and
- expanding state government energy efficiency programs.

Improving energy efficiency is the most effective and immediate step to minimize global climate change. Measures to improve energy efficiency

"Improving energy efficiency is the single most important thing we can do to protect the global climate. Using energy more wisely will save consumers money as well as enhance the environment."

• Governor Mario M. Cuomo
New York

can be put in place over a relatively short period. Benefits can be realized immediately. Moreover, a wealth of opportunities are available for cost-effective energy efficiency improvements in the American economy and worldwide. For efficiency investments that pay for themselves over the life of the equipment through reduced energy costs, the accompanying reduction in carbon dioxide emissions is essentially a cost-free by-product of a more efficient economy. Efficiency improvements also can reduce emissions of other pollutants, improve economic competitiveness, and enhance U.S. environmental quality, energy independence, national security, and public health.

The energy decisions made in the next decade will have a major bearing on the environmental quality of this nation in the next century and beyond. While the federal government has a critical role to play, states are the primary mechanism for influencing and implementing energy efficiency policy objectives. At the same time, the federal and state partnership in meeting the nation's energy and environmental goals must be strengthened.

More specifically, states and the federal government should pursue energy policy options that not only are prudent, cost-effective, and practical, but also have the potential for playing a key role in minimizing carbon dioxide emissions.

Figure 8 U.S. Carbon Dioxide Emissions by Sector

Utilities	35%
Transportation	32%
Manufacturing	20%
Residential/Commercial	13%

Note: Active carbon dioxide emissions by agriculture are excluded because they are small and associated with transportation.

Source: U.S. Department of Energy, Office of Environmental Analysis, *A Compendium of Options for Government Policy to Encourage Private Sector Responses to Potential Climate Changes*, vol. 1 (Washington, D.C.: U.S. Department of Energy, 1989), p. 2.6.

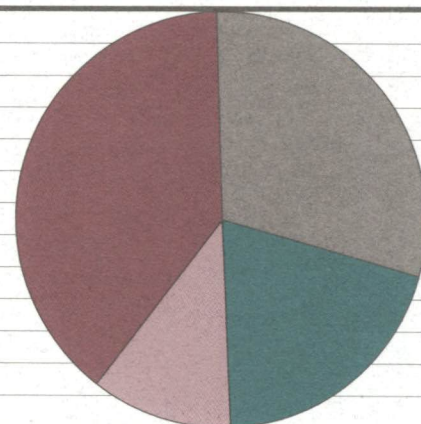


Table 4 Annual U.S. Carbon Dioxide Emissions Per Capita

Activities		Emissions (in equiv. lb. of CO ₂)
Residential	Appliances	3,100
	Space heating	3,000
	Water heating	1,200
	Air conditioning	660
Transportation	Automobiles	6,400
	Air travel	1,100
	Rail (freight and passenger)	350
	Buses	110
	Bicycles	approx. 0
	Other (incl. trucks, boats, pipelines, military, and off-road)	6,600
Industrial & Commercial		21,600
Total		44,000

Source: The National Audubon Society, "The Audubon Activist Carbon Dioxide Diet" (New York, N.Y.: The National Audubon Society, 1990).

STRATEGY: Promote Utility Regulatory Reform. States, through their public utility commissions, have the primary authority to regulate and affect the ability of electric and gas utilities to improve the efficiency of electricity and natural gas use. Several specific tools available to states can encourage improvements in the generation and use of electricity and natural gas, including least-cost planning and rate design reform.

Integrated Resource Planning for Energy Integrated resource planning (least-cost planning) focuses on meeting a state's future energy needs at the lowest possible cost considering all factors. Using this process, utilities identify and implement all practicable and cost-effective efficiency opportunities that meet energy needs. If utilities need additional supply, they may purchase them at auctions either from independent energy service companies, who may be able to find unexploited energy efficiency opportunities, or from independent power producers offering new electricity generation projects. In a fully developed and integrated competitive bidding system, the environmental benefits and costs of energy efficiency should be explicitly considered in ranking bids for new capacity. New York, Vermont, and several other states are now implementing competitive bidding systems that account for external environmental costs in the evaluation of alternative energy supply systems. Currently, seventeen states have approved utility bidding programs, while eight states are reviewing the option.

Utility energy requirements can be met by a combination of sources, including energy efficiency and demand-side management programs. The Edison Electric Institute (EEI) estimates that nationwide since 1977 electric utilities have increased the number of energy efficiency and demand-side management programs by nearly tenfold, from more than 130 programs to nearly 1,300 programs today. EEI estimates that these programs have deferred the need for investing more than \$21 billion on new electric generating capacity. The best electric utility demand-side management programs in the country are reducing customer electricity use by 10 to 30 percent (depending on end-use and building type), and are reducing utility peak load growth by up to 5 percent at an estimated cost of less than four cents per kilowatt-hour.³³ The EEI estimates that by the year 2000, savings from such efficiency programs will exceed 45,000 megawatts of capacity and \$45 billion in investment.

The importance of using integrated resource management to meet the nation's future electricity needs is underscored by the increasing importance of electricity in America's energy supply mix. Electricity currently accounts for 37 percent of U.S. energy use. Although total U.S. energy use has risen by less than 7 percent since 1972, electricity use has increased by 55 percent, and electric utilities currently account for about one-third of U.S. carbon dioxide emissions.³⁴ Because a typical power plant converts fossil fuel to electricity with about 33 percent efficiency, an improvement in electricity end-use efficiency will yield a threefold reduction in carbon dioxide.³⁵

Another series of promising efficiency improvements increases the efficiency of existing power plants by actions ranging from increased maintenance to "repowering" (i.e., replacing a major portion of an existing plant, such as the boiler, while retaining other portions of the plant, such as the steam generation equipment). A repowered plant using new boiler technology can significantly increase its efficiency.

Rate Design Reform

Utilities traditionally generate revenue by selling energy supplies. To successfully use utility demand-side management and efficiency to meet environmental goals and future load growth, the utility's current disincentive to saving energy must be removed. States can begin to reconcile shareholder and ratepayer interests by giving utilities proper incentives to implement programs that improve the efficient use of energy by all ratepayer classes. This can ensure that it is as profitable for utilities to save energy as it is to develop new supplies. The options include:

- breaking the link between utility sales and profits so that utility profits do not fall in lockstep with conservation and efficiency improvements;
- allowing rate-basing and incentive rates of return for utility investments in customer conservation measures;
- encouraging financial incentives in the form of equipment rebates, low-cost loans, or shared savings arrangements to all classes of customers; and
- offering energy audits and technical assistance to homeowners, businesses, and industries.

STRATEGY: Improve Building Energy Efficiency Standards. The residential, commercial, and industrial sectors are estimated to contribute more than 35 percent of the nation's carbon dioxide emissions. This figure climbs to 50 percent if electricity use in these sectors is included. Significant potential exists to improve the efficiency of buildings through efficiency measures aimed at lighting, heating, cooling, ventilation, and building envelopes. The tools available to states include building codes, loans for conservation investments, and mortgage subsidies for energy-efficient buildings.

A number of states have documented significant energy and carbon dioxide savings from building energy efficiency programs. The Illinois Home Energy Loan Program, for example, provided grants and low-interest loans for home energy efficiency improvements and reduced the average heating bill by 22 percent for participating homes. This program resulted in an average reduction of more than one and one-half tons of carbon dioxide annually from each home. Vermont offers technical assistance through its Industrial Energy Conservation Advisory Program and estimates its program has resulted in a 20 percent saving in fossil fuels and a 10 percent saving in electricity use in more than 700 industries visited since 1980. This program has reduced annual carbon dioxide by an estimated 3,600 tons.

One of the more ambitious energy-efficient home programs in the nation is operated in the Pacific Northwest, through the Northwest Power Planning Council, the Bonneville Power Administration, state governments in Washington, Oregon, Idaho, and Montana, and northwest utilities. The Super Good Cents Program, a private-public partnership between government and utilities, certified more than

6,000 energy-efficient homes last year. The states and utilities have provided training for builders, consumers, lenders, appraisers, and realtors to build the infrastructure necessary to increase energy efficiency throughout the region. Utilities within the Northwest have also paid a portion of the incremental cost of building to the high standards to guarantee that new homes use cost-effective energy efficiency measures.

In 1989 Iowa saved more than \$1 million in fuel costs and nearly 40,000 tons of carbon dioxide from state buildings as the result of its building energy management program. The state operates a similar program for schools and institutions. The state of Washington has had a residential building energy efficiency code since 1977, and the latest standards include insulation specifications by fuel type for the state's two climate regions. These standards have reduced annual space heating by approximately 60 percent in homes heated with electricity and 43 percent in homes heated with natural gas. In partnership with the federal government, states should establish an aggressive model building efficiency code and

"Many practical opportunities exist for states to reduce the risk of climate change. Such actions make sense for a host of environmental reasons and set the stage for a safer and more productive future."

• Governor Steve Cowper
Alaska

urge its adoption and enforcement in all jurisdictions throughout the country where no such standards currently exist.

STRATEGY: Improve and Adopt Appliance Efficiency Standards. Similarly, states and the federal government should pursue the potential for improving the efficiency of appliances, lighting, and electric motors. States and the federal government could act in concert to build on the National Appliance Energy Conservation Act (NAECA) and the U.S. Department of Energy's recent rules on refrigerators and freezers to implement more stringent national standards for fluorescent and incandescent lamps and fixtures.

Lighting accounts for 20 percent of the electricity used in United States—25 percent if air conditioning and ventilation needed to remove heat from inefficient lights is included.³⁶ Using currently available high-efficiency lighting technology could cut the amount of electricity used for lighting by 50 to 92 percent.³⁷ Dramatic improvements also have been made in the efficiency of electric motors, which are estimated to account for more than 60 percent of all electrical consumption in the commercial and industrial sectors. Adopting minimum motor efficiency standards for new and replacement motors could result in significant electricity savings. These efficiency gains also cut carbon emissions significantly by reducing the need for electricity generation.

STRATEGY: Improve Transportation Efficiency. The nation's transportation sector contributes nearly one-third of the nation's carbon emissions. Although much of our transportation policy is established at the federal level through the corporate average fuel economy (CAFE) standards and federal excise taxes, states also can improve the efficiency of the transportation sector through such measures as gas guzzler taxes on automobiles, carpool

Figure 9 Building Energy Use by End-Use Function and Fuel Type, 1984

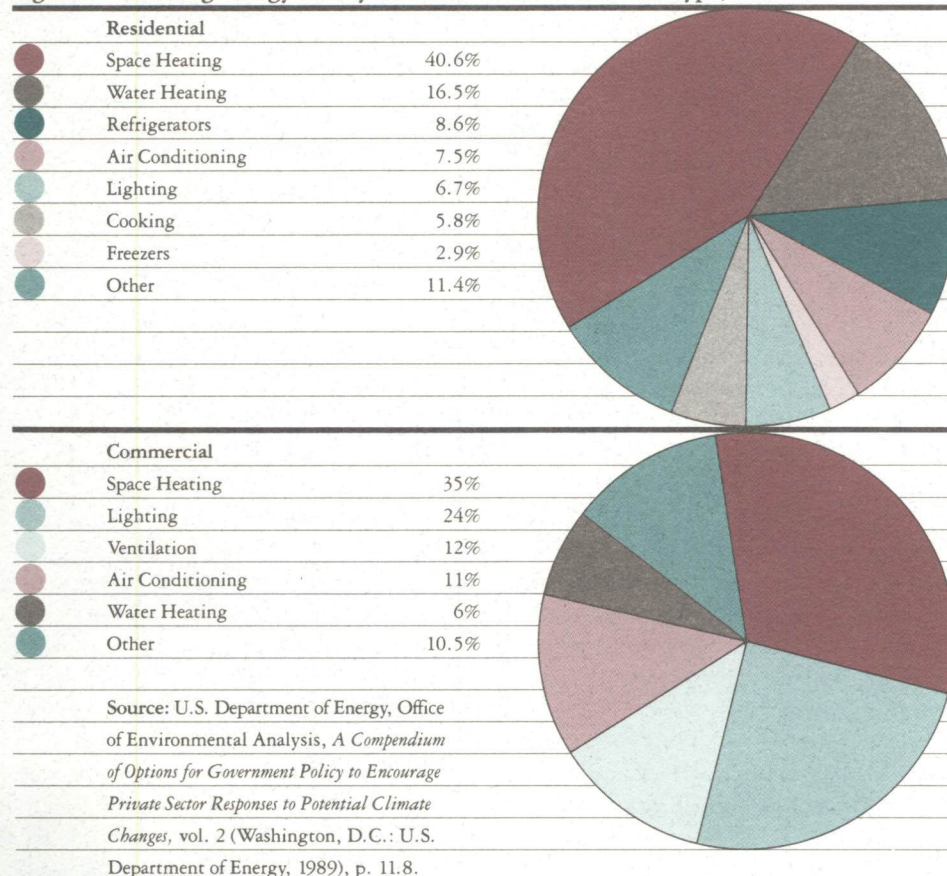
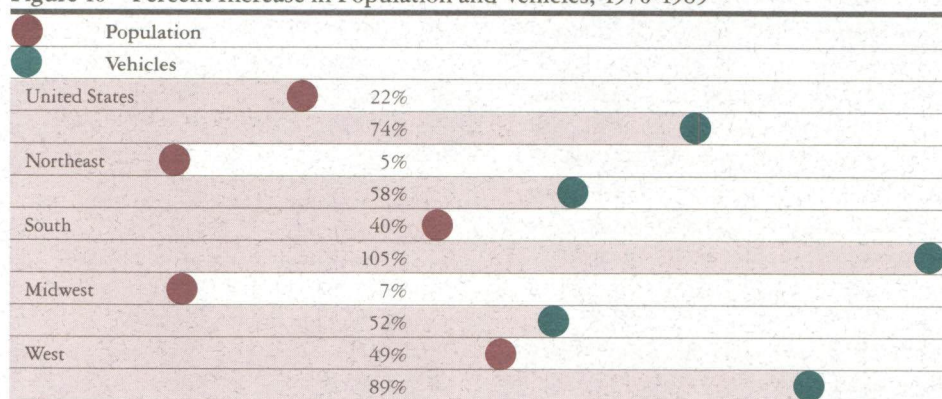


Figure 10 Percent Increase in Population and Vehicles, 1970-1989



Source: Population Reference Bureau, Inc., "America in the 21st Century: Environmental Concerns" (Washington, D.C.: Population Reference Bureau, 1990), p. 6.

Table 5 Carbon Dioxide Emissions for Various Transportation Modes

	Amount of Carbon Dioxide Released (in pounds per mile)
Automobile	1.15
Air travel	0.9
Bus (urban)	0.7
Bus (intercity)	0.2
Railway or Subway	0.6

Note: Figure for automobiles assumes a fleetwide average fuel economy of 19 miles per gallon.

Source: The National Audubon Society, "The Audubon Activist Carbon Dioxide Diet" (New York, N.Y.: The National Audubon Society, 1990).

requirements, promotion of alternative automotive fuels, mass transit improvements, and control of traffic patterns. All potential alternative fuels, including ethanol, methanol, compressed natural gas, electricity, and reformulated gasoline, should be fairly considered.

The imperative to improve transportation efficiency is particularly compelling in urban areas. Many such areas are already suffering from the pressures of congestion and air pollution from mobile sources. At current rates of population and GNP growth, the Federal Highway Administration estimates that vehicular miles traveled will increase by 70 to 140 percent by the year 2020.³⁸ Counteracting this trend, and the automotive emissions associated with it, will be a formidable challenge to policymakers.

To date, efforts to control growth in vehicular miles traveled have resulted in modest reductions in transportation growth rates. Most programs have focused on commuters, who account for 30 percent of all miles. An estimated 20 percent of all commuters carpoolled in 1983, resulting in a 4 percent reduction in trans-

portation energy use.³⁹ Consumer preferences in transportation are strongly motivated by fuel costs and the high value placed on privacy. By making carpooling more appealing through high-occupancy vehicle benefits and other incentives, commuters can be encouraged to reduce both vehicular miles traveled and greenhouse gas emissions associated with transportation.

The task force recommends a multifaceted approach to improve transportation efficiency:

- The federal government should increase the corporate average fuel economy beyond the current standard of 27.5 miles per gallon. The technology to improve fuel efficiency has already been developed by both domestic and foreign automakers. Some of these prototypes have achieved efficiencies of more than 100 miles per gallon, without compromising vehicle interior space, comfort, and safety.⁴⁰
- All levels of government should encourage the use of transportation modes that release less carbon dioxide. Depending on their energy source, electric-powered subway and rail systems

result in significant carbon dioxide savings while reducing congestion and air pollution. On average, switching from automobiles to subways reduces carbon dioxide emission per mile traveled by about half.

- Telecommuting holds great potential for energy savings, by allowing greater work at home via personal computers and modems and reducing travel between home and office. A major pilot program is now underway in the state of Washington, where rapid urban growth in the Puget Sound area has caused substantial traffic congestion. The telecommunications program will document motor fuel savings as well as employer/employee benefits and problems.

- Government should encourage increased utilization of ride sharing and high-occupancy vehicle lanes, especially where public transit is not practical. These programs limit the number of cars on the road and can reduce carbon dioxide emissions as well as pollutants responsible for ozone pollution.

STRATEGY: Expand State Government Energy Efficiency Programs.

States play a critical role in delivering objective energy information, technical assistance, and financial incentives to improve energy efficiency. State energy efficiency programs target all end-users and all fuel forms. State strategies that improve energy efficiency and also reduce air emissions include the following:

- providing financial incentives or rebates to improve the efficiency of appliances and residential furnaces and boilers;
- developing energy rating systems for new housing to provide consumers with objective energy efficiency information;
- implementing energy audit programs for small and medium-sized commercial and industrial facilities;
- establishing financial incentive programs to provide lower cost financing, through interest breaks or principal reduction, for implementing energy efficiency improvements in commercial, industrial, agricultural, and multifamily housing facilities; and
- stimulating the increased use of state-of-the-art solar designs and renewable resources in home and business design and construction.

States currently operate a range of programs from energy hotlines to energy audits and lower cost financing for implementing identified energy efficiency measures. For example, Georgia operates two programs designed to help agricultural producers save energy. The program aimed at irrigation saves farmers more than \$3.5 million annually, while eliminating 50,000 tons of carbon dioxide, at a cost of about one dollar per ton. Georgia also has developed a program for dairy farmers, using the "waste" heat in fresh milk to heat wash water in the dairy. It takes about two years for the average dairy to recoup costs through energy cost savings.

Among other energy programs, Pennsylvania has developed a research project aimed at demonstrating advanced weatherization technologies in the homes of low-income families. The project has demonstrated energy savings averaging 29 million Btu's per household—or about 34 tons of carbon dioxide per household if operated over twenty years—at a negative cost of about forty dollars per ton. The carbon dioxide reduction itself has a negative cost because the energy savings in the home more than pays for the weatherization services at current energy prices.

New York's national award-winning Energy Advisory Service to Industry provides free on-site energy surveys to small and medium-sized commercial and industrial firms throughout the state. To date, more than 8,500 audits have been performed. They are estimated to have saved more than 4 million gallons of oil, 14.3 million therms of natural gas, and more than 600 million kilowatt-hours of electricity. These savings translate into annual emissions reductions of more than 3,700 tons of sulfur dioxide, 1,400 tons of oxides of nitrogen, and nearly 700,000 tons of carbon dioxide.

In recent years, states have used petroleum overcharge recovery funds to implement the most aggressive energy efficiency programs in this nation's history. Unfortunately, the federal government has not maintained its support for state energy programs. The federal government should encourage state energy efficiency initiatives through increased emphasis and financial support to further tap the vast potential for energy efficiency improvements. Petroleum overcharge funds are diminishing at a time when the environmental dividends of energy efficiency are most needed.

G O A L ③

STOP PRODUCTION OF AND RECYCLE CHLOROFLUORO- CARBONS AND USE COST-EFFECTIVE MEASURES TO STABILIZE OR REDUCE OTHER GREENHOUSE GASES

Carbon dioxide accounts for about half of all greenhouse gases from human sources, and it has been the focus of much of the global warming controversy. However, any climate stabilization strategy must consider other climate-altering gases as well. In cases where controlling these other gases is not immediately feasible, further research is crucial. There are several important steps that should be taken as expeditiously as possible.

STRATEGY: Phase Out Chlorofluorocarbons. Chlorofluorocarbons are the strongest greenhouse gases on a per molecule basis and have been linked to stratospheric ozone depletion. With atmospheric life spans of up to hundreds of years, chlorofluorocarbons released into the atmosphere today will be trapping heat well into the future. Despite the ban on "nonessential" chlorofluorocarbon uses, U.S. emissions have grown rapidly over the last several years. Efforts to phase out the use of chlorofluorocarbons by the year 2000 or sooner have begun under the auspices of the Montreal Protocol. These negotiations mark a milestone in international environmental law and may serve as a model in future international negotiations on other greenhouse gases. The federal government should seek an international agreement phasing out chlorofluorocarbons at the earliest possible date and requiring the recapture and recycling of those currently in use. Improper disposal can have very destructive effects. An auto air conditioner, for example, contains the chlorofluorocarbon equivalent of 17,500 pounds of carbon dioxide if released

to the atmosphere. The average car emits the equivalent of 2,600 pounds annually through use, leakage, and servicing.⁴¹ In New Jersey, state fleet vehicles are required to recycle their automotive chlorofluorocarbons. Hawaii, Vermont, and Wisconsin are phasing out all chlorofluorocarbon-based auto air conditioners statewide and are requiring the recapture and recycling of existing chlorofluorocarbons.

STRATEGY: Recover Methane for Energy Use. When organic matter decays in oxygen-deprived conditions, methane is produced. Methane from waste can be captured and used to produce heat and electricity. Methane from landfills accounts for 3 percent of global methane emissions. This share is expected to increase significantly in the future. According to EPA, each ton of municipal solid waste produces between 1,000 and 7,000 cubic feet of methane.⁴² The United States generates approximately 148 million tons of municipal solid waste annually, enough to produce between 148 billion and 1,036 billion cubic feet of methane. About 17 percent of all municipal solid waste landfills recover, vent, or flare methane. Less than 2 percent of landfills recover the gas for energy use. EPA reports that the methane resource from landfills is equivalent to 1 percent of the nation's annual energy needs.⁴³

Coal seams are responsible for 3 to 10 percent of annual methane emissions.⁴⁴ Before the development of methane recovery technology, the gas was usually vented to the surface using high-powered fans. Today, recovery of methane from this source has become an economically viable alternative to atmospheric release. Energy companies are capturing the methane for use as natural gas. The Colorado School of Mines estimates that 95 trillion cubic feet of methane are economically recoverable from this source, more than four times the amount of natural gas

consumed annually in the United States. Federal tax credits have encouraged energy companies to capture methane from their coal seams.⁴⁵

STRATEGY: Expand Research into Animal Diets that Reduce Methane. In their digestive process, cows and other ruminants convert plant fiber into usable animal products. This process also accounts for 13 to 20 percent of the methane emitted annually.⁴⁶ With the cattle population growing at more than 1 percent annually, ruminant animals will continue to be a significant methane source in the future. Increasing the productivity of livestock decreases the amount of methane produced per unit of animal product. Livestock diets also can influence the amount of methane produced per animal.

STRATEGY: Improve the Efficiency of Fertilizer Application. Measurements of nitrous oxide in the atmosphere suggest that its sources are widely variable; furthermore, they are not all identified. Nitrogenous fertilizer use in agricultural crop production appears to be a major anthropogenic source and probably has the most potential for control. Use of this fertilizer is growing 1.3 percent annually in industrialized countries and 4.1 percent in developing countries.⁴⁷ In addition to its effects on atmospheric concentrations of nitrous oxide, increased fertilizer usage can degrade water quality. According to EPA, these emissions can be reduced by improving the efficiency of fertilizer application and using advanced fertilizers that inhibit nitrous oxide. These methods derive more fertilization benefits from a smaller amount of fertilizer, while reducing the associated nitrous oxide releases and increasing the farmer's profit margin. Through their departments of agriculture and agriculture extension services, states can encourage more efficient and environmentally sensitive use of fertilizers.

Table 6 Annual U.S. Releases of CFCs Per Capita from Use, Leakage, and Servicing

Item	Emissions (in equiv. lb of CO ₂)
Mobile air conditioners	2,600
Rigid plastic foam (insulation for walls)	1,800
Flexible plastic foam (seat cushions, car seats, packing material)	370
Residential refrigeration	110
Other (including retail refrigeration, building air conditioning, solvent cleaning, halon fire extinguishers)	6,200
Total	11,000

Source: The National Audubon Society, "The Audubon Activist Carbon Dioxide Diet" (New York, N.Y.: The National Audubon Society, 1990).

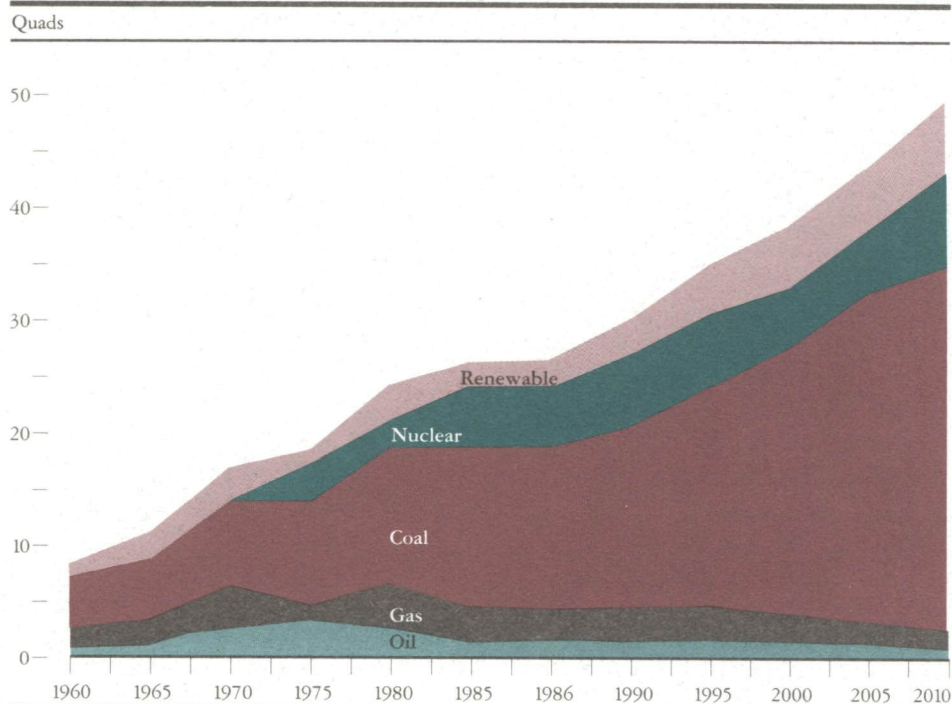
DEVELOP AND COMMERCIALIZE ALTERNATIVE ENERGY SYSTEMS, INCLUDING CLEAN FOSSIL, RENEWABLE ENERGY SOURCES, AND SAFE NUCLEAR POWER

Fossil fuels have been crucial in the development of the industrial age. The history of the industrial economies is one of increasingly intense energy use, as power substituted for labor as a factor of production. In recent decades, however, problems associated with the pollution inherent in energy use have become apparent. Cleaner energy for transportation and cleaner electric power generation are especially critical.

The nation is becoming increasingly electrified, and according to the U.S. Department of Energy, at least 77 gigawatts of new generating capacity will be needed by the year 2000, in addition to the 75 gigawatts already planned or under construction.⁴⁸ The use of alternative energy technologies can allow the country to meet this demand for electricity while minimizing carbon dioxide emissions. States have powerful tools available to affect the choice of generating technologies, including electric utility regulation, technology incubation and transfer programs, and tax incentives. Alternative sources for electricity generation include:

- cleaner coal and other fossil fuel technologies;
- cogeneration;
- solar energy;
- wind power;
- geothermal energy;
- biomass;
- hydroelectricity; and
- nuclear power.

Figure 11 Electricity Generation by Fuel Type



Note: Includes electricity generated by utilities and non-utilities.

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook—Long-Term Projections* (Washington, D.C.: U.S. Department of Energy, 1990), p. 45.

From a historical perspective, the mix of fossil-fired electric power generation in the United States in 1986 produced an average of 874 metric tons of carbon dioxide per gigawatt-hour, compared with 18 metric tons of carbon dioxide per gigawatt-hour for renewable energy technologies (solar, geothermal, wind, biomass, and hydropower). Renewable sources, primarily hydroelectricity, contributed about 11 percent of U.S. electric power generation in 1988. According to one DOE study, based on "conservative estimates of future energy use and renewable energy contribution," renewable energy technologies could displace 519 million tons of carbon dioxide (18 percent) in 2010, compared with an equivalent electric output from fossil-fired power facilities.⁴⁹

STRATEGY: Utilize Cleaner Coal Combustion Technologies. The United States has extensive coal reserves—almost 29 percent of the estimated global recoverable reserves—and cannot forego coal's contribution to the nation's energy supply. The only presently available technological option for removing carbon dioxide from conventional coal plants involves the use of scrubbers, which uses 25 to 50 percent of the plant's output of electricity to remove 90 percent of the carbon dioxide in the tail gas.⁵⁰ Moreover, the reuse or disposal of captured carbon dioxide is constrained by inadequate markets and uncertain disposal capacity. These considerations make carbon dioxide recapture infeasible at the present time.

There are several near-term options for the cleaner use of coal in electrical generation, including pressurized fluidized bed combustion and integrated gasification combined cycle technologies. Development of these technologies has been progressing rapidly, and many are on the market today. Because they are more efficient than conventional coal technologies, they use less coal and produce less carbon dioxide for a given electricity output. It is expected that carbon dioxide reductions of 10 to 20 percent are possible, compared

"The nation—and the world—needs a major investment in the development and use of clean fuels and energy technologies, not just out of respect for the global climate, but because of the energy security and other benefits it will bring."

• Governor Henry Bellmon
Oklahoma

with conventional technologies.⁵¹ These systems also control sulfur dioxide, oxides of nitrogen, and other pollutants more effectively.

In the longer run, even more efficient coal use is expected to be available through coal-based fuel cells and magnetohydrodynamics. These technologies will operate with thermal efficiencies of 45 to 60 percent, reducing carbon dioxide emissions 25 percent or more, compared with today's emission levels.⁵²

STRATEGY: Promote Cogeneration of Electricity and Heat. Another way to use fossil energy more effectively is to cogenerate electricity and heat. Most older power plants waste the heat remaining in their steam after it has passed through the turbines. Frequently those who generate steam for process purposes waste the opportunity to produce electricity as well. Cogeneration ties steam and electricity production together. At Iowa State University, for example, the central heating plant generates power for the university with a coal-fired steam turbine, then uses the spent "extraction steam" to heat campus buildings, drive steam chillers that produce 22,000 gallons of 40 degree water per minute used for cooling purposes, and compress air for university applications. Because so little heat is wasted, the plant is about 50 percent more efficient than a conventional power plant, and saves the institution some \$600,000 annually in fuel costs.

The Public Utilities Regulatory Policies Act (PURPA) encourages cogeneration by requiring utilities to buy power from small producers in order to avoid costs of building new capacity. Of the 62,000 megawatts that qualified for PURPA benefits from 1980 to 1987, almost three-fourths came from cogeneration.⁵³

STRATEGY: Utilize Solar Energy. Solar energy is perhaps the most familiar of the renewable energy resources developed in the 1970s. While virtually any region with normal sun exposure can benefit from solar energy applications, development of this source has been concentrated in the Southwest. No longer limited to simple pool heaters or small consumer electronics, solar energy can now provide baseload electricity to the power grid. It continues to have numerous other applications in everything from rechargeable street lights to Coast Guard buoys. Nationwide, more than 1.2 million buildings employ solar water heaters.⁵⁴ In Phoenix, a twenty-four-home subdivision of all-electric homes is powered by

"If built to their most cost-effective size, solar facilities will become economical in a much broader geographic range. I look forward to the day when clean and renewable sources of electricity will be adequate to meet the needs of many states."

• Patrick Francois
Executive Vice President
Luz International Limited
Sacramento Regional Hearing

a central photovoltaic grid-tied system. The system offsets more than 455 tons of carbon dioxide each year.

Photovoltaic cells are semiconductors that convert the energy of the sun directly into electricity. The task force toured a Sacramento research facility that produces about 20 kilowatts of photovoltaic power. Photovoltaic electricity still costs more than conventional power, but enormous technological advances have been made in recent years and the signs are encouraging that costs may decrease. Even with reductions in federal research support, photovoltaic prices have dropped to one-fortieth of their 1978 level.⁵⁵ At current prices, photovoltaic electricity is competitive in several niche markets including rural water irrigation, lighting, and communications.

In a solar thermal electric generating system, an array of mirrored solar collectors focus the rays of the sun onto a receiver, which heats a liquid, driving a turbine to produce electricity. The Luz facility uses this technology to produce 200 megawatts of electricity for the Southern California Edison Company at a cost of about eight cents per kilowatt-hour, competitive with conventional fossil-fueled power plants. The Department of Energy estimates that solar thermal electricity will become even more competitive by 1995. System costs for solar thermal plants would decline further if Public Utility Regulatory Policies Act regulations did not currently limit qualifying plant size to 80 megawatts, thus preventing economies of scale.⁵⁶ According to industry representatives, the entire electricity needs of Southern California Edison could be provided on as little as 1 percent of the Mojave desert. The electricity needs of Los Angeles could be provided on 150 square miles of the Mojave, an area about one-third the size of Edwards Air Force Base.⁵⁷

In the long term, solar energy also has the potential to be used as a transportation fuel through hydrogen production. Electricity generated from a solar thermal or photovoltaic plant can be used to divide water into hydrogen and oxygen through electrolysis. The hydrogen can then be burned as a transportation fuel. The only by-products of hydrogen combustion are water vapor and a small amount of oxides of nitrogen, which is easily controlled.⁵⁸ Currently, storage and transport limitations restrict the practicality of solar hydrogen. With continued research into solar power, fuel cells, battery technology, and storage systems, solar hydrogen could provide a substantial portion of transportation fuel while reducing carbon dioxide and air pollutant emissions.

STRATEGY: Utilize Wind Power. Wind turbines have been used for centuries to grind grain and pump water, but it was not until the 1970s that modern wind power came into being. The tax credits available in the late 1970s and early 1980s rushed wind power into the marketplace, sometimes without sufficient testing. In California, the incentives for utilities to use wind power were particularly great; key factors included a 15 percent federal energy tax credit, 10 percent federal investment tax credit, and 50 percent California state energy credit.⁵⁹

Part of the appeal of wind power is its simplicity; blades are mounted on a tower along a horizontal or vertical axis, which turns a generator to produce electricity. The amount of power produced depends primarily on the efficiency of the generator and the wind speed at the location. The environmental impact of wind energy is minimal; the most serious is sight pollution from large-scale "wind farms." In most cases, wind systems do not preclude other land uses. Prime wind sites in the San Geronio Pass, for example, produce between \$8,000 and \$12,000 of electricity per acre in addition to the income the land earns for cattle grazing. By comparison, prime farmland planted in corn produces about \$400 per acre per year.⁶⁰ Many of the advances that have brought wind power into the modern age have relied on lightweight materials and new designs for rotors. Future research should be directed at harnessing wind from medium- and low-wind sites in order to make more use of this energy source in more regions.

Figure 12 Geothermal Power Generation Capacity in the United States, 1975-1989

	Amount in Megawatts (Year-End Total in Net Megawatts Electricity)
1975	502
1976	502
1977	502
1978	502
1979	665
1980	926
1981	929
1982	1049
1983	1336
1984	1447
1985	1836
1986	1970
1987	2006
1988	2373
1989	2698

Source: Renew America, *Sustainable Energy* (Washington, D.C.: Renew America, 1989), p. 31.

Although the industry has suffered somewhat with the end of the tax credits in 1986, wind power can produce electricity at rates comparable with conventional energy sources. Advanced wind generators are currently producing 2 billion kilowatt-hours of electricity at a cost of seven to nine cents per kilowatt-hour. The next generation of wind power is expected to reduce costs even further. This installed wind energy offsets 11 million pounds of air pollutants and 304,000 tons of carbon annually.⁶¹ With improvements in engineering and siting, wind turbines have become highly reliable, achieving an average availability of 95 to 98 percent. Operation and maintenance costs average 1.2 cents per kilowatt-hour compared with 2.2 cents per kilowatt-hour for coal and 2.0 cents per kilowatt-hour for nuclear power plants.

As with most renewable energy sources, growth of the wind energy market is limited by the current low costs of fossil fuels. Oregon State University concluded that the Pacific Northwest could produce 19,000 megawatts of energy from wind systems.⁶² Since the region already has adequate existing power plants, however, wind energy has not been integrated into the region's energy system. With continued improvements in the technology, some studies indicate that wind energy could provide a significant portion of the U.S. energy needs.

STRATEGY: Utilize Geothermal Energy. Using the earth's heat, geothermal resources provide an opportunity in some areas to provide very inexpensive power virtually free of air

emissions. Moreover, the resource is renewable, at least for several thousand years. In some areas on the West Coast, geothermal electricity is being generated at costs that are actually lower than baseload costs at coal-fired power plants. The U.S. Department of Energy has estimated that the United States has about 1.2 million quads of technically recoverable geothermal resources.⁶³ Unlike other renewable energy sources, the technology to tap geothermal energy is largely developed and ready to be used. Since 1968, U.S. geothermal power capacity has grown from 78 megawatts to nearly 2,700 megawatts. Geothermal energy does not rely on wind, sunlight, or other unpredictable variables, and has earned a reputation for high reliability. Applications exist to use both medium- and high-temperature geothermal resources. In several areas in the world, geothermal is the largest source of residential heating.⁶⁴

STRATEGY: Develop Biomass Fuels. Biomass—essentially wood and plant products—is the oldest and most extensively used form of renewable energy. Before the development of coal and other fossil fuel resources, wood was the energy source of choice in the world. Currently, biomass provides only about 14 percent of all energy consumed in the world, but it is the only source of energy for more than 2 billion people.⁶⁵ In the United States, biomass supplies 4 percent of all energy, more than any other renewable source.⁶⁶ Because of its diverse sources and uses, biomass is very promising.

Figure 13 Electricity Generation from Biomass Feedstocks, 1979-1989

	Installed Capacity (Megawatts)
1979	250
1981	1100
1983	1700
1985	3800
1987	5600
1989	7700

Source: National Wood Energy Association, *Biologie*, vol. 6, no. 5 (November-December 1989/January 1990), p. 1.

Table 7 Projected Renewable Electricity Costs

	Levelized Costs (in cents per kilowatt-hour)				
Technology	1990	2000	2010	2020	2030
Conventional Electricity	5.0	5.25	5.5	5.75	6.0
Geothermal					
— Hydrothermal	4.4	4.2	4.1	4.3	4.5
— Magma	21.9	16.8	12.6	9.4	6.0
Hydropower	5.6	5.6	5.6	5.6	5.6
Photovoltaics	30.0	15.0	9.0	6.0	5.0
Solar Thermal	8.0	7.5	5.5	4.7	4.0
Wind	8.0	5.3	4.7	4.3	4.0

Notes: Based on business-as-usual scenario, which assumes currently projected conventional energy prices and demand and federal research and development funding for renewable energy at current levels. Costs include, where appropriate, capital costs, operation and maintenance, and fuel cost. Assumes a 6.1 percent discount rate.

Source: U.S. Department of Energy, *The Potential of Renewable Energy* (Golden, Colo.: Solar Energy Research Institute, 1990).

Table 8 Alternative Energy Resources

Resource	Current Use	Current Cost	Recoverable Resource ¹
Clean coal	Under development	\$.062-.068/kWh ²	19,040 Quads ³
Cogeneration	13 GW ⁴	N/A ⁵	100 GW ⁶
Solar	.06 Quads		100 Quads
Solar Thermal		\$.08/kWh	
Photovoltaics		\$.25-.35/kWh	
Wind	.02 Quads	\$.07-.09/kWh	10-40 Quads
Geothermal	2700 MW ⁴	\$.045-.055/kWh	1.2 million Quads
Biomass	3 Quads		13-26 Quads
Wood Fired Power Plant		\$.042-.054/kWh	
Ethanol		\$1.28/gallon ⁷	
Methanol		\$0.75/gallon ⁸	
Gasoline		\$1.60/gallon ⁸	
Hydropower	3 Quads	\$.03-.06/kWh	6 Quads
Nuclear	5.7 Quads	\$.043/kWh ⁹	5,162 Quads ¹⁰

Abbreviations: kWh = kilowatt-hour GW = gigawatt MW = megawatt

Notes: 1. Amount of energy recoverable if resource is used to its fullest technical extent, regardless of cost. 2. Cost range is for atmospheric fluidized bed combustion systems and integrated gasification combined cycle systems. Costs are based on a 300-megawatt unit located in the Midwest using 3.5 percent sulfur coal. 3. Assumes the use of all U.S. proven mineable reserves. Based on an average of 25 million tons per quad. 4. Installed capacity. 5. Cogeneration prices are widely variable. 6. Installed capacity expected by industry in 2000. 7. Current selling price for ethanol produced from corn. 8. Cost per gallon. Does not include distribution, markups, taxes, etc. For comparison, the refinery price of normal gasoline is about \$0.68 per gallon, assuming crude oil cost \$20 per barrel. 9. Includes operation, maintenance, fuel, and capital costs. 10. Assumes the use of all U.S. uranium recoverable for less than \$130 and a conversion efficiency of 33 percent, which yields 3,800 kilowatt-hours per gram.

Sources: National Coal Association, 1990; U.S. Council on Environmental Quality, 1981; Atomic Industrial Forum, 1985; World Resources Institute, 1989; Renew America, 1989; U.S. Department of Energy, 1990; Union of Concerned Scientists, 1990; U.S. Environmental Protection Agency, 1989.

In terms of impact on global climate and other environmental problems, biomass can have a positive effect if managed responsibly. During photosynthesis, plants absorb carbon dioxide from the atmosphere. If these plants are later burned to produce fuel, electricity, or heat, the same amount of carbon is released into the atmosphere. If plant growth exceeds burning and decay, more carbon dioxide is absorbed than created. At least one company has harnessed this process by planting trees to reduce net carbon emissions from fossil-fired power plants.

The sources of biomass for energy production range from agriculture, forestry, and municipal wastes, to liquid fuels made from energy crops, plant oils, and exotic genetically engineered algae. The forestry industry produces between 150 million and 300 million dry tons of waste each year that can be used to produce energy.⁶⁷ Currently the industry provides much of its own power by consuming 100 million tons of biomass in its own power plants. In some cases, excess capacity is sold to the local power grid. In 1985, for example, the Hawaiian sugar industry supplied 58 percent of the electricity on the island of Kauai and 33 percent on the island of Hawaii.⁶⁸ Louisiana and Florida use 80 megawatts of power from similar power plants. Numerous technologies could help convert a portion of the 160 million tons of municipal waste into usable energy. While it is currently cheaper for the forestry industry to use these wastes than to dump them, the feasibility of using all of the remaining wastes is uncertain.

STRATEGY: Utilize Hydroelectricity.

Hydroelectric power has played an important role in U.S. electricity production since the 1880s. Over this period, hydropower has grown to 2,029 plants and 88,000 megawatts of capacity. These plants range from less than 1 megawatt to the engineering marvel of the 6,180-megawatt Grand Coulee dam in Washington. Hydropower provides more electricity than any other renewable source at low costs and without any carbon dioxide emissions.⁶⁹ In the United States, much of the potential for hydropower has already been developed or is unable to be development due to environmental regulations. Of the remaining 147,000 megawatts of potential hydropower resources, it is likely that only 37,000 megawatts will be available for actual development. Through upgrades and retrofitting, however, existing power units could

produce considerably more power. Of the 67,000 existing U.S. dams, less than 3 percent produce electricity. Originally built for flood control, many of these idle dams could be retrofitted to generate electricity. According to the Department of Energy, 10,000 megawatts of small-scale hydropower could be derived from this source.⁷⁰

STRATEGY: Develop a New Generation of Safe Nuclear Power. The United States should not foreclose the option of generating nuclear electricity. Currently, 111 nuclear power plants are licensed for operation in the United States. They produce almost 20 percent of the nation's electricity and, after coal, constitute the second largest source of electricity. Production of concrete used in the construction of nuclear power plants and the nuclear fuel assemblies produces carbon dioxide. The operation of nuclear power plants, however, produces virtually no carbon dioxide. According to industry sources, the 527 billion kilowatt-hours of electricity generated by nuclear plants in 1988 reduced American carbon dioxide emissions by about 128 million tons in that year compared with coal-fired generation.⁷¹

Despite the carbon-free nature of nuclear electricity, the future of nuclear power in the United States is in doubt at this time. No new nuclear generating units have been ordered in the United States since the Three Mile Island accident in 1979, and all those ordered since 1973 have been cancelled. Four nuclear units are currently under construction in the United States. Once those are completed, it is unlikely that there will be additions to nuclear generating capacity for at least ten years, because it takes that long to plan and build a new nuclear plant.

If nuclear power is to play a major role in America's energy future, the federal government must press for the resolution of certain critical issues. It will be necessary to ensure the safety of nuclear technologies, ensure the safe disposal of nuclear waste, and lower the cost of nuclear power; nuclear plants completed in recent years have cost an average of \$2,700 per installed kilowatt of capacity, not including \$800 to \$900 per kilowatt in real interest costs incurred during construction. This makes electricity generated by these nuclear units almost twice as expensive as new coal-fired units, on average.⁷² Priority should be given to the development and evaluation of advanced, passively safe reactor designs; waste management technologies; nuclear fusion research; and plant retrofit and life extension.

G O A L 5

IMPLEMENT FORESTRY PROGRAMS TO REDUCE THE EFFECTS OF GLOBAL CLIMATE CHANGE

The ability of the forests to sequester carbon has raised interest in their use to reduce greenhouse gases. While the exact mechanisms of exchange are unknown, the land biota holds approximately 420 billion to 660 billion tons of carbon; 90 percent of this amount is held in the woody biomass of the world's forests, while the remaining share resides in crops and grasslands.⁷³ Forests are 20 to 100 times more efficient at storing carbon dioxide than croplands, depending on the location and plant regimes.⁷⁴

By destroying vast areas of carbon-rich tropical rain forests, humans have started to eliminate a huge natural sink for carbon. Before human disturbances, forests covered 47 percent of the earth's land area. Today, forests account for about 39 percent of the earth's surface.⁷⁵ When these forests are burned, they release the carbon they hold into the atmosphere. Currently, human alteration of forest ecosystems accounts for emissions of carbon dioxide equal to about 10 to 30 percent of total emissions from human sources.⁷⁶

At current rates of forest carbon uptake, it would require 1.65 billion acres of new plantation forests to absorb the 5.5 gigatons of annual worldwide carbon emissions, or roughly 73 percent of landmass in the United States.⁷⁷ A total offset of all carbon emissions is probably not a practical response to global warming, but it is clear that some role for forestry is needed as a part of any global climate strategy. The strategies include:

- encouraging forest offsets for new carbon dioxide emissions;
- improving forest management; and
- planting trees, especially in urban areas.

STRATEGY: Develop Forest Offsets for New Carbon Dioxide Emissions. Several studies have concluded that increased forest cover can be used to offset the increases in carbon emissions expected from future electric capacity expansions. One study projects that by 1996, 22,643 megawatts of coal-fired and 2,580 megawatts of oil-fired new electric generating capacity will come on-line in the United States. This additional capacity will add more than 166 million tons to the annual carbon dioxide emissions in the United States. Using relatively inefficient trees for carbon storage (silver maples, for example) would require more than 11 million acres of new plantings. Using a more efficient tree, such as eucalyptus, could reduce the required acres to under 7.5 million.⁷⁸

Increasing tree planting can be done through numerous existing mechanisms. The Conservation Reserve Program (CRP) of the U.S. Department of Agriculture uses economic incentives to encourage farmers to set aside highly erodible land for conservation purposes. Under current law, land owners enter into a ten-year contract that pays them about fifty dollars an acre plus half the costs of implementing an approved conservation program. The goal of the program is to set aside 40 million to 45 million acres, but by February 1989 only 30 million acres (between two-thirds and three-quarters of all eligible acres) were in the program. Of the total acreage set aside in 1988, only a small portion was planted with trees. CRP payments could be increased to encourage greater participation and to encourage planting of trees rather than some other land cover. If payments were doubled for acreage planted in trees, first-year costs for sequestering the carbon dioxide from all new power plants expected to be built by 1996—9.26 million acres of trees, using trees of average carbon dioxide uptake efficiency—would amount to \$1.62 billion, or about 7 percent of the total cost of the new power plants. These figures do not include any of the costs recouped from the forest harvest in future years.⁷⁹

Applied Energy Services (AES), an energy company in Virginia, launched a carbon offset project in 1989. The 15 million tons of carbon that will be emitted over the forty-year life span of a new 183 megawatt coal-fired station will be offset by 52 million trees planted in Guatemala. AES contributed \$2 million to

Figure 14 Carbon Dioxide Uptake by Species of Tree

	Metric Tons of Carbon Dioxide Removed Annually Per Acre
Silver Maple	15
Black Locust	18
American Sycamore	20
Eucalyptus	22.5

Source: Daniel J. Dudek, *Offsetting New CO₂ Emissions* (New York, N.Y.: Environmental Defense Fund, 1988), p. 10.

the project and received further funding through CARE, the Peace Corps, the U.S. Agency for International Development, and the Guatemalan Forestry Service.⁸⁰

STRATEGY: Improve Forest Management. Other possibilities for improving the forest absorption of carbon dioxide emissions involve state forestry programs, intensive forest management, and the creation of tree plantations. Modern forestry practices have increased the productivity of Douglas fir and loblolly pine—and hence increased carbon uptake by 26 to 100 percent. However, many experts warn that converting of our varied forests to plantation-style monoculture would have devastating ecological effects.⁸¹ The loss of genetic diversity would lessen the forests' resistance to pests and disease, which would increase both the need for pesticides and the strain placed on water resources. In the near term, intensely managed tree plantations are probably uneconomical compared with the crop set-aside approach. According to some studies, converting mature old growth forests, such as those in the Northwest, to tree plantations would lead to an increase in net carbon dioxide emissions. Although old growth forests do not absorb large amounts of carbon, they hold tremendous carbon stores in the woody biomass.⁸² The carbon in the trunks, branches, roots, leaves, and soils could take more than 250 years to replace. However, if extremes are avoided, management of existing forests can significantly improve productivity without disturbing the overall health of the forests. Accordingly, forestry strategies in response to global climate change should probably concentrate on marginal lands, reforestation, and a sensible management of existing forests rather than conversions of old growth forests to fast growing tree plantations.

STRATEGY: Plant Trees, Especially in Urban Areas. Trees are valuable in urban areas for numerous environmental and aesthetic reasons. In an urban setting, trees serve the dual role of absorbing carbon dioxide and controlling energy use. Trees can be used to shade buildings from the sun and reduce the demand for air conditioning. During the winter they both slow evaporative cooling and shelter buildings from wind. According to one study, three strategically placed trees per house can reduce energy needs by 10 to 50 percent.⁸³ Moreover, trees break up the urban "heat island," the warming effect caused by absorption of solar energy by city buildings and other structures. Because they reduce the need for energy and break up the urban heat island, an urban tree is about fifteen times more valuable in reducing carbon dioxide emissions than a tree in the wilderness.⁸⁴ Despite the obvious benefits to be gained from urban trees, their numbers have diminished drastically; on average, only one urban tree is planted for every four removed. Because of these circumstances, the President has recently proposed a program to plant a billion trees a year in rural and urban areas. As part of its centennial celebration, North Dakota has developed an initiative to plant 10 million trees annually, adding 100 million trees by the year 2000. The project is being voluntarily coordinated through several state agencies.

Another opportunity for tree planting exists through the highway system. In 1985, highways covered 29.5 million acres of land (1.3 percent of the contiguous United States). EPA estimates costs of \$777 million for tree plantings on 20 percent of highway corridors.⁸⁵ This option can be used to beautify the nation's roadways while sequestering a considerable amount of carbon. Planting trees on 20 percent of interstate, state, and local highways would offset roughly 20 percent of the carbon from new power plants.

PLAN AND ACT NOW TO ADAPT TO A CHANGING CLIMATE

Many scientists believe that some change in our climate is now inevitable due to past emissions of greenhouse gases, even if drastic changes are made to control future emissions. On the other hand, economic infrastructure has been developed on the assumption that the present climate will be stable over the long term. The task force considers it prudent to begin planning now for adaptation to a different climate. It is likely that considerable funds will be needed to adjust the nation's infrastructure to climatic change. This cost must be balanced against the crucial role infrastructure plays in the productivity of the national economy. Three steps are particularly important:

- ensure that coastal development is consistent with the possibility of sea level rise;
- consider changes that may be necessary in water programs in response to different hydrologic conditions; and
- take steps to prepare for agriculture under conditions very different from those most farmers have experienced.

Adapting to Sea Level Changes

One of the most probable results of global warming will be an increase in sea level. Global warming causes sea level to rise through thermal expansion of oceans, and by net melting of glaciers and ice sheets. Assuming a global temperature increase of 3 to 10 degrees Fahrenheit, the most recent predictions are that mean global sea level would rise between

"Because of the risks of global climate change, we must begin now to plan for adaptation and change. The impacts on our shorelines, water resources, and agricultural productivity could be profound. Above all else, we need flexibility."

-
- Governor Michael N. Castle
Delaware
-

"The risk that global climate change poses to our farms, our forests, our water resources, and our way of life demands that we seek a greater understanding of this issue and take prudent action."

-
- Governor Tommy G. Thompson
Wisconsin
-

one and two feet.⁸⁶ Because the oceans have a large thermal inertia, it could take fifty years or more for higher sea levels to follow increased temperatures. Rising sea levels could devastate coastal areas by exacerbating coastal flooding; accelerating the destruction of wetlands; intensifying coastal erosion; inundating lowlands; and increasing the salinity of rivers, bays, and aquifers. As a result of these changes, communities could lose their water supplies as they become too salty to drink. Infrastructure and natural resources could be damaged or destroyed by flooding, erosion, and saltwater intrusion.

STRATEGY: Strengthen Coastal Zone Management Programs. In order to adapt to the changing coastal environment, a concerted effort must be made to promote further research, planning, evaluation, and assessment about the effects of rising sea level. Institutions that manage the coastal zone should be strengthened so that they can effectively develop and implement policies that anticipate sea level rise and increased frequency and severity of meteorological events. New Jersey is conducting a comprehensive study of sea level rise and other coastal changes to better understand their effects on the New Jersey shore. Policies will be developed to respond to anticipated changes, in consultation with the public and affected governmental entities.

The impact of future climate change on the levels and ecosystem of the Great Lakes is even less well understood at this time. A significant increase in temperature and drought conditions could result in a substantial lowering of lake levels and an increase in ambient lake water temperatures. A directed effort to determine the economic and environmental impacts of such changes on this major freshwater resource is critical.

STRATEGY: Develop Appropriate Land-Use Plans. In planning for less developed areas, incorporating land-use controls and management strategies could substantially

reduce the impact of a rising sea level as well as protect the natural environment. Among other things, proper land-use planning can allow wetlands and other natural areas to migrate inland in response to rising sea level, reducing the loss of such natural areas. A substantial portion of the nation's coastal wetlands have already been lost as a result of human activities. According to EPA, a three-foot rise in sea level could destroy 25 to 80 percent of the remaining wetland resources.⁸⁷ Maine and Texas have recently implemented protective land-use policies requiring all structures located in coastal areas to move inland in response to migrating coastal ecosystems. Not only does this policy protect wetlands, but it also is flexible and cost-efficient in that if no rise in sea level occurs then no action need be taken. States also can use their flood insurance systems to encourage the development of land-use plans that account for the possibility of climate change.

STRATEGY: Develop Appropriate Protective Infrastructure. Erecting bulkheads and levees is one option for protecting low-lying communities and lands. However, such measures generally lead to beach erosion in other nearby coastal areas. Pumping sand onto beaches is another option for protecting beaches against erosion. Not only does this protect the beach, but it also prevents increased erosion induced by the installation of hard erosion control structures.

Since the timing and magnitude of sea level rise is not clear, anticipatory strategies need not be implemented immediately. While it may be appropriate in highly developed areas to delay protective measures until the threat is imminent, it may be more cost-effective to gradually incorporate protective structural measures into a community's infrastructure than to wait until the impact of sea level increase occurs.

"I'd like to emphasize that any rise in sea level causes serious problems in coastal zones. We have a critical window within the next ten to twenty years to plan for the inevitable impacts of sea level rise."

• Dr. Robert Nicholls
Visiting Scholar, Center for Global Change, University of Maryland
New Orleans Regional Hearing

In many areas, the best option for protecting drinking water supplies and agricultural land from saltwater contamination is to construct barrier dams in canals and estuaries to divert saltwater.

Adapting to Changes in Agriculture

Predictions are inconclusive on the effects of global climate change on agriculture. Possible changes include the migration of climate zones northward, changes in plant and animal pests and diseases, and changes in the demand and availability of water. According to the most extensive studies to date, American agricultural production may shift regionally but will still maintain sufficient supplies for domestic demand.⁸⁸ Although net output may not change (or may even increase marginally), the disruption of traditional farming patterns could cause significant problems for regional economies. Adaptive strategies developed in the near term can ease the possible transitions necessary and provide benefits to producers today.

STRATEGY: Strengthen Agricultural Research and Planning. Substantially increased research efforts are needed with regard to global climate change and agriculture. Priority should be given to identifying the most vulnerable regions and farming types given anticipated changes in climate; establishing the efficacy of various adaptation and mitigation measures; identifying response strategies for new diseases and pests; establishing more tolerant crop varieties; and modifying or improving traditional farming practices.

Land-use plans also can be altered to account for potential changes in agricultural suitability in the future. Long-term development plans should be made to reflect the possibility of a northward shift in climate regimes. Water use planning should incorporate the possibility of increased demand for irrigation (due to low rainfall in some areas and higher evaporation everywhere) and strained water supplies. More careful long-term planning also benefits water quality and quantity.

Under most climate change scenarios, the range and abundance of agricultural pests increases. The ability of surveillance and pest

control programs to detect and respond to the introduction of new pests should be assessed and strengthened. Land grant universities and extension services can play a critical role in these efforts.

Research into drought-resistant species of crops and livestock could ease the transition to a climate with higher temperatures and lower soil moisture. Results from this research could lessen the need for northward migration of the agricultural belt. Advances in biotechnology have the potential to make agricultural products more climate-resistant.

STRATEGY: Improve Conservation of Soil and Water. The relationship between excess soil erosion and diminished yields is well established. Excessive loss of top soil and inefficient use of water will exacerbate farm yield reductions that may be caused by increased heat waves and drought. Conversely, improved conservation will better protect our farms and give farmers more options. In Oregon, the Governor's Task Force on Global Warming has recognized that water availability is likely to be the most important factor in determining future crop patterns, and the state Water Resources Commission is developing a water conservation plan focusing on irrigation efficiencies and reducing waste.

Increased use of conservation tillage and crop rotation improves the sustainability of soils and may lessen the need for pesticides. These practices also improve the resilience of crops to extreme weather events (e.g., droughts, floods, and storms) that may occur with greater frequency due to climate change. The states' cooperative extension programs can be used to promote the adoption of these methods by farmers.

STRATEGY: Encourage Greater Diversity and Flexibility in Farming Systems. The resilience of agriculture to changes in climate can be increased substantially by encouraging greater diversity in farming systems, including the development of new crops and more mixed-crop systems. In addition, the agricultural infrastructure, such as irrigation systems, can be made more flexible to allow adjustment to a range of future conditions. Finally, efforts to maintain genetic diversity and propagate

heat-and drought-tolerant crop and livestock varieties will allow greater adjustment to future climate changes.

Adapting to Changes in Water Supply and Demand

A number of studies suggest that global climate change will increase the frequency and severity of drought, particularly in mid-continental areas such as the American Midwest. Moreover, higher temperatures can increase the evaporation of soil moisture, exacerbating the effect of drought. These conditions result in both increased demand for and reduced supply of water. For some regions, severe water shortages are anticipated. In other areas, water tables may rise, necessitating different policy responses.

STRATEGY: Improve the Efficiency and Flexibility of Water Use. Improving the efficiency of water use provides a cushion against drought. There are numerous ways to conserve water. More efficient irrigation systems can improve the efficiency of water use dramatically. Pricing water at its replacement cost would discourage waste. Water managers can examine the use of market mechanisms to transfer water rights.

If new reservoirs or dams are constructed, planners should evaluate the marginal cost of adding capacity that could be used to respond to changing conditions in the future. Although it may not make sense to undertake large investments now in anticipation of future needs, it may be much less expensive to add marginal capacity to water systems while the reservoir is being built rather than later.

It may also make sense to protect options for future water supply development through a number of means, such as protective easements or land-use restrictions protecting potential reservoir sites. Water resource managers should also explore issues surrounding the transfer of water during periods of drought or excess supply.

STRATEGY: Protect Water Quality. The quality of water directly affects its availability for certain uses. By assuring that all water bodies are clean, more water can be made available for use in times of shortage. Cleaner waters will also reduce the impact on aquatic ecosystems during low stream flow conditions. States manage programs to control point source and non-point source water pollution; these programs can be used to address potential climate-related water quality threats. Meeting state and federal water quality standards is essential.

PURSUE AN AGGRESSIVE RESEARCH PROGRAM TO REDUCE KEY UNCERTAINTIES ABOUT GLOBAL CLIMATE CHANGE

National and international efforts have already begun to address the uncertainties surrounding the science of global warming. Internationally, the United Nations and the World Meteorological Organization have organized the Intergovernmental Panel on Climate Change. This group will release a report on the state of the art in global climate science, predicted effects of climate change, and strategies for reducing global warming. Its work will then be reflected in the process for developing an international framework convention on the atmosphere.

In the United States, multidisciplinary research is being coordinated by the U.S. Global Change Research Program. The President's fiscal 1991 budget calls for more than \$1 billion to fund this program, a 57 percent increase over fiscal 1990. As a joint effort of seven agencies and departments within the executive branch, this research program will be directed to improving the scientific basis for national and international policy formulation.

As a worldwide leader in basic and applied scientific research, the United States must aggressively pursue a research program to

"Perhaps the greatest single need now is for substantially more research. Some of the most important discoveries—such as the depletion of atmospheric ozone—have come through basic research in chemistry, physics, and the earth sciences. There is also a strong need for research in engineering and applied sciences, so that we can develop new technologies and buy time. Humanity faces the need for a very profound transition, to a way of life and an economic system compatible with long-term protection of the planet. We can't understand the issues or make that change without significantly more research."

• Gordon J. MacDonald
*Vice President, MITRE Corporation
United Nations Hearing*

improve understanding of the planet's climate, including its effects on the environment and its socioeconomic impacts. The Governors strongly support efforts to improve the state of scientific knowledge surrounding the climate change issue at both the national and international levels.

"There's a cliché, 'Everyone talks about the weather but nobody does anything about it.' The time to act on global climate change is now, but our policies must be based on sound economic and scientific analysis. Only then will we derive true societal and environmental benefits."

• Governor Stan Stephens
Montana

CONCLUSION

During the last several decades, the world has become more deeply aware of the relationship between people and the environment. New insights have reaffirmed that we are a part of nature rather than master over it. The potential for a catastrophic change in the global climate reinforces the need to consider the long-term effects of human actions. The balance between the necessities of economy and environment must be struck rationally and with full consideration of all the risks involved. Continued human prosperity can occur only in a healthy and habitable environment.

Global warming is at once one of the most threatening and the most misunderstood challenges humanity has ever faced. There is irrefutable evidence that human activities are changing the composition of the atmosphere. Physical laws indicate that a buildup of greenhouse gases should lead to a warmer climate. But the conjecture involved in predicting the actual effects of increased greenhouse gas concentrations make policy choices particularly complicated. With the scientific knowledge currently available, the choice is between waiting for more proof or ensuring against the possibility of a future disaster. Waiting may either prevent an unnecessary waste of resources or vastly exacerbate the predicted effects. Taking steps now could significantly reduce climate change in the future and avert disaster, or squander valuable resources and effort. Avoiding the negative impact of either extreme is at the center of the dilemma faced by policymakers at all levels.

The task force reviewed the extensive literature produced in the last several years on climate change and consulted representatives from the scientific, government, business, and environmental communities. Each of these groups has devoted serious and extensive consideration to global climate issues. It remains for representatives in government at state, federal, and international levels to make the weighty decisions—decisions that will be felt for generations. Ideally, these choices would be based on irrefutable evidence. In reality, they must be based on existing data.

The most important finding for the task force is that some steps should be taken now that can reduce the risk of future climate alteration while yielding other benefits in the short term. Many of these activities are already being undertaken by states, both as precautions against global warming and for the good economic, environmental, and social sense they make. The task force believes that these measures, many of which are described in this report, will not give us cause to regret our commitment to them. They are the most sensible steps to take now to achieve our goals.

Climate studies have deservedly received increased research priority and funding from the federal government. Depending on the results of these studies and others from around the world, our response may have to be adjusted to account for new understanding. The measures outlined above will provide the necessary flexibility to adjust to these developments. Great strides have been made toward understanding the planet; it is imperative that human actions continue to progress commensurate with available knowledge.

GLOSSARY

biomass energy—In its most familiar form, wood is burned to heat buildings or provide cooking heat. Wood or almost any form of plant fiber can also be burned to run a generator and produce electricity. Plant fiber can also be chemically altered to produce methanol and ethanol to be used as automotive fuels.

British Thermal Unit (Btu)—Basic unit of energy consumption in English system. One Btu is roughly equivalent to the energy of one blue-tip kitchen match.

clean coal technology—A technology that removes a significant proportion of the pollution-forming impurities in coal. Some of these technologies raise the efficiency of coal-fired power plants, and thereby reduces carbon dioxide emissions by requiring less coal to produce the same amount of electricity.

cogeneration—A technology that makes use of the heat generated through industrial processes to produce electricity. Many production plants use steam for heat or to make their products. Cogeneration takes advantage of some the heat to make electricity.

exajoule (EJ)—A unit of energy equal to 10^{18} joules. The United States consumes about 84 EJ of energy annually.

geothermal energy—Energy that relies on the natural heat of the earth to produce electricity. There are several different forms of geothermal energy in various stages of development, ranging from hydrothermal—the most common form used today—to systems that rely on molten rocks in volcanic areas.

hydroelectric power—A hydroelectric system relies on falling water to turn a turbine, which generates electricity.

joule—Basic unit of energy consumption; it is the energy required to lift a 1-kilogram weight about 10 centimeters.

kilowatt (KW, 1,000 watts) megawatt (MW, 1 million watts) gigawatt (GW, 10^9 watts)—Units of measure for generating capacity.

kilowatt-hour—A unit of measure for the amount of electric energy produced. In a conventional steam-turbine plant, about 10.9 megajoules (10^6 joules) of primary energy are required to produce 1 kilowatt-hour of electricity. One barrel of crude oil equals approximately 1,700 kilowatt-hours of electricity consumed.

quad—An abbreviation for quadrillion Btu (British Thermal Units). The United States consumes about 80 quads of energy annually. One quad is a little more than one EJ.

solar thermal electric energy—A solar thermal system uses mirrors to direct the sun's rays onto a receiving surface. A heating liquid is pumped through the element, which in turn produces steam that drives a turbine to produce electricity.

solar photovoltaic electricity—Photovoltaics are semiconductors that convert sunlight directly into DC electricity.

watt—Units of power; 1 watt is equal to $1/746$ of a horsepower.

wind power—Wind power converts the power contained in moving air into electricity using a windmill.

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