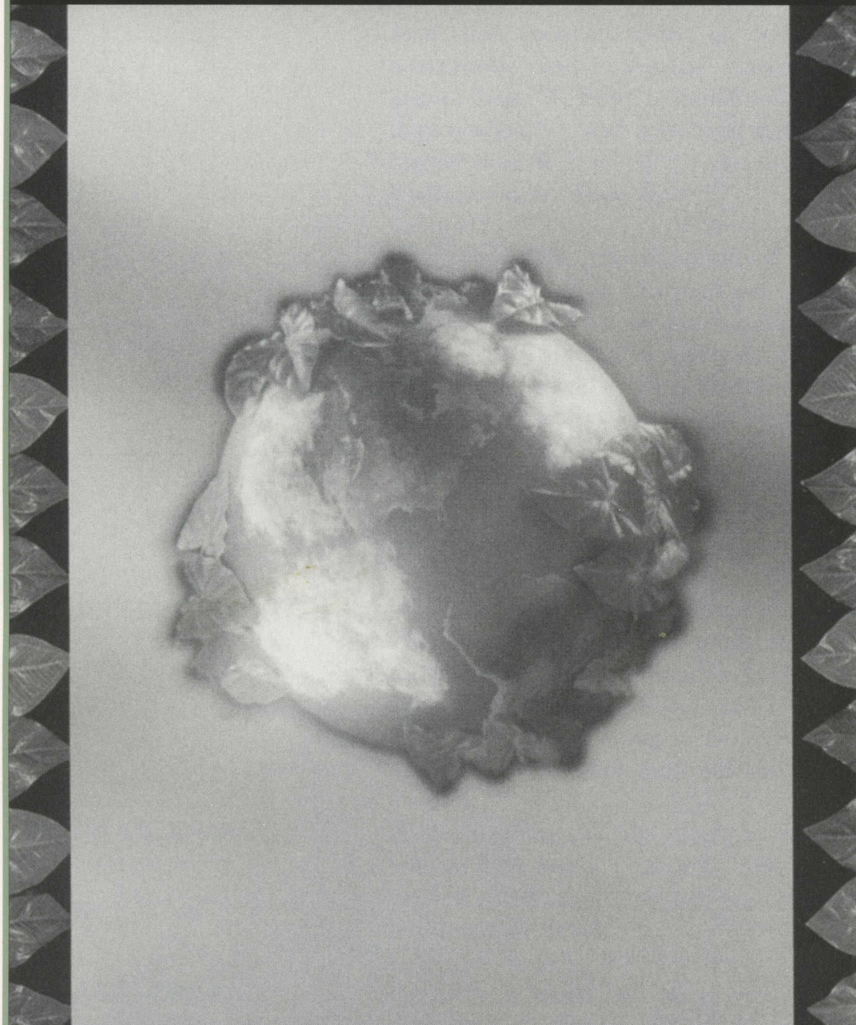
THE GREENING OF Planet Earth



• Transcript •

Transcript of
THE GREENING OF PLANET EARTH©

NARRATOR: Dawn of the Industrial Revolution. Western society is primarily agricultural and commercial. The concentration of carbon dioxide in the atmosphere is 270 parts per million.

And then, factories spring up across the countryside and industrial towns grow around them. We begin to burn fossil fuels in large quantities – and then burn more. The carbon dioxide level of the air rises. The level rises again. Then again.

The 1950s. The concentration of carbon dioxide in the air is 315 parts per million. Still more fossil fuels are burned. More and more carbon dioxide is emitted into the atmosphere. More industrialization – then more. More carbon dioxide – then more.

The year 2085. The atmospheric level of carbon dioxide has doubled to 540 parts per million. What kind of world have we created?

DR. HERMAN MAYEUX: A better world, a more productive world. Plants are the basis for all productivity on earth. They're the only organisms that can utilize the sun's energy and create matter, food. And they're going to do that much more effectively, much more efficiently.

DR. BRUCE KIMBALL: With a doubling of CO_2 – why cotton growers can look forward to yields that are 60 percent and more greater than what they are at present-day levels.

DR. MARY BRAKKE: For citrus it would be a very, very positive thing.

DR. GERD-RAINER WEBER: Our world will be a much better one.

DR. KENNETH BOOTE: In terms of plant growth, it's nothing but beneficial.

DR. HARTWELL ALLEN: We would expect a world in which crop plants would produce about 30 to 40 percent more than they currently are producing.

DR. SHERWOOD IDSO: A doubling of the CO_2 content of the atmosphere will produce a tremendous greening of planet earth.

NARRATOR: Carbon dioxide is the major building block of life. Plants extract it from the atmosphere during photosynthesis and transform it into the food we need to survive. As a by-product of this process, oxygen is released.

Throughout the history of life on earth, there has generally been much more CO_2 in the atmosphere than there is today.

These higher levels of carbon dioxide encouraged life. Vegetation in prehistoric eras was lush and grew profusely over wide areas. As this vegetation died and decayed, much of its trapped carbon was transformed into the coal, oil and natural gas the world depends on today.

The carbon dioxide that was in the atmosphere is now being returned to it by the burning of fossil fuels, a natural by-product of man's industrial evolution. And, as more and more scientists are confirming, our world is deficient in carbon dioxide and a doubling of atmospheric CO_2 is very beneficial.

"AGRICULTURE"

DR. LEON ALLEN:
Agronomy Department
University of Florida

We are investigating the effects of elevated levels of atmospheric carbon dioxide on plants using controlled environment chambers wherein we can control CO_2 levels very precisely. We are interested in this because we want to know how C_3 crop species such as rice and soy bean may respond to future levels of atmospheric carbon dioxide.

What we are finding is that these species respond quite nicely to a doubling of carbon dioxide and give increased yields up to 30 to 40 percent.

DR. KENNETH BOOTE:
Agronomy Department
University of Florida

Most of the temperate plants grown in the United States – the temperate cool-season cereals, soy bean, peanut – are plants that respond to carbon dioxide. The temperate plants will respond with about a 35 percent increase in growth and yield in response to a doubling of CO_2.

We've done a simulation of a doubling of CO_2 effect on soy bean dry matter accumulation and seed yield and I have an example of that with this simulation. This shows the 330 part per million CO_2 dry matter and this shows a doubling of CO_2 at 660 parts per million. I'll run another example here of just the seed weight. This shows the seed dry weight increase over time until final maturity for a normal 330 part per million CO_2 and a doubling of CO_2 (660 parts per million) showing about a 35 to 40 percent increase in seed yield.

DR. JEFFREY BAKER:
Agronomy Department
University of Florida

With our work with soy beans we have found that soy bean responds favorably to elevated CO_2 concentration. The net benefit in grain yield is similar to that for what we're seeing for rice. With rice, elevated CO_2 levels stimulate growth and ultimately this translates into increased grain yield.

We're getting, typically, anywhere from 30 to 40 percent increases in grain yield. We get increased carbon uptake through photosyn-

Dr. Baker: continued

thesis. We get a decline in carbon loss during nighttime respiration. We also get a decline in total water use, and all this translates into an increase in grain yield, which is the useful portion of the plant with rice.

DR. HERMAN MAYEUX:
Agricultural Research Service
U.S. Department of Agriculture

We grew a wheat crop – two varieties of wheat – across a CO_2 gradient from well below what it was in pre-industrial times, up to what it is now. And we found that both of those varieties increased their yield by a factor of three.

DR. HYRUM JOHNSON:
Agricultural Research Service
U.S. Department of Agriculture

Earlier, we did an experiment with oats. At the time we took the oats out, then we did measure the biomass, the total increase in stem and leaf weight, and so on. It was on the same order of increase as we found with the wheat.

DR. BRUCE KIMBALL:
Water Conservation Laboratory
U.S. Department of Agriculture

Elevated CO_2 levels have greatly increased the growth of our cotton crops. We found that in enriching the crop to about 550 parts per million (which is 200 parts per million above our control plots) that the growth is increased by about 40 percent or more.

A world in which the CO_2 concentration has doubled is one in which the plants will enjoy it a lot more. They have been, in effect, eating the CO_2 out of the air for a long time and they're rather starved for CO_2. So the plants are really going to like this high CO_2 world that we're going into now.

DR. ALLEN:

The increase in atmospheric CO_2 is a benefit that will occur around the globe, regardless of where you're located. There'll always be some benefit for somebody, for everybody perhaps.

"WATER-USE EFFICIENCY"

NARRATOR:

Enriched levels of atmospheric carbon dioxide not only enhance plant growth, but they also make plants more water efficient. In fact, a doubling of CO_2 would also double most plants' water-use efficiency.

Plants exposed to higher levels of CO_2 do not open the stomates, or pores, in the leaves as widely as when there is less CO_2 in the air. And the smaller the openings, the less water is lost by evaporation into the atmosphere. But what does this imply?

DR. MARY BRAKKE:
Botany Department
University of Florida

The idea of increased water-use efficiency for citrus is very, very positive and it's a good sign for areas such as Florida which are facing severe reductions in the water use for agricultural purposes, even at present.

DR. MAYEUX:

The marvelous thing about the increase in water-use efficiency is that all plants experience it to some degree or another. And most plants experience it to a significant degree. The research shows that when CO_2 levels double from what they are, to now, there'll be some large response.

Our research shows that the 30 percent increase we've already experienced in CO_2 has already had an effect on plants in this regard.

DR. KIMBALL:

Another question that comes up is: What happens to the yield of the crop when it's water-stressed and you have higher CO_2? And an interesting thing happens. We find, that for the most part, it appears that there is a greater stimulation of growth under conditions of water stress at high CO_2. So to some extent the higher CO_2 compensates somewhat for water stress.

DR. ALLEN:

As CO_2 rises in the atmosphere we expect more crop production per unit of land area and slightly decreased water use per unit of

Dr. Allen: continued

land area, so we expect this to lead to overall production with less water requirements.

In areas that are irrigated we expect there to be maybe 40 percent, at least 40 percent, greater productivity per unit of water applied. This could lead to either greater areas being irrigated, but more likely to a very nice increase in crop yield with no further inputs into the agricultural system.

DR. SHERWOOD IDSO:
Water Conservation Laboratory
U.S. Department of Agriculture

As the efficiency with which plants utilize water increases in the years ahead as the CO_2 content rises, plants will obviously be able to grow and survive in areas where they currently cannot because of a lack of water. That means that you should see a tremendous redistribution of plants on the face of the earth.

In very general terms, you should see a real greening of the desert. You should see grasses and small shrubs moving out onto areas where they could not live, survive, and reproduce before. Then there should also be a tendency for bushes and shrubs to grow where only grasses have grown in the past. And of course, forests should greatly expand their ranges.

"COMPUTER SIMULATIONS"

NARRATOR:

This real-world evidence of CO_2's positive effects has been challenged over the years by theoretical computer models.

Some of these models say that the earth is warming to a frightening degree due to the man-made *greenhouse effect* – a phenomenon in which CO_2 plus harmful greenhouse gases trap the heat escaping into the atmosphere and send it back to earth.

The models say that this will cause the polar icecaps to melt, drought to grip the heartland of the U.S., and "super storms" to ravage the planet. But are these models accurate? What role does CO_2 play? Has there actually been any global warming? What are the computer simulations trying to do?

DR. GERD-RAINER WEBER: *German National Coal Association*

What computer models are doing is they are trying to simulate the physics and the chemistry that is going on in our atmosphere. However, the chemistry and the physics are so complex that even if we knew all the processes that have a bearing on climate, it would be very hard to model it – to simulate it – with a set of physical or chemical equations.

DR. RICHARD LINDZEN: *Center for Meteorology and Oceanography Massachusetts Institute of Technology (MIT)*

An easy way of describing their inability is to note that there are all sorts of things like cloud cover, water vapor, heat transport, that in present models have errors on the order of 50 percent. And such errors absolutely swamp the effects of a doubling of carbon dioxide. As long as the models have errors that can swamp the effect you're looking for, you cannot regard the models as credible.

DR. WEBER: We don't even know all the process, for instance, that are taking place between the biosphere of the earth and the atmosphere. We do not know all the processes that are taking place between the oceans and the atmosphere – clouds and the atmosphere.

DR. LINDZEN: The same models that, for instance, predict five degrees for a doubling are predicting we should have seen two degrees (or at least one degree) Centigrade in the last century. Nobody claims we've seen anything more than about a half degree. The number often centers on something a little smaller than that. And that is overtly inconsistent with the

Dr. Lindzen: continued models. Moreover, there is virtually no one who believes that the half degree is due to greenhouse gases, because climate has always varied by itself without man's intervention.

DR. WEBER: So the reality falls about at least 50 percent short of what the models predict. This is really one of the major issues: We simply don't see, at this point, the warming the models predict.

DR. LINDZEN: It's garbage in, garbage out. If you put in a bad parameterization, if you put in inadequate resolution, you do not have credible answers coming out. It's not as though I would believe the models if they only gave me that it would get colder. There's no basis for believing them.

We've gone from ice ages to warm periods. We've had a warming since then, but we're not as warm as it was in the Medieval Period when you had grape growth in Scotland, you know, and so on. So the climate is always fluctuating and there is nothing in what we have seen in the last 100 years that looks any different from these fluctuations.

DR. WEBER: Now, as we move into the late 1980s and early 1990s, oceanic models have become much more sophisticated. There have been several attempts by major modeling groups to couple realistic oceans to atmospheric models. And some of those models show that, indeed, the warming that people expect for coming decades is considerably less than what older models had expected.

DR. LINDZEN: I probably share the puzzlement of a lot of people in trying to understand why modest warming is treated as one of the gravest dangers facing mankind. I simply do not know why. I do know what I have seen, as have most other people, on television. You know, pictures of palm trees in Boston, Washington under water. And those indeed are part of what I suppose one could call a cataclysmic scenario. But to the best of my knowledge, they have nothing to do with what any scientist has predicted regardless of which side of the issue he is on.

"THE SYSTEM"

NARRATOR: But even if the earth does warm a certain amount, what effect will this have?

DR. IDSO: If there ever were to be a warming of the world, there would be a warming of the oceans. And this would increase the productivity of the unicellular algae, or phytoplankton, that live there. This would increase their production of various substances that, when they die, are released to the surface waters of the ocean.

One of these substances is something we call dimethylsulfide, or DMS. It makes its way into the atmosphere as a gas, where it is converted into particles around which water vapor condenses to create more cloud particles. With more cloud particles you have brighter clouds. This reflects more of the incoming solar radiation back to space and it cools the planet.

On land very much the same thing would happen. If you have an increase in temperature on land, you have an increase in the productivity of many soil micro-organisms. When this happens, they give off sulfur gases in greater quantities. One of these is also dimethylsulfide.

You may even have a situation where you don't need an increase in temperature to kick

Dr. Idso: continued

this mechanism into operation. That is, just the increased productivity of plant life caused by enriching the air with CO_2 will put ultimately more organic matter into the soil. This is the food for microbes. You give them more food, they produce more – more evolution of dimethylsulfide, more cloud condensation particles. And you could have a situation whereby there could be a cooling of the planet due to the increase in CO_2 content of the atmosphere that could overpower the greenhouse effect.

"TREES AND ANCIENT FORESTS"

NARRATOR:

Trees account for about three-quarters of all photosynthesis done by land plants and two-thirds of all photosynthesis done globally. What effect will a doubling of CO_2 have on them?

Part of the answer comes from an experiment being conducted with sour orange trees and another part from Bristlecone pines – the oldest living organisms in the world.

DR. DONALD GRAYBILL:
Laboratory of Tree Ring Research
US Department of Agriculture

We're here at 11,000 feet in the White Mountains of eastern California to discuss the growth of Bristlecone pine. It has shown some phenomenal increases, in the past one hundred years or so, that we can't attribute to temperature or to precipitation. We think that the increasing carbon dioxide may have had a very important effect on this growth.

Now the Bristlecone pine is very important in this respect – and especially at these elevations – because it's the only natural laboratory where we've seen this effect. And so we've begun to study this all over the dry, arid mountain ranges of the western United States. And we've found that it's quite widespread, again only at these very high elevations where a little bit more carbon dioxide is very helpful for growth.

DR. IDSO: The experiment that we have been conducting here for four years deals with growing sour orange trees under normal conditions of atmospheric CO_2 concentration. And then, where the CO_2 content of the air has been enriched to an approximate doubling, not quite a doubling, of the current concentration.

We have followed these trees, as I said, for about four years now and the enriched trees have almost tripled their biomass. That is, they have grown approximately three times faster than the trees growing in normal air. Now this response is so incredible. It suggests that were the CO_2 content of the atmosphere to double, the growth rates of earth's trees would triple. And the studies that we have done over the past couple of months, looking at the photosynthetic response of these trees to atmospheric CO_2 enrichment, suggest that it does not stop there. In other words, if we tripled or quadrupled the CO_2 content of the atmosphere, it looks like the growth response of the trees would just continue to increase linearly.

DR. GRAYBILL: One of the very important points that must be understood and is crucial to this story is that we see a tremendous growth spurt in the past one hundred or so years that we have not seen in the past few thousand years in these trees. Now, this corresponds precisely with the tremendous increases in carbon dioxide that are even now measured from Mauna Loa in Hawaii, from ice cores and from other places.

DR. IDSO: Most recently we have put in several new chambers where we are looking at five other

Dr. Idso: continued

species of trees. We are looking at them under a range of CO_2 concentrations that actually go far above what we have looked at with the large sour orange trees over the past few years. And we find that these other trees appear to respond exactly the same way as the sour orange trees to atmospheric CO_2 enrichment. And as the CO_2 content continues to rise beyond what we've looked at in the past, the response seems to be linear. It continues to go up and up and up. We have gone out to a level of 1200 parts per million of CO_2 and there seems to be no drop-off in the response. It means that we may have way more than a tripling of the growth of these trees – a quadrupling, maybe five or six times more. It's absolutely incredible!

DR. GRAYBILL:

If carbon dioxide levels continue to increase, and it is critical to the growth of plants (as we know it is) then we might well begin to see increases in productivity – forest productivity, wood production – as we go down the mountainside as carbon dioxide levels increase. And again we might see increased efficiency in use of water in those forests as well. This might have another ramification in that, over large areas, we might see a surplus of water over time.

DR. IDSO:

As the CO_2 content of the air continues to rise in the future, the planet's trees will become more and more stimulated. That is, they will grow at greater and greater rates. And as they do this they will extract more and more CO_2 from the atmosphere. As time goes on and their growth rates are doubled or tripled or even quadrupled (which is a real likelihood as far as our experiments indicate), you will have so much CO_2 being removed from the atmosphere that there will come a point where the CO_2 content of the atmosphere will rise no further because the trees of the planet will be yearly extracting as much CO_2 from the atmosphere as mankind yearly puts into it.

"WETLANDS"

NARRATOR: Since 1986, the Smithsonian Institution in Washington, D.C. has sponsored research into the effects of enriched levels of CO_2 on marshland plants. Cosponsored by the U.S. Department of Energy, these experiments are being conducted near the Chesapeake Bay in Edgewater, Maryland.

In this field plants are growing in open-topped chambers. Some are being exposed to twice today's level of CO_2. For comparison, others are growing in chambers with current levels of CO_2. Both C_3 and C_4 plants are being studied.

C_3 plants comprise about 95 percent of all plant species on earth and the enriched C_3 plants react very positively. They take in more CO_2 during the day and release less at night. They don't decay as quickly. They increase their growth rate dramatically, both above ground and below it. They use water more efficiently and they use less of it.

So what do these Smithsonian experiments suggest?

Will the earth's huge areas of marshland become a depository where excess CO_2 can be stored? What about the possibility of food crops doubling or even tripling worldwide? What if areas of the world unable to support crops or forests can one day do so? And what if more productive plant life can ultimately stop the rise of atmospheric CO_2 completely?

The research continues.

"THE CO_2 CYCLE"

NARRATOR: Every spring, vegetation awakens and takes in vast quantities of CO_2 for the growing season. Then, in the fall and winter, the vegetation dies and decays, and the CO_2 is put back into the air. We have about a 30-year record of this cycle.

DR. IDSO: Scientists that have looked in detail at this record have determined that each year the difference between the high and low points of the seasonal oscillation is getting greater and greater. The only explanation that anybody has ever been able to come up with that explains the magnitude of this rise has to do with the fact that the plant life of the planet must be becoming more and more robust each year in response to the gradually-rising CO_2 content of the atmosphere.

DR. JOHNSON: Undoubtedly there has been already a considerable increase in the yields that are coming from the fields because of the CO_2 enrichment that's in the atmosphere.

DR. BOOTE: In the last 30 years we should have had a five to six percent yield increase from the CO_2 increase that already has happened.

DR. MAYEUX: We know from historical records and from personal observations that crop productivity has increased dramatically, especially since World War II. Three, four, five times more cotton, corn, wheat, soybeans, rice – and we think we know why this is.

We have better crop varieties. The plant breeders have come up with hybrids and much more productive, better-adapted strains of these crops. We've learned to do a much better job applying fertilizers, controlling diseases, controlling insects, and our cultural practices are fairly well-developed in the world today. But it also makes sense that many of these crops are the kind that respond dramatically to increasing CO_2. So it makes sense that the 30 percent increase in CO_2 that we've experienced since pre-industrial time should have increased crop growth.

"THE FUTURE"

NARRATOR: What does the future hold? In great measure it holds a variety of questions – questions about the wholesale destruction of our tropical rain forests, about becoming the most efficient energy users we can, and questions about how we intend to feed our exploding global population.

In addition to these questions, however, the future also holds great promise. And contributing to this promise is the positive effect that carbon dioxide has on our world.

As we have seen, enriched levels of CO_2 in the air greatly enhance growth and water-use efficiency in almost all the world's vegetation. Crop plants will continue to grow more productively, contributing ever-greater supplies of food. Forests will extend their ranges, grasses will grow where none grow now, and great tracts of barren land will be reclaimed. In fact, it is not inconceivable that the vitality of our entire biosphere could rise by a full order of magnitude over the next few centuries to a new greening of planet earth.

–THE END–

With special thanks to:

Dr. Leon H. Allen, Jr., Agronomy Department, University of Florida

Dr. Jeffrey T. Baker, Agronomy Department, University of Florida

Dr. Kenneth J. Boote, Agronomy Department, University of Florida

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Dr. Donald A. Graybill, Laboratory of Tree Ring Research, University of Arizona

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Dr. Hyrum B. Johnson, Agricultural Research Service, U.S. Department of Agriculture

Dr. Bruce A. Kimball, Water Conservation Laboratory, U.S. Department of Agriculture

Dr. Richard S. Lindzen, Center for Meteorology and Physical Oceanography, Massachusetts Institute of Technology

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WESTERN FUELS ASSOCIATION INC.

The National Fuel Supply Cooperative

Western Fuels Association, Inc.
4301 Wilson Boulevard, Suite 805
Arlington, Virginia 22203-4193

Phone: (703) 907-6160
Fax: (703) 907-6161
E-mail: wfa@cais.com
www.westernfuels.org