S. HRG. 108–357

# CLIMATE CHANGE ISSUES: AGRICULTURAL SEQUESTRATION OF CARBON DIOXIDE

## HEARING

BEFORE THE

SUBCOMMITTEE ON CLEAN AIR, CLIMATE CHANGE, AND NUCLEAR SAFETY

OF THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS UNITED STATES SENATE

ONE HUNDRED EIGHTH CONGRESS

FIRST SESSION

JULY 8, 2003

ON

THE POTENTIAL OF AGRICULTURAL SEQUESTRATION TO ADDRESS CLIMATE CHANGE THROUGH AFFECTING ATMOSPHERIC LEVELS OF CARBON DIOXIDE

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# CLIMATE CHANGE ISSUES: AGRICULTURAL SEQUESTRATION OF CARBON DIOXIDE

**TUESDAY, JULY 8, 2003**

U.S. SENATE,
SUBCOMMITTEE ON CLEAN AIR, CLIMATE CHANGE AND NUCLEAR SAFETY,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
*Washington, DC.*

The subcommittee met, pursuant to notice, at 9:42 a.m. in room 406, Senate Dirksen Building, the Hon. George V. Voinovich [chairman of the committee] presiding.

Present: Senators Voinovich and Carper.

## OPENING STATEMENT OF HON. GEORGE V. VOINOVICH, U.S. SENATOR FROM THE STATE OF OHIO

Senator VOINOVICH. The meeting will please come to order.

I apologize to you for being late. I had a breakfast downtown and ran into a lot of traffic.

We are here today to discuss agricultural sequestration of carbon. Specifically, today's hearing will focus on the potential for agricultural sequestration to reduce concentration of atmospheric greenhouse gases, and the Administration's action to understand and enhance that potential.

As everyone in this room is aware, the issue surrounding greenhouse gas emissions and climate change have become fairly controversial with people on both sides of the issues. To an extent, they have become the quid pro quo to move forward on legislation dealing with SOx, NOx, and mercury.

I have stated several times that we need to enact a comprehensive energy policy that harmonizes the needs of our economy and our environment. Nowhere is that need more important than with the issue of greenhouse gas emissions and climate change, where the options that have been proposed to mitigate potential human impacts on the climate and related environmental systems are likely to have substantial economic and societal consequences, and where there is a raging debate about whether there are any conclusive environmental benefits from implementing them.

As we look to the issue of surrounding greenhouse gas emissions and the stability of our utility manufacturing and industrial sectors, it is very clear that the nexus between the environment and the economy, rather than an academic or political exercise, is a real issue for those who will be affected by the decisions we make on this Committee and in the Senate.

We in the Senate are here as public policymakers and must have reliable and readily understood information in order to make informed decisions about them. In 2002, the total greenhouse gas emissions in carbon dioxide equivalent terms were about 14 percent higher than emission levels in 1990. $CO_2$ accounted for 82 percent of total U.S. greenhouse gas emissions; methane accounted for 9 percent; nitrous oxide accounted for 6 percent; and other gases accounted for the rest.

The Administration projects that total U.S. greenhouse gas emissions will increase by 43 percent between 2000 and 2020. Several uncertainties are associated with this projection including forecast methodology, meteorological variations, and rates of economic growth and technological development. Further, the Administration's projections do not incorporate future measures to address greenhouse gas emissions or legislative and regulatory actions not yet in effect.

Despite the fact that many of the environmental community argue that the science of the causes, effects, and extent of climate change is settled there is, in fact, real controversy over whether or not greenhouse gas emissions affect the climate. The National Research Council has noted that fundamental scientific questions remain regarding the specifics of the connection between atmospheric greenhouse gas concentration and projections of climate change.

According to the National Academy of Sciences, potential risks of increased concentration of greenhouse gases are generally characterized as long-term in nature and the current scientific knowledge and ability are insufficient to conclude whether these shifts are a result of human activities.

Just yesterday, former Secretary of Energy James Schlesinger published an op-ed in the Washington Post noting that we are making only slow progress in our understanding. I would just like to quote from a couple of paragraphs from his op-ed piece.

"We cannot tell how much of the recent warming trend can be attributed to the greenhouse effect and how much to other factors. In climate change we only have a limited grasp of the overall forces at work. Uncertainties have continued to abound and must be reduced. Any approach to policy formation under conditions of such uncertainty should be taken only on an exploratory and sequential basis. A premature commitment to a fixed policy can only proceed with fear and trembling."

He finishes the op-ed piece with this:

"There is an idea among the public that the science is settled. Aside from the limited facts I cited earlier, that remains far from the truth. Today we have far better instruments, better measurements, and better time series than we ever had. Still, we are in danger of prematurely embracing certitudes and losing open-mindedness. . . . We need to be more modest."

I want to insert in the record this op-ed.

Without objection, so ordered.

[The article follows:]

[From the Washington Post, July 7, 2003]

CLIMATE CHANGE: THE SCIENCE ISN'T SETTLED

(By James Schlesinger)

Despite the certainty many seem to feel about the causes, effects and extent of climate change, we are in fact making only slow progress in our understanding of the underlying science. My old professor at Harvard, the great economist Joseph Schumpeter, used to insist that a principal tool of economic science was history—which served to temper the enthusiasms of the here and now. This must be even more so in climatological science. In recent years the inclination has been to attribute the warming we have lately experienced to a single dominant cause—the increase in greenhouse gases. Yet climate has always been changing—and sometimes the swings have been rapid.

At the time the U.S. Department of Energy was created in 1977, there was widespread concern about the cooling trend that had been observed for the previous quarter-century. After 1940 the temperature, at least in the Northern Hemisphere, had dropped about one-half degree Fahrenheit—and more in the higher latitudes. In 1974 the National Science Board, the governing body of the National Science Foundation, stated: "During the last 20 to 30 years, world temperature has fallen, irregularly at first but more sharply over the last decade." Two years earlier, the board had observed: "Judging from the record of the past interglacial ages, the present time of high temperatures should be drawing to an end . . . leading into the next glacial age." And in 1975 the National Academy of Sciences stated: "The climates of the earth have always been changing, and they will doubtless continue to do so in the future. How large these future changes will be, and where and how rapidly they will occur, we do not know." These statements—just a quarter-century old—should provide us with a dose of humility as we look into the more distant future. A touch of that humility might help temper the current raging controversies over global warming. What has concerned me in recent years is that belief in the greenhouse effect, persuasive as it is, has been transmuted into the dominant forcing mechanism affecting climate change—more or less to the exclusion of other forcing mechanisms. The $CO_2$/climate-change relationship has hardened into orthodoxy—always a worrisome sign—an orthodoxy that searches out heretics and seeks to punish them.

We are in command of certain essential facts. First, since the start of the 20th century, the mean temperature at the earth's surface has risen about 1 degree Fahrenheit. Second, the level of $CO_2$ in the atmosphere has been increasing for more than 150 years. Third, $CO_2$ is a greenhouse gas—and increases in it, other things being equal, are likely to lead to further warming. Beyond these few facts, science remains unable either to attribute past climate changes to changes in $CO_2$ or to forecast with any degree of precision how climate will change in the future.

Of the rise in temperature during the 20th century, the bulk occurred from 1900 to 1940. It was followed by the aforementioned cooling trend from 1940 to around 1975. Yet the concentration of greenhouse gases was measurably higher in that later period than in the former. That drop in temperature came after what was described in the National Geographic as "six decades of abnormal warmth."

In recent years much attention has been paid in the press to longer growing seasons and shrinking glaciers. Yet in the earlier period up to 1975, the annual growing season in England had shrunk by some 9 or 10 days, summer frosts in the upper Midwest occasionally damaged crops, the glaciers in Switzerland had begun to advance again, and sea ice had returned to Iceland's coasts after more than 40 years of its near absence.

When we look back over the past millennium, the questions that arise are even more perplexing. The so-called Climatic Optimum of the early Middle Ages, when the earth temperatures were 1 to 2 degrees warmer than today and the Vikings established their flourishing colonies in Greenland, was succeeded by the Little Ice Age, lasting down to the early 19th century. Neither can be explained by concentrations of greenhouse gases. Moreover, through much of the earth's history, increases in $CO_2$ have followed global warming, rather than the other way around.

We cannot tell how much of the recent warming trend can be attributed to the greenhouse effect and how much to other factors. In climate change, we have only a limited grasp of the overall forces at work. Uncertainties have continued to abound—and must be reduced. Any approach to policy formation under conditions of such uncertainty should be taken only on an exploratory and sequential basis. A premature commitment to a fixed policy can only proceed with fear and trembling.

In the Third Assessment by the International Panel on Climate Change, recent climate change is attributed primarily to human causes, with the usual caveats regarding uncertainties. The record of the past 150 years is scanned, and three forcing mechanisms are highlighted: anthropogenic (human-caused) greenhouse gases, volcanoes and the 11 year sunspot cycle. Other phenomena are represented poorly, if at all, and generally are ignored in these models. Because only the past 150 years are captured, the vast swings of the previous thousand years are not analyzed. The upshot is that any natural variations, other than volcanic eruptions, are overshadowed by anthropogenic greenhouse gases.

Most significant: The possibility of long-term cycles in solar activity is neglected because there is a scarcity of direct measurement. Nonetheless, solar irradiance and its variation seem highly likely to be a principal cause of long-term climatic change. Their role in longer term weather cycles needs to be better understood.

There is an idea among the public that "the science is settled." Aside from the limited facts I cited earlier, that remains far from the truth. Today we have far better instruments, better measurements and better time series than we have ever had. Still, we are in danger of prematurely embracing certitudes and losing open-mindedness. We need to be more modest.

The writer, who has served as secretary of energy, made these comments at a symposium on the 25th anniversary of the Energy Department's $CO_2$/climate change program.

Senator VOINOVICH. I think in order to address the potential risks associated with greenhouse gas and emissions, the Administration has initiated several administrative and regulatory actions intended to reduce greenhouse gas emissions and enhance carbon sequestration, including agriculture carbon sequestration initiatives at the Department of Agriculture.

Last month, Secretary Veneman announced several new initiatives to encourage greenhouse gas reduction and support voluntary actions by private land owners including farmers, and forest and grazing land owners to increase carbon storage. Specifically, the USDA will give consideration to management practices that store carbon and reduce greenhouse gases and setting priorities and implementing forest and agricultural conservation programs such as the Environmental Quality Incentives Program, the Wetland Reserve Program, and the Forest Land Enhancement Program.

The USDA will also fund financial incentives, technical assistance, demonstration, pilot programs, education and capacity building, along with the measurements to assess the success of these efforts.

I have long been a supporter of such programs, even when I was unaware of their benefits in reducing greenhouse gas concentration. When I was Governor of Ohio, we planted 15 million trees during the 8 years that I was Governor of the State. At the same time, I knew that it was good for the environment, and it would certainly help the air. But it was only later, once I had moved onto this Committee, that I was told by Dr. Lal, who will be testifying today, that that kind of program and the legislation that I sponsored when I was in the State legislature on reclaiming all of our strip mines, has had a real measurable impact on reducing carbon in our atmosphere.

I hope that today's hearing will provide us with an understanding of the agricultural sector's potential to sequester carbon and to increase productivity, and where the Administration's programs are providing resources and research in the most effective manner to ensure that our farmers can reach that potential.

We are very fortunate today that our first witness is Bruce Knight, the Chief Executive Officer of the Natural Resources Con-

servation Service at the Department of Agriculture. Mr. Knight, we are very happy to have you here with us this morning. We are looking forward to hearing your testimony.

**STATEMENT OF BRUCE KNIGHT, CHIEF EXECUTIVE OFFICER, NATURAL RESOURCES CONSERVATION SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE**

Mr. KNIGHT. Thank you, Mr. Chairman, for the opportunity to discuss the Department of Agriculture's carbon sequestration activities.

The issue of climate change is a high priority for Secretary Veneman and for each of our respective mission areas across the Department. Last month, as you know, Secretary Veneman announced a series of actions that the Department will take to increase carbon sequestration and reduce greenhouse gas emission from forest and agriculture.

The actions represent a major step forward for the Department. For the first time, USDA will include the reduction of greenhouse gases as a consideration while setting priorities and in allocating resources for the conservation programs that we administer.

Coupled with the increases in overall conservation spending, these actions are expected to increase the carbon sequestration and greenhouse gas emissions reductions from the conservation programs by over 12 million tons of carbon equivalent in 2012. This represents approximately 12 percent of President Bush's goal to reduce greenhouse gas intensity by 18 percent in the next decade.

I would point out to members of the Subcommittee that we are talking about carbon and carbon equivalents, which includes methane and nitrous oxide. Also, it is important to note that greenhouse gas intensity refers to the rate of emissions as compared to overall domestic economic performance. USDA's conservation programs were designed to offer assistance and incentives to farmers and other land owners in addressing multiple conservation and environmental challenges.

Historically, programs have focused on reducing soil erosion, improving water quality, creating wildlife habitat, reducing air pollution, and protecting sensitive areas. While maintaining these priorities, the programs will now also include explicit consideration of greenhouse gas reductions and carbon sequestration. We can accomplish this without compromising our other objectives because in many cases the technologies and practices that reduce greenhouse gas emissions and increase carbon sequestration also address other conservation priorities.

For example, the very item that you mentioned, Senator, planting trees and other natural covers can increase above and below ground carbon. Most importantly—and this is one that I cannot stress enough—crop land does not need to be taken out of production in order to be able to sequester carbon. For example, conservation tillage increases the level of soil organic matter and provides many related benefits, while continuing strong and vibrant crop production.

There are many opportunities to apply these practices in the U.S. As a farmer myself for much of my life in the State of South Dakota, I would note that nationally crop land soils have lost at least

a third, and some up to 60 percent of their carbon, since they were first converted to crop production, beginning about 200 years ago.

In the case of my own farm operation, most of those soils have not been under cultivation for over 100 years. Many areas of my own operation have come into production within the past 20 years, while maintaining an under-intensive conservation tillage. In fact, today's no-till practices, along with our rest/rotation grazing system, had been aimed at improving soil functions and health. I can state firsthand that I have seen tremendous benefits to my own operation from season-to-season, but also benefits by building soil organic matter for the long-term as well.

While those of us in agriculture see the benefits up close, at the Department we are working to utilize the portfolio of existing conservation programs to build carbon above and below the soil on a much more broad scale. Within the Agency I oversee, NRCS provides financial and technical assistance that can help with carbon sequestration under the Environmental Quality Incentives Program. We have provided guidance to States, to reward actions that sequester carbon and reduce greenhouse gases within the equipped ranking system. These efforts can include the soil conservation practices already mentioned, and technologies to reduce methane emissions from livestock waste.

We also recently hosted a summit on one of these promising technologies—anaerobic digesters. Anaerobic digesters, in fact, work to convert animal waste to energy by capturing and converting the methane that is given off. At that summit, we unveiled three new conservation practice standards specifically for digesters.

These new standards will have two major benefits. They will make it possible for producers to fit anaerobic digesters into their equipped contracts as parts as a comprehensive nutrient management plan and they will make it possible for producers to use outside resources, technical service providers, to plan and construct those digesters.

Many other conservation programs, including the Conservation Reserve Program, Wetlands Reserve Program, Wildlife Habitat Improvement Program, and the Forest Land Enhancement Program, have excellent prospects for sequestration of greenhouse gases.

For example, under the new farm bill, the Wetland Reserve Program alone will restore and protect about 1.2 million acres of wetlands, roughly a land area the size of Delaware alone. We know that what happens on farms and ranches can have a tremendous positive impact for everyone. It is important for us to better measure those efforts and to get the message out.

To summarize, I would like to highlight the key steps that USDA plans to undertake. First, improve the methods for measuring and estimating above and below ground carbon storage on forest and agricultural systems. Next, collect carbon flux measurement data at specific locations that can, in turn, be scaled to regional and national statistics. Third, develop management practices and techniques for increasing carbon sequestration and reducing greenhouse gas emissions. Fourth, support demonstration projects to facilitate the incorporation of carbon sequestration into USDA programs. And finally, finalize new accounting rules and guidelines for

estimating and reporting carbon sequestration and greenhouse gas emissions from forest and agricultural activities.

USDA continues to invest in research to improve our understanding of how crops, livestock, trees, and even pests in other facets of our ecosystems will respond either positively or negatively to higher levels of greenhouse gases in the atmosphere. We are seeking cost effective ways to make agriculture and forests more adaptable to any changes in climate and weather should they occur.

We are pursuing an improved understanding of the role of natural and managed ecosystems in the global carbon cycle. We are developing technologies and practices to reduce emissions of greenhouse gases and increase carbon sequestration. We are now harnessing the portfolio of conservation programs to build carbon back into the soil and vegetation, integrating greenhouse gas considerations in all our conservation efforts.

Mr. Chairman, thank you again for the opportunity to address this Subcommittee. I would be happy to attempt to respond to any questions that you may have. I would ask that my written statement be placed in the record in its entirety.

Senator VOINOVICH. Without objection, so ordered. Thank you very much.

You mentioned in your testimony how this initiative on the part of the Department of Agriculture fits in with the President's 18 percent reduction in greenhouse gases. Would you underscore it some more?

Mr. KNIGHT. The initiative that we are putting under way is really intended to put the enabling platform out there for the farmers and ranchers who would voluntarily need to step forward in being able to help achieve these objectives. We put that enabling platform in place by ensuring that when we are doing any sort of conservation work on the ground, that we also keep an eye at what we can do for carbon sequestration.

I mentioned that as much as 12 percent of the overall President's objectives could be met thorough these methodologies. EQIP alone would bring us halfway to that goal, simply by having ensured that as we are implementing these programs we are doing things that either do greenhouse gas avoidance, mitigation, or sequestration.

Senator VOINOVICH. You talked about being able to measure and capture the statistics. How precise is that technology that would allow you to do that? How precise can you get in terms of measuring what impact it has in terms of sequestration?

Mr. KNIGHT. We are continuing to work to improve the precision, the reliability, and the ability to verify and repeat each of those measures. The Department of Agriculture, NRCS, is in a leading position and is working very closely with the Department of Energy and EPA in ensuring that across the Agency lines we have agreement on the verifiability and the measurability of each of these practices.

There are continuing efforts to enhance that. It is a real struggle to ensure that you have something that is reliable enough for the market place to step in. We have actually been working very closely with some of the folks in the private community that are interested in doing carbon trading. It is very important that we provide this basis of measurements that they can then use in the private

sector to make the private carbon trading sequestration efforts work, and work reliably.

Senator VOINOVICH. Mr. Knight, I have always been a strong supporter of the public-private partnership. I believe this is the way the Government should be run. I was interested to read in your testimony how the Department is working on sequestration with private entities such as the American Forest and Paper Association. Can you give us a little more information about these partnerships and how along are they? Have these just come about in the last month or two?

Mr. KNIGHT. Certainly the American Forest and Paper Association, Weyerhauser, and several of those have been working very closely with the Forest Service on how to build those partnerships. In the case of the Natural Resources Conservation Service, we have been working on the measurement side with a couple of the companies that are trying to put the trading mechanisms in place, either from the Chicago Exchange or others, that are looking at being able to do that. There is a real ground-swell of private sector interest in moving forward on these voluntary partnership approaches.

Senator VOINOVICH. Does that anticipate that down the road there would be some trading going on?

Mr. KNIGHT. That is certainly the expectation of that community that is working with us on the measurability and verifiability of these practices.

Senator VOINOVICH. In terms of the Department of Agriculture, I am delighted to know that this could be a two-for. I was one of those that was a little skeptical about the farm bill. We put a lot of money into this proportion of it. Do you recall the number?

Mr. KNIGHT. We have nearly an $18.5 billion increase for conservation programs alone over the life of the farm bill.

Senator VOINOVICH. The fact is that you are going to coordinate that expenditure of money with the sequestration is very encouraging.

Mr. KNIGHT. Thank you. It is also very important that while the science is still evolving, we are able to make the best and most practical decisions of how we achieve our other conservation objectives—soil erosion, water quality—while being able to find that win-win solution. That may be able to help us on greenhouse gases while the science continues to evolve and build. In that way we are not sacrificing in any way our core objectives of water and soil quality, but we are able to find these win-win solutions that have enhancements.

Senator VOINOVICH. Do you think that beyond the money that the Department of Agriculture puts into this, that there is a potential to even do more in the arena? By that, I mean, you are going to be paying farmers to get involved in these projects and to spend this money. Is there any other possibility that beyond what you are doing that, for example, if private sector people wanted to invest and encourage people in the agriculture and the forest business to do more in that area, that that is a potential?

Mr. KNIGHT. It is certainly a potential, sir. It is to make meaningful gains on carbon sequestration. Even with the resources that the Department of Agriculture has, they are modest compared with the potential that you can see as we have illustrated already.

That is one of the reasons why in the Environmental Quality Incentives Program, we clarified the rules this year that would allow a producer who is utilizing the EQIP Program, to go ahead and trade any carbon sequestration credits that may result of that investment on the open market, should those markets come about. Short of a market place development, that is going to be very important and key for the long-term ability to achieve these sorts of objectives.

Senator VOINOVICH. One of the things that I was interested in is this. You stated that the Department is involved "in the Government's activities to address climate change, including international bilateral and multilateral cooperation. Can you tell the Committee what the Department has been involved with in terms of the international arena?

I think sometimes we think about the issue of greenhouse gases and carbon as being a U.S. situation. It is a worldwide situation, and one of the concerns that many people have is that we could deal with our problem and not see any kind of corresponding activity going on in other parts of the world since we are all part of this whole situation. Could you tell me what is going on in that arena?

Mr. KNIGHT. When Mr. Connaughton testified before you a year ago, he made mention of several of the bilateral negotiations that have been going on. There are nearly 14 agreements with countries around the world that the USDA and the State Department have been involved in—India, China, and Russia, for example. We would be pleased, in follow up work, to give you a more detailed list of those endeavors that the Department has been involved in.

Senator VOINOVICH. Thank you.

Without objection, so ordered.

[The information referred to follows:]

USDA works closely with the Department of State and other technical agencies and departments to support US bilateral and multilateral climate change efforts. The United States international global climate change strategy emphasizes cooperation with key partners and promotes work with other nations to develop an efficient and coordinated response to global climate change. Over the past 2 years, the Department of State has pursued a series of 14 bilateral agreements with other countries and groups of countries. The countries include: Australia, Canada, China, seven Central American countries CONCAUSA (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama), the European Union, India, Italy, Japan, Mexico, New Zealand, Republic of Korea, South Africa, Brazil, and the Russian Federation. There is a keen interest in forest and agriculture issues related to climate change in many of these countries. The range of interests includes assessments of the potential impacts of climate change, inventories of greenhouse gas emissions and sinks from forests and agriculture, and the pursuit of mitigation opportunities.

Specifically the Department of State requested assistance from USDA in coordinating potential forestry and agriculture activities and projects in response to requests from these countries. USDA has provided inventories of current activities, explored proposals to initiate new cooperative work, and served on State Department delegation that met with representatives of other governments.

USDA also supports the Department of State in multilateral efforts. USDA representatives have served on State Department led delegations to international scientific and policy meetings, including ongoing negotiations under the Framework Convention on Climate Change (UNFCCC) and scientific meetings of the Intergovernmental Panel on Climate Change (IPCC).

Senator VOINOVICH. Senator Carper, do you have an opening statement?

**OPENING STATEMENT OF HON. THOMAS R. CARPER, U.S. SENATOR FROM THE STATE OF DELAWARE**

Senator CARPER. Thank you, Mr. Chairman. I am pleased to be with you, and I am pleased that you are with us.

Mr. Knight, welcome. It is good to see you. I apologize for being a little bit late.

I have a statement here. I think this hearing is a revival to all of us. I have not been able to read your testimony, Mr. Knight, but I will see a summary of it. I look forward to reading that.

In the legislation that Senators Gregg, Chafee, and I have introduced, we anticipate reductions in $CO_2$ over the next dozen years. In doing that, we permit utility plants to invest in technology to reduce $CO_2$ emissions. If they choose to change their mix of fuels, they could do that. We also enable the emitter to underwrite the costs of reforestation, the changes in planting patterns, and even changes out of feedlot operations, in order to address the issues of increasing greenhouse gases.

Could you just talk with me a little bit today about how such a system would work? You have the emitter on the one hand who needs the credit for the emission reductions. They choose not to change the fuel mix. They choose not to invest in technology. They say they are going to go a third way.

I think I am pretty clear on reforestation. Talk with me a little bit about planting patterns and how this might help us in this battle. Talk with me a little bit about feedlot operations. Talk about any others that I am not aware of.

Mr. KNIGHT. At the Department we have continued to work on this issue. You are seeing quite an evolution of mindset on what you can do. I will just give a couple of examples. This is as much from my own experience as a farmer as it is from the experience from the Department.

I have no-till on my operation, which means that I have replaced what used to be three or four tillage passes with one-plant/one-pass at planting. This means a lot less soil disturbance. I have removed the summer fallow that I used to have in the operation where we would let it rest for a year to save moisture.

All of those tillage practices churn up the soil, mixes the stubble and the aftermath into the soil, and speeds up decomposition. Instead that is sitting on top of the soil building organic matter. It is improving the overall level of organic matter in that soil. That means that we have dramatically boosted the overall amount of carbon that is sequestered on those soils.

I will give you an example from the livestock side. There are two ways to control greenhouse gas emissions on livestock. One are things like the methane digesters, where we capture the methane that may be given off by the manure, and are able to run that through a generation facility of some sort, burn that off, create electricity, and convert that into hopefully a better and more stable gas. Or, you do avoidance. You can do avoidance by how you either manage the manure, or in what you feed the critter at the front end and have a better match of their nutritional needs.

Each of those are methods that we can do to either avoid greenhouse gases, or control them from being emitted.

Senator CARPER. The animal operations with respect to methane, is that something that is being talked about or is it something that is actually being done on a widespread basis?

Mr. KNIGHT. We are working very aggressively on that. We put several standard changes in place this year in one of our most important programs, EQIP, in order to ensure that we could do cost-share and assistance with farmers and ranchers that are wanting to put methane digesters in place. So, yes, we are doing that very rapidly.

Senator CARPER. In addition to reforestation, the kind of no-till approach you have described, and the animal lot operations, what other opportunities are there out there that maybe I am not mindful of?

Mr. KNIGHT. The other side of the work that the Department of Agriculture is doing a great deal of effort on is how to ensure that we have a registry established between the Department of Agriculture, DOE, and EPA. Once we have these efforts underway, the question is how do you measure them, how do you make sure that they are repeatable and verifiable, and able to register them. The market place can then help those utilities trade that particular credit that may result from the activities that a farmer is doing and the activities that the utility may want to be able to offset.

The final component that you see folks already starting to work on, and is going to be very important, is that the utilities tend to not want to work with 500 farmers out there. What is needed is an aggregator that actually combines the interests and efforts of 400 or 500 farmers across the geographic area, puts that together, pools that, and then transfers that pooled collective action to something that a utility or some other purchaser of those credits may be interested in buying.

Senator CARPER. If I understood you correctly, you are talking about a registry? I would call it almost an entity to certify the value of the amount of sequestration or reduction of $CO_2$. There has to be some entity there.

I had not thought about the aggregator before we talked about the registry. I am sure that others, like Jim Reilly sitting right behind me, have thought about the aggregation. If I were an utility, I would not want to deal with 500 or 5,000 farmers if I could deal with just one entity.

I was just thinking, Mr. Chairman, we have farmers in Ohio and Delaware and a lot of other places where they are badly strapped financially these days. Commodity prices are not what they need in order to make much of a living. In order to be able to come up with ways for farmers to sustain themselves economically, one of the ways they can do it is to encourage the use of more bio-fuels, whether it is bio-diesel or ethanol. That will enable the farmers to supplement their incomes as well through a market system instead of a system that some would describe as welfare payments to our farmers.

Let me ask another question of you, if I could, Mr. Knight. Do you believe that it would be prudent to reduce our net emissions of greenhouse gases given what we have heard from the National Academy and other world scientists? If you think it might be prudent, would you explain why?

Mr. KNIGHT. Sir, I tend to be a pragmatist on these things. There is a clear opportunity in managing this Agency for us to be able to find these win-win solutions of the work that we are doing on conservation, on water quality, on soil conservation, and to be able to have a reduction in greenhouse gases as a result of carbon sequestration from that aspect.

While I continue to see a vast array of scientific debate about how far to go and how rapidly to go, I see for the Agency an opportunity while that debate swirls, for us to manage our way through it in a manner that just continues moving ahead on those things and finding that win-win solution. We are going ahead with those opportunities of being able to do that while that larger debate swirls.

Senator CARPER. It is going to swirl for a while.

What do you think some of the risks are to American agriculture of increasing greenhouse gas emissions and global climate change?

Mr. KNIGHT. One of the more intriguing scientific efforts that the Department is pursuing is what the potential impacts of greenhouse gases are on the pest community. We have to look not only what the greenhouse gas emissions do conceivably to the production of corn, soybeans, cotton, or rice, but also what do those greenhouse gas emissions do to the weeds that are in that field. Does that put a particular weed at a greater advantage compared with those crops in competing for the limitations of soil, water, air, and sunlight?

You have the same sort of things with the insect community if you have changes in temperatures, growing degree days, all of those sorts of things. There is a large amount of research that has to be done in that arena as well as we move forward on looking to manage through this very difficult issue.

Senator CARPER. Can you talk with us a little bit about weather patterns and how that may have some impact on agriculture?

Mr. KNIGHT. I may have to beg off and have us follow up with you on that one. Weather patterns are a little beyond my comfort level to discuss.

Senator CARPER. All right.

Senator VOINOVICH. Without objection, so ordered.

[The information referred to follows:]

Recent studies have examined the potential implications of climate change for U.S. agriculture. Most studies indicate that, for a range of potential climate changes and atmospheric $CO_2$ levels, crop production in the United States during the 21st century will not be imperiled. Under some scenarios, productivity of many major crops increased at a national level. However, not all agricultural regions of the United States are projected to be affected to the same degree or in the same direction by the climates simulated in the various scenarios. In general, the Midwest (especially the northern half), West, and Pacific Northwest exhibit large gains in yields for most crops while the South and Southern Plains exhibit losses in yields.

However, the multifaceted impacts of climate change defy a simple characterization. The results for one crop or one region may be opposite the results for another crop or another region. Further, the details of climate change and its impacts on agriculture remain hard to predict with confidence given the existing state of the science, but the results of this study offer some detailed estimates as a first step toward thinking about how U.S. agriculture can better prepare for the climate changes it may face in the future.

As noted by the National Research Council, in response to questions from the Administration on the state of climate change science "one of the weakest links in our knowledge is the connection between global and regional predictions of climate change." The National Research Council's response to the President's request for a

review of climate change policy specifically noted that fundamental scientific questions remain regarding the specifics of regional and local projections (NRC 2001). Predicting the potential impacts of climate change is compounded by a lack of understanding of the sensitivity of many environmental systems and resources—both managed and unmanaged—to climate change.

Senator CARPER. Mr. Chairman, I have one more question, if you do not mind.

Senator VOINOVICH. Go ahead.

Senator CARPER. I read your biographical information. Do you grow corn on your farm? What do you grow on your farm?

Mr. KNIGHT. I have corn, wheat, sunflowers some years, soybeans, alfalfa, and a cow-calf operation.

Senator CARPER. I am a proponent of bio-diesels. In Delaware we use a mixture of 20 percent soy oil and 80 percent diesel. As I understand from the perspective of corn growers and their position on ethanol, and that of bio-diesel proponents, these non-petroleum products have several beneficial effects, including reducing greenhouse gas emissions.

What is the Department, to your knowledge, to treat greenhouse gas emissions in its own operations and reducing its petroleum consumption? I think there are two goals identified in an Executive Order. One of them deals with greenhouse gas reduction goals and the other relates to petroleum.

Please comment on what the Department itself is doing.

Mr. KNIGHT. I will make mention of a couple of things. I will have staff follow up with you and provide you that for the record.

Senator CARPER. Thank you.

Senator VOINOVICH. Without objection, so ordered.

[The information referred to follows:]

USDA's Energy and Environment program strives to improve the "greening" of USDA's facilities, fleets, and operations nationwide by implementing pertinent energy legislation and "Greening the Government" Executive Orders. The program focuses on increasing energy efficiency and use of renewable energy sources at USDA facilities; use of alternative fuels in Agency fleets; acquisition of environmentally preferable, biobased, and recycled content products; and recycling and waste prevention activities.

The Department has developed an Energy Implementation Plan focused on specific action areas targeted to achieve the 30 percent energy consumption goal for fiscal year 2005. The Forest Service, Agricultural Research Service, and Office of Operations each developed agency specific plans that are part of the overall plan. More information is available at: http://www.usda.gov/energyandenvironment/index.html

Mr. KNIGHT. There is a good study recently completed that talks about the net energy balance of bio-fuels—ethanol and bio-diesel—as it pertains to greenhouse gas emissions. It shows there is a very positive balance there. That supplements work a couple of years old that Argonne National Laboratories had conducted that was very positive.

We are continuing to move forward in the implementation of the farm bill on each of those sections including the acquisition of renewable products and the acquisition there. That has turned to be a fairly problematic provision to implement because of the way that it was constructed. We are continuing to move forward very quickly on that. I will include in that follow up work the time line we are on there.

There is, however, the continued efforts that each of the Agencies do as it pertains to new vehicle acquisitions and those sorts of things. I believe last year, in the case of the Natural Resources

Conservation Service, nearly 90 percent of our vehicle acquisitions last year fell into the flexible fuel category, which meant that they, in turn, could operate on a traditional blend of gasoline, a 10 percent ethanol blend, or even as high as an 85 percent ethanol blend.

Each of the Agencies have tried to meet those objectives in a variety of ways. Certainly the vehicle acquisitions have been an important component of that endeavor.

Senator CARPER. All right. Mr. Knight, thank you for being here today. I look forward to some follow from you. We appreciate your presence, your testimony, and your stewardship.

Mr. KNIGHT. Thank you.

Senator VOINOVICH. Thank you very much. It was very good testimony. It was very good hands-on. You really understand it. Thanks for being here today. We look forward to working with you.

Mr. KNIGHT. Thank you.

Senator VOINOVICH. We are very fortunate to have our next panel, which includes Robert Stallman, President, American Farm Bureau Federation; Dr. Rattan Lal, Director, Carbon Management and Sequestration Center, the Ohio State University. Dr. Lal has testified before this Committee a couple of times during the last several years. I was fortunate to have a presentation made by Dr. Lal when I was there at the Ohio State University a couple of weeks ago. We were talking about sequestration and what they are doing on that in conjunction with the Battelle Institute.

We also have Joseph Bast, President, the Heartland Institute. Mr. Bast, I am sure you will tell us a little bit about the Heartland Institute. It sounds healthy.

We have Debbie Reed, Legislative Director, National Environmental Trust; and Dr. Cynthia Rosenzweig, Research Scientist, Goddard Institute for Space Studies. We will get that perspective on things.

Without further words, we will call on Mr. Stallman from the American Farm Bureau. I would like to say, Mr. Stallman, that I have an excellent relationship with the Farm Bureau in the State of Ohio. They have been my good friends. We have worked together since the days when I was Governor. They provide me with an enormous amount of input whenever I need it, and sometimes when I do not need it. They are doing a good job. We are glad to have you here.

## STATEMENT OF ROBERT STALLMAN, PRESIDENT, AMERICAN FARM BUREAU FEDERATION

Mr. STALLMAN. I am glad to hear that they are doing a good job, Mr. Chairman.

Mr. Chairman, and members of the Subcommittee, I am Bob Stallman, President, of the American Farm Bureau Federation, and a rice and cattle producer from Columbus, Texas. On behalf of the 5.3 million members of the American Farm Bureau, I am pleased to be speaking to you today on agriculture's role in sequestering carbon in our Nation's soil.

Carbon is the key building block for all things living. For those of us in agriculture, we have learned through years of research and practical experience that soil carbon is essential for optimizing the

production of food and fiber, as well as improving the profitability of farming and ranching.

The USDA's Agricultural Research Service estimates that 20 million metric tons of carbon are currently sequestered each year in U.S. farm and grazing land soils. Many producers have made a decision on an economic basis to employ conservation tillage practices such as minimum till, no-till, and cover crop regimens in their operations. With more producers changing farm management practices, USDA and State Department personnel estimate that an additional 180 million metric tons annually could be stored in farm and range land acres.

Carbon and its role in the climate change issue has been the subject of recent debate and will continue to be. We are not here today to discuss the merits or demerits of the theory of the climate change issue. With regard to carbon sequestration, our message is that agriculture can play a vital role.

In 2001, President Bush announced the development of a comprehensive strategy to reduce greenhouse gas intensity in the United States by 18 percent by 2012. A vital component of the strategy is to encourage increased sequestration of carbon in forest and range lands.

In February of this year, the President announced the Climate VISION Program. A voluntary public-private partnership, the primary goal of the program is to pursue cost-effective initiatives that will reduce the projected growth in American's greenhouse gas emissions. AFBF has begun discussions with the Administration to see what role the agricultural sector can play in the President's Climate VISION Program.

Chief Knight did a good job of describing the new rules with respect to considering a greenhouse gas management practices in evaluating conservation programs. We view that as a very positive development. I will not repeat those comments.

America's farm and ranch community has long supported and responded to voluntary incentive based programs, as evidenced by the waiting list to participate in the many conservation programs. Time and time again, when an environmental challenge has presented itself, American agriculture has answered the call.

I would be remiss if I did not reiterate our opposition to any mandatory measures pertaining to climate change and carbon sequestration, but rather the need to maintain a voluntary approach to agricultural sequestration.

While a mandatory cap and trade may increase the value of the carbon being sequestered, an analysis by Sparks Companies re-released last month, concludes that the increased energy cost to the agricultural sector associated with any Kyoto-like mandatory program would more than offset any cash value in the sequestration of carbon by farmers and ranchers on a per-acre basis.

Agriculture has in the past, and will in the future, respond if the appropriate voluntary incentive-based tools are employed. Some of the needed tools like EQIP and CRP already exist. Private entities are also developing and piloting other tools such as voluntary carbon trading systems.

In one case the Iowa Farm Bureau and Kansas Farm Bureau are involved. They are disseminating information to farmers and

ranchers and helping to put land owners together with the carbon trading exchanges in an effort to trade carbon under free market rules. AFBF supports the development of a practical, voluntary carbon trading system and the development of trading criteria standards and guidelines.

While the potential for agricultural carbon sequestration exists, many challenges do remain. One area that must be addressed is the development of methods and procedures to credit farmers and ranchers who have already employed conservation tillage practices and their operations.

Other challenges include the refinement of carbon trading guidelines, the establishment of accurate crediting and values for sequestered carbon, and the development of other cost-effective incentives to further advance carbon sequestration in agricultural soils.

None of these challenges is insurmountable. AFBF looks forward to working with the USDA, the Department of Energy, the EPA, Congress, and many others within the private sector to find solutions and move forward with this endeavor.

There is no doubt that agriculture can and will play an expanded role in sequestering carbon American's farmlands. We strongly support President's Bush voluntary approach to climate change issues and his call for the public and private sectors to work together to increase the sequestration of carbon on America's farm and range land.

The American Farm Bureau appreciates this opportunity to come before you today to share our view on agriculture's role in sequestering carbon. I look forward to answering any questions you may have later. I would ask that my written statement be placed in the record in its entirety. Thank you.

Senator VOINOVICH. Without objection, so ordered. Thank you very much, Mr. Stallman.

Dr. Lal?

**STATEMENT OF RATTAN LAL, DIRECTOR, CARBON MANAGEMENT AND SEQUESTRATION CENTER, THE OHIO STATE UNIVERSITY**

Mr. LAL. Thank you, Mr. Chairman, and members of the Committee.

I greatly appreciate the opportunity to address this Committee today. I am Rattan Lal, Professor of Soil Science and Director of the Carbon Management and Sequestration Center at the Ohio State University.

At the very outset, I acknowledge the very strong cooperation. We have a seed from the USDA, especially the NRCS. I would also like to point out that OSU is a member of the CASMGS initiative, which is indeed a very important undertaking to enhance carbon soil sequestration.

The question of an increase in the atmospheric concentration of $CO_2$ since the 1850's can partly be addressed by: (a) reducing emissions, and (b) sequestering emissions. Strategies for emission reductions include enhancing energy production and user efficiency, and using renewable bio-fuels.

Emission sequestration, on the other hand, involves natural and engineering options. Important natural options include carbon se-

questration in soils, vegetation, and wetlands. Some bio-fuel options are to switch grass, fast growing trees, and enhanced carbon sequestration.

The weather carbon sequestration in soil and vegetation is called terrestrial sequestration, which I am going to address today.

Aside from reducing the carbon dioxide concentration in the atmosphere, the terrestrial carbon sequestration has numerous benefits. Some of them were pointed out by Chief Knight, including for example, erosion and sedimentation control, water quality improvement, and increase in soil diversity. Over and above these environmental benefits, there is also a definite improvement in soil quality and crop productivity.

In contrast to geologic and oceanic sequestration which may be expensive and perhaps have some unknown ecological impacts, the terrestrial carbon sequestration is the most cost effective option to date.

An ecosystem with the capacity to absorb carbon dioxide from the atmosphere are called carbon sinks. Ocean and land are the two natural carbon sinks, which are presently absorbing about 4.7 billion tons of the total human-induced emissions of 8 billion tons, which is about 60 percent of the total global emissions.

Therefore, it is prudent to identify and enhance the carbon storage capacity of the natural sinks, such as soil and vegetation. It is in this context that agriculture, as Mr. Stallman has already pointed out, indeed has a very important and positive role to play in enhancing the capacity of the natural sinks.

I might state that all the potential for the carbon sequestration in soil is about one million tons per day which is about 360 million metric tons of carbon equivalent per year. In addition to that, the forest biomass carbon capacity is 250 million tons. Therefore, the total terrestrial sink capacity of forest and vegetation soils is 610 million tons, of which 220 million tons are being absorbed today. Out of the 220 million tons, only 20 million tons are being absorbed in the soil sinks.

This 610 million ton capacity contrasts with the 1,890 million tons of carbon equivalent emitted by the Nation ever year. Out of that, 140 million tons is from agriculture. Therefore, the terrestrial sink capacity of 600 million tons potential is about one-third of the total national emissions, which is a very large amount indeed.

Let us now look at the global picture comparing what was just pointed out. The soil carbon sink capacity on the world scale is about one billion tons a year, of which control has the capacity of about a half-billion tons. Now, one billion tons contrasts with about a three billion ton increase in the atmospheric $CO_2$ every year. That is one-third of the total annual increase.

This potential, which is very large indeed, is possible through the Conservation Reserve Program. We indeed have one million hectares, 2.5 million acres, of unrestored strip mine land, which has a tremendous potential. The rate of carbon sequestration in soil in the United States ranges from a low of about 100 pounds per acre per year in a very dry climate, to perhaps as much as 1,000 pounds per acre per year in humid and cold climates. There is tremendous potential.

I would like to make four points here which I think are very important. No. 1, the Conservation Reserve Program that Chief Knight has pointed out already, has been extremely successful. We have almost 14 million acres of land which is in a set-aside Conservation Research Program. The sediment load in the U.S. rivers, because of this conservation activity and other activities, has been reduced by 50 percent. It is a global success story which the farm ranches and the farm lands can also duplicate with carbon sequestration.

The second point is promoting natural soil carbon sequestration and biomass carbon sequestration buys us time and relieves pressure in the industry to put a cap on the emissions.

No. 3, the world soil has the potential of one billion tons over a 50 to 60 year period of the soil carbon sequestration. This potential has a very important implication in developing countries, especially the tropics. The Amazon Forest, which will have a pressure of reducing deforestation at a rate of nine to ten million hectares a year, that pressure can be relieved because we can produce more from the existing land to an adoption of conservation programs. Indeed, soil carbon sequestration is a land-saving option. We save the forestation to that.

No. 4, the world soil has lost 60 to 80 billion tons of carbon. The U.S. soils have lost three to five billion tons of carbon. While we sequester that carbon, with or without climate change, the important thing is that we ensure global security by doing that. Therefore, climate change is not the only reason for soil carbon sequestration.

Mr. Chairman, I thank you for the opportunity given to me in offering this testimony. I would be very glad to answer any questions that you may have. I would ask that my written statement be placed in the record in its entirety. Thank you.

Senator VOINOVICH. Without objection, so ordered. Thank you very much, Dr. Lal.

Mr. Bast?

**STATEMENT OF JOSEPH BAST, PRESIDENT, THE HEARTLAND INSTITUTE**

Mr. BAST. Thank you, Mr. Chairman, for inviting me to be here. Senator Carper, thank you for attending.

The Heartland Institute, my organization, is a 19-year-old nonprofit research organization based in Chicago. The "heart" in Heartland is a geographical reference and not to the body's organ. It is a mistake often made.

Senator VOINOVICH. Our State motto is, "Ohio is the heart of it all."

[Laughter.]

Mr. BAST. I think Kansas would disagree.

[Laughter.}

Mr. BAST. This is a joint research project by economists at the Heartland Institute, the Hudson Institute, and the American Farm Bureau Federation. The opinions I am about to express are my own and those of my coauthors.

Carbon sequestration certainly appears at a distance to be an attractive alternative to mandating reductions in greenhouse gas

emissions, especially since many experts believe that forcing utilities and other significant emitters to reduce their emissions would be very costly and would produce very few offsetting benefits.

Upon closer inspection, carbon sequestration in agriculture faces some daunting problems of its own. I would like to comment on four such problems.

First, paying farmers and livestock producers to sequester carbon would lead to heavy-handed and potentially ruinous regulation of farms and ranches. Farmers can indeed help store carbon in their crops and in their soil, but farming, especially dairy farming and cattle ranches, are also a significant source of greenhouse gases.

According to the EPA in 2001, agricultural soil sequestered on net only 15.2 million tons of carbon dioxide equivalent, whereas agriculture as an industry released 526 million metric tons of carbon dioxide equivalent, 35 times as much. If you want to be paid to store carbon, you had better expect to be charged for admitting carbon as well. Farmers are going to be very vulnerable to any proposal to regulate their emissions.

Second, endorsing sequestration may mean endorsing cap-and-trade programs which, in turn, mean higher energy costs. Without a Government-imposed cap on greenhouse gas emissions, few emitters would need to buy the emission permits that farmers would earn by sequestering more carbon. But a cap-and-trade program would have the same effect as higher energy taxes. Such a tax would have to be the equivalent of at least 50 cents a gallon of gasoline or more in order to reduce emissions enough to make a difference.

Higher energy prices, in turn, would dramatically reduce profits in the U.S. agricultural sector. Research that I conducted in 1998 with the American Farm Bureau estimated that a 50 cent per gallon tax on gasoline would reduce net profits for dairy farmers as much as 84 percent, and typically 50 percent if gasoline taxes are raised by 50 cents per gallon.

Total annual U.S. farm production expenses would increase by $20 billion. Since it is difficult for farmers to pass cost increases along to consumers, a cap-and-trade greenhouse gas program would cause a 48 percent decrease in net farm income. Following what Mr. Stallman said, the net impact on farmers of higher energy costs, which is part-and-parcel of proposals to reward farmers for sequestrating carbon, would be extremely negative.

Third, environmentalists would be disappointed as well. Even if a carbon sequestration program benefited farmers, it would do very little to moderate greenhouse gas emissions. Agricultural soils in the U.S. today capture only 1/20th of 1 percent of the total annual U.S. greenhouse gas emissions. This is according to EPA's latest assessment of greenhouse emissions and sinks for 1990–2001.

Once saturation levels are reached, there would be no more gains on cropland with known farming systems, which means sequestration is not a long-term tool for reducing greenhouse gas emissions.

Finally, my fourth point is that emissions trading is more problematic than its advocates admit. In thirty seconds I cannot describe all of those problems, but I should say that current programs for trading sulfur dioxide, for example, are not as robust and not as successful as many of their advocates would claim. They are

characterized by very thin markets. Over 80 percent of trades in sulfur dioxide, for example, are trades within companies, not between companies. Government overregulation kills innovation.

There are examples in California where innovative programs to remove carbon have been killed by the emissions trading program under RECLAIM. Changing rules leave investors high-and-dry, making a very risky sort of endeavor. There are verification problems and problems with Government changing the rules halfway through. As a result, farmers, especially, should be very wary about making investments in emissions trading.

I conclude that carbon sequestration by farmers and ranchers in the United States may be a good thing for the farmers, and may be a good thing for the soil. Ultimately, though, it is a false hope for those seeking to be paid to do what they would do anyway. It is a false dream for environmentalists who see it as a major part of the solution to global warming. It is a poor strategy for an industry that should know better than to join a movement composed of groups and individuals who have been among its most strident critics.

Thank you very much for allowing me to testify today. I would ask that my written statement be placed in the record in its entirety. Thank you.

Senator VOINOVICH. Without objection, so ordered. Thank you very much, Mr. Bast.

Ms. Reed?

**STATEMENT OF DEBBIE REED, LEGISLATIVE DIRECTOR, NATIONAL ENVIRONMENTAL TRUST**

Ms. REED. Chairman Voinovich and Senator Carper, I am Debbie Reed. I am the Global Warming Campaign Director and Legislative Director at the national Environmental Trust. We are a nonprofit organization located in Washington, DC.

I am pleased to have the opportunity to talk with you today about what I think is perhaps the greatest environmental issue confronting the world today, and that is global climate change.

U.S. agriculture can make important cost-effective contributions to offset a portion of U.S. emissions of greenhouse gases in the near and medium-term. But it is not a panacea, nor is it a solution. Agriculture can provide a bridge to a less fossil-carbon intensive future while improving the sustainability, environmental quality, and profitability of a vital U.S. economic sector.

Global warming is occurring. Evidence continues to accumulate that human activities and man-made greenhouse gases contribute to global climate change. Just last week the World Meteorological Organization issued an unprecedented alert indicating that record extremes in weather and climate events were continuing to occur around the world.

The organization documented recent extreme weather events in several countries, including the United States. To prevent dangerous consequences from climate change, we must reduce our reliance on the burning of fossil energy sources. Mandatory credible policies to reduce greenhouse gases and emissions are needed, but will take time to implement.

We should pursue with vigorous strategies, such as agricultural sequestration, to help offset greenhouse gas emissions in the interim. Global warming is a threat to agriculture. U.S. agriculture is a major industry. Farming contributed $80.6 billion, or .8 percent to the national gross domestic product in 2001. However, the threat of global warming and potentially severe weather events jeopardize the very livelihood of farmers in rural communities, as well as the ability of agriculture to continue to fuel U.S. prosperity.

Catastrophic storm events, flooding, or drought can overwhelm not just individual farmers, but entire communities and regions. Agriculture and forestry do represent a net sink in the U.S., and helped to offset just over 7 percent of U.S. emissions in 1999. Policies to promote more widespread adoption of proven management practices to enhance this sink effect can boost this potential above current business-as-usual levels.

Agricultural soils alone were about .6 percent of the total net sink in 1999 but scientists estimate that soils have the capacity to offset an additional 10 percent of U.S. emissions. Changes in tillage practices can result in net sequestration of $CO_2$, reduce fossil fuel use, reduce nitrous oxide emissions from soils and fertilizers, improve water quality, and increase wildlife habitat.

Simply put, soil carbon enhances agricultural sustainability. Fortunately, soil carbon is a component of soil that can be changed by management practices. Soil scientists estimate the potential for U.S. agricultural soils to sequester additional carbon at 187 million metric tons of carbon per year, or fully 10 percent of U.S. annual emissions.

This capacity represents the upper potential for soils and will only occur if all croplands were immediately managed to maximize carbon intake. Carbon uptake could go on for a period of decades, but a saturation level would be reached. Agriculture can act as a Band–Aid, but it will not prevent climate change.

Farmers experiences with no-till have confirmed the research. Some compelling stories from farmers who have converted to conservation tillage and no-till farming perhaps best provide a picture of the many benefits to society and farmers of this management practice. At a recent briefing on global warming and soil carbon sequestration, Elmon Richards of the Richards Farms in Circleville, Ohio, shared his experiences.

Beginning in the 1970's, the Richards Farms began planting their 3,500 acres of corn and soybeans without tilling the soil. Among the benefits of no-till farming documented by the Richards Farms, are the need for fewer, smaller tractors, the need for fewer passes over their fields, reduced fuel use, reduced labor costs, and more free time.

Specifically, the tractors the Richards use for conventional tillage consumed an average of three to four gallons of fuel per acre. No-till, with its reduced passes, consumes an average of .3 or .4 gallons of fuel per acre, or one-tenth the fuel use per acre.

If we were to apply the Richards' figures on a national scale, we could begin to appreciate the potential impacts of just one aspect of this agricultural management change. If all farmers in the U.S. were to convert to no-till, the savings in fuel use could be as much as 744 million gallons of fuel annually. Since each gallon of fuel

burn represents 6.1 pounds of carbon released to the atmosphere, this would reduce carbon emissions by approximately 2.1 million metric tons of carbon annually, which does not even account for the carbon which is also sequestered in the soil.

Evidence from other farmers who have converted to no-till is just as compelling, showing, for instance, higher yields and thus, higher profits during drought years compared with their neighbors who are conventionally tilling, increased soil carbon content, significantly improved water infiltration and water holding capacity of the soils, reduced nitrogen fertilizer applications by up to 50 percent, which reduces the leaching of nitrogen in runoff, and reduced phosphorus runoff.

In conclusion, credible policies to reduce net U.S. greenhouse gas emissions are needed to prevent the potential economic, social, and environmental consequences of unmitigated climate change. The agricultural sector is particularly vulnerable to global climate change and severe weather events, but with the right mix of policies and incentives to enhance its sink effect, agriculture can also help to mitigate the greenhouse effect by reducing U.S. greenhouse gas emissions.

The enhanced sink effect of agriculture can be a win-win solution for this sector, for farmers, for society, and the environment, but it is not a panacea for greater action. Rather, it can be a useful and cost-effective bridge as we transition to a less fossil carbon intensive future.

Thank you. I can answer any questions you might have. I would ask that my written statement be placed in the record in its entirety. Thank you.

Senator VOINOVICH. Without objection, so ordered. Thank you very much, Ms. Reed.

Dr. Rosenzweig?

**STATEMENT OF CYNTHIA ROSENZWEIG, RESEARCH SCIENTIST, GODDARD INSTITUTE FOR SPACE STUDIES, COLUMBIA UNIVERSITY**

Ms. ROSENZWEIG. Mr. Chairman and Senator Carper, I am Cynthia Rosenzweig, a research scientist from the Goddard Institute for Space Studies at Columbia University.

After nearly two decades of research on potential impacts of climate change on agriculture, attention is now turning to mitigation and adaptation responses. Mitigation actions, such as carbon sequestration in agricultural soils, are aimed at reducing the atmospheric concentration of $CO_2$ and other greenhouse gases, thereby countering climatic change.

Adaptation actions, such as changes in crop types and management practices, are responses that optimize production under changing climate conditions. Here, I analyzed these response actions and suggest that it is both useful and necessary for them to be considered jointly.

A review of a combination of approaches, including field experiments, regression analyses, and modeling studies leads to the following conclusions regarding how a changing climate may influence agriculture, and how mitigation and adaptation responses may interact.

First, agricultural regions will experience change over time under a changing climate. Some regions will experience increases in production and some declines due to the presence of minimum and maximum thresholds for crop growth. Adaptation, such as adjustments in planting dates, crop types, and irrigation regimes will likely be required. Geographic shifts in crop growing areas are likely to occur with associated changes in production systems.

Although climate influence changes in agriculture are likely in the coming decades, the magnitudes and rates of these changes are uncertain at the regional scale.

Despite these general uncertainties, agricultural production in developing countries is more vulnerable. Studies have consistently shown that overall production in mid and high latitudes is likely to benefit in the near term, approximately to mid-century, with increasing $CO_2$ and warming, while production systems in the low latitudes are likely to decline. This finding has implications for world food security since most developing countries are located in lower latitude regions.

Third, long-term effects on all agricultural regions are negative. If climate change effects are not abated, agricultural production in the mid and high latitudes, even here in the United States, is likely to decline in the long term. This is a long-term problem for the end of this century. These results are due primarily to the detrimental effects of heat and water stress on crop growth as temperatures rise. Increased climate variability, such as droughts and floods, under climate change, is also likely to negatively affect agriculture.

I turn now to solutions and responses to climate change. A changing climate will affect mitigation potential. Responses to a changing climate will contribute to determining which mitigation techniques are successful and at what levels over the coming decades. Because some carbon sequestration projects have long durations on the order of 40 to 50 years in temperate regions—farmers may need to consider which sequestration techniques have the better chance to succeed under changing climate regimens.

If changing climate is not taken into consideration, calculations of carbon, in terms of how much carbon can be sequestered, may be in error.

It is important to know that mitigation and adaptation responses are synergistic. Mitigation practices can also enhance the adaptation of agricultural systems. For example, carbon sequestration in agricultural soils lead to more stable soil-water dynamics, enhancing the ability of crops to withstand droughts and flood, both of which may increase under changing climate conditions.

Finally, a new way to look at the issue of mitigation and carbon sequestration in agriculture is to consider that mitigation practices may help to make the U.S. sector carbon neutral. The combination of management techniques, reduced no-till, modified irrigation and fertilization application has the potential to sequester, by our calculations, about 50 million tons of carbon yearly. These approximately match greenhouse gas emissions from the U.S. agricultural sector.

However, we need to recall the caveat that the capacity for agricultural soil carbon sequestration is constrained by the amount of

carbon previously lost during conversion for agriculture so that its effectiveness as a mitigating activity for climate change is not unlimited. In this way, the U.S. agricultural sector could take the lead as a key sector in our Nation to address the significant issue of climate change.

In conclusion, our research suggests that planning and implementation of mitigation and adaptation measures in response to the global climate change issue should be coordinated, and proceed hand-in-hand. Investments in programs and research will be needed to assure effectiveness in both adaptation and mitigation activities for U.S. agriculture.

Thank you. I would ask that my written statement be placed in the record in its entirety. Thank you.

Senator VOINOVICH. Without objection, so ordered. Thank you very much, Dr. Rosenzweig.

This has been very interesting testimony. Obviously there have been different perspectives presented on carbon sequestration in terms of its effectiveness and maybe it is not as effective as we think it would be.

What I would like to do with my portion of the questioning is to allow each one of you to have an opportunity to comment for the record on what someone else has said.

Dr. Lal?

Mr. LAL. Maybe I can begin with my colleague, Mr. Bast. He gave some numbers which obviously are different than my numbers. As a professor, I have a habit of finding out where the mistake is when two students give different numbers.

He is giving carbon emission numbers as carbon dioxide gas equivalent, $CO_2$, and he is giving carbon sequestration numbers as carbon equivalent. For example, the EPA report which he quoted, talks about 6,952 million metric tons of carbon dioxide equivalent as total emissions annually.

If you can work that to carbon equivalent where all the sequestration data is, that is approximately one-fourth of the total number. So, 6,952 million metric tons of carbon dioxide converts to 1,892 million metric tons of carbon.

His quotation on carbon sequestration in soil of 15 million metric tons is almost right. It is about 20. But his conversion that it was one-fiftieth of that, he was taking $CO_2$. That is the discrepancy and I would like to correct that.

Mr. BAST. May I respond to that?

Senator VOINOVICH. Mr. Bast?

Mr. BAST. I thought this might become an issue of some contention so I brought with me EPA's report on greenhouse gas emissions and sinks. The table here in carbon dioxide equivalents—not carbon, but carbon dioxide equivalents—is net sequestration from agriculture of 15.2 million metric tons, only 15.2.

Total emissions from agriculture, according to the same report, was 526 million metric tons carbon dioxide equivalent. This is an apples-to-apples comparison, and not apples-to-oranges. The total emissions from agriculture, including methane, are 35 times what is currently net being sequestered on agricultural soil.

Where I do not disagree with my distinguished colleague here is in the area of forestry and perhaps overall sequestration. I think

there are tremendous opportunities in forestry to sequester more carbon, but I would worry if we subsidize tree planting that what we do is reduce U.S. agricultural production, and encourage Third World countries to clear forests in order to create more food. So you get what economists call a leakage effect, where for every acre you reforest cropland or grazing land in the United States, you might end up with two acres, or even five acres, being cleared for low productivity agricultural growth in a Third World country. I do not know that that would be an effective alternative, either.

Senator VOINOVICH. Any other comments?

Mr. Stallman?

Mr. STALLMAN. I would just have a little clarification. This is not "Pick on Joe Bast Day." But the Heartland study that he referenced, we did participate in. I think many of the comments that Mr. Bast made with respect to mandatory cap-and-trade systems, we would agree with. We do not think that is a good route to go.

However, we do support the voluntary system and the incentives as proposed under the President's plan for agriculture to play a greater role in carbon sequestration. I think we can do that.

The larger questions of how long can that role last before you are saturated, and what net benefit that would be long term, that goes beyond the scope of where we are right now. We are looking at what can we do in the short-term, in terms of a voluntary incentive-based plan to help with the issue of carbon sequestration.

Senator VOINOVICH. Any other comments?

I thought that would be a little more lively.

[Laughter.]

Senator VOINOVICH. The thing that strikes me is that whatever we do here, we have to take into consideration what is happening over there. In other words, this is a world problem that we have. We are really focusing in on just what contribution we are making here in the United States to the solution to it.

Would anyone like to comment on that?

Mr. Bast?

Mr. BAST. I perhaps already have, but I absolutely agree with you. I think we need to be looking at this as a world problem and at net and life cycle emissions rather than short-term sorts of projects. It is very easy for an utility, or for a manufacturer, or for a farmer to be able to point to a project that reduces greenhouse gas emissions. You simply stop producing something, or you outsource the production of it. Instead of producing electricity at your plant, you simply start buying electricity.

On paper it looks like there is a reduction in emissions. In fact, all you have done is shifted the emission to some other source, either in another business nearby, in another State, or in another country.

Because the United States has the most productive agriculture in the word, anytime we discourage farming in the United States, we end up encouraging deforestation in other parts of the country. I do not think that that is a healthy prospect. So, even a voluntary program, as much as I respect the American Farm Bureau's distinction between voluntary and mandatory programs, I would worry that a voluntary program sets the stage for a mandatory program.

In order for those emission permits to be worth anything, there has to be a mandatory cap on emissions. That takes us down the path to imposing restrictions on agriculture and industry in the United States, with the consequence that a lot of this moves to other countries where the environmental impact is many times worse.

Senator VOINOVICH. I would just to comment on that. One of the things that is really boiling in my State is the importation of products from China and how they are displacing our manufacturing sector. Two millions jobs have been lost in the last 2 years.

All of a sudden it struck me that what tradeoffs are we having in regard to the environment. They are impacting on our manufacturing sector, but the question is how much are they contributing to the climate change and some of the other pollution problems that we have. I do not think we have even thought about that or have investigated it.

There are so many parts to this. You keep turning it, and you see something else that is there that needs to be taken into consideration. At the same time I think all of us feel that regardless of what the facts are, we ought to be doing everything that we possibly can to reduce greenhouse gas emissions.

Senator Carper?

Senator CARPER. Thank you, Mr. Chairman. To all of our witnesses, thank you for coming here and for casting some light on what we all agree is an important subject.

Mr. Stallman from Columbus, Texas, Dr. Lal from Columbus, Ohio. I am an old Buckeye myself. The two of us are both Buckeyes, Ohio State graduates. We are really pleased to welcome you.

I used to live in Texas myself when I was a Naval flight officer, down near Flower Bluff, which most people have never heard of. It is nice to have a Texan here at the table. We welcome all of you for coming.

Rob Baker is our Farm Bureau president in Delaware. His predecessor is Joe Calhoun. Before that was Jack Tarnburn. Jack Tarnburn was my Secretary of Agriculture for the 8 years I was privileged to be Governor of Delaware.

We have worked on a commodity problem in Delaware. It is also a pollution problem. We raise a lot of chickens in Delaware. Most people do not think of Delaware as much of an agricultural State.

I think we raise more chickens in Sussex County, Delaware, which is where we have a lot of beach resorts—Fenwick Island, Bethany Beach, Rehoboth Beach, Dewey Beach, Cape Henlopen. Most people probably think of Sussex County as a place to go on vacation. It is a great place for that. But we also raise more chickens in Sussex County, Delaware, than in any county in America. I think we raise more soybeans in Sussex County, Delaware than any county in America.

All those chickens create a fair amount of waste. In our State what we have historically done is that we have taken the chicken waste and after it has been cleaned out of the chicken houses, we use it to fertilize our fields. Over the years we have had more and more chickens to come along, and more and more waste, and fewer acres over which they are spread. As a result, there is a lot of phos-

phorous and nitrogen in our waterways that eventually gets into our inland bays and even to the Chesapeake and Delaware Bay.

One of the things that we have done is that we have a real interesting partnership between the State of Delaware and Perdue which raises a lot of broilers. We have created, with their good work, a technology that enables us to take chicken litter through a treatment process. We create a product high in nitrogen and high in phosphorous that can be used as a fertilizer. It is shipped all over the world. It can be shipped to the Midwest. The size of the pellets can be used and used for lawns. It can be used for golf courses and so forth.

The idea there is to take what had been a problem polluting our waterways and to try to transform it into a marketable commodity for our farmers. We have only been doing this now for about 2 years, but I am encouraged that we are getting our sea legs and that it is going to be a successful proposition for Perdue and for poultry growers, and for our farmers as well.

I am always looking at ways to help raise commodity prices for farmers and to reduce the amount of subsidies that are paid to farmers. I want to find a way to provide another source of cash for our farmers, whether they are in Delaware, Texas, or any other State.

Talk with me a little bit about the potential for us helping increase commodity prices and provide another commodity source of cash for our farmers through a system that enables the emitter of $CO_2$ to enter into a contract with farmers or those who aggregate on behalf of farmers. Talk with me about the potential of what they can mean for our farmers?

Mr. STALLMAN. Well, the potential would obviously vary across the country, depending on the type of land, the type of crops, and those kinds of things. We are encouraged by some of the private efforts that I mentioned in my testimony to put farmers in touch with entities that need to do this. TVA, I think, was doing some reforestation. There were some farmers involved in that at one point.

Throughout all this discussion about the long-term effects of carbon on the atmosphere and some of the projections, I think what is missing—and you cannot quantify it—is what will technology do. The example you have laid out as to what Perdue and some of the poultry farmers are doing in Delaware, is one example of many.

But I truly believe that technology, through additional research, will allow us ways of handling a lot of these problems, whether it is waste, better incorporation practices, and sequestration of carbon. As long as the systems that are in place, in terms of providing farmers some additional dollars—and all of us are in favor of that happening—are voluntary incentive-based and done through a market approach, we would support that.

It will take awhile before the research and the technology, to quantify what "x" practice will mean in terms of "y" benefit that you can actually get paid for. Those are some of the hurdles that we have to overcome if we are going to put forth a successful system.

But I think the potential is there to do that. The question is: Can we get the extra research and the dollars associated there to quan-

tify those things better? Can we have private entities, aggregators, like some of our State farm bureaus, in terms of getting groups of farmers together, and selling those credits to some industry?

I think all that potential is there. But it is going to take some work to get there.

Senator CARPER. Ms. Reed, would you mind responding to the same question? Let me know what that potential might be.

Ms. REED. I think there is a great potential. I would like to give you one example of a situation in the Pacific Northwest where an energy company called Entergy, has entered into a 3-year contract with a group of farms to purchase carbon from them. Entergy feels that climate change is a risk that we need to deal with. They want to reduce their emissions of greenhouse gas.

They have purchased, over a 3-year period, carbon from a group called the Pacific Northwest Direct Seed Association. They are a no-till and conservation tillage group. As Carl Cooper, of the Pacific Northwest Direct Seed Association would tell you, the check is not in the mail. It is in the bank. They have been paid for the carbon that they have sequestered. There are, in fact, emerging carbon markets that are operating in this country. Agriculture has often been looked at as a source of low cost offsets. Energy companies are, in fact, talking with groups like the Pacific Northwest Direct Seed Association about doing that. So I think it is not only a possibility, it is a reality.

Senator CARPER. All right. Thank you.

Dr. Lal, let me go back. I think you are the member of the panel who talked about the amount of carbon that is being emitted and how much could reasonably be sequestered or drawn into, whether it is forest or agriculture or the oceans.

Could you just go back and review some of those numbers for me, please?

Mr. LAL. We have the potentials. That is not what is actually happening. The potential for the U.S. cropland—and Ms. Reed gave that number also—is 142 million tons a year. The potential of our U.S. grazing lands is 70 million tons a year. The potential for forest lands is 118 million tons a year. For all three categories of land, you have the potential for U.S. soils of 360 million tons, which I calculate at about one million tons per day. That is in the soil only.

In addition to that, the potential forest biomass carbon is 250 million tons. The total comes to about 600 million tons, which is about one-third of the total emissions, which is about 1,900 million tons.

Senator CARPER. The best case, if we were to use all of the avenues you have just described, we might be able to address about a third of our current $CO_2$ emissions?

Mr. LAL. That is correct, sir.

Senator CARPER. Mr. Chairman, that is pretty encouraging. I do not pretend to believe that we could maximize the potential in all those areas, but that is a pretty good potential.

Mr. LAL. I would also mention that on a global scale, as Senator Voinovich mentioned, the potential is about one billion tons a year in soils. That is more difficult because of the developing countries in Africa and Asia may not be able to do what we can do in the

United States. The potential is tremendous, especially because the full security in Africa is linked to that carbon sequestration.

Senator CARPER. Dr. Rosenzweig, I want to ask a question of you. I like the question that our Chairman asked of the panel. He asked if you wanted to comment on any of the testimony of any other witnesses. One of the great things about having a panel like this is that we have really diverse perspectives. I always look for a common ground. What we have to do is to try to figure out what the consensus is, what the middle ground is, and to propose that to our colleagues.

As you listened to the testimony here today of each of our other witnesses, what were some of the elements of commonality that you heard that you think might help us in producing consensus legislation, that addresses $CO_2$, greenhouse gases, and global warming?

Ms. ROSENZWEIG. I do not think I can say that there is complete common ground. But there is a strong opinion across the panel that encouraging carbon sequestration in the agricultural sector is a beneficial thing to do for a number of reasons.

The idea of the win-win situation, I think, is very powerful. It will benefit crop productivity and soil-water runoff erosion by increasing carbon in our soils. And, at the same time, it will work on the larger uncertain, but still looming issue of global warming.

When I look across the testimony, that is what I see. I think clearly we need more research on carbon sequestration potential, because we have heard various estimates presented here. The estimates are dependent on changing climate conditions—dynamic climate conditions. Most of the calculations that have been presented here do not take the potential for a changing climate into account. I believe that they should.

We should also look to the warming that has already occurred over the past 100 years. The global temperature has risen 0.6 degrees Centigrade, about 1 degree Fahrenheit. Because of the greenhouse gases that we have put into the atmosphere already, there is likely to be a continuing potential for a change. I think those are important things that we need to take into account as we go forward.

Senator CARPER. Thank you.

Mr. Chairman, I would ask unanimous consent that three items be included in the record. One was actually alluded to, I think, by Ms. Reed.

It says, "Statement from the World Meteorological Organization." They forecast weather around our planet. They apparently met last week and said, as Ms. Reed mentioned in her testimony, that the number of severe weather events are likely to increase due to climate change. That would be one request.

The National Farmers Union is not present with us today. They have a statement that I would ask be submitted. They encourage efforts to establish a strong $CO_2$ reduction strategy, and to include agriculture in that strategy.

There is a statement of a group of leading climate scientists who have researched weather data. They determined that the warmth experienced in the late 20th century was an anomaly, and that

human activity likely played an important role in causing that warming.

Those would be the three that I would ask unanimous consent to place in the record.

Senator VOINOVICH. Without objection, so ordered.

[The statement appears at the end of the following the hearing record:]

Senator VOINOVICH. I am getting a little bit confused here with these numbers. The estimate of the incentives just announced by the USDA show that if widely used, they will sequester 12 million metric tons of carbon in 2012. Did we just say that right now we are sequestering 15 million tons currently; is that right?

Dr. Lal?

Mr. LAL. My guess is that that is not 12 million. That is 12 percent of the emissions. I think that was probably 12 percent and not 12 million. That is my interpretation on that. We are already sequestering 20 million tons, not 15. That is in soils alone. So 12 million tons sequestered by 2012 is grossly inaccurate. I think it is 12 percent of the emissions.

Senator VOINOVICH. Mr. Bast?

Mr. BAST. I believe he was referring to the sequestration of specific programs that the Department of Agriculture was planning to fund rather than making a forecast of how much could be sequestered. That is why it is a seemingly small amount.

Concerning this confusion between tons of carbon and carbon dioxide, carbon is 12/44 of the weight of carbon dioxide. So you can convert one into the other by multiplying it by either 12/44ths or 44 12ths, which is 3.66666.

We can take the estimates that Dr. Lal has been giving us, multiply it by 3.66, and you will get what the United Nations and the EPA both now use as the standard method of measuring. EPA, when it uses tons of carbon dioxide equivalent, comes up with 15 million metric tons. That is not carbon. That is actually the higher of the two numbers. If you express it only as tons of carbon, it would be even less than that.

The 20 million tons that other people have used here is the Department of Agriculture's estimate. That is just tons of carbon. If you convert that into carbon dioxide, it is about 73 million metric tons.

EPA says 15 million metric tons. The Department of Agriculture says 73 million metric tons. If EPA is right, it is about 1/20th of 1 percent of total U.S. greenhouse gas emissions every year, just 1/20th of 1 percent. If the Department of Agriculture is right, it is still just about 1 percent—73 million metric tons is about 1 percent of 6.9 billion metric tons, which is what EPA estimates total U.S. emissions to be.

Total sequestration, regardless of whose number we are using, currently is very small—one percent at best, 1/20th of 1 percent if EPA is correct—of current U.S. emissions. How much and how rapidly that could be increased has been the subject of speculation on this panel. I am certainly not a soil specialist, but EPA notes that total sequestration has only increased 14 percent over the last 11 years. From 1990 to 2001, the amount of carbon stored in soil has only increased 14 percent.

Now we are proposing perhaps to very rapidly increase it by 100 percent or 1,000 percent in order to get up to some of the numbers that other speakers are talking about. I would doubt that that is feasible.

Senator VOINOVICH. I will check this out. I thought they said they were talking about 12 million metric tons of carbon in 2012.

Ms. Rosenzweig?

Ms. ROSENZWEIG. I just have a comment further to the point that I was making about thinking about agriculture as a carbon neutral sector, and thinking about other sectors as well.

From sitting on many panels over about the 20 years that I have been doing research on climate change and agriculture, one thing that I have come to learn is that there are no silver bullets for the global warming issue. Really, there is only silver buckshot. When you look at the sector, compared to the whole problem, yes, it could be small. But it can play a very important role by beginning the address the issue and doing what it can, vis-a-vis its own sector and also helping out the other sectors.

Senator VOINOVICH. Dr. Lal?

Mr. LAL. Senator, your point about the numbers being confusing, like the estimates by UDSA on soil carbon sequestration of 20 million tons, are based on sensory model use. We really do not have actual measurements on farm conditions. Most of the data that we have presented is based on the research.

What really is needed is validation of which farmers have adopted practices in different regions in the United States, actually going out there and monitoring how the carbon is changing. That data is just being collected. That is the kind of information that is really needed to verify what is actually happening.

Senator VOINOVICH. You are saying that we still are not there to really get the real numbers of what is really being captured and that there is speculation on these numbers?

Mr. LAL. Yes, Senator.

Senator VOINOVICH. I know we throw numbers around here and I always ask: Where do they come from: You peel it back. A lot of it is speculation. We are still in a speculative arena in terms of what this is really going to do?

Mr. LAL. That is very correct. The actual on-farm assessment of soil carbon sequestration numbers and the on-farm conditions are few. Some are being collected. I think Jack is collecting some. We are collecting some. But it is very few. We have only a few farms.

The other point that I want to mention is the 20 million tons that the USDA uses is net sequestration by soil. When I say "net," there is a lot of emission by cultivation by organic soils. These are cultivated organic soils, like sugar cane plantations in Hawaii, and some vegetable production in some parts of Ohio. We have very serious emissions from those soils which is really quite a large number. When you calculate the net part of the soil carbon sequestration happening, we deduct that the emissions from the organic soils. So the net number given is not really the net number. The soil carbon sequestration number is much bigger.

The other point which I think is important to mention is that soil carbon sequestration, carbon offsetting is only one of the benefits.

Improving the quality of our soil resources is a very important factor.

Senator VOINOVICH. I think that Mr. Stallman would agree with this, that going forward with this program has other benefits to the agriculture community, correct?

Mr. LAL. Yes, sir, to the environmental community as well—sedimentation control, the water quality benefits, the bio-diversity benefits, and the pollutants use of land. There are numerous other things.

Soil organic matter is what makes the soil a living entity. We have lost three to five billion tons of carbon from the soil in the U.S. We need to put it back, regardless of the debate of climate change. We have lost 60 to 80 billion tons of carbon from the world's soils. Why the full security situation perpetuates in Africa? We are talking about a 30 percent loss in the U.S. They are talking about a 90 percent loss in the soil in Africa. We need to put it back before even those soils can respond to fertilizer use. We cannot possibly achieve the full security without restoring the soil carbon. The benefits are tremendous.

Senator VOINOVICH. Thank you.

Mr. Stallman, Mr. Bast testified that mandatory carbon controls could increase gasoline costs by 50 percent, driving up agri-production costs. There is a big issue around here about cap-and-trade. I am opposed to cap-and-trade. I think we should go ahead and move forward and do what we can without cap-and-trade. There are others that say that if you do not have cap-and-trade, then you are not going to get people to do some of these things that we are talking about here today. It is a dilemma.

Frankly, it is standing in the way of moving forward with reducing NOx, SOx, and mercury. There are certain groups in this country who say unless you do four of them, we are not going to do anything about the other three. We have been coasting around here in the last 2 or 3 years.

Would you like to comment on the cap-and-trade thing? Do you agree with that in terms of the impact that it will have on agriculture? You are going to get involved in sequestration, but you are saying if you get into this cap-and-trade, the cap-and-trade will impact negatively on farmers in this country and drive up their costs; is that correct?

Mr. STALLMAN. Yes, we strongly believe that any kind of mandatory cap-and-trade system would be a net detriment in terms of the economic impact to agriculture.

Senator VOINOVICH. Let me ask you another thing. In your opinion, would it put us in a noncompetitive position in the global market place?

Mr. STALLMAN. Certainly less competitive, and probably noncompetitive in many instances. If we implemented some Kyoto-like mandatory greenhouse gas regulations, the Sparks study indicates that it would lower net farm income by over $21 billion a year. Production costs would increase about $16 billion, due to the higher energy and fertilizer costs. Agriculture is a very intensive energy user.

Senator VOINOVICH. Part of that comes from that if you do cap-and-trade, the concept is that the energy companies would stop

burning coal. They use more natural gas. More natural gas equals higher costs for fertilizer. That is the scenario.

Mr. STALLMAN. A lot of that is in the Sparks study that I referenced. We will be glad to get a copy of it to you.

Senator VOINOVICH. OK. I would like to get that Sparks study.

Mr. STALLMAN. We will provide it, Mr. Chairman.

Without objection, so ordered.

Senator VOINOVICH. Senator Carper?

Senator CARPER. Thank you, Mr. Chairman.

I have two last questions.

Ms. Reed, I think in an earlier life you worked for Senator Bob Kerry; is that true?

Ms. REED. Yes, I did.

Senator CARPER. Subsequent to that, I think maybe you had a stint at EPA. You had to think, by virtue of some of your former jobs, about what we and our staffs go through in crafting legislation and looking for some compromises.

Let me just ask this, if I could. What should the Administration, and what should Senator Voinovich and I and our colleagues do to more effectively address climate change, including promoting carbon sequestration. What should we do?

Ms. REED. I do not think, first of all, that we should discount the idea of a cap-and-trade program. Senators McCain and Lieberman have a bill called the "Climate Stewardship Act," which is a cap-and-trade program. It would impact just the major and most intensive emitting sectors of the economy.

MIT recently completed an analysis of that bill that showed, for instance, the two phases to the bill. The first phase of the bill would decrease U.S. greenhouse gas emissions to 2000 levels by 2010. It would have no net impact and no cost to the economy. It might even be beneficial to the economy.

The reason is that it is set up as a cap-and-trade program that allows market flexibility to take over. It would allow, for instance, agricultural sequestration to be a low cost source of offsets, and other sources of sequestration. So I think you need to think about using the market to actually help us get the lowest price reductions where we can. Your bill, as a matter of fact, does the same thing.

So I think that there are ways to do this. We need to overcome the obstacles that people throw up that have not been proven. Certainly, there is a sulfur dioxide trading program, for instance. It has shown that we can, in fact, reduce emissions of pollutants using the market.

Senator CARPER. All right.

Does anyone have a closing thought that you would have for us coming out of the hearing of hearing your colleagues on the panel? Do you have a closing thought for us that you might have?

Mr. Stallman, are there any parting thoughts you might want to leave with us?

Mr. STALLMAN. Well, in terms of the silver buckshot, agriculture is willing to be one of the BBs.

Senator CARPER. Good. Thank you. Hopefully we will find some more.

Dr. Lal, I might just say that this issue of global warming and greenhouse gases first came to my attention thanks to a research

couple from Ohio State University, Drs. Thompson, who have done a lot of work around the globe. Maybe sometime we could actually have them come and testify and talk about the work that they have done on examining the melting of the ice caps around some of the tallest mountains in the world.

Mr. LAL. He predicts that some of the tropical glaciers, like Kilimanjaro, might disappear within the next 15 to 20 years because of the climate.

Senator CARPER. It is sobering stuff.

Mr. LAL. I would like to mention that agriculture has been considered as an environmental pollutant. I think agriculture, in addition to providing full security, can really be a solution, if done properly.

Senator CARPER. That is a great thought to close with. Thank you.

Mr. Bast?

Mr. BAST. Mr. Stallman at the outset said that we are not here to debate the science, but I note now that it has come up on several occasions. I cannot hardly leave this hearing without mentioning that the satellite data show no warming over the last 29 years, and that there is indeed a fierce debate taking place among scientists as to whether or not there is any human role in the temperature trends that we have observed.

Finally, there is a lot of debate over whether or not some global warming would have a negative effect either on the United States or the rest of the world. The most authoritative research on that by Robert Mendelson at Yale University, recently published by Oxford Press, suggests that a 2.5 degree Celsius warming would actually benefit agriculture in the United States to the tune of $41 billion a year through its fertilizing effect and through more rain and other things like that.

We should not assume that we have a problem here in need of solving. I think that would be the first step. Secondarily, if we try to solve this nonexistent problem, let us make sure the unintended consequences do not make it even worse by leading to deforestation and other problems in Third World countries.

Senator CARPER. Thank you. A friend of mine likes to say, in response to those kind of arguments, if we can get the temperature up high enough, we can eliminate all the agricultural subsidies for the farm community. But that is his sense of humor.

Ms. Reed?

Ms. REED. I commend you for dealing with the issue of climate change. I do think it is time for us to start taking action. I think we can do so in a way that is not prohibitive, either to the economy or to the agricultural sector. Most farmers operate on a three-to-four percent profit margin. Agriculture can clearly benefit from starting to help mitigate our greenhouse gas emissions.

Senator CARPER. Thank you.

Ms. Rosenzweig?

Ms. ROSENZWEIG. I am actually a coauthor on a chapter in the book that Mr. Bast mentioned. I think it is important to remember that unabated temperatures are likely to continue to rise even above 2.5 degrees Centigrade. That is why it is so important that

we address both mitigation of greenhouse gas emissions and adaptation to a changing climate, a dynamic climate, jointly.

Senator CARPER. Thank you all.

Thank you, Mr. Chairman.

Senator VOINOVICH. I would just like to make one point. I am anticipating the McCain–Lieberman bill. According to the energy information from the Administration, it will increase electricity costs, natural gas costs, and have a major impact on all aspects of the economy.

So there is a difference of opinion, Ms. Reed, about what that bill will do or not do. I just wanted to get that on the record.

Thank you very much.

We are adjourned.

[Whereupon, at 11:35 a.m., the subcommittee was adjourned, to reconvene at the call of the Chair.]

[Additional statements submitted for the record follow:]

STATEMENT OF BRUCE I. KNIGHT, CHIEF, NATURAL RESOURCES CONSERVATION SERVICE, U.S. DEPARTMENT OF AGRICULTURE

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to discuss the Department of Agriculture's carbon sequestration programs and outline the steps being taken within USDA to address the long-term challenge of global climate change. The issue of climate change cuts broadly across the Department, involving several agencies and mission areas. To provide policy guidance, the Secretary created a climate change working group that is chaired by the Deputy Secretary and includes the Under Secretaries for all of the relevant mission areas: Farm and Foreign Agricultural Service; Natural Resources and the Environment; Research, Education, and Economics; and Rural Development, as well as the General Counsel and Chief Economist. The Department plays an active role in the government's activities to address climate change, including: Scientific research, technology development, international bilateral and multilateral cooperation, efforts to encourage actions in the private sector, and policy development and implementation.

Last month, Secretary Veneman announced a series of actions that the Department will take to increase carbon sequestration and reduce greenhouse gas emissions from forests and agriculture. The actions represent a major step for the Department. For the first time, USDA will consider the reduction of greenhouse gases in setting priorities and in allocating resources within the portfolio of conservation programs we administer. The actions build on a foundation of ongoing research and technology development. USDA researchers and our cooperators are improving our understanding of climate change and its implications for managed and unmanaged natural systems, the potential risks to agriculture and forests, and effective ways to sequester carbon and reduce greenhouse gas emissions from agriculture and forests.

The actions announced by USDA include financial incentives, technical assistance, demonstrations, pilot programs, education, and capacity building. We are also setting out to improve our ability to measure and monitor changes in carbon storage and greenhouse gas emissions so that we can accurately track our progress in implementing these actions.

Coupled with the increases in overall conservation spending, these actions are expected to increase the carbon sequestration and greenhouse gas emissions reductions from the conservation programs by over 12 million tons of carbon equivalent in 2012, which represents approximately 12 percent of President Bush's goal to reduce greenhouse gas intensity of the American economy by 18 percent in the next decade.

USDA's conservation programs were designed to offer assistance and incentives to farmers and other landowners in addressing multiple conservation and environmental challenges. Historically, programs have focused on reducing soil erosion, improving water quality, creating wildlife habitat, reducing air pollution, and protecting sensitive areas. While maintaining these priorities, the programs will now also include explicit consideration of greenhouse gas reductions and carbon sequestration. We can accomplish this without compromising our other objectives because, in many cases, the technologies and practices that reduce greenhouse gas emissions and increase carbon sequestration also address other conservation priorities. Plant-

ing trees and other natural covers can increase above and below-ground carbon. However, cropland doest not need to be taken out of production to sequester carbon. For example, conservation tillage (reduced, minimum, or no-till) reduces the extent of soil organic matter oxidation and decomposition by soil microorganisms that occur with plowing and tillage. Thus, more of the organic matter added to the soil remains, leading to increases in soil carbon.

There are many opportunities to apply these practices in the U.S. Most U.S. cropland soils have lost at least a third and some up to 60 percent of their carbon since they were first converted to crop production beginning about 200 years ago. This diminished carbon pool can be replenished by improvements in land management.

Under the Environmental Quality Incentives Program (EQIP), NRCS provided guidance to States to reward actions that sequester carbon and reduce greenhouse gases within the EQIP ranking system. These practices can include the soil conservation practices already mentioned and technologies to reduce methane emissions from livestock waste. Last month, we hosted a Summit on one of these promising technologies anaerobic digesters. Anaerobic digesters can reduce odors and pathogens and methane (a powerful greenhouse gas) from manure. The methane from digesters can be captured and used as fuel for power generation or direct heating. The Summit, held in Raleigh, North Carolina brought together farmers, Federal and State conservation officials, representatives from the power industry, inventors and technology developers, and the conservation and environmental organization representatives.

At the summit, we unveiled three new conservation practice standards specifically for digesters. The performance standards lay out standard expectations for the technology but do not prescribe or endorse a particular vendor's product. One of the standards is for covers for new and existing lagoons; the second standard is for new ambient temperature digesters; and the third standard is for new controlled temperature digesters. These new standards will have two major benefits. They will make it easier for producers to fit anaerobic digesters into their EQIP contracts as part of a comprehensive nutrient management plan. They will also make it easier for producers to use technical service providers to plan and construct digesters.

The Conservation Reserve Program (CRP) and Wetlands Reserve Program (WRP) can provide significant amounts of carbon sequestration. Conversion of cultivated lands back into forests, grasslands or wetlands, which occurs on CRP and WRP lands, fosters the accumulation of carbon in soils and vegetation. On Earth Day, Secretary Veneman announced that the Farm Services Agency (FSA) will target 500,000 acres of continuous signup enrollment toward bottomland hardwood trees, an action that will increase the amount of carbon stored by the CRP. Bottomland hardwoods are among the most productive ecosystems for carbon sequestration in the United States. In another step to provide incentives for carbon sequestration, FSA modified the environmental benefits index (EBI) used to score and rank bids into the program. The revised EBI will give points specifically for practices that sequester carbon, giving these practices a higher priority under the program than they otherwise would have.

The Forest Service also has responsibilities for implementing actions announced by the Secretary. Using new authority established under the Farm Security and Rural Investment Act of 2002, carbon sequestration will be one of the formal objectives of the Forest Land Enhancement Program (also known as FLEP). Through FLEP, the Forest Service, working with States, can promote carbon sequestration with tree planting, forest stand improvements, and agroforestry practices.

Forests and agriculture can also be the source of domestic, renewable energy. USDA recently announced the availability of $44 million in grants for energy efficiency, biomass energy, and biomass products development. Twenty-three million dollars of this will be available from USDA's Rural Development for the Renewable Energy Systems and Energy Efficiency Improvements program to assist farmers, ranchers, and rural small businesses to develop renewable energy systems and make energy efficiency improvements to their operations. Farmers and ranchers are eligible for loan guarantees for renewable energy systems, including anaerobic digesters under the Rural Business and Industry Programs administered by Rural Development.

Through the Biomass Research and Development Initiative, in cooperation with the Department of Energy, $21 million in grants are available to carry out research, development and demonstration of biomass energy, biobased products, biofuels and biopower processes. USDA also recently announced key revisions to the Commodity Credit Corporation Bioenergy Program to expand industrial consumption of agricultural commodities by promoting their use in the production of ethanol and biodiesel.

USDA is also working with partners in the private sector. This February, Secretary Veneman announced commitments from two industry groups with strong nat-

ural resource ties. The members of the American Forest and Paper Association have committed to actions that they expect will improve their greenhouse gas intensity by 12 percent by 2012. The members of the National Rural Electric Cooperative Association agreed to work with USDA to break down the barriers that farmers and ranchers face in generating renewable power. America's rural landowners can be a source of solar, wind, and biomass power. These opportunities can be win-win partnerships for the rural utilities and farmers.

Companies and industrial sectors are making commitments under the Administration's Climate VISION program. Companies with an interest in forest and agricultural carbon sequestration are looking to USDA to give them the tools they need to measure and report on their actions.

Last year, USDA was directed to develop new accounting rules and guidelines for reporting greenhouse gas activities on forests and agricultural lands. The new accounting rules and guidelines will be used by companies and individuals to report their activities to the Department of Energy under their voluntary greenhouse gas reporting system. The DOE reporting program is undergoing revisions that are expected to be completed by January 2004. The Forest Service and NRCS have taken the respective leads for the forest and agriculture components of the guidelines. USDA has undertaken an extensive public comment process including two well-attended workshops in January 2003. We solicited written comments from the public on our process and will provide additional opportunities for public input before the accounting rules and guidelines are finalized.

USDA's research program plays an important role in the government's efforts to understand climate change. The budget for USDA's participation in the US Global Change Research Program (USGCRP) and Climate Change Research Initiative (CCRI) has increased in each of the last 2 years. The USDA fiscal year 2003 budget for CCRI and USGCRP combined is $63 million, up from $57 million in fiscal year 2002. In fiscal year 2004, USDA is requesting an additional $7.1 million for the President's CCRI priorities. The increases requested for fiscal year 2004 fall primarily in the following areas: Improving the methods for measuring and estimating above and below-ground carbon storage on forest and agriculture systems; Collecting carbon flux measurement data at specific locations that can be scaled to regional and national statistics; Developing management practices and techniques for increasing carbon sequestration and reducing greenhouse gas emissions; Demonstration projects to facilitate the incorporation of carbon sequestration into USDA programs; Finalizing the new accounting rules and guidelines for estimating and reporting carbon sequestration and greenhouse gas emissions from forest and agricultural activities. Finally, USDA continues to invest in research to improve our understanding of how crops, livestock, trees, pests, and other facets of ecosystems will respond, either positively or negatively, to higher levels of greenhouse gases in the atmosphere. We are seeking cost-effective ways to make agriculture and forests more adaptable to any changes in climate and weather, should they occur. We are pursuing an improved understanding of the role of natural and managed ecosystems in the global carbon cycle. We are developing technologies and practices to reduce emissions of greenhouse gases and increase carbon sequestration. We are now harnessing the portfolio of conservation programs to build carbon back into the soil and vegetation, integrating greenhouse gas considerations in our conservation efforts.

Thank you again for the opportunity to address this Subcommittee. I am now available to answer your questions.

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STATEMENT OF BOB STALLMAN PRESIDENT, AMERICAN FARM BUREAU FEDERATION

Chairman Voinovich, members of the Subcommittee, my name is Bob Stallman. I am President of the American Farm Bureau Federation (AFBF) and a rice and cattle producer from Columbus, TX. On behalf of the 5.3 million members of the American Farm Bureau I am pleased to be speaking to you today on agriculture's role in sequestering carbon in our nation's soil. Carbon is the key building block and cornerstone element for all things living. For those of us in agriculture, we have learned through years of research and practical experience that soil carbon is essential for optimizing the production of food and fiber in addition to the profitability of farming and ranching. Carbon used in crop production is replenished in the soil by crop and root residues, with less soil carbon being lost when minimum or no-till regiments are implemented.

The USDA's Agricultural Research Service estimates that 20 million metric tons of carbon is currently sequestered each year in U.S. farm and grazing land soils. This estimate indicates that U.S. farms and ranches are indeed a net "carbon bank" or sink, sequestering carbon in the soil and keeping it out of the atmosphere. Many

producers have made a decision on an economic basis to employ conservation tillage practices such as minimum/no till and cover crop regimens in their farm and ranch operations. With more producers changing individual farm management practices, USDA and State Department personnel estimate that an additional 180 million metric tons annually could be stored in farm and range land acres. This would account for 12 to 14 percent of the total U.S. emissions of carbon according to the State Department.

Carbon and its role in the climate change issue has been the subject of recent debate, and will continue to be as attempts are made to attach climate change legislation to the energy bill or other legislative vehicles. We are not here today to discuss the merits or demerits of the theory of the climate change issue. With regard to carbon sequestration, it is undeniable that agriculture can play a vital role.

In 2001, President Bush announced the development of a comprehensive strategy to reduce greenhouse gas intensity in the United States by 18 percent by 2012. A vital component of the strategy is to encourage increased sequestration of carbon in forests and rangelands. In February of this year, the President announced the Climate Voluntary Innovative Sector Initiatives: Opportunities Now, or Climate VISION program. A voluntary, public-private partnership, the primary goal of the program is to pursue cost-effective initiatives that will reduce the projected growth in America's greenhouse gas emissions. AFBF has begun discussions with the Administration to see what role the agricultural sector could play in the Climate VISION program.

Last month, Secretary of Agriculture Ann Veneman announced that the USDA would consider greenhouse gas management practices when evaluating applications for the Environmental Quality Incentives Program (EQIP), the Conservation Reserve Program (CRP) and the Forest Land Enhancement Program (FLEP). America's farm and ranch community has long supported and responded to voluntary, incentive based programs, as is evident by the waiting lists to participate in many conservation programs such as EQIP and CRP. Time and time again, when an environmental challenge has presented itself, American agriculture has answered the call.

I would be remiss if I did not reiterate our opposition to any mandatory measures pertaining to climate change and carbon sequestration but rather the need to maintain a voluntary approach to agricultural sequestration. Some involved in the climate change issue have advocated a mandatory cap and trade approach for carbon as a way to "establish" a carbon market and increase sequestrations and trading participation. We strongly disagree with that approach. While a mandatory cap and trade may increase the value of the carbon being sequestered, an analysis by Sparks Companies, Inc., re-released, last month concludes that the increased energy costs to the agricultural sector associated with any Kyoto-like mandatory program would more than offset any cash value in the sequestration of carbon by farmers and ranchers on a per-acre basis.

Like many other industries, agriculture has in the past, and will in the future, respond if the appropriate incentive-based tools are employed. Some of the needed tools like EQIP and CRP already exist. Other tools, like voluntary carbon trading, are just now being developed. Private entities are currently developing and implementing voluntary pilot carbon trading systems. In one case, the Iowa Farm Bureau and Kansas Farm Bureau are already involved with private trading entities, disseminating information to farmers and ranchers and helping to put landowners together with carbon-trading exchanges in an effort to trade carbon under free market rules. The American Farm Bureau Federation supports the development of a practical, voluntary carbon trading system and the development of trading criteria, standards and guidelines.

While potential for agricultural carbon sequestration in the United States exists, many challenges remain. One area that must be addressed before increased sequestration can be realized is the development of methods and procedures to credit farmers and ranchers who have employed in the past, and continue to employ, conservation tillage practices in their operations. Other challenges include the continued development of carbon trading guidelines, the establishment of accurate crediting and values for sequestered carbon on farm and ranch lands, and the development of other cost effective incentives to further advance carbon sequestration in agricultural soils. None of these challenges is insurmountable and AFBF looks forward to working with the USDA, Department of Energy, the Environmental Protection Agency, Congress and many others within the private sector to find solutions and move forward with this endeavor.

There is no doubt that agriculture can and will play an expanded role in sequestering carbon on America's farmland. We strongly support President Bush's voluntary approach to climate change issues and his call for the public and private sec-

tors to work together to increase the sequestration of carbon on America's farm and rangeland. The American Farm Bureau appreciates this opportunity to share our views on agriculture's role in helping solve the carbon sequestration puzzle. We look forward to working with you.

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STATEMENT OF RATTAN LAL, DIRECTOR CARBON MANAGEMENT AND SEQUESTRATION CENTER/FAES, OARDC THE OHIO STATE UNIVERSITY

Mr. Chairman, members of the Senate Committee on Environment and Public Works. I am Rattan Lal, Professor of Soil Science and Director of the Carbon Management and Sequestration Center at The Ohio State University. I am especially thankful to Senator Voinovich for the opportunity to offer testimony on "Soil Carbon Sequestration by Agriculture and Forestry Land Uses for Mitigating Climate Change."

Let me begin by expressing my appreciation of strong cooperation with several institutions and organizations across the country. During the past decade, the program at The Ohio State University (OSU) has been supported by USDA–Natural Resource Conservation Service (NRCS). We have also worked with scientists from USDA–Agricultural Research Service (ARS). The multi-institutional team comprised of OSU/NRCS/ARS has published 15 books, which constitute a major literature on this topic. In addition, OSU also has on-going activities under the C-site program with the Pacific Northwest National Laboratory and the Oak Ridge National Laboratory. Being a founding member of the "Consortium for Agricultural Soils Mitigation of Greenhouse Gases (CASMGS)," the OSU team is collaborating with faculty from ten universities in assessing soil carbon (C) sequestration in the U.S. cropland. The OSU/NRCS/ARS team has completed assessment of the potential of U.S. cropland, grazing lands and forestlands to sequester C. In cooperation with the Ohio Coal Development Office, American Electric Power, and the Los Alamos National Laboratory, we are assessing the rate of soil carbon sequestration and soil quality improvement by reclamation of mineland sites in Ohio and New Mexico. We have collaborated with USDA–Economic Research Service (ERS) on the topic of soil degradation and its effects on productivity and soil carbon dynamics. We are now developing a National Soil Carbon Assessment Program (NSCAP) with NRCS. The objective of NSCAP is to assess soil carbon sequestration under on-farm conditions for principal ecoregions, major soils and dominant land uses of the U.S. It is our hope to continue receiving funding for this important undertaking. We are working with these partners because we share the same values and goals of "sustainable management of soil and water resources, reducing net emissions, and creating a clean environment."

The basis of our shared commitment is the mutual concern about the quality of the nation's soil and water resources and the environment. We realize how important and critical the quality of soil resources is for maintaining high economic agricultural production while moderating the quality of air and water. Soils constitute the third largest carbon pool (2,300 Gt or billion tons), after oceanic (38,000 Gt) and geologic (5,000 Gt) pools. The soil carbon pool is directly linked with the biotic (600 Gt) and atmospheric (770 Gt) pools. Change in soil carbon pool by 1 Gt is equivalent to change in atmospheric concentration of $CO_2$ by 0.47 ppm. Therefore, increase in soil carbon pool by 1 Gt will reduce the rate of atmospheric enrichment of $CO_2$ by 0.47 ppm.

The atmosphere carbon pool has progressively increased since the industrial revolution. With industrialization and expansion of agriculture, through deforestation and plowing, came soil degradation and emission of gases into the atmosphere. Indeed, the atmospheric concentration of three important greenhouse gases (carbon dioxide, methane and nitrous oxide) has been increasing due to anthropogenic perturbations of the global carbon and nitrogen cycles. For example, the pre-industrial concentration of $CO_2$ at 280 parts per million (0.028 percent or 600 Gt) increased to almost 365 ppm (0.037 percent or 770 Gt) in 1998 and is increasing at the rate of 0.43 percent/yr or 3.2 Gt/y. The historic gaseous increase between 1850 and 1998 has occurred due to two activities: (1) fossil fuel burning and cement production which has contributed 270 (+30) Gt of carbon as $CO_2$, and (2) deforestation and soil cultivation which has emitted 136 (+55) Gt. Of this, the contribution from world soils may have been 78 (+12) Gt of which 26 (+9) Gt may be due to erosion and related soil-degradative processes. In comparison with the global emissions, cropland soils of the United States have lost 3 to 5 Gt of carbon since conversion from natural to agricultural ecosystems.

The projected climate change caused by increase in atmospheric concentration of $CO_2$ and other trace gases can be mitigated by reducing emissions and sequestering

emissions. Strategies for emission reductions include enhancing energy production and use efficiency, and using biofuels. Emission sequestrations involve biotic and abiotic options. Important biotic options include carbon sequestration in soils, vegetation and wetlands. Together, biotic sequestration in soil and vegetation is called "terrestrial sequestration."

Terrestrial carbon sequestration is a natural process with numerous ancillary environmental benefits. In contrast to geologic and oceanic sequestration, which may be expensive and have unknown ecological impacts, terrestrial sequestration is the most cost effective option. Natural carbon sinks (terrestrial and oceanic) are presently absorbing 4.7 Gt out of the total anthropogenic emissions of 8.0 Gt or about 60 percent of the total emission. It is prudent, therefore, to enhance the carbon storage capacity of natural sinks (such as soils and vegetation) through conversion to a judicious land use and adoption of recommended management practices for soil, water, and crop/vegetation. Agriculture has an important and positive role to play in enhancing the capacity of natural terrestrial sinks.

Greenhouse gases are released into the atmosphere when trees are cut down and burnt, soils plowed, and wetlands are drained and cultivated. In addition, excessive soil cultivation and inappropriate or inefficient use of nitrogenous fertilizers can result in emission of greenhouse gases from soil to the atmosphere. Finally, accelerated soil erosion can lead to a drastic reduction in soil organic carbon (SOC) content. Although the fate of the carbon that is transported by wind and water is not well understood, it is believed that a considerable portion of the eroded carbon may be mineralized and emitted into the atmosphere. It is estimated that soil erosion annually emits 1 Gt of carbon globally and 0.15 Gt from soils of the United States. Although agricultural processes are presently not the main source of gaseous emissions, they have clearly been a significant source. Yet, the emissions of carbon from soils are reversible through conversion to a restorative land use and adoption of recommended agricultural practices. These estimates of the amount of lost C, crude as these may be, provide a reference point about the sink capacity through land use conversion and adoption of recommended practices.

Soil organic matter (SOM), of which 58 percent is carbon, is one of our most important national resources. It consists of a mixture of plant and animal residues at various stages of decomposition and by-products of microbial activity. The SOM is a minor component of the soil (1–3 percent), but plays a very important role in biological productivity and ecosystem functions. Enhancing SOM concentration is important to improving soil quality, reducing risks of pollution and contamination of natural waters, and decreasing net gaseous emissions to the atmosphere. The SOM pool can be enhanced through: (1) restoration of degraded soils and ecosystems, and (2) intensification of agriculture on prime soils.

Enhancing the SOM pool is an important aspect of restoration of soils degraded by severe erosion, salinization, compaction, and mineland disturbance. Degraded soils have been stripped of a large fraction of their original SOM pool. Globally, there are 1216 million hectares (Mha) (3 billion acres) of degraded lands of which 305 Mha (753 million acres) are strongly and extremely degraded soils. U.S. cropland prone to moderate and severe erosion is estimated at 19.4 Mha (48 million acres) by wind erosion and 26.2 Mha (65 million acres) by water erosion. An additional 0.3 Mha (0.7 million acres) are affected by salinization, 2.1 Mha (5.2 million acres) of land affected by all mining, and 0.6 Mha (1.5 million acres) of land strip-mined for coal is in need of restoration. Land conversion and restoration transforms degraded lands into ecologically compatible land use systems. The Conservation Reserve Program (CRP) is designed to convert highly erodible land from active crop production to permanent vegetative cover for a 10-year period. In addition to erosion control, land under CRP can sequester carbon in soil at the rate of 0.5 to 1.0 t/ha/y (450 to 900 lbs C/acre/y). Erosion control also involves establishing conservation buffers and filter strips. These vegetated strips, ranging from 5 to 50 m wide (16.5 to 165 ft. wide) are installed along streams as riparian buffers and on agricultural lands to minimize soil erosion and risks of transport of non-point source pollutants into streams. The rate of carbon accumulation in soil under conservation buffers is similar to that of the land under CRP. The USDA has a voluntary program to develop 3.2 million km (2 million miles) of conservation buffers.

Wetlands are also an important component of the overall environment. Approximately 15 percent of the world's wetlands occur in the United States (40 Mha or 100 million acres) of which 2 Mha (5 million acres) are in need of restoration. Natural wetlands have a potential to accumulate carbon (net of methane) at the rate of 0.2 to 0.3 t/ha/y (180 to 270 lbs/acre/y).

Surface mining of coal in the U.S. affected 2 Mha (5 million acres) between 1978 and 2002, of which 1 Mha (2.5 million acres) have been reclaimed. The land area affected by surface mining of coal was about 40,283 ha (100,000 acres) during 2002.

Restoring minelands, through leveling and using amendments for establishment of pastures and trees, has a potential to sequester 0.5 to 1 t C/ha/y (450 to 900 lbs C/acre/y) for 50 years. Similar potential exists in restoring salt-affected soils.

The overall potential of restoration of degraded soils in the United States is 17 to 39 million metric tons (MMT) per year for the next 50 years or until the sink capacity is filled. Intensification of agriculture involves cultivating the best soils using the best management practices to produce the optimum sustainable yield. Some recommended agricultural practices, along with the potential of SOC sequestration are listed in Table 1. Conversion from plowing to no till or any other form of a permanent conservation till has a large potential to sequester carbon and improve soil quality. There is a strong need to encourage the farming community to adopt conservation tillage systems.

Adoption of recommended practices on 155 Mha (380 million acres) of U.S. cropland has a potential to sequester 75 to 208 MMTC/y. Grazing lands, rangeland and pastures together, occupy 212 Mha (524 million acres) of privately owned land and 124 Mha (300 million acres) of publicly owned land.

Total soil carbon sequestration potential of U.S. grazing land is 30 to 110 MMTC/y.

The potential of U.S. forest soils on 302 Mha (746 million acres) to sequester carbon is 49 to 186 MMTC/y.

Thus, the total potential of U.S. agricultural and forest soils (Table 2) is 171 to 546 MMTC/y or an average of 360 MMTC/y. In addition to crop residue, there are other biosolids produced that can be composted and used on agricultural lands. The potential of using manure and compost on agricultural lands need to be assessed. Of the total national emission of about 1,892 MMTCE/y for 2001, agricultural practices contribute 143 MMTCE/y. Therefore the potential carbon sequestration in U.S. soils represents 19 percent of total U.S. emissions, and 2.5 times the emissions from agricultural activities. Thus, soil carbon sequestration alone can reduce the net U.S. emissions from 1,892 MMTCE to 1,532 MMTCE/y.

If the full potential of soil carbon sequestration is realized, the total sink capacity can be 609 MMTC/y (Table 3). These statistics indicate the need for a serious consideration of determining what fraction of the total potential is realizable, at what cost and by what policy instruments. There is a widespread perception that agricultural practices cause environmental problems, especially those related to water contamination and the greenhouse effect. Our research has shown that scientific agriculture and conversion of degraded soils to a restorative land use can also be a solution to environmental issues in general and to reducing the net gaseous emissions in particular. Thus, soil carbon sequestration has a potential to reduce the net U.S. emissions by 360 MMTC/y. This potential is realizable through promotion of CRP, WRP, erosion control and restoration of degraded soils, conservation tillage, growing cover crops, improving judicious fertilizer use and precision farming, and composting. Actions that improve soil and water quality, enhance agronomic productivity and reduce net emissions of greenhouse gases are truly a win-win situation. It is true that soil carbon sequestration is a short-term solution to the problem of gaseous emissions. In the long term, reducing emissions from the burning of fossil fuels by developing alternative energy sources is the only solution. For the next 50 years, however, soil carbon sequestration is a very cost-effective option, a "bridge to the future" that buys us time in which to develop those alternative energy options.

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Table 1. Recommended practices for soil C sequestration

| Practice | Potential rate of soil carbon sequestration (t/ha/yr) |
|---|---|
| Conservation tillage & mulch farming | 0.1–0.5 |
| Compost and manuring | 0.05–0.5 |
| Elimination of summer fallow | 0.05–0.4 |
| Growing winter cover crops | 0.2–0.5 |
| Integrated nutrient management/precision farming | 0.1–0.4 |
| Improved varieties and cropping systems | 0.05–0.4 |
| Water conservation and water table management | 0.05–0.3 |
| Improved pasture management | 0.05–0.3 |
| Afforestation/reforestation | 0.08–0.4 |
| Fertilizer use in forest soils | 0.8–3.0 |
| Restoration of eroded mineland and otherwise degraded soils | 0.3–1 |

Source: Lal et al. (1998); Follett et al. (2000); Birdsey (2000)

Table 2. Total potential of U.S. agricultural soils for carbon sequestration.

| Strategy | Potential of soil carbon sequestration (MMT C/yr) |
|---|---|
| Land conversion and restoration | 17–39 |
| Intensification of cropland | 75–208 |
| Improved management of grazing land | 30–110 |
| Improved management of forest soils | 49–189 |
| Total | 71–546 (360) |

Source: Lal et al. (1998); Follett et al. (2000); Birdsey (2000); Kimble et al. (2002)

Table 3. Potential sink capacity of terrestrial ecosystems.

| Activity | Sink capacity (MMTC/yr) |
|---|---|
| Above-ground forest | 247 |
| Soils | 360* |
| Landfill | 2 |
| Total | 609 |

*The soil sink potential can be realized through policy intervention, and needs to be adjusted for hidden carbon costs of input used.

Table 4. Potential of soil carbon sequestration.

| State/region | Potential (MMTC/y) |
|---|---|
| Ohio | 8–12 |
| U.S.A. | 147–546 |
| World croplands | 600–1200 |

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STATEMENT OF JOSEPH L. BAST, PRESIDENT, THE HEARTLAND INSTITUTE

Thank you, Mr. Chairman, for inviting me to testify here today. My testimony is based on a joint research project by economists at The Heartland Institute, the Hudson Institute, and the American Farm Bureau Federation. Our opinions are our own.

Carbon sequestration, the topic of this hearing, certainly appears from a distance to be an attractive alternative to mandating reductions in greenhouse gas emissions, especially since many experts believe forcing utilities and other significant emitters to reduce emissions is very costly and would produce few offsetting benefits. But upon closer inspection, carbon sequestration faces daunting problems of its own.

I would like to call your attention to four such problems.

1. Paying farmers and livestock producers to sequester carbon would lead to heavy-handed and potentially ruinous regulation of farms and ranches.

Farmers can indeed help store more carbon in their crops and soil, but farming especially dairy farms and cattle ranches is also a significant source of greenhouse gases. It is unrealistic to expect the industry would be for long exempted from the same emission permit requirements imposed on other emitters. Soon, other regulations would be imposed on farmers in the name of fighting global warming, including limitations on production per acre for some crops, mandatory fallowing of crop land, limits and restrictions on livestock production, and restrictions on the use of fertilizer.

2. Endorsing sequestration may mean endorsing "cap and trade" programs, which in turn means higher energy costs.

Without a government-imposed cap on greenhouse gas emissions, few emitters would need to buy the emission permits farmers would earn by sequestering more carbon. But a cap and trade program would have the same effect as an energy tax, and such a tax would have to be set high the equivalent of $0.50 a gallon of gasoline or more in order to reduce emissions enough to make a difference.

Higher energy prices would dramatically reduce profits in the U.S. agricultural sector. Farmers stand to see their net profits fall by as much as 84 percent, and typically 50 percent, if gasoline taxes are raised by 50 cents per gallon. Total annual U.S. farm production expenses would rise over $20 billion. Since it is difficult for farmers to pass cost increases along to consumers, a cap and trade greenhouse gas program could cause a 48 percent decrease in net farm income.

3. Environmentalists will be disappointed, too. Even if a carbon sequestration program benefited farmers, it would do little to moderate global warming. Agricultural soils in the U.S. today capture only one-twentieth of 1 percent of total annual greenhouse gas emissions, according to EPA, or 1 percent according to USDA. According to EPA, agricultural greenhouse emissions are 35 times greater than the amount being sequestered. And once saturation levels were reached, there could be no more gains on cropland with known farming systems, meaning sequestration is not a long-term solution.

The biggest gains in carbon storage occur when cropland is returned to forests. Subsidizing tree planting, however, would reduce U.S. farm exports and prompt more farm output in countries where there are no artificial constraints on farming. This would lead to more clearing of forests in Third World countries, where deforestation is already a major problem. On a global scale, more carbon, not less, would be released into the atmosphere.

4. Emissions trading is more problematic than its advocates admit.

The ubiquitous presence of carbon dioxide in ambient air makes it very difficult to associate emissions with any specific source. Unlike sulfur dioxide, there are potentially hundreds of thousands or even millions of sources of carbon dioxide and other greenhouse gases. To avoid participants "gaming the system," complex and probably unenforceable rules would be needed to determine that emission reductions are genuine, entity-wide, and net of any increases in emissions caused by higher energy use or other emission-generating activity in some other division of a plant or company, either concurrently or at some later time.

Existing emissions trading programs are characterized by thin markets, government over-regulation that kills innovation, changing rules that leave investors high and dry, verification problems, and government meddling. All this uncertainly will, and quite rightly should, discourage participation by businessmen and women. The new Sarbanes–Oxley Act, which criminalizes even minor accounting mistakes, could hold the chief executive officer liable if a restatement of the value of permits earned or purchased becomes necessary.

I conclude that carbon sequestration by farmers and ranchers in the U.S. is a false hope for those seeking to be paid to do what they would do anyway. It is a false dream for environmentalists who see it as a major part of the solution to global warming. And it is a poor strategy for an industry that should know better than to join a movement composed of groups and individuals who have been among its most strident critics.

Thank you again for giving me this opportunity to be with you today. I am happy to answer any questions you might have.

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STATEMENT OF DEBBIE A. REED, LEGISLATIVE DIRECTOR, GLOBAL WARMING CAMPAIGN, DIRECTOR, NATIONAL ENVIRONMENTAL TRUST

*Introduction*

Mr. Chairman and members of the Subcommittee, I am Debbie Reed, the Global Warming Campaign Director and Legislative Director at the National Environmental Trust, a nonprofit organization located in Washington, DC, with an organizing presence in 15 States. The National Environmental Trust conducts public education campaigns on important environmental issues through media education and field outreach.

I am pleased to have this opportunity to share my expertise and that of the National Environmental Trust on what we feel is perhaps the greatest environmental issue confronting the world today: global climate change. While climate change is one of several important campaigns we work on at the National Environmental Trust, it is an overarching issue which affects virtually all the areas that we are concerned with as an organization. We commend this Committee and the Senate for dealing with the issue, and hope that you will continue to grapple with ways to reduce U.S. emissions of greenhouse gases (GHG).

Global climate change can have a major impact on agriculture, and yet agriculture can play a positive role in helping to combat climate change. These two areas are of particular interest to me and my organization. Prior to joining NET in 2000, I was the Legislative Director and Director of Agricultural Policy at the White House

Climate Change Task Force, and I previously worked for Senator J. Robert Kerrey of Nebraska, and at the U.S. Department of Agriculture. It was while I worked for Senator Kerrey that I began working on the issue of agriculture and global climate change. Coming from a largely rural, agricultural State, Senator Kerrey was concerned first with the impact of global climate change on agriculture, which, as a business conduced largely outdoors, may be hardest hit by increased global temperatures, changes in precipitation, and severe weather events. He was equally concerned with strategies to deal with climate change in order to prevent the potentially devastating consequences of unmitigated global warming. Fortunately, there is a nexus between agriculture and mitigation strategies to begin dealing with climate change.

U.S. agriculture can make important, cost-effective contributions to offset a portion of U.S. emissions of GHG in the near-and medium-term. But it is no panacea, nor is it a solution. With the proper mix of policies and incentives, agriculture can provide a bridge to a less fossil carbon-intensive future, while improving the sustainability and perhaps profitability of a beleaguered but nonetheless vital U.S. economic sector. Agriculture and climate change policy, approached correctly, offer truly "win-win" opportunities for society and the environment.

I will limit my remarks today to the U.S. situation and domestic agricultural policies and practices, but the impacts of these policies and practices are universal. The same process by which agricultural soils absorb carbon, leading to improved agricultural sustainability and soil fertility and reduced erosion, also helps to reverse desertification and soil degradation in lands the world over.

Forests and forest soils are also important carbon reservoirs in the U.S. and worldwide. Currently, deforestation, or the cutting and clearing of forests, accounts for approximately 25 percent of global GHG emissions, and is responsible for significant environmental degradation.[1] Policies to protect forest ecosystems and manage forests for climate change benefits are extremely important, but are not the focus of my testimony.

http://www.ipcc/ch/pub/un/syreng/spm.pdf.

Global Warming is Occurring As the overwhelming majority of scientists internationally and in this country have concluded, global climate change is occurring, and is linked to increased atmospheric concentrations of GHG.[2] Evidence continues to accumulate that human activities and man-made GHG are contribute to global climate change.[3] Fossil fuel combustion in the U.S. and globally accounts for the greatest amount of GHG emissions and increasing atmospheric concentrations, but other activities, including land use, land-use change and agriculture, also contribute.[4]

Just last week, on July 2, 2003, the World Meteorological Organization issued an unprecedented alert indicating that record extremes in weather and climate events were continuing to occur around the world, stating: "(r)ecent scientific assessments indicate that, as the global temperatures continue to warm due to climate change, the number and intensity of extreme events might increase."[5] The Organization documented recent extreme weather events in several countries, including the following in the United States:

"In the United States, there were 562 tornados during May, which resulted in 41 deaths. This established a record for the number of tornados in any month. The previous monthly record was 399 tornadoes in June 1992. In the eastern and southeastern part of the US, wet and cold conditions prevailed for well over a month. Weekly negative temperature anomalies of—2 degrees Celsius to—6 degrees Celsius were experienced in May while precipitation excesses, ranging from 50 mm to 350 mm over a period of more than 12 weeks starting in March 2003, have been recorded."

To prevent dangerous consequences from climate change, the U.S. and other countries must reduce our reliance on the burning of fossil energy sources.[6] Mandatory policies to reduce GHG emissions are needed to command the resources and ingenuity necessary to convert to a less fossil-carbon-intensive future, and in a time-

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[1]IPCC, (2001), "Third Assessment Report Climate Change 2001", The Third Assessment Report of the Intergovernmental Panel on Climate Change, IPCC/WMO/UNEP. Summary for Policymakers

[2]Ibid.

[3]Ibid.

[4]Ibid; U.S. Department of State, U.S. Climate Action Report 2002, Washington, DC, May 2002. Report at http://www.epa.gov/globalwarming/publications/car/index.html.

[5]World Meteorological Organization, WMO–No 695, Geneva, 2 July 2003.

[6]IPCC, (2001), "Third Assessment Report Climate Change 2001", The Third Assessment Report of the Intergovernmental Panel on Climate Change, IPCC/WMO/UNEP. Summary for Policymakers http://www.ipcc/ch/pub/un/syreng/spm.pdf.

frame that prevents potentially devastating consequences for our society and others. Such policies, once enacted, will take time to implement. But until the U.S. begins to approach global climate change with credible policies that reduce net GHG emissions, we should pursue with vigor strategies such as agricultural sequestration to help offset as much of our emissions as possible.

*Global Warming is a Threat to Agriculture*

U.S. agricultural is a major industry. Farming contributed $80.6 billion (0.8 percent) to the national gross domestic product (GDP) in 2001.[7] The U.S. agricultural sector provides the safest, most abundant and economical food and fiber supply in the world, and is the engine behind U.S. growth and prosperity, literally fueling our ability to prosper. However, farmers and many rural communities operate on the financial edge, within narrow profit margins and under variable environmental conditions. The threat of global warming and potentially severe weather events jeopardize the very livelihood of farmers and rural communities, as well as the ability of agriculture to continue to fuel U.S. prosperity. The potential impact of global climate change on agriculture should not and cannot be ignored.

Some general circulation models (GCMs) predict that regional temperatures and moisture shifts caused by warming trends will require adaptive changes in agriculture across the country.[8] However, predictions for reduced crop yields, increased flooding, droughts, pests and diseases also raise the possibility that U.S. agricultural production will be harmed.[9] U.S. farmers are a resilient, market-savvy group, keeping up with futures markets and trade boards, reacting as necessary to optimize profits and remain viable. However, catastrophic storm events can overwhelm a farmer's resilience and ability to adapt, as can changes in moisture that can devastate harvests, forage, and livestock production. Warmer climates also favor the proliferation of insect pests and crop and livestock diseases. Potential severe weather events, such as flooding or drought, can overwhelm not just individual farmers, but entire communities and regions. The agricultural sector and rural communities alike thus have vested interests in addressing the threat of climate change.

*Agriculture and Forestry as a Source and Sink of GHG Emissions*

Agriculture and forestry currently represent a "net sink" in the U.S., and helped to offset just over 7 percent of U.S. emissions in 1999. The enactment of policies to promote more widespread adoption of proven management practices to enhance this sink effect can boost this potential above current "business as usual" levels. Agricultural soils were but 0.6 percent of the total net sink, for instance, but scientists estimate the soils have the capacity to offset up to 10 percent of U.S. emissions.

Total U.S. emissions in 1999 were 1840 million metric tons of carbon equivalents (MMTCE).[10] The agricultural and forestry sectors contributed roughly 134 MMTCE, or 7 percent of total U.S. emissions, but also reduced emissions by 270 MMTCE, or nearly 15 percent of total U.S. 1999 GHG emissions. Thus, agriculture and forestry accounted for a net reduction of 137 MMTCE, or just over 7 percent of total U.S. emissions in 1999.

Approximately 91 percent of the "net sink" effect of agriculture and forestry (or approximately 125 of the 137 MMTCE) was due to forest sequestration, including trees, forest soils, and harvested wood. Agricultural soils accounted for 8 percent of the 137 MMTCE net sink, or 11 MMTCE.[11] For both agricultural soils and forests, this represents the net sink effect under current, "business as usual" conditions.

*Agriculture as a source of GHG Emissions*

Agriculture contributes emissions of 3 of the 6 GHG's of concern: carbon dioxide, methane, and nitrous oxide. For $CO_2$, agricultural emissions are primarily from fossil fuel use, soil carbon release, and biomass burning. Methane emissions from agriculture are primarily from enteric fermentation in ruminant animals, rice cultivation, and biomass burning. For nitrous oxides, soils, fertilizers, manures and bio-

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[7] U.S. Department of Commerce, Bureau of Economic Analysis, http://www.bea.gov/bea/dn2/gpoc.htm).

[8] International Food and Policy Research Institute, 2020 VISION: "Global warming changes the forecast for agriculture," April 2001. (http://www.ifpri.org/2020/newslet/nv—0401/nv—0401—Global—Warming.htm)

[9] Rosenzweig, C., A. Iglesias, X.B. Yang, P.R. Epstein, and E. Chivian, "Climate Change and U.S. Agriculture: The Impacts of Warming and Extreme Weather Events on Productivity, Plant Disease, and Pests;" Center for Health and the Global Environment, Harvard Medical School, May 2000.

[10] U.S. Department of State, U.S. Climate Action Report 2002, Washington, DC, May 2002. Report at http://www.epa.gov/globalwarming/publications/car/index.html

[11] Ibid.

mass burning contribute to releases from agriculture, with the greatest amount coming from the use of fertilizers.

Reductions from any of these sources can help to offset U.S. emissions. Scientists and policymakers are working on many of these areas.

For example, wind power on agricultural lands can reduce some of our reliance on fossil fuel combustion, as can the production of renewable energy sources and biofuels produced from agricultural materials (plant materials, animal wastes). Changes in tillage practices and the use of cover crops can reduce on-farm fuel use and nitrogen fertilizer applications rates. Methane from livestock and manures can be reduced through improved diets and changes in manure treatment. And soil carbon sequestration can be increased through improved management practices such as no-till and other conservation practices, the use of shelterbelts, grass waterways, site specific management, restoration of wetlands, and improved irrigation management, to name a few. Taken individually and together, these practices can make significant contributions toward offsetting our national emissions.

The Conservation Technology Information Center (CTIC), a public-private partnership dedicated to sharing information and data on agricultural management systems, estimates that approximately 80 percent of environmental issues that result from cropland and cropping practices can be corrected with the proper management approaches, including integrated conservation tillage.[12]

*Production Agriculture as a Sink*

I would like to focus specifically on agricultural soils, and practices that can increase soil carbon sequestration. Changes in tillage practices can reduce fossil fuel use; result in net sequestration of $CO_2$ in soils as soil organic carbon, or humus (the "life bread" of soils); reduce nitrous oxide emissions from soils and fertilizers; improve water quality; and increase wildlife habitat. Simply put, soil carbon enhances agricultural sustainability. Fortunately, soil carbon is a component of soil that can be changed via management practices.

Soil scientists estimate that the potential for U.S. agricultural soils to sequester additional carbon ranges from 98–276 MMTCE per year (average 187 MMTCE per year) which represents fully 10 percent of U.S. annual emissions.[13] However, this capacity represents the upper potential for soils, and would only occur if all cropland soils were immediately managed to maximize carbon uptake. If that were to occur, the ability of these soils to absorb carbon at these levels would still fall over time, since soils have a finite ability to absorb carbon, until a 'saturation' level is achieved. Rates of carbon sequestration drop as saturation levels are approached. In other words, maximization of agricultural soil carbon sequestration could mitigate up to 10 percent of our national emissions annually, but only for a 10-to 20-year period. But that timeframe is enough to offset some of our emissions as we transition our economy away from the current reliance on fossil fuels, and toward a less fossil-carbon intensive energy base. Agriculture can be a band-aid, but it won't prevent global climate change.

*Soil Carbon: Multiple benefits to farmers and society*

Agricultural and soil scientists have measured the carbon content of soils for more than a century; USDA maintains test plots where they've collected and monitored soil carbon content for well over 100 years. Carbon monitoring in soils did not begin because of a potential link to global warming, however. The carbon content of soils is indicative of the "health" of soils. Increased soil carbon content or soil carbon sequestration leads to improved soil "tilth" (structure), thus reducing erosion of soils from wind and water; improved soil fertility and crop productivity; reduced runoff of agricultural nutrients and chemicals; and improved air quality.

Soil carbon content is increased via the addition of organic matter to soils also known as "humus." Plants, via photosynthesis, remove $CO_2$ from the air for the production of plant biomass, which over time is sequestered in the soil as soil carbon, or humus. The carbon remains sequestered and stable in the soil as long as it is not disturbed or tilled. Tillage or the turning over of soils leads to exposure of the humus, and the resulting release of carbon. Thus, traditional tillage practices that "inverted" soils have led to the release of carbon. In this way, conversion of lands for agricultural uses in this country historically has led to emissions of carbon dioxide. Traditional tillage practices continue to add to U.S. carbon releases, albeit at a lower rate, since most agricultural soils that are traditionally tilled have reached a low-point of carbon emissions, a near-equilibrium.

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[12]Conservation Technology Information Center (WWW.ctic.purdue.edu).

[13]Lal, R., R.F. Follett, J.M. Kimble, 2003, pre-publication data.

Scientists have shown that the adoption of conservation or no-till by farmers can reverse the historic and continued carbon loss thus helping to reduce U.S. emissions, while contributing to agricultural sustainability and ancillary environmental benefits.[14]

*Farmer's Experiences with No–Till: Practice Confirms Research*

Some compelling stories from farmers who have converted to conservation tillage and no-till farming perhaps best provide a picture of the many benefits to society and farmers of this management practice. At a February, 2003 congressional briefing on global warming and soil carbon sequestration,[15] Elmon Richards of Richards Farms in Circleville, Ohio shared his experiences with Senate and House staff.

Beginning in the 1970's, Richards Farms began planting their 3,500 acres of corn and soybeans without tilling the soil. By converting to "no-till," they found that the time it took to plant their fields was significantly reduced, as were fuel use, labor and equipment costs. Through experimentation they additionally found that by planting crop rows closer together, the crop canopy developed earlier and reduced the use of herbicides for weed control. Despite initial reduction in yields, the Richards' found that after 5 years of complete no-till on their croplands, yields increased back to pre-conversion rates or even higher, due mainly to increased soil quality and improved water infiltration and retention. Additionally, the carbon content of the soils started to increase, leading to improved aggregate stability and higher earth worm populations in other words, the soil began to look more like natural soils, teaming with biological life.

Among the benefits of no-till farming documented by the Richard's family are:

- the need for fewer, smaller tractors;
- the need for fewer tractor passes over fields;
- reduced fuel use;
- reduced labor costs; and
- more free time.

More specifically, the tractors the Richards' used for conventional tillage consumed an average of 3–4 gallons of fuel per acre for chiseling, disking, field cultivating, planting and spraying. The smaller no-till tractors consume an average of 0.3 to 0.4 gallons of fuel per acre for planting and spraying or one-tenth the fuel use per acre.

If we were to apply the Richards' figures on a national scale, we can begin to appreciate the potential impacts of just one aspect of this agricultural management change. Cropland nationwide accounts for 420 million acres, of which about 240 million are used for the major grain crops. Traditional tillage methods on these 240 million acres would use approximately 840 million gallons of fuel to till and plant. Using the Richards' data, fuel use would drop to 96 million gallons nationwide for no-till planting a savings of 744 million gallons of fuel annually. Since each gallon of fuel burned releases 6.1 pounds of carbon to the atmosphere, a reduction of 744 million gallons would reduce carbon emissions from fuel savings alone by approximately 2.1 MMTCE per year[16] which does not even account for the carbon sequestered in the soil!

Gordon Gallup of Idaho, who is currently President of the Idaho Grain Grower's Association, offers similar evidence of the benefits of no-till. Gordon, his wife and sons currently farm about 3,000 acres in a wheat-barley rotation on the Snake River plateau in Southeast Idaho. The Gallup's switched to no-till in 1985, and documented the following results:

- Tractor hours reduced from 1,400 to 120 per year;
- Water adsorption tests show the soils adsorb at a rate of 3.25 inches per hour of rainfall, compared to the neighbor's conventionally tilled soils, which adsorb at 0.6 inches per hour;
- "Phenomenal soil structure," evidenced by rarely having to clean sediment basins (which collect eroded soil sediments) since converting to no-till;
- Higher yields (higher profit) during drought years, compared to neighbors who conventionally till;

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[14]Lal, R., J.M. Kimble, R.F. Follett, and C.V. Cole, "The Potential of U.S. Cropland to Sequester Carbon and Mitigate the Greenhouse Effect," Sleeping Bear Press, Inc., 1998.

[15]February 10–11, 2003 briefing on Agriculture and Climate Change, sponsored by the National Environmental Trust, the National Academy of Sciences, the Conservation Technology Information Center, the American Society of Agronomy, the Crop Science Society of America, the Soil Science Society of America, and the National Farmers Union; and hosted by Senators Sam Brownback and Tom Harkin, and Congressmen Wayne Gilchrest and John Olver.

[16]Calculation: [(774 million gal. fuel X 6.1 tons carbon per gal. fuel)/2000 lbs/ton) x 0.907 U.S. tons to metric tons = MMTCE].

- No significant difference in crop diseases between the Gallups' fields and neighboring, conventionally tilled fields; and
- Carbon content of soils has more than doubled.

Terry Davis of Roseville, Illinois also shared his experiences with congressional staff at the February briefing. Among the benefits he emphasized, Terry documented the effect of no-till on water infiltration, run-off, and soil erosion. He found that carbon sequestration from no-till:

- Significantly improved water infiltration and the water holding capacity of his soils, and virtually eliminated run-off and soil loss (compared to neighboring fields experiencing same weather impacts);
- Led to an increase in the organic content of his soils from 2.1 percent in 1980 to 3.4 percent in 1995 an increase in soil carbon content of nearly two-thirds; and
- Allowed him to cut nitrogen fertilizer applications by 50 percent, which translates into less nitrous oxide emissions and less leaching of nitrates into groundwater (which would ultimately end up in the Gulf of Mexico).

Finally, the following data are from farmers in the Colonial Soil and Water Conservation District in nearby Virginia. Conversion to no-till planting:

- Reduced run-off by 75 percent;
- Reduced sediment loss by 98 percent;
- Reduced nitrogen fertilizer losses in run-off by 95 percent;
- Reduced phosphorus run-off by 92 percent; and
- During Hurricane Floyd in 1999 (a 500+ year storm event), the soils held up incredibly well, showing no evidence of concentrated flows, a lack of down-stream bank erosion, of sediment deposition, and affected vegetation.

*Barriers to Adoption of Conservation Tillage*

The percentage of total planted acres in the U.S. under conservation tillage rose from 25 percent in 1989 to nearly 37 percent in 2002.[17] No-till increased from 5 to 20 percent in that same period. While not all crops and soils are suited to no-till, policies to promote conservation tillage could ensure greater adoption rates.

The Richards', the Gallups', Terry Davis and other agricultural producers have attested that landowners are reticent to change from conventional tillage to no-till for a variety of reasons, including: tradition and culture; the prohibitive costs of purchasing or renting new equipment; and the need for technical assistance.

There is a 2–5 year 'risk period' when converting from traditional to conservation tillage, where management practices are unfamiliar, and soils need to become "reestablished" in the absence of tillage. Technical assistance is especially important during this period. However, some farmers are unable to weather the short-term drop in yields during the 'risk period' even though yields tend to rebound and in many cases are higher under no-till, once the soil and the farmer adapt to this management change. Financial incentives may help.

Finally, it is important to ensure that policies to promote practices that optimize carbon sequestration do not have unintended (negative) environmental impacts. Assessments of the impacts on other GHG and on wildlife should be conducted prior to enactment.

*Measurement, Monitoring, and Verification of Soil Carbon Content*

Soil carbon content and changes in content can be accurately measured and monitored, and have been for many years. Farmers routinely collect soil samples to determine fertilizer application needs, and soil carbon is one of the parameters measured. Over two million such samples are collected every year, and these samples document changes in carbon over time. Specific sampling performed at experimental plots also shows changes in carbon content over time.

Natural variability of soils and carbon content of soils exists, even within the same field, making it difficult to accurately assess soil carbon content over large areas without a large number of soil samples. However, recent research has shown that soil scientists can apply their knowledge of landforms (topography) to selectively and precisely measure carbon within fields such that the aggregate carbon content of the soils can be reported with less than 10 percent variability.[18] Such data can then be extended to large areas with the use of computer modeling, soil maps, and other resource information.

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[17]Conservation Technology Information Center, Crop residue management data. (WWW.ctic.purdue.edu).

[18] Nishantha, F., G. Watson, C. Rice, J. Kimble, and M. Ranson, "Establishment of Benchmarks for the Measurement and Monitoring of Soil Carbon Sequestration," pre-publication data.

With additional research, rates of change in soil carbon content can be calculated and predicted for various management practices, and remote sensing and other methods can be used to confirm and calibrate carbon data. Models such as CENTURY are already being used to show changes in soil carbon content over time in areas as large as the continental U.S.[19] Continued work can enhance the accuracy of the data at smaller spatial scales, to ensure accuracy at the field level for individual farmers.

*Carbon Markets*

Carbon markets are forming and operating in this country. The concept of emissions trading can provide financial opportunities to farmers who sequester additional carbon (i.e., above "business as usual") on their lands. Agriculture offers the prospect of sequestering carbon in a low-cost, societally beneficial way for the emerging carbon market. If carbon tons sequestered on agricultural lands are to be traded or sold by farmers, it is important that such issues as baselines, additionality, leakage and permanence be addressed, and that transparent accounting protocols be developed.

*Conclusions*

Credible policies to reduce net U.S. GHG emissions are needed to prevent the potential economic, social, and environmental consequences of unmitigated climate change. The agricultural sector is particularly vulnerable to global climate change and severe weather events, but with the right mix of policies and incentives to enhance its sink effect, agriculture can also help to mitigate the greenhouse effect by reducing U.S. GHG emissions. The enhanced sink effect of agriculture can be a "win-win" for the sector, for farmers, for society, and the environment, but it is not a panacea for greater action. Rather, it can be a useful and cost-effective bridge as we transition to a less fossil carbon intensive future.

I would be happy to answer any questions you have about any portion of my testimony.

Thank you.

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STATEMENT OF CYNTHIA ROSENZWEIG, GODDARD INSTITUTE FOR SPACE STUDIES AT COLUMBIA UNIVERSITY

Agriculture and climate are mutually dependent. Their interactions involve temperature effects, water supply and demand, and fluxes of carbon through the processes of photosynthesis and respiration. Climate also affects the crop pests and predators. Climate is important not only in terms of average conditions, but also in regard to the frequency and intensity of extreme events, such as floods, droughts, and heat spells.

Agricultural soils can be both a contributor to and a recipient of the effects of a changing climate. In the past, land management has generally resulted in considerable depletion of soil organic matter and the release of carbon dioxide. Now, there is the potential to restore soil organic carbon through improved management techniques, enhancing soil structure and fertility and helping to counter climate change. An important caveat is that the capacity for agricultural soil carbon sequestration is constrained by the amount of carbon lost during the conversion of natural ecosystems to agriculture, so that its effectiveness as a mitigating activity for climate change is not unlimited.

After nearly two decades of research on potential impacts of climate change on agriculture (see Rosenzweig and Hillel, 1998), attention is now turning to mitigation and adaptation responses. Mitigation actions such as carbon sequestration in agricultural soils are aimed at reducing the atmospheric concentration of $CO_2$ and other greenhouse gases, thereby countering climatic change. Adaptation actions such as changes in crop types and management practices are responses that optimize production under changing climate conditions. Research on these actions is proceeding on parallel tracks.

Here, we analyze these response actions and suggest that it is both useful and necessary for them to be considered jointly. A review of a combination of approaches, including field experiments, regression analyses, and modeling studies, leads to the following conclusions regarding how a changing climate may influence agriculture and how mitigation and adaptation responses may interact:

1) Agriculture regions will experience change over time. Effects on agricultural production systems will be heterogeneous across the Nation and the world. Some

[19]Kimble, J.M., R. Lal, and R.F. Follett, eds, "Agricultural Practices and Policies for Carbon Sequestration in Soil," CRC Press LLC, 2002.

regions will experience increases in production and some declines, due to the presence of minimum and maximum thresholds for crop growth. Adaptations, such as adjustments in planting dates, crop types, and irrigation regimes will likely be required. Geographic shifts in crop growing areas are likely to occur, with associated changes in production systems. Some production systems will likely expand while others contract. Although climate-influenced changes to agriculture are likely in the coming decades, the magnitudes and rates of these changes are uncertain at the regional scale, given the range of projected temperature and precipitation changes from global climate models and the unknown degree of manifestation of direct physiological effects of increasing $CO_2$ on crops growing in farmers' fields.

2) Agricultural production in developing countries is more vulnerable. Despite general uncertainties, studies have consistently shown that overall production in the mid-and high latitudes is likely to benefit in the near term (approximately to mid-century), while production systems in the low-latitudes are likely to decline. This finding has implications for world food security, since most developing countries are located in lower-latitude regions. The vulnerability of developing countries is related to the growth of crops under current climate conditions nearer their optimum temperature limits and the potential for greater increases in water stress under a warming climate. Developing countries also have fewer resources for development of appropriate adaptation measures to counter negative impacts.

3) Long-term effects on agriculture are negative. If climate change effects are not abated, agricultural production in the mid-and high-latitudes is likely to decline in the long term (approximately by the end of 21st century). These results are consistent over a range of projected temperature, precipitation, and direct $CO_2$ effects tested. They are due primarily to detrimental effects of heat and water stress on crop growth as temperatures rise. Increased climate variability under climate change is also likely to negatively affect agriculture.

4) A changing climate will affect mitigation potential. Responses to a changing climate will contribute to determining which mitigation techniques are successful, and at what levels, over the coming decades. Because some carbon-sequestration projects have long durations (?40–50 years needed to accumulate carbon in agricultural soils in temperate regions), farmers may need to consider which sequestration techniques have the better chance to succeed under changing climatic regimes. Our research shows that the soil carbon sequestration potential of agricultural soils is likely to vary under changing climate conditions (Fig. 1). If changing climate is not taken into consideration, calculations of carbon to be sequestered may be in error.

5) Mitigation and adaptation responses are synergistic. Conversely, mitigation practices can also enhance the adaptation potential of agricultural systems. For example, carbon sequestration in agricultural soils leads to more stable soil-water dynamics, enhancing the ability of crops to withstand drought and floods, both of which may increase under changing climate conditions. In addition, many of the strategies proposed for reduction of greenhouse gas emissions from agriculture are "best practices," i.e., they increase input efficiency while limiting environmental damage. For instance, use of tree shelterbelts can help to minimize soil erosion and stabilize soil carbon; mulches added between row crops help to conserve soil water, reduce erosion, and sequester carbon (Fig. 2).

6) Mitigation practices may help to make the U.S. agriculture sector "carbon-neutral." A combination of management techniques, from reduced or no-tillage, to modified irrigation and fertilization application, has the potential to sequester ?50 million tons of carbon yearly, approximately matching yearly greenhouse gas emissions from the U.S. agricultural sector, estimated at ?50 million tons carbon (Fig. 3). Recall, however, the caveat that the capacity for agricultural soil carbon sequestration is constrained by the amount of carbon previously lost during conversion to agriculture, so that its effectiveness as a mitigating activity for climate change is not unlimited.

In conclusion, our research suggests that planning and implementation of mitigation and adaptation measures in response to the global climate change issue should be coordinated and proceed hand-in-hand. Investments in programs and research will be needed to assure effectiveness in both adaptation and mitigation activities for U.S. agriculture.

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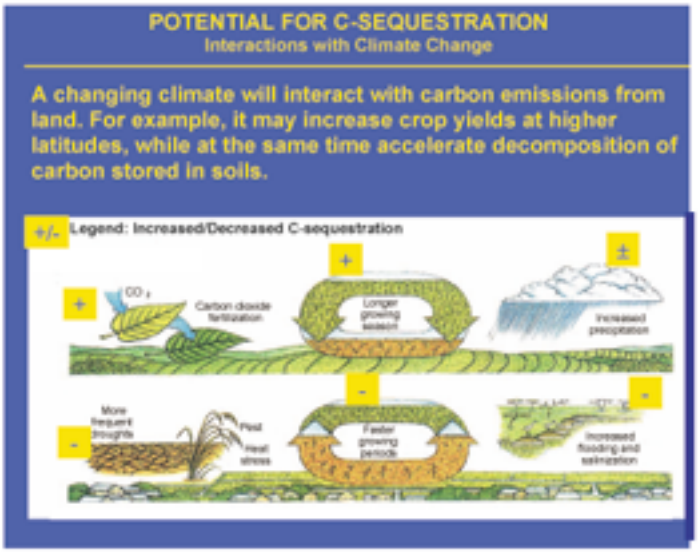


**Fig. 1**. Interactions of a changing climate with soil carbon sequestration (Source: Tubiello, 2002; Scientific American).

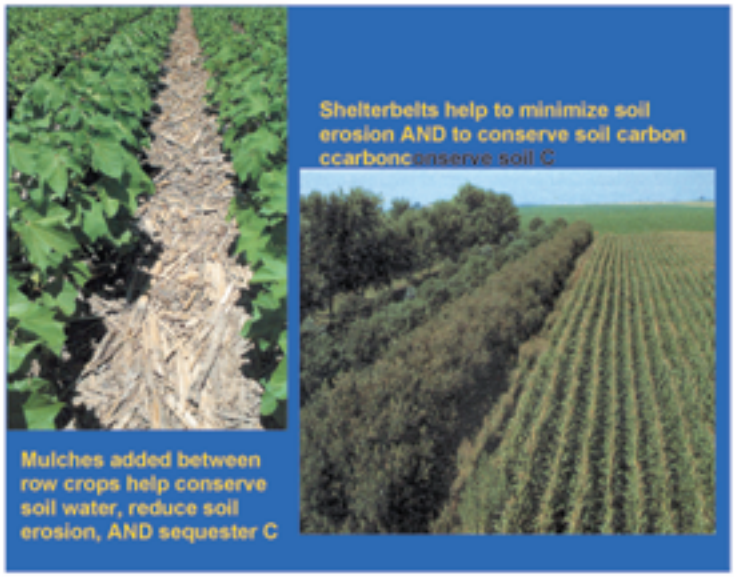


**Fig. 2**. Potential synergies between adaptation and mitigation actions. (Source: GISS, 2002; CAST).

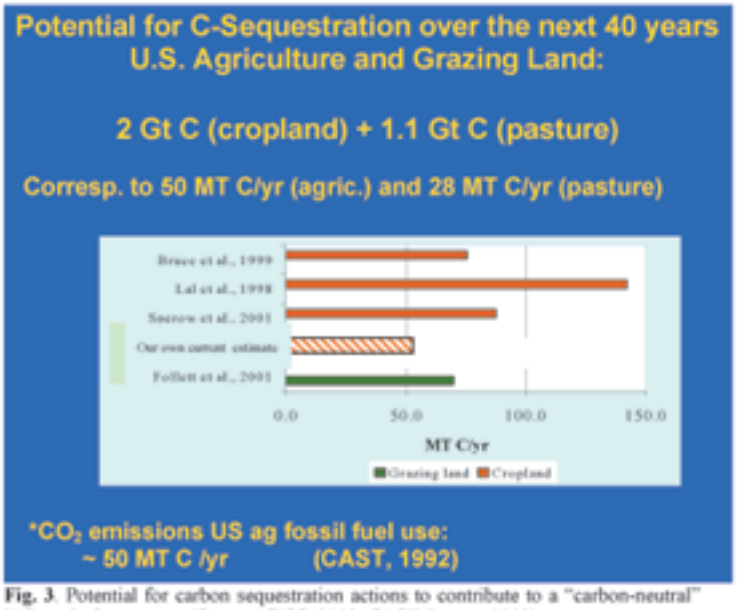


**Fig. 3**. Potential for carbon sequestration actions to contribute to a "carbon-neutral" U.S. agriculture sector (Source: GISS, 2002; CAST Report, 1992).

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STATEMENT OF DAVID J. FREDERICKSON, PRESIDENT, NATIONAL FARMERS UNION

Chairman Voinovich, Ranking Member Carper, and Members of the Subcommittee, I am grateful to have the opportunity to submit a statement on behalf of the National Farmers Union 300,000 independent, diversified, owner-operated family farms and ranches from 27 States across the Nation. We commend your efforts today to discuss the complex issues surrounding agriculture production, carbon sequestration and climate change.

What we do know is that farmland, rangeland, and forests will play an important role in meeting the challenge of climate change through carbon sequestration and renewable bioenergy. Farmers Union members historically have been very interested in, and our stated policy has specifically called for, increased funding for carbon sequestration and bioenergy research, development, and deployment.

We encourage you to significantly expand efforts to conduct a comprehensive scientific inventory of carbon stored in U.S. soils and to develop methods to predict how soil carbon levels would be affected by different practices and policies. For example, over the past few years the USDA Natural Resources Conservation Service has invested over $3 million in projects to demonstrate and test various means of reducing greenhouse (methane) gas emissions in agriculture, such as compost based waste-handling facilities, rotational grazing systems, and improved feed and forage systems. We suggest that this effort could be expanded and made more comprehensive.

Our farmers and ranchers also see opportunities for increased income and increased environmental benefits in projects that will expand efforts aimed at broadening the use of biomass to produce power, fuels, and chemicals. In the late 1990's we saw funding for this specific research at a level of $251 million; $105 million for USDA and $146 million for the Department of Energy. We encourage you to keep a close eye on the level of basic research funding that will provide the necessary data and information that will hopefully make carbon sequestration and biomass energy and fuels programs a reality for farmers and ranchers.

Our members are agricultural producers, both row croppers and ranchers, and they participate in all of USDA agricultural, rangeland, grassland and forestry conservation programs, in one way or another. Our members also hope to participate in climate change studies and pilot projects, especially if these studies and projects benefit the future of America's family sized farms and ranchers.

Our members are anxious to learn from experiences with farming methods that promote soil carbon sequestration and improve soil quality and agricultural sustainability, as these practices can identify additional benefits beyond carbon sequestration. We have as well supported greater emphasis on improved farm management techniques, because we believe that teaching farmers to be the best possible stewards of their resources is a better long-term approach to sustainability than simple land retirement.

It is said that the feed-grain crops and soils most prevalent in the areas farmed by our membership are among the highest in potential carbon sequestration, especially in our row crop farming States. We will be glad to see the results of a National Soil Carbon Inventory that might verify this claim, so that our farmers and ranchers can better understand and realize the potential benefits they are producing for climate change efforts, especially now that it is grasped that they might be considered active participants in a global climate change carbon sequestration program. Our farmers and ranchers want to contribute to and participate in programs that produce potential environmental and biomass energy benefits for our country.

Our membership is also very interested in any studies that will help us better understand the potential future consequences of global climate change as it affects the various farming regions of the United States. We have seen that climate changes brought about by the El Nino and La Nina events in the past few years have affected the U.S. farming regions in different ways. We hope to better understand these phenomena so that out family farmers and ranchers can plan for the future, and so that policymakers can make voluntary climate change and agricultural policy more effective for our producers.

However, if there are costs associated with climate change and carbon sequestration policy approaches that result in an undue burden borne by the family farm and ranch, we will ask that Congress actively seek an appropriate mechanism that will provide incentives for the cash-strapped family owned farm and ranch to participate fully in these initiatives.

We as well look forward to the further development of legislative initiatives that have already been offered (that we are aware of) in this Congress such as Senator Carper's Clean Air Planning Act of 2003 (S. 843); Senator Lieberman's Climate Stewardship Act of 2003 (S. 139); and Senator Jeffords' Clean Power Act of 2003 (S. 366). We think the voluntary programs that have been described in these types of legislative vehicles could be valuable in pushing forward initiatives that could create useful opportunities for farmers and ranchers.

Thank you for the chance to offer our comments today and we look forward to working with you and your staff's on these important issues.

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## INTEGRATING CONSERVATION PRINCIPLES INTO THE DEVELOPMENT OF ACCOUNTING RULES AND GUIDELINES FOR TERRESTRIAL CARBON SEQUESTRATION: A WHITE PAPER OF THE INTERNATIONAL ASSOCIATION OF FISH & WILDLIFE AGENCIES

### *Introduction*

This paper is intended to serve as a guide to the International Association of Fish and Wildlife Agencies (IAFWA) member agencies, as well as the conservation community in general, in developing and articulating positions relative to pending and future policies and legislation pertaining to carbon sequestration. Specifically, this paper will deal with the issue of accounting rules and guidelines that are to be developed for terrestrial carbon sequestration, and how conservation principles can and should be integrated into those rules and guidelines. We will offer the view that carbon sequestration is, in essence, a conservation issue, with tremendous potential to not only offset the emissions of greenhouse gases through the storage of carbon, but also to restore the ecological functions of terrestrial ecosystems and their capacity to store carbon.

Much in the same way that Farm Bill conservation programs have had a tremendous impact on the Nation s wildlife and fish habitats since 1986, carbon sequestration programs are likely to be as influential, if not more so, on the landscapes of tomorrow. Therefore, the conservation community must devote the same level of attention to the development of these new programs as we have to the Farm Bill conservation programs that we are already familiar with. Considering that land in the United States is a finite resource, which is being subjected to increasing pressure

to provide a variety of societal needs, it is essential that carbon sequestration initiatives accomplish as many additional environmental purposes as possible. It will be a poor bargain for society if efforts to offset greenhouse gases through carbon sequestration result in a diminishing of other natural resources for which society would have to pay separately and additionally to correct.

*Background*

Carbon sequestration can be defined as the capture and secure storage of carbon that would otherwise be emitted to or remain in the atmosphere. As the Department of Energy s third approach (in addition to increased fuel efficiency, and alternative technologies) in managing greenhouse gas emissions in the United States, carbon sequestration is believed to have immediate potential to reduce greenhouse gases in ways and at a cost that is both economically feasible and environmentally acceptable. The Department of Energy in its "Carbon Sequestration Technology Roadmap" has identified two goals for carbon sequestration, one of which is to demonstrate environmental acceptability. However, some in the environmental community have expressed ideological resistance to carbon sequestration as a greenhouse gas management tool, primarily due to its being seen as solely an emissions-offset issue, and a way around other strategies to reduce greenhouse gas emissions, such as increased efficiency of automobiles, or the use of alternative technologies to produce energy.

In addition to the release of atmospheric carbon through the emissions of fossil fuels, another major cause of the loss of stored carbon, as much as 50 percent over the last 50–70 years, has been the wide-scale alterations in the landscape through de-forestation and conversion to agriculture, urbanization, and other activities. According to USDA (2002), "The dominant drivers in terrestrial carbon emissions have been the conversion of forest and grassland to crop and pastureland, and the concomitant depletion of soil carbon from conventional agricultural management practices." This has resulted in increased carbon emissions to the atmosphere and reduced capacity of the terrestrial ecosystem to capture and store atmospheric carbon.

On February 14, 2002, President Bush announced his Administration s Global Climate Change Initiative, which is aimed at reducing the growth of GHG emissions in the U.S. while sustaining economic growth. The President established a target of reducing the greenhouse gas intensity of the U.S. Economy (a measure of the ratio of GHG emissions to Gross Domestic Product) by 18 percent over the next 10 years. As part of the Global Climate Change Initiative, a range of new and expanded domestic energy policies will be implemented, including carbon sequestration. To accomplish this aspect of the initiative, President Bush "directed the Secretary of Agriculture to provide recommendations on further, targeted incentives for forest and agricultural sequestration of greenhouse gases. The President further directed the Secretary of Agriculture, in consultation with the Environmental Protection Agency and Department of Energy, to develop accounting rules and guidelines for crediting sequestration projects, taking into account emerging domestic and international approaches."

Through terrestrial carbon sequestration, the Department of Energy has established "regional improvements in ecosystem stability, biodiversity and water quality" as expected outcomes of the ancillary or collateral benefits of terrestrial carbon sequestration. In other words, conservation benefits are seen only as a potential byproduct of terrestrial carbon sequestration. However, there is also potential and the need to create a paradigm whereby terrestrial carbon sequestration is seen as an ecosystem restoration tool, providing both carbon storage benefits and ecosystem restoration benefits. Without this new paradigm becoming an integral component in the development of carbon storage programs, the potential for programs with harmful impacts to natural ecosystems and their health will increase.

*Conservation Issues*

As the development of accounting rules and guidelines moves forward, there are a number of issues that the conservation community should be prepared to address. The resolution of these issues will greatly influence whether carbon sequestration will be viewed as an environmental asset or an environmental liability. To strengthen carbon sequestration s potential as an environmental asset, public agencies with fish and wildlife population management responsibilities must be brought into the decisionmaking process.

- Terrestrial carbon sequestration, as the third approach in managing greenhouse gas emissions, will become a conservation catalyst, much the same way that farm policies and other major land use policies have been catalysts for large-scale habitat change in the past. This force for change has both positive and/or negative potential impacts on ecosystems and their habitats.

- Terrestrial carbon sequestration will introduce an economic variable into land use and land management decisions that will likely be unprecedented in scope, and unknown in effect. In essence, carbon sequestration programs will affix an economic value onto an ecological function, a value which heretofore has never been part of the equation in making land use or land management decisions.
- Without appropriate guidelines and restrictions and/or incentives, economic forces of carbon sequestration could negatively influence the ability to restore native habitats and ecosystem integrity. Non-native species may be shown to possess greater carbon storage capability than native species, thus creating an economic market force that will provide cheaper carbon storage methods, but yield no ecological benefits, or perhaps even cause further degradation of ecosystems.
- Within the environmental community, a number of organizations harbor an ideological resistance to carbon sequestration programs, seeing these programs as ways to avoid other alternatives for reducing greenhouse gases. Without incorporating conservation principles into the development of guidelines and accounting rules, ideological resistance to carbon sequestration programs is likely to become stronger and broader among many mainstream conservation organizations, especially if carbon programs result in adverse impacts to floral and faunal communities.

*The Farm Bill and Carbon Sequestration*

The President s Global Climate Change Initiative has identified the Farm Bill and its conservation provisions as a primary vehicle for accomplishing significant carbon sequestration benefits in the next 10 years. In his fiscal year 2003 budget, President Bush requested a $1 billion increase in Farm Bill funding "as part of a 10-year (2002–20 11) commitment to implement and improve the conservation title of the Farm Bill, which will significantly enhance the natural storage of carbon." Activities and program objectives pertaining to carbon sequestration are identified in three titles of the 2002 Farm Bill:

- Title 2, Conservation. Sec. 1240H. Conservation Innovation Grants *"implement projects, such as". . . . "(B) innovative conservation practices, including the storing of carbon in the soil"*
- Title 8, Forestry. Sec. 4. Forest Land Enhancement Program Program Objective #4 is *"Increasing and enhancing carbon sequestration opportunities."*
- Title 9, Energy. Sec. 9009. Cooperative Research and Extension Projects Purposes:
  - Developing data addressing carbon losses and gains in soils and plants (including trees) and the exchange of methane and nitrous oxide from agriculture;
  - Understanding how agricultural and forestry practices affect the sequestration of carbon in soils and plants (including trees);
  - Evaluating the linkage between Federal conservation programs and carbon sequestration;
  - Developing methods, including remote sensing, to measure the exchange of carbon and other greenhouse gases sequestered, and to evaluate leakage, performance, and permanence issues.

It is clear that the Farm Bill will be of emerging importance as a vehicle for delivering a significant portion of the Nation s carbon sequestration efforts. Coupled with the Secretary of Agriculture s responsibilities "to provide recommendations on further, targeted incentives for forest and agricultural sequestration of greenhouse gases" and "to develop accounting rules and guidelines for crediting sequestration projects", conservation organizations must be prepared to become engaged in this process to ensure that sound conservation policies are considered and incorporated into carbon sequestration program development.

*Operating Principles to Guide the Development of Accounting Rules and Guidelines*

The following principles are offered as guiding principles for IAFWA and its member organizations in developing positions and recommendations relative to carbon sequestration accounting rules and guidelines.

- Adopt a Conservation-based Vision of Terrestrial Carbon Sequestration
  - The vision should recognize that carbon sequestration is a conservation issue in a fundamental sense, and not just in an ancillary or collateral sense.
  - The vision should be eco-regionally based (temperate forests, forested wetlands, prairies, grasslands, etc.), recognizing that different ecosystems have inherently different carbon storage mechanisms and capabilities, and carbon sequestration activities should be tailored to those capabilities while recognizing the priority fish and wildlife habitat needs unique to each eco-region.
- Apply the *Principle of Concurrent Restoration* to determinations.

- The *Principle of Concurrent Restoration* seeks to restore the natural ecological capability of the terrestrial ecosystem to store carbon by promoting policies and guidelines that will restore that ecosystem in an environmentally sustainable way. Carbon sequestration activities should not diminish other natural resources, including fish and wildlife.

*Principle of Concurrent Restoration: Whereas the process of terrestrial carbon sequestration involves the restoration of a degraded ecological function, the restoration of that function should not come at the expense of other ecological functions and values and should in fact produce concurrent restoration benefits.*

- Identify fish and wildlife as public resources that are managed by States for the benefit of present and future generations.
  - These public resources make significant contributions to the Nation s economy through fish and wildlife-related recreation, with 82 million participants spending over $100 billion in 2001. Because terrestrial carbon sequestration has the potential to alter the current landscape and habitats that fish and wildlife depend on, States occupy an important and unique role as a stakeholder in the development of these programs. Rules and guidelines that assign value to land use and that may result in large-scale conversions of habitat require consultation with State fish and wildlife agencies.

*USDA Accounting Rules and Guidelines*

As the USDA moves through its process of developing accounting rules and guidelines, as directed by the President, there are a number of issues and questions concerning their development that should be addressed relative to the *Principle of Concurrent Restoration* for terrestrial carbon sequestration. Therefore, we offer the following conservation principles that should be considered in evaluating and developing recommendations relative to Accounting Rules and Guidelines:

- Qualifying activities for terrestrial carbon sequestration should provide benefits to both carbon sequestration and ecological restoration. Under Section 1605(b) of the *Energy Policy Act of 1992*, the Department of Energy developed a Voluntary Reporting of Greenhouse Gases Program, including voluntary reporting of carbon sequestration projects. Within this program, a number of forestry and agricultural activities are listed with potential carbon sequestration benefits. Some activities, such as afforestation of agricultural lands, have the potential to provide ecological benefits if conducted with an ecological restoration objective. Likewise, such activities could also adversely impact wildlife habitat if, for instance, exotic species were used or a monoculture plantation forest were established. The Department of Energy also recognizes that prairie and grassland ecosystems hold great promise to provide carbon storage benefits, though less work has been conducted in these systems compared to forested systems. Therefore, carbon sequestration programs designed for prairie and grassland ecosystems should be carefully constructed to maintain and/or enhance the ecological integrity of the system while providing carbon storage benefits.
  - Qualifying activities should be eco-regionally based, to ensure compatibility of carbon sequestration practice(s) with the climate and soil characteristics of the area. Incentives should be established to promote and encourage carbon sequestration projects that include an ecological restoration component.
  - Qualifying activities should require or provide incentives to use native species rather than exotic or invasive species in carbon sequestration projects.
  - Qualifying activities should require or provide incentives for carbon sequestration projects to promote diverse landscapes utilizing endemic species as opposed to exotic or monoculture systems (except in cases where restoring natural forests favor monoculture systems, e.g., longleaf pine ecosystems). These incentives should be developed for both forested and prairie ecosystems.
  - Qualifying activities should encourage and promote the development of carbon sequestration projects utilizing natural vegetation systems, as opposed to "enhanced" vegetation.
  - Qualifying activities for primary and secondary existing forests should include provisions that allow and encourage thinning and other forest stand improvement practices, when needed, to reduce excessive stocking levels. This will result in benefits to many wildlife species, with the added benefit of increased timber quality at the end of the rotation.
  - Careful consideration must be given to the integration of carbon sequestration benefits and credits into existing Farm Bill conservation programs such as the Conservation Reserve Program and the Wetlands Reserve Program. Likewise, new Farm Bill conservation programs, such as the Conservation Security Program and Grassland Reserve Program have the potential to sig-

nificantly influence conservation on private lands, and provide further carbon sequestration benefits. If carbon sequestration benefits are included as part of the ranking process for these programs, they should not detract from other intended conservation benefits to wildlife habitat, soil conservation, and water quality, and in fact should be structured to enhance these benefits. If carbon sequestration credits are to be allowed within these publicly financed programs, then practices should be required to provide concurrent environmental benefits.

- Addressing the issues of additionality, leakage, permanence, and verification
  - To ensure that carbon sequestration programs result in a net gain of stored carbon within an environmentally sustainable context, the issues of additionality (carbon storage benefits accrued in addition to what would occur in the absence of a carbon project), leakage (migration of carbon emitting activities such as logging or land clearing to other areas outside the project area, effectively offsetting carbon sequestration benefits), permanence (duration of carbon storage methods), and verification (methods for measuring and verifying carbon sequestration benefits) should be addressed with careful consideration of their ecological impacts.
- Addressing the issue of scale
  - Scale refers to the land area that will be used to determine baseline carbon storage capacity (no carbon offset programs in place), and also to evaluate additionality and leakage as carbon programs are established. The scale for carbon sequestration programs should be of sufficient size to enable effective monitoring of additionality and leakage. At a minimum, carbon programs should be accounted for and reported at the county level. This would allow for State and region-wide summaries with minimal effort. However, consideration for an ecological scale is also warranted, which will require more sophisticated measurements and analyses. Therefore, carbon projects should be geospatially referenced, to allow for GIS analyses utilizing remote sensing data and other technologies.
- Development of demonstration and research projects
  - In the energy title (Title IX) of the 2002 Farm Bill, emphasis is placed on developing demonstration and cooperative research projects to further the understanding of carbon sequestration on the carbon cycle, increase the understanding of how agricultural and forestry practices affect the sequestration of carbon in soils and plants, develop cost-effective means of measuring and monitoring changes in carbon pools in soils and plants, evaluate the linkage between Federal conservation programs and carbon sequestration, and to establish benchmark standards for future carbon programs. However, none of these objectives will lead to an evaluation of environmental acceptance of carbon storage methods, or whether concurrent restoration benefits will result. Therefore, In addition to these objectives, demonstration projects should assess concurrent restoration benefits and the environmental acceptability of carbon sequestration methods. Demonstration projects should also promote additionality, and not result in the conversion of native grasslands to forests or other non-native systems.
- Monitoring and evaluation should address not only the carbon response, but also the ecological response.
  - A monitoring and evaluation component for a carbon sequestration program should be able to evaluate the following: 1) Sequestration estimates and measurement; 2) Baseline development; 3) Leakage assessment; 4) Permanence; 5) Ecological benefits, including habitat restoration, water quality, flood storage, etc.

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INTERNATIONAL ASSOCIATION OF FISH AND WILDLIFE AGENCIES
444 NORTH CAPITOL STREET, NW,
*Suite 544, Washington, DC 20001, February 28, 2003*

Mr. WILLIAM HOHENSTEIN
*Global Change Program Office*
*United States Department of Agriculture*
*Room 12-A, J.L. Whitten Building*
*1400 Independence Ave., NW*
*Washington, DC 20250–3814*

DEAR MR. HOHENSTEIN: The International Association of Fish and Wildlife Agencies (Association) appreciates the opportunity provided by the United States Department of Agriculture (USDA) to comment on the development of revisions to the agri-

culture and forestry sections of the Voluntary Greenhouse Gas Reporting Program and accounting rules and guidelines for crediting carbon sequestration projects in agriculture and forestry.

The Association represents all 50 State fish and wildlife agencies and their interest in the professional management of the Nation s fish and wildlife resources. Along with fish and wildlife agencies from Canada and Mexico and many non-governmental conservation organizations that are contributing members, the Association develops, supports and defends legislation, rules and policies which safeguard and improve the well-being of North America s fish and wildlife resources.

Much in the same way that Farm Bill conservation programs have had a tremendous impact on the Nation s wildlife and fish habitats since 1986, carbon sequestration programs are likely to be as influential, if not more so, on the landscapes of tomorrow. Considering that land in the United States is a finite resource, which is being subjected to increasing pressure to provide a variety of societal needs, it is essential that carbon sequestration initiatives accomplish as many additional environmental purposes as possible. It will be a poor bargain for society if efforts to offset greenhouse gases through carbon sequestration result in a diminishing of other natural resources for which society would have to pay separately and additionally to correct.

The Association believes that carbon sequestration is, in essence, a conservation issue, with tremendous potential to not only offset the emissions of greenhouse gases through the storage of carbon, but also to restore the ecological functions of terrestrial ecosystems and their capacity to store carbon. Rather than viewing terrestrial carbon sequestration activities as simply a carbon storage mechanism that may have some ancillary or collateral conservation benefits that occur by chance, we believe carbon sequestration activities should be viewed as an ecosystem restoration tool, with the express purpose of providing both carbon storage benefits and ecosystem restoration benefits. Rules and guidelines developed for greenhouse gas reporting and sequestration accounting should make clear the expectation that qualifying activities will provide benefits to both carbon sequestration and ecological restoration and protection. The Association offers the following operating principles to guide development of accounting rules and guidelines by USDA and the Department of Energy (DOE):

- *Adopt a conservation-based vision of terrestrial carbon sequestration.* The vision should recognize that carbon sequestration is a conservation issue in a fundamental sense, and not just in an ancillary or collateral sense. The vision should be eco-regionally based (temperate forests, forested wetlands, prairies, grasslands, etc.), recognizing that different ecosystems have inherently different carbon storage mechanisms and capabilities, and carbon sequestration activities should be tailored to those capabilities.
- *Apply the Principle of Concurrent Restoration to determinations.* The Principle of Concurrent Restoration seeks to restore the natural ecological capability of the terrestrial ecosystem to store carbon by promoting policies and guidelines that will restore that ecosystem in an environmentally sustainable way. Carbon sequestration activities should not diminish other natural resources, including fish and wildlife.

  *Principle of Concurrent Restoration:* Whereas the process of terrestrial carbon sequestration involves the restoration of a degraded ecological function, the restoration of that function should not come at the expense of other ecological functions and values and should in fact produce concurrent restoration benefits.
- *Fish and wildlife are public resources that are managed by States for the benefit of present and future generations.* The economic benefits generated by the Nation s fish and wildlife resources are enormous, with 82 million U.S. residents 16 years old and older participating in fish and wildlife associated recreation and spending over $100 billion in 2001. Because terrestrial carbon sequestration has the potential to alter the current landscape and habitats that fish and wildlife depend on, States occupy an important and unique role as a stakeholder in the development of these programs. Rules and guidelines that assign value to land use and that may result in large-scale conversions of habitat require consultation with State fish and wildlife agencies.

Without incorporating these operating principles into the development of guidelines and accounting rules, ideological resistance to carbon sequestration programs is likely to become stronger and broader among many mainstream conservation organizations, especially if carbon programs result in adverse impacts to floral and faunal communities.

As the USDA and DOE move through the process of developing accounting rules and guidelines, there are a number of issues and questions concerning their development that we believe must be addressed relative to the Principle of Concurrent Restoration for terrestrial carbon sequestration:

• *Qualifying activities for terrestrial carbon sequestration should provide benefits to both carbon sequestration and ecological restoration.* Under DOE's Voluntary Reporting of Greenhouse Gases Program, a number of forestry and agricultural activities are listed with potential carbon sequestration benefits. Some activities, such as afforestation of agricultural lands, have the potential to provide ecological benefits if conducted with an ecological restoration objective. Likewise, such activities could also adversely impact wildlife habitat if, for instance, exotic species were used or a monoculture plantation forest were established. DOE also recognizes that prairie and grassland ecosystems hold great promise to provide carbon storage benefits, though less work has been conducted in these systems compared to forested systems. Therefore, carbon sequestration programs designed for prairie and grassland ecosystems should be carefully constructed to maintain and/or enhance the ecological integrity of the system while providing carbon storage benefits.

- Qualifying activities should be eco-regionally based, to ensure compatibility of carbon sequestration practice(s) with the climate and soil characteristics of the area. Incentives should be established to promote and encourage carbon sequestration projects that include an ecological restoration component.
- Qualifying activities should require or provide incentives to use native species rather than exotic or invasive species in carbon sequestration projects.
- Qualifying activities should require or provide incentives for carbon sequestration projects to promote diverse landscapes utilizing endemic species as opposed to exotic or monoculture systems (except in cases where restoring natural forests favor monoculture systems, e.g., longleaf pine ecosystems). These incentives should be developed for both forested and prairie ecosystems.
- Qualifying activities should encourage and promote the development of carbon sequestration projects utilizing natural vegetation systems, as opposed to "enhanced" vegetation.
- Qualifying activities for primary and secondary existing forests should include provisions that allow and encourage thinning and other forest stand improvement practices, when needed, to reduce excessive stocking levels. This will result in benefits to many wildlife species, with the added benefit of increased timber quality at the end of the rotation.
- Careful consideration must be given to the integration of carbon sequestration benefits and credits into existing Farm Bill conservation programs such as CR? and WRP. Likewise, new Farm Bill conservation programs, such as the Conservation Security Program and Grassland Reserve Program have the potential to significantly influence conservation on private lands, and provide further carbon sequestration benefits. If carbon sequestration benefits are included as part of the ranking process for these programs, they should not detract from other intended conservation benefits to wildlife habitat, soil conservation, and water quality, and in fact should be structured to enhance these benefits. Carbon sequestration credits should be allowed within these publicly financed programs in ways that will provide concurrent restoration benefits. All carbon sequestration projects developed with government financing should be clearly identified and tracked as such to distinguish them from privately financed projects.

• *How will demonstration and/or research projects be developed?* In the energy title (Title IX) of the 2002 Farm Bill, emphasis is placed on developing demonstration and cooperative research projects to further the understanding of carbon sequestration on the carbon cycle, increase the understanding of how agricultural and forestry practices affect the sequestration of carbon in soils and plants, develop cost-effective means of measuring and monitoring changes in carbon pools in soils and plants, evaluate the linkage between Federal conservation programs and carbon sequestration, and to establish benchmark standards for future carbon programs. However, none of these objectives will lead to an evaluation of environmental acceptance of carbon storage methods, or whether concurrent restoration benefits will result. Therefore, in addition to these objectives, demonstration projects should assess concurrent restoration benefits and the environmental acceptability of carbon sequestration methods. Demonstration projects should also promote additionality, and not result in the conversion of native grasslands to forests or other non-native systems.

• *How will additionality, leakage, permanence, and verification be addressed?* To ensure that carbon sequestration programs result in a net gain of stored carbon within an environmentally sustainable context, the issues of additionality (carbon storage benefits accrued in addition to what would occur in the absence of a carbon project), leakage (migration of carbon emitting activities such as logging or land clearing to other areas outside the project area, effectively offsetting carbon seques-

tration benefits), permanence (duration of carbon storage methods), and verification (methods for measuring and verifying carbon sequestration benefits) should be addressed with careful consideration of their ecological impacts. The concept of independent third party verification of emission reductions could also be applied to verification of ecosystem restoration benefits by enlisting the State agency with resource management responsibility (e.g., the State fish and wildlife agency) to verify project benefits, such as whether the project contributes to fish and wildlife resource management objectives.

- *How should the issue of scale be incorporated?* Scale refers to the land area that will be used to determine baseline carbon storage capacity (no carbon offset programs in place), and also to evaluate additionality and leakage as carbon programs are established. The scale for carbon sequestration programs should be of sufficient size to enable effective monitoring of additionality and leakage. At a minimum, carbon programs should be accounted for and reported at the county level. This would allow for State and region-wide summaries with minimal effort. However, consideration for an ecological scale is also warranted, which will require more sophisticated measurements and analyses. Therefore, carbon projects should be geospatially referenced, to allow for GIS analyses utilizing remote sensing data and other technologies.
- T3Monitoring and evaluation should address not only the carbon response, but also the ecological response. A monitoring and evaluation component for a carbon sequestration program should be able to evaluate the following: 1) Sequestration estimates and measurement; 2) Baseline development; 3) Leakage assessment; 4) Permanence; 5) Ecological benefits, including habitat restoration, water quality, flood storage, etc.

The Association commends USDA and DOE for soliciting input from stakeholders on revisions to the Voluntary Greenhouse Gas Reporting Program and the accounting rules and guidelines for carbon sequestration projects through public workshops and the opportunity to submit written comments. The Association looks forward to working with USDA and DOE as the process moves forward to insure that conservation benefits become an integral part of the reporting and accounting rules and guidelines.

Sincerely,

JOHN G. BAUGHMAN,
*Executive Vice President,*
*National Farmers Union.*

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