GLOBAL WARMING'S GROWING CONCERNS: IMPACTS ON AGRICULTURE AND FORESTRY

HEARING

BEFORE THE

SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING HOUSE OF REPRESENTATIVES

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GLOBAL WARMING'S GROWING CONCERNS: IMPACTS ON AGRICULTURE AND FORESTRY

THURSDAY, JUNE 18, 2009

HOUSE OF REPRESENTATIVES,
SELECT COMMITTEE ON ENERGY INDEPENDENCE
AND GLOBAL WARMING,
Washington, DC.

The committee met, pursuant to call, at 9:33 a.m. in Room 2175, Rayburn House Office Building, Hon. Edward J. Markey [chairman of the committee] presiding.

Present: Representatives Markey, Blumenauer, Herseth Sandlin, Salazar, Cleaver, Speier, Inslee, Sensenbrenner, and Blackburn.

Staff present: Ana Unruh-Cohen and Aliya Brodsky.

The CHAIRMAN. This hearing is called to order.

On Tuesday, the Obama administration released a new report, "Global Climate Change Impacts in the United States." It is the most comprehensive look at the current and potential impacts of global warming on the United States to date.

The results are sobering. Temperatures are increasing. Sea level is rising. More extreme downpours are occurring. The report makes clear that global warming is happening and that the impacts are now being felt in every region of America and across society.

Today, in the first of a series of hearings on that report, we are examining the impacts of global warming on agriculture and forestry. All Americans should be concerned with the impacts on these critical sectors. We all must eat. We all use products from forests every day.

The findings of the report that rising temperatures, precipitation changes, and increasing weeds, disease and pests will impact the productivity of farms and forests should make all of us apprehensive. Land managers rely on the cumulated knowledge about their land, weather, and crops. But climate change is rewriting the Farmers' Almanac. The past is no longer prologue, and farmers must make decisions in the face of growing uncertainty. The serious consequences for agriculture and forestry provide yet another reason to take action now to curb global warming pollution.

The report indicates that the growing season now starts 2 weeks earlier, impacting farming and crops in rural America. Heavy downpours in the last 50 years increased 67 percent in the Northeast and 31 percent in the Midwest. Unsurprisingly, this time has been marked by record flooding in those regions. Yet, in the rapidly growing Southwest, they face a different climate challenge as water supplies are becoming increasingly scarce.

Indeed, farmers and foresters are already suffering the consequences of climate change. But unlike other impacted sectors, they can also contribute to the solutions. According to the Environmental Protection Agency, U.S. forests and soils sequestered over 1 billion metric tons of carbon dioxide in 2007, almost 15 percent of the Nation's greenhouse gas emissions. Land management practices designed to increase this carbon sink can pull even more carbon dioxide out of the atmosphere.

Biomass can be used to generate renewable electricity, reducing global warming pollution from the burning of fossil fuels. Biomass can also produce renewable liquid fuels, allowing American consumers desperate for energy independence the ability to power their cars with cellulosic fuels from Middle America rather than oil from the Middle East.

Wind turbines are sprouting on farms and ranches, generating clean electricity, while continuing the land's traditional use for food production.

These practices are already growing clean-energy jobs and generating new revenue in our rural communities. With the right energy and climate policies, American farmers and foresters will play a crucial role in curbing the dangerous build-up of global warming pollution while creating new sources of income; money can grow on trees after all.

The witnesses before us will help the select committee understand the challenges and opportunities global warming presents to U.S. agriculture and forestry. I look forward to their testimony.

Let me now turn and recognize the ranking member of our committee, the gentleman from Wisconsin, Mr. Sensenbrenner.

[The prepared statement of Mr. Markey follows:]

Openings Statement
Chairman Edward J. Markey
"Global Warming's Growing Concerns: Impacts on Agriculture and Forestry"
June 18, 2009

On Tuesday, the Obama Administration released a new report, *Global Climate Change Impacts in the United States*. It is the most comprehensive look at the current and potential impacts of global warming on the United States to date.

The results are sobering. Temperatures are increasing. Sea-level is rising. More extreme downpours are occurring. The report makes clear that global warming is happening and that the impacts are being felt now in every region of America and across society.

Today -- in the first of a series of hearings on the report -- we are examining the impacts of global warming on agriculture and forestry. All Americans should be concerned with the impacts on these critical sectors. We all must eat. We all use products from forests every day.

The findings of the report that rising temperatures, precipitation changes and increasing weeds, disease and pests will impact the productivity of farms and forests should make us all apprehensive. Land managers rely on the accumulated knowledge about their land, weather and crops, but climate change is rewriting the Farmer's Almanac. The past is no longer prologue, and farmers must make decisions in the face of growing uncertainty. The serious consequences for agriculture and forestry provide yet another reason to take action now to curb global warming pollution.

The report indicates that the growing season now starts 2 weeks earlier, impacting farming and crops in rural America. Heavy downpours in the last 50 years increased 67 percent in the Northeast and 31 percent in the Midwest. Unsurprisingly, this time has been marked by record flooding in those regions. Yet in the rapidly growing Southwest, they face a different climate challenge as water supplies are becoming increasingly scarce.

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These practices are already growing clean energy jobs and generating new revenue in our rural communities. With the right energy and climate policies, American farmers and foresters will play a crucial role in curbing the dangerous build up of global warming pollution while creating new sources of income. Money may grow on trees after all!

The witnesses before us today will help the Select Committee understand the challenges -- and opportunities -- global warming presents to U.S. agriculture and forestry. I look forward to their testimony.

Mr. SENSENBRENNER. Thank you very much, Mr. Chairman. Today's hearing gives the select committee the opportunity to explore the impacts the proposed climate legislation will have on the agriculture industry and the effect that it will have on consumers.

The House Democratic leadership has spent the last 2 months rushing to pass a carbon emissions reduction scheme that I call cap-and-tax. I call it cap-and-tax because the legislation is a hidden energy tax that will increase the price of nearly every staple in American life, including electricity, goods and services, and gasoline. Today's hearing will allow us to explore how this flawed policy will hurt American farmers.

Cap-and-tax will reduce the security of America's food supply. If the government mandates a cap on fossil fuel emissions, many utilities will switch from coal to natural gas to generate electricity because natural gas produces fewer CO_2 emissions. As demand for natural gas rises, the price will rise as well. But natural gas isn't used solely for electricity. As Ford West, president of The Fertilizer Institute says in his written testimony, there is no substitute for natural gas in nitrogen production.

The U.S. domestic nitrogen fertilizer industry supplied about 85 percent of America's nitrogen in the 1990s, but the high cost of natural gas has moved much of this production and its jobs overseas. Today, just 55 percent of this vital farming resource is made in the United States. Much of the imported nitrogen is made in places that offer cheap natural gas like the Middle East, China, Russia, and Venezuela. These countries have no restrictive climate policies like cap-and-tax, and their energy efficiency is generally lower than that in the United States.

Mr. West cites a study by the Doane Advisory Services that shows that a cap-and-tax scheme would add $6 billion to $12 billion in additional costs for farmers by 2020.

A recent study by the Heritage Foundation on the Democrat's cap-and-tax proposal also shows the devastating effects this scheme will have on agriculture. Farmers will be forced to pay more, and those costs will be reflected in the price of nearly every agricultural product. The Heritage study shows that increases in costs are expected to reduce farmers' incomes by $8 billion in 2012, and by more than $50 billion in 2035. The average net income loss between 2010 and 2035 is projected to be $23 billion.

With numbers like these, it isn't surprising that 37 food and agriculture groups have opposed the cap-and-tax legislation. In addition to expanding taxes, cap-and-tax will expand the government, especially the Environmental Protection Agency.

Because enforcement of a true carbon cap would debilitate the U.S. economy, the legislative proposal currently before the House of Representatives allows covered entities to make substantial portions of their reduction outside the cap go through what are called offsets. The bill allows 2 billion tons of offsets per year, 1 billion of which must come from domestic sources. The value of these billion offsets will easily reach into the tens of billions. Because the cap is so broad, agriculture and forestry are the only areas where offsets can be applied. The result will be tens of billions of tax dollars flowing into the farm industry.

As financial and auto industries have learned, Federal money does not come without strings. Under the current bill, the EPA will be in charge of pulling these strings, and the EPA has no useful experience regulating agriculture.

We have already got a whiff of what would happen if the EPA tries to regulate greenhouse gases. The American Farm Bureau Federation has said that if the EPA were to apply the Clean Air Act to greenhouse gases, nearly every dairy, cattle, and swine farm would fall under the regulations, resulting in literally a cow flatulence tax. The EPA has sworn this isn't their plan, but to exclude these farms from the regulations the EPA would have to take steps to exempt them, steps that could be challenged in court. This is the kind of absurd regulation that is exactly the type of policy we could see if the EPA becomes too involved in regulating greenhouse gases and agriculture production.

Republicans believe that any climate change legislation must meet four simple principles: It must protect jobs and the economy; produce tangible improvements to the environment; advance technological progress; and feature international participation, including that of China and India. If we keep these principles in mind, we can address climate without threatening American farmers or our economic health.

And I thank the Chair.

The CHAIRMAN. I thank the gentleman very much.

The Chair recognizes the gentleman from Oregon, Mr. Blumenauer.

Mr. BLUMENAUER. Thank you, Mr. Chairman.

And I do appreciate your having the hearing at this time. I am a little frustrated, because I have two other hearings that are going on. I did want to be here at least for the beginning and wanted to share some of my support for what you are doing, because there is nobody that has a greater stake in our getting our policies right with greenhouse gases more than agriculture. They have much at risk. We are seeing it in the Northwest with declining snow pack, with changing temperature patterns. If we don't get this right, agriculture and forestry, in the area that I represent, will be seriously at risk.

Second, we have legislation that has been advanced from our friends on the Energy and Commerce Committee, which our distinguished Chair has helped craft, that can make a big difference for farmers, opportunities for farms and forests to reduce global warming pollution, for them to make money. As my good friend, the ranking member, pointed out, there are potentially billions of dollars available for American agriculture. This is an important opportunity. They also can earn more money, and we are seeing this in my State, leasing their land for wind turbines.

A national renewable portfolio standard is going to develop that market even more, and thoughtful members of the agricultural community that I have been discussing are excited about it. Done right, there is an opportunity for cleaner fuels to come from forestry and agriculture, not questionable things where it is not clear that it actually creates more energy and has dire economic and environmental consequences. But we can get this right. We can provide a safety net to protect rural families from higher energy prices.

And I commend you, Mr. Chairman, for the work that you have done in your other committee hat to do that.

This is serious business. The notion that somehow there will not be regulation of agriculture, not just for its greenhouse gas emissions but for other things that are consequences of massive family—massive factory farms that put at risk American family agriculture is a pipe dream. We are seeing demands for more thoughtful regulation to protect people, and we are seeing millions of people in urban areas having to spend massive amounts of money to deal with the consequences of not having appropriate environmental regulation. It is coming.

This is part of a framework that can help them make money. Everybody is going to be better off. I appreciate what you are doing with this hearing, and look forward to working with you and other distinguished members of this panel who have the expertise to make sure that we get this right.

Thank you.

The CHAIRMAN. I thank the gentleman.

The Chair recognizes the gentlelady from South Dakota, Ms. Herseth Sandlin.

Ms. HERSETH SANDLIN. Thank you, Mr. Chairman.

I thank you and the ranking member for holding this important hearing today on the impact of climate change on agriculture and forestry.

As the at-large Member for the State of South Dakota, a predominantly rural State, this issue is particularly important to my constituents. Moreover, the opportunities in the agriculture and forestry sectors to participate in mitigating climate change is equally an important topic.

It is estimated that agriculture and forest lands currently sequester approximately 12 percent of our Nation's carbon emissions. With proper proactive management techniques, it has been estimated that the ag and forest sectors can sequester up to 25 percent of emissions. As such, the ag and forestry industries are essential partners in our efforts to mitigate climate change.

Forests can both emit and sequester carbon, and through proper forest management, which includes thinning overstocked stands, working to ensure diversity of types of ages of trees, and other steps, we can increase carbon sequestration.

At the appropriate time, I will look forward to introducing one of my constituents on the panel today, but again, I thank the chairman for holding the hearing and yield back.

The CHAIRMAN. The gentlelady's time has expired.

The Chair recognizes the gentleman from Colorado, Mr. Salazar.

Mr. SALAZAR. Thank you, Mr. Chairman.

I am very interested in this hearing today mainly because I am a farmer, and my wife and I still farm 3,000 acres back in Colorado. So I look forward to hearing your testimony, and I want to thank the chairman for calling this important hearing.

While I have my concerns about the cap-and-trade bill that is coming up, I hope that we get it right. So thank you very much.

[The prepared statement of Mr. Salazar follows:]

Opening Statement
Congressman John T. Salazar
Select Committee on Energy Independence and Global Warming
'Global Warming's Growing Concerns: Impacts on Agriculture and Forestry'
June 18, 2009

Thank you Mr. Chairman.

Good morning, I'm looking forward to hearing the testimony today.

We have a complex problem before us.

The information found in the publication released Tuesday by the U.S. Global Change Research Program is alarming.

The potential impact of global warming on our Agriculture industry and forests is something we need to prepare for.

I'm very interested to hear what the panel members are presenting today.

Colorado, and the 3rd Congressional district, has both rich agricultural resources and millions of acres of forests.

It is a rural district, and as such, has different needs then the urban areas.

Just this week a hearing was held on the Mountain Pine Beetle and Strategies for protecting the West.

Over 2 million acres of forests in Colorado are dead because of mountain pine beetle.

This beetle has reached epidemic levels, in part because of changing climate regimes.

The forests have experienced drought and warmer than normal temperatures. These weather changes have caused the beetle population to explode.

This epidemic will change the landscape of Colorado for decades.

We need to manage our forests for resiliency in the future so they can withstand the changes in weather.

We need a forest of diverse species and ages. To do this we must support our existing forest products industry and encourage new, community based industries that can use the wood.

I am a farmer. Agriculture is a cornerstone of my life and also the District I represent.

In my District we produce wheat, potatoes, barley, beef and many other crops. Agriculture is one of our top three economies.

The demand to produce more food will only increase as the population increases.

Climate change has the potential to negatively affect growth and yield of many crops, as well as increase the populations and vigor of a variety of weed and insect species.

We have to reduce our carbon emissions to lessen the risk of these pests; however we must remember our rural communities as we move forward.

The current formula for distributing allowances to electricity producers heavily favors populous states and larger companies over rural areas and smaller independent producers.

This means rural-state consumers may face a disproportionally high increase on their utility bills compared with consumers in urban areas.

The climate change legislation must consider rural America in its implementation.

Cellulosic ethanol is one of those potential solutions.

A plant in nearby Wyoming just doubled its capacity. The potential of this technology is great if we give it a chance.

Biochar is another technology that has great potential and I look forward to hearing more about it today.

Thank you for your testimony and time today.

The CHAIRMAN. Thank you.

The Chair recognizes the gentleman from Missouri, Mr. Cleaver.

Mr. CLEAVER. Thank you, Mr. Chairman.

Missouri is a part of the U.S. breadbasket, and we produce in our State, at least generally, depending of course on weather conditions, about 382 million bushels of corn a year. And I am very proud to represent a district in a State that is a leader in promoting alternative energy sources.

In 2008, my State, Mr. Chairman, was the third State to begin implementing a renewable fuels standard, requiring the sale of 10 percent ethanol blends when ethanol is cheaper than fossil fuels.

And it is perhaps a little less known that Missouri places outdoor recreation up high in terms of its annual production of revenue. And I think at a time like this, when recreation sometimes bumps heads with agricultural desires and goals, we have got to be very, very careful. And my concern is that global warming is real. It is no longer a political issue. It is an issue revolving around the survival of this planet as we know it. And the more we can produce renewables for fuel, the better off we will be.

As I have said before, we, this world in which we live, went through a time when there were salt wars. People actually fought wars over salt. And then as we progressed and made salt less valuable and alternatives more viable, we stopped having wars over salt. And refrigeration was a big part of it.

And I think the same thing can happen with renewables, alternative fuels, that we can reduce the need to have wars over oil. Not that we have ever had one. But I thought I might just mention that. And so I look forward to listening to our experts and have some questions that I would like to raise that would hopefully help me.

Thank you, Mr. Chairman. I yield back the balance of my time.

[The prepared statement of Mr. Cleaver follows:]

U.S. Representative Emanuel Cleaver, II
5th District, Missouri
Statement for the Record
House Select Committee on Energy Independence and Global Warming Hearing
"Global Warming's Growing Concerns: Impacts on Agriculture and Forestry"
Thursday June 18, 2009

Chairman Markey, Ranking Member Sensenbrenner, other Members of the Select Committee, good morning. I would like to welcome our distinguished panel of experts to the hearing today.

My home state of Missouri sits in the breadbasket of the nation, producing more than 382 million bushels of corn last year. I am proud to represent a state that is a leader in promoting alternative energy sources. In 2008 Missouri was the 3rd state to begin implementation of a renewable fuel standard, requiring the sale of 10 percent ethanol blends when ethanol is cheaper than gasoline. Also last year, Missouri voters enacted a ballot initiative for a Renewable Electricity Portfolio Standard of 15 percent by 2021. The state government and private sector are also working together to investigate potential energy sources such as algae, wastes from forest products, and poultry litter.

Perhaps less well known, is the high value Missourians place on outdoor recreation and the state's wildlife. Missouri has an incredible diversity of species and is home to 85 state parks and historic sites totaling more than 140,000 acres. Annual spending in outdoor recreation in 2006 was more than double the cash receipts for cattle and calves – one of the state's most valuable agricultural commodities.

Domestic, renewable energy can enable our country to achieve real energy independence in a sustainable way and I believe we can do it while also protecting and enjoying our natural spaces.

I thank the panel for their insight and their suggestions concerning the challenges and possibilities ahead for agriculture and forestry as Congress moves ahead with a new national energy and environmental policy.

Thank you.

The CHAIRMAN. I thank the gentleman very much.

And now we are going to turn to our very distinguished panel. Each witness will be recognized for 5 minutes. At 5 minutes, I am going to begin to tap. You will have 15 seconds to conclude your statement after that 5-minute period when I tap, just so I can give you that notice in advance.

STATEMENTS OF JERRY L. HATFIELD, SUPERVISORY PLANT PHYSIOLOGIST, USDA AGRICULTURAL RESEARCH SERVICE, NATIONAL SOIL TILTH LABORATORY; HEATHER S. COOLEY, SENIOR RESEARCHER, PACIFIC INSTITUTE; THOMAS A. TROXEL, DIRECTOR, BLACK HILLS FOREST RESOURCE ASSOCIATION; FORD B. WEST, PRESIDENT, THE FERTILIZER INSTITUTE; AND JOHANNES LEHMANN, ASSOCIATE PROFESSOR OF SOIL FERTILITY MANAGEMENT/SOIL BIOGEOCHEMISTRY, CORNELL UNIVERSITY.

The CHAIRMAN. Our first witness is Dr. Jerry Hatfield, supervisory plant physiologist at the U.S. Department of Agriculture and the lead author on the agriculture chapter in "The Global Climate Change Impacts on the United States" Report. Dr. Hatfield has had a distinguished scientific career, authoring over 325 publications and serving as laboratory director of the National Soil Tilth Laboratory. He has also served as the president of the American Society of Agronomy.

So we thank you, sir. Whenever you are ready, please begin.

STATEMENT OF JERRY L. HATFIELD

Mr. HATFIELD. It is a pleasure to be able to present this information on climate impacts on agriculture to this committee.

Agriculture is extremely sensitive to climate and weather, and resilience of our production systems to changes in climate occurs by understanding these impacts and their effects. It is also important to realize that U.S. agriculture is diverse and that simple, general statements about the impacts of climate are not possible.

Climate change is evidenced by rising temperatures, increasing precipitation and intensity of storms, rising carbon dioxide and ozone levels that will impact agriculture. These changes are not consistent across the United States and may affect some agricultural areas more than others.

The scenarios of climate change in the U.S. have implications for agriculture, which must be understood to protect the capability of food, feed, fiber, and fuel production and quality.

One of the easier ways for us to understand the implications of climate on agriculture is to consider the impacts of climate on animals. The increase of temperature and the potential for more heat waves and extreme heat events will affect animal production. Animals respond to a combination of temperature and humidity in a similar fashion than do humans. When it is hot and humid, we decrease our activity, reduce our food intake, and generally are less energetic than at other times. High temperature and humidity reduce the feed intake of animals, which in turn reduces the rate of meat, milk, or egg production.

At the opposite end of the range, cold temperature extremes can reduce increase feed intake, but the extra energy is consumed to keep the animals warm, which results in reduced growth or milk production.

Extremes in hot or cold have negative impacts on animals, and heat waves can have serious consequences on animals and can create conditions in which there is increased death of animals in feedlots or barns.

High temperature extremes will affect plants as well as animals, and of particular concern is the probability of heat waves or high temperature events at the pollination stage. Exposure of pollen to high temperatures can destroy the pollen and reduce the production of seed or fruit. Occurrences of heat waves at pollen time can have significant and negative impacts on plant production.

Plants differ in their reaction to temperature. Cool season plants which are best suited to lower temperatures include many of the vegetables, like peas or spinach. Warm season plants, like watermelon, cotton, or cucumber, thrive when the temperatures are warm. As temperature warms, this causes the plants to progress to their stage of development at a rate which does not allow for maximum expansion of leaves, stems, or fruits.

One example of potential impacts of warming temperatures on crop yield has been found for soybean. As temperatures increase, soybean yields in the southern U.S. are predicted to decrease by 3.5 percent, while in the Midwest they are projected to increase by 2.5 percent. Rising temperatures will exceed the optimum range for soybeans in the South while bringing soybean into the optimum range in the Midwest.

Likewise, for many vegetables, warming temperatures will cause a reduction in production even more quickly because these are cool season crops. While many of the vegetables are grown during the winter in temperate climates, the length of this time in which this period is optimal will decrease. Increasing winter temperatures does increase the length of the growing season, and there are potential negative impacts on fruit trees, which require a certain amount of cooling or chilling in order to set fruit.

Climate models and observations indicate that nighttime temperatures are rising faster than daytime temperatures. This shift in temperature patterns during the day has significant impacts on plants, particularly during the grain or fruit development periods. Warm temperatures at night increase the respiration rate, which reduces the amount of sugars and starches which can be stored in grain or fruit. This causes the fruit or grain size to be smaller and reduces the length of the grain-filling period.

Quality of agriculture produce is not often thought of when we discuss climate change. However, there are many impacts of climate and weather on product quality. Variations in wine quality among years are related to subtle changes in weather†sensitive periods in the growing season. And there are direct and indirect effects of climate on agriculture.

Agriculture has and can adapt to a changing climate. The areas in which we grow certain plants demonstrates how we adapt plant production systems to the climate. This adaptation has been occurring in agriculture for centuries as farmers have selected the best crops for their regions, changed their cultural practices to cope with the risks from environmental stresses, and modified their practices to reduce the impacts of biological stresses caused by weeds, insects, or diseases. Research has been able to help speed this process by providing information to guide the decisions.

Thank you very much, Mr. Chairman.

[The statement of Mr. Hatfield follows:]

Testimony of Dr. Jerry L. Hatfield

Director, National Soil Tilth Laboratory – Ames, Iowa

Before the

House Select Committee on Energy Independence and Global Warming

June 18, 2009

Introduction: Chairman Markey, Ranking Member Sensenbrenner, members of the committee, I am Dr. Jerry L. Hatfield. I am an employee of the USDA's Agricultural Research Service and the Director of the National Soil Tilth Laboratory in Ames, Iowa. It is a pleasure to be able to present the current information on climate impacts on agriculture to this committee. Agriculture is extremely sensitive to climate and weather and the resilience of our production systems to changes in climate is enhanced by understanding these impacts and their effects. It is also important to realize that US agriculture is diverse and that simple statements about the impacts of climate are not possible. For example, the effects of climate on corn production are different from those on tomatoes except in the broadest of generalities. Agriculture is extremely complex in its response to climate change. It should also be understood that agriculture does play a role on climate because of the effects of changing land cover and management on greenhouse gas concentrations, reflectivity of the land surface, and water exchanges. However, the focus of this discussion is on the impacts of climate on agriculture.

Climate change as evidenced by warming temperatures, increasing precipitation and intensity of storms, and rising carbon dioxide (CO_2) and ozone (O_3) levels that will impact agriculture. Warming temperatures of 1.5°F over the past 100 years with projections of continued increases over the next 50 years will alter the length of the growing season. The increase in the winter temperatures and especially nighttime temperatures over the next 50 years will affect agricultural systems. The projected increase in heat waves and extreme temperature events will impact agriculture as much as the human population. The projections of continued increases in precipitation over the northern areas and drier conditions over the southern regions of the US will further impact water supplies for agriculture and water management strategies. Increases in the intensity of rainfall events will increase the likelihood of soil erosion and water quality problems from agricultural lands. Extreme events, like heat waves and regional droughts, have become more frequent and intense in the past 50 years and affect agricultural operations and decision making. Rising CO_2 levels are a positive influence on plants and increase plant growth; however, the effects vary among different plants. All of the aspects of the changing climate have been detailed in a recently released report entitled "Global Climate Change Impacts in the United States" from the U.S. Global Change Research Program. Details on the impact of climate on agriculture are presented in Synthesis and Assessment Product 4.3 "Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States" from the U.S. Climate Change Science Program which was released in May 2008. The scenarios projected for climate change in the US have implications for agriculture which must be understood to protect the capability for food, feed, fiber, and fuel production. The information presented here represents a summary of the information contained in these reports which was developed by a team of agricultural experts studying the impacts of climate on agriculture.

Animal Response: One of the easier ways for us to understand the implications of climate change on agriculture is to first consider the impacts of climate on animals. Unless farmers are able to insulate animals from climate change, the increase in temperature and the potential for more heat waves and extreme heat events will affect animal production. Animals respond to a combination of temperature and humidity in a similar fashion to humans. When it is hot and humid, we decrease our activity, reduce our food intake, and generally are less energetic than at other times. In a similar way, high temperatures and humidity reduce the feed intake of animals which in turn reduces the rate of meat, milk, or egg production. At the opposite end of the range, cold temperature extremes can increase feed intake but the extra energy consumed is used to maintain warmth which also results in reduced growth or milk production. Extremes at either hot or cold have negative impacts on animals. Heat waves can have serious consequences on animals and can create conditions in which there is increased death of animals in feedlots or barns. There are recent examples of heat waves in California and the impact on milk production and heat waves in the High Plains resulting in increased deaths in feedlot beef cattle. An additional implication for beef and dairy animals is that as the temperature rises there is a decrease in the conception rate. Livestock producers will have to understand that climate changes will affect their management decisions. Changes in temperature will have impacts on animal production which must be considered in designing improved management strategies to cope with these stresses.

Changing precipitation patterns affect animals in a multitude of ways. Range animals that are dependent upon stored water in surface ponds may have to have supplemental water provided or even supplemental feed if drought reduces plant production or surface water recharge. Water supply to rangeland animals will be a critical concern in areas with the potential for increased drought. Excess precipitation can create muddy conditions in feedlots and increase stress on animals and the potential risk of runoff from feedlots into nearby water bodies.

In terms of environmental management needed to address global climate change, the impacts can be reduced by recognizing the adaptive ability of the animals and by proactive application of appropriate counter-measures (sunshades, evaporative cooling by direct wetting or in conjunction with mechanical ventilation, etc.). Specifically, the capabilities of livestock managers to cope with these effects are quite likely to keep up with the projected rates of change in global temperature and related climatic factors. However, coping will entail costs such as application of environmental modification techniques, use of more suitably adapted animals, or even shifting animal populations to other locations.

Climate change will affect the presence and range of parasites and pathogens. The increased presence of parasites and pathogens will increase the pressure on animals and lead to lost productivity or survival. Duration and intensity of potential stressors are of concern with respect to the coping and/or adaptive capabilities of an animal. Further, exposure to one type of stressor (heat or humidity) may lead to altered resistance to other types of stress (parasites or pathogens). Other interactions may exist such that animals stressed by heat or cold may be less able to cope with other stressors (restraint, social mixing, transport, etc). Improved stressor characterization is needed to provide a basis for refinement of sensors providing input to control systems. Animal producers will have to increase their awareness of these factors in order to maintain productivity under conditions of climate change.

Plant Response: Plants are more complex in their response to climate. Temperature, precipitation, and CO_2 and O_3 are all critical factors that affect plant growth and the harvestable products from plants. Unlike animals, plants do not maintain their temperatures and are more affected by the air temperatures. Extremes of temperatures can have devastating effects on plants. Plants are also dependent upon the water that is supplied to them by precipitation or irrigation and when these amounts are either in excess or in deficit there are negative impacts on plant growth. A basic building block for plants is CO_2 and up to a point increases in CO_2 concentrations generally have a positive impact on plant growth but these impacts do not necessarily improve harvestable yield or commodity quality. Yet, building resilient agronomic crop, vegetable, and fruit production systems which can cope with the changing climate can be accomplished as we understand the interactions among temperature, water supply, and CO_2 levels.

Agriculture has and can adapt to changing climate. The areas in which we grow certain plants demonstrate how we adapt plant production systems to the climate. This adaptation has been occurring in agriculture for centuries as farmers have selected the best crops for their regions, changed their cultural practices to cope with risks from environmental stresses, and modified their practices to reduce the impacts of biological stresses caused by weeds, insects, and diseases which also respond to the climate. Research has been able to help speed this process by providing information to help guide decisions about the impacts of climate on agricultural systems and the magnitude of the response from various stresses. There are three components to the current climate change scenarios that are critical to agriculture; the trends in temperature, precipitation, and CO_2 and O_3 over years compared to within growing season variation in these climatic components. Adaptation strategies will be different for each of these components and there is a different form of risk in each of these as well.

In addition to the general trends in climate, a major factor is the extremes in temperature and precipitation which occur within the growing season. Similar to animals, the occurrence of these extremes may be the most detrimental to plant growth and agricultural production.

Plants differ in their response to temperature. There are cool-season plants which are best suited to lower temperatures, e.g., many of the vegetables like peas or spinach. Warm-season plants like watermelon, cotton, or cucumber thrive when the temperatures are warm. Temperature responses for plants have three values that describe their response: the minimum temperature below which there is no growth, the maximum temperature at which growth ceases, and the optimum temperature at which there is the maximum rate of growth. Just as important, there is a difference between the vegetative periods of growth, when the plant is producing leaves or stems, compared with the reproductive period when the plants are producing seed or fruit. The optimum temperature ranges for the vegetative period are warmer than for the reproductive period.

Warmer temperatures cause plants to progress through their stage of development at a rate which does not allow for maximum expansion of leaves, stems, or fruits. Exposure to warmer temperatures also increases the rate of water evaporation from the plant. Since plants use the evaporation of water to cool their leaves, the warmer the air, the more water that will be used by the plant. In water limited areas this creates a situation in which plants may be under some amount of water stress, which in turn reduces growth. Based on a projected temperature increase of 1.8°F over the next 50 years, soybean yields in the southern US are predicted to decrease by

3.5% while in the Midwest they are projected to increase by 2.5%. Rising temperatures will exceed the optimum range for soybean in the south while bringing the soybean into the optimum range in the Midwest. Likewise, for many vegetables warming temperatures will cause a reduction in production even more quickly in these cool season crops, compared to warm season crops. Many of these vegetables are grown during the winter in temperate climates; with warmer winters the length of time that this period is optimum will decrease. Increasing winter temperatures does increase the length of the growing season, there is a potential negative impact on fruit trees, e.g., apples, which require a certain amount of chilling or exposure to cool temperatures. The warmer temperatures during winter may create a situation in which these chilling requirements are not fulfilled and reduce the production of fruit.

A sensitive portion of the growth cycle for plants is the pollination stage when plants are producing pollen for seed or fruit. The temperature ranges for pollen survival are lower than those for vegetative or reproductive development; and exposure of pollen to high temperatures can destroy the pollen and reduce the production of seed or fruit. Occurrences of heat waves at pollen time could have a significant negative impact on plant production. While we tend to focus on the extremes in temperature, there are more subtle effects that occur in rice because of the time of day in which they shed their pollen. If the temperatures are above the threshold temperature for pollen survival at this time then the grain set is reduced. Timing of pollen release in plants relative to temperature patterns may provide new insights into management methods to reduce the impacts of climate on yield.

Climate models and observations indicate that night-time temperatures are rising faster than day-time temperatures. This change has significant impacts on plants particularly during the reproductive stage of development. Warm temperatures at night increase the respiration rate which reduces the amount of sugars and starches that can be stored in grain or fruit. This causes the fruit or seed size to be smaller and also the length of the grain or fruit-growing period to be shorter. As a result these warmer nighttime temperatures reduce the grain or fruit yield of plants. Conversely, cooler nighttime temperatures decrease the respiration rate and lengthen the period of seed or fruit development leading to a larger yield.

Increases in the occurrence of heat waves may require a change in planting date so that the crop is not flowering at a time with the highest probability of high temperatures. Heat waves can also impact growth because of the impact on crop water use. If the amount of water available to the plant is decreased then the impact of even moderate heat waves will be large because the plant will not be able to have adequate water to cool the leaves. As an example, the drought in the Southeastern US had such a large impact because these soils do not have a large reservoir of water they can hold and without timely rainfall there is a severe impact of drought on plants. In contrast, areas of the US that have soils with larger soil water reservoirs can cope with less frequent rainfall if the rainfall from each event is stored within the soil.

Precipitation is the ultimate source of water for plant growth. This can be either directly from events that recharge the soil with water or indirectly from irrigation supplied from water captured in streams, lakes, or dams that originates as rainfall or snowfall. Excesses and deficiencies in water cause negative impacts on plant growth. Changes in the rainfall distribution across the US have implications for being able to provide adequate water supplies for crop growth. In the southern and southwestern US the projections are for reduced precipitation and these areas require large amounts of water for crop production because of the warmer temperatures. There are shifts in the form of precipitation that is occurring in many areas with a trend toward more rainfall compared to snowfall and also earlier melting of the snowfall because of the warmer temperatures. These changes in precipitation patterns will affect water availability in areas capturing precipitation for later use as irrigation water.

Increases in precipitation amounts in the Midwest and the intensity of storms has implications for agriculture. Wetter conditions in both the spring and fall can impact production by delaying planting in the spring and creating problems for harvest in the fall. When soils are saturated and have excess water, not only is there an increased potential for flooding, but also a negative impact on plant growth because excess water decreases plant growth from the deprivation of oxygen in the soil. Increases in precipitation intensity will increase erosion from agricultural lands unless adequate protection of the soil surface is provided by conservation tillage, crop residues, or cover crops. Soil erosion occurs when the soil can no longer efficiently absorb the rainfall and the continuing rain begins to move off of the land creating a condition in which the moving water loosens the soil and causes it to move with the water. Providing adequate soil cover to protect the soil surface will be necessary to reduce the potential for increased runoff or soil erosion from agricultural fields. Water management strategies for rain-fed and irrigated agriculture provide opportunities for more water use efficient cropping systems that increase the amount of biomass, grain or fruit yield per unit of water.

Carbon dioxide is one of the basic building blocks of plants. The photosynthetic process converts CO_2 into sugars which in turn are combined into other plant components, starches, proteins, carbohydrates, etc. Plants are efficient users of CO_2 and respond positively to increases by increasing their growth. An interesting observation is that as the CO_2 increases there is also a decrease in water use by the crops which increases their water use efficiency. Therefore, we produce more plant material per unit of water used by the plant. Not all plants respond the same to increases in CO_2 levels; plants like corn show less response than do wheat or soybean and vegetable crops. There are varying degrees of change in water use efficiency by plants subjected to the higher CO_2 levels.

Increasing CO_2 concentrations benefit weeds even more than crops and cause them to grow more quickly and produce more seed. There are observations which suggest that weed management may be more difficult under the conditions of increasing CO_2 because weeds may become more tolerant of herbicides. This effect alone would impact agricultural production because increased weed pressure leads to reduced crop yield and increased costs for weed control.

An interesting example of the impacts of changing CO_2 on plant growth has been observed in rangeland plants. Increases in CO_2 cause the plant to grow more quickly; however, in doing so the growth of the plant exceeds the capacity of the root system to absorb nitrogen from the soil. As a consequence there is a decline in the protein content of the grass. Since these rangeland systems provide food for grazing animals there is a less nutritious food source for these animals and a requirement for these animals to consume more grass in order to meet their dietary requirements. The changes in the climate also cause a shift in the species that grow in these rangelands toward less desirable plants for grazing animals to eat. Climate changes and their effect on plants have to be examined from many different perspectives in order to fully appreciate the significance of the potential impact on agriculture.

Although not considered as part of climate change scenarios, the changes in O_3 may be as important as greenhouse gases with a significant impact on plant growth. Ozone at the land surface has risen in rural areas of the US, particularly over the past 50 years, and is forecast to continue increasing over the next 50 years. Levels of ozone during the day in rural areas of the Midwest are six times higher than 100 years ago. Ozone is toxic to many plants and studies in greenhouses and small chambers have shown soybean, wheat, peanut, and cotton are the most sensitive. Exposure to O_3 results in decreased photosynthesis, dry matter, and yield. Ozone is a complicating factor affecting crop yield that should not be ignored in the evaluation of the impacts of climate change on crops.

Crop Quality: Most of the attention on climate impacts on agriculture focuses on the amount of commodity produced; however, there are impacts of climate and weather on product quality. Variations in wine quality among years are often related to subtle changes in the weather at sensitive periods of the growing season. Grain quality in wheat across the Great Plains is related to timing of rainfall events during the grain-filling period while excess rainfall during the harvest period can reduce quality by delaying harvest or causing the plant to fall over, exposing the grain to moisture on the soil. Excess rainfall during hay harvest can reduce the quality by continued exposure to unfavorable harvest conditions. One example of product quality that is affected by weather events is aflatoxin in grains, spices, and nuts that is induced by either high humidity levels or drought during the latter stages of reproductive development. This affects product quality and also produces a health hazard from the products. Quality impacts from changes in the climate should be considered as important as production impacts in helping producers understand appropriate management strategies to cope with climate change.

Direct and Indirect Effects of Climate Change on Agriculture: Temperature, precipitation, and CO_2 provide direct effects on plant growth and production of biomass, seed, fiber, or fruit.

These effects are detectable in altered growth and there are compensating effects of warming temperatures and rising CO_2. However, the impacts of changing climate on agriculture are significant and will greatly impact production. As one example, corn yields in the US show a steady increase with time; however, the majority of the deviations below the trend line are a result of abnormal weather conditions within the growing season that affect a region of the country. Late season frosts impact fruit production in many areas and early rainfall events cause reductions in the raisin grape harvest in California. All crops produced outside of greenhouses in the US are subject to variations in climate which impact their production.

There are also indirect effects from climate change. These are due to the impacts of climate on weeds, insects, and diseases. Warmer temperatures over the winter will allow some insects to survive and maintain viable populations that can infest the next crop with a greater intensity. Increasing temperatures can expand the range for insects which will increase the impacts due to insect damage. In a similar way warmer temperatures and wetter soil conditions can lead to more favorable environments for disease causing pathogens to populate and grow. Increased pressure from insects and diseases will require that producers be more vigilant in their control efforts. Changing where crops or livestock are produced may not alleviate the risks from pests and may expose these production systems to new pests. Weeds show a great adaptability to climate and have been responding to increases in CO_2, this coupled with the warmer temperatures have expanded the range of some weeds. For example, kudzu is limited in its northward migration because of temperatures below 68°F in the winter; however, as temperatures warm this invasive weed will expand its range. Invasive weeds will respond favorably to changing climate and efforts to evaluate how climate is affecting these species will be critical to ensure appropriate weed management strategies are in place.

To ensure future food security and viability of production systems there are some critical questions which need to be addressed.

- How much resilience is there in our crop germplasm, which can be used to develop varieties that can withstand temperature and precipitation extremes and take advantage of increased CO_2?
- How can linkages among crop growth and yield, pest biology, and epidemiology be quantified in response to climate change that would reduce the risk of production losses and enhance product quality?
- How can resource managers ensure the availability and delivery of adequate water quantity and quality under changing climate conditions?
- What are the best agricultural management practices for creating systems that are economically competitive and environmentally sustainable?

Summary Comments: Climate impacts on agriculture will be regionally specific because of the combinations of climate and agricultural commodities in that region. Increases in heat waves and extreme temperature events will impact both animals and plants. Heat stress on animals and plants will impact their ability to produce harvestable products. Increases in temperature will increase the rate of plant development but not the size of the plant which will reduce the amount of biomass, seed, fruit, or fiber produced. The projected increases in nighttime temperature will hasten the rate of development during the reproductive stage of growth which in turn causes reduced production because of a shorter growing period. Efficient agricultural production is dependent upon a consistent water supply and as precipitation amounts, and in some areas the form becomes more variable there will be an impact on plant growth because of this variability. More intense storms can lead to flooding but also more runoff from fields or delay planting or harvesting operations. Increased rainfall during harvest can lead to damaged crops and reduced quality of the produce. While increasing CO_2 levels are regarded as a positive for plants, this has to be considered in combination with the temperature and precipitation changes. The direct impacts of climate change on plants must not ignore the indirect impacts that result from climate impacts on weeds, insects, and diseases. These biological systems respond to climate changes and in many cases there will be increased populations of pests along with an expanded range of pests.

The impact on agriculture can be both positive and negative; however, avoiding the negative impacts will require management strategies and practices that consider the impact of climate and the development of alternative strategies that will mitigate the risk of climate impacts and increase the resilience of our agricultural systems. Agriculture has adapted to climate and weather risks throughout history. Producers and researchers have developed an understanding of the environmental and biological risks that are mediated by climate and weather and have adapted by changing plants or animal breeds, identifying more resistant production systems to stress, altering planting dates, and adjusting their culture methods. These have been effective in enhancing the efficiency of our current production systems; however, the anticipated change in climate that has been described will present a new challenge for more robust agricultural systems to cope with the magnitude of the change and the degree of variability within a growing season. Agriculture has responded to these challenges in the past and can do so again.

The CHAIRMAN. Thank you, Dr. Hatfield, very much.

Our next witness is Ms. Heather Cooley, senior researcher at the Pacific Institute. Ms. Cooley works with the Pacific Institute's water program, researching climate change, water privatization, and California water issues. She has also studied climate and land-use change at the Lawrence Berkeley Laboratory in California.

We welcome you.

STATEMENT OF HEATHER S. COOLEY

Ms. COOLEY. Thank you.

Mr. Chairman, and members of the committee, thank you for inviting me here today to offer testimony regarding the effects of climate change on agriculture. As directed, I will limit my discussion here to those impacts related to water resources.

Impacts on water resources will be especially problematic for agriculture. Numerous national and regional assessments, including the study released earlier this week, demonstrate that climate change is already affecting U.S. freshwater resources, and that these impacts will intensify in the future.

The U.S. Geological Survey regularly reports that agriculture uses 70 percent of the Nation's freshwater resources; thus, impacts on water resources will have major consequences for agriculture.

Rain-fed agriculture is especially vulnerable to changing precipitation patterns. In response to these changes, farmers may shift to supplemental irrigation, which may increase tensions over limited water resources. We are already seeing this in some areas. For example, in Georgia's Flint River Basin, farmers are rapidly shifting from rain-fed to irrigated agriculture, and this shift is one of the factors fueling the ongoing tensions between Georgia, Alabama, and Florida.

Surface water supplies will be increasingly out of phase with agricultural water demand. Surface runoff is expected to decline during summer months at precisely the time when agricultural water demand peaks. Floods and droughts will become more common and more severe, and these extreme events will have a greater effect on crop production than changes in average conditions. Losses from droughts already total $6 billion to $8 billion annually, much of which is due to impacts on agriculture, and these losses could rise in the future.

Many of the impacts of climate change are now unavoidable. In fact, they are already occurring. The good news is that adaptation can substantially reduce the risk of climate change for the agricultural sector. But we cannot be complacent. The time to act is now. In the time available, I will offer a set of recommendations to reduce agriculture's vulnerability to changes in water resources.

First, we must improve the management of surface resources. Specifically, the Bureau of Reclamation and Army Corps of Engineers should adopt new rules for the operation of water infrastructure in light of climate change. And based on these experiences and the methodologies they develop, the Bureau and Corps should provide guidance and oversight to local and state agencies to do similar analyses.

We must also improve groundwater management. Our dependence on groundwater may increase in the future in response to more frequent and severe droughts. Throughout much of the United States, however, groundwater basins are mismanaged and overdrafted. In particular, the Federal Government should require all States to design and implement comprehensive groundwater monitoring and management programs.

We must also capture water conservation and efficiency potential. Reducing agricultural water use reduces vulnerability to drought. However, many conservation practices require substantial investment. To help defray these initial costs, the government should expand funding for water conservation efficiency within the Federal Farm Bill. In addition, we should provide tax exemptions or rebates for efficient irrigation equipment and infrastructure.

We must also eliminate Federal policies that inadvertently increase vulnerability to climate change. For example, the Farm Bill provides substantial direct payments for water-intensive crops that may not be appropriate under future climate conditions and may ultimately increase vulnerability to climate change.

In its place, we should support new policies that promote climate change adaptation. Specifically, the Environmental Quality Incentives Program provides cost shares for practices that promote agricultural production and environmental quality. EQIP, however, accounts for less than 1 percent of the overall budget, and Congress has threatened to reduce funding further. The Federal Government should expand funding for Farm Bill conservation programs, especially EQIP.

We must also continue research and development. Although climate change is a global problem, its impacts are local. Accordingly, detailed assessments of climate change risks require thorough analysis at the regional level. Without significant investment to generate estimates of regional impacts, climate change will remain a vague and unwieldy threat.

The information must then be communicated to the agricultural community. Farmers and local communities will ultimately be responsible for implementing adaptation strategies, and the information that is available has not been adequately conveyed to farmers. Additional outreach is best accomplished by building on existing relationships. The U.S. Department of Agriculture in consultation with NRCS and extension agents should develop training and provide guidance about climate change impacts and adaptation strategies for the agricultural sector.

We know that climate change is already occurring and that our farms are on the front lines. The challenge is to quickly equip the most vulnerable sectors and communities with tools to plan for and adapt to unavoidable impacts. Thank you.

[The statement of Ms. Cooley follows:]

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Testimony of Heather S. Cooley and Dr. Juliet Christian-Smith[1] to the
United States Congress
Select Committee on Energy Independence and Global Warming
For the Hearing on Global Warming Effects on Agriculture and Forestry
June 18, 2009

Thank you for the opportunity to testify today on the effects of climate change on agricultural production in the United States. Our testimony will focus on those impacts related to water resources – a critical connection especially in the western United States. These detailed comments are intended to supplement our oral testimony.

Key Messages:

- Agriculture is a water-intensive industry, using about 70% of the nation's freshwater resource. As a result, impacts of climate change on water resources will have major consequences for agriculture.
- Rainfed agriculture is especially vulnerable to altered precipitation patterns.
- Surface water supplies will be increasingly out-of-phase with agricultural water demand. Surface runoff is expected to decline during summer months, when agricultural water demand peaks. The impacts of climate change on groundwater resources remain largely unknown; however, recent research suggests they may decline.
- Changes in extreme weather events will have a greater effect on crop production than changes in average conditions.
- Adaptation can substantially reduce the risk of climate change for the agricultural sector. To support adaptation efforts:
    - The federal government must support adaptation efforts, including better management of surface and groundwater resources and improvements in water conservation and efficiency.

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- The federal government should support outreach to the agricultural community about the impacts of climate change and potential adaptation strategies.
- The federal government should support additional research and development. Specifically, more regional assessments and better weather forecasting are needed.

The Agricultural Sector Is Particularly Vulnerable to Climate Change

The global food crisis made headlines in 2008. This crisis was the result of a variety of factors, including low grain reserves, drought in multiple grain-producing regions, rising energy prices, and a massive increase in biofuel production, among other things. But it points to a larger problem: the growing vulnerability of global food systems. Pressures and demands on our agricultural systems are rising as populations continue to grow and as countries traditionally dependent on grain-based diets are shifting towards greater meat consumption. At the same time, urbanization, deforestation, and poor agricultural practices is contributing to the loss of prime farmland. Over the coming years, many of these factors will be made even more acute due to climate change.

The agricultural sector is particularly vulnerable to climate change because it is directly tied to land and water resources. Even modest changes in temperature and precipitation patterns, the length of growing seasons, or the frequency of extreme events will have large consequences for many farmers. In our testimony, we begin with an overview of the effects of climate change on agriculture, focusing on those impacts related to water resources. We discuss strategies that the agricultural sector can take to adapt to these impacts. We conclude with ways that Congress and the federal government can help farmers implement these strategies.

Climate Change: What Can We Expect for Agriculture?

Climate change will have a direct effect on agricultural crops. Plants require sunlight, water, heat, carbon dioxide, and nutrients. Changes in any of these factors affect plant growth and development in complex and non-linear ways. Warmer temperatures, for example, may shift the geographic range of crops, permitting them to expand into areas that were previously too cold for production and preventing them from growing in areas that are now suitable for production. Warmer temperatures also increase crop water requirements.

The effects of climate change on crop production will reverberate throughout the agricultural community and the national economy. Reduced yields, and in severe cases, complete crop failure will affect the profitability of farms. In turn, farmers will purchase less fertilizer, seeds, equipment, and other products from farm suppliers. Revenue and employment may decline for local businesses, as well as processors and distributors. In addition, lower yields will increase food prices for consumers.

Climate change will also adversely affect the health of farm workers. Farm laborers typically spend long hours in the field, where they are exposed to the elements and often lack access to water, shade, and shelter. Extreme heat events increase the risk of heat-related illnesses, including heat exhaustion, stroke, heart attack, and death. Under future climate conditions, the frequency and intensity of these extreme heat events are projected to increase, increasing risks to farm workers.

Impacts on Water Resources Will Be Problematic for Agriculture

The U.S. Geological Survey regularly reports that the agricultural sector uses about 70% of the nation's water resources. Numerous national and regional studies indicate that climate change is already affecting U.S. freshwater resources and that these impacts will intensify in the future (Figure 1). Indeed, all of the Intergovernmental Panel on Climate Change (IPCC) reports concludes that freshwater systems are especially vulnerable. Because agriculture is water-intensive, impacts on water resources will have major consequences for agriculture. Here, we describe impacts on freshwater resources, including supply, demand, quality, and floods and droughts, and their effects on the agricultural sector.

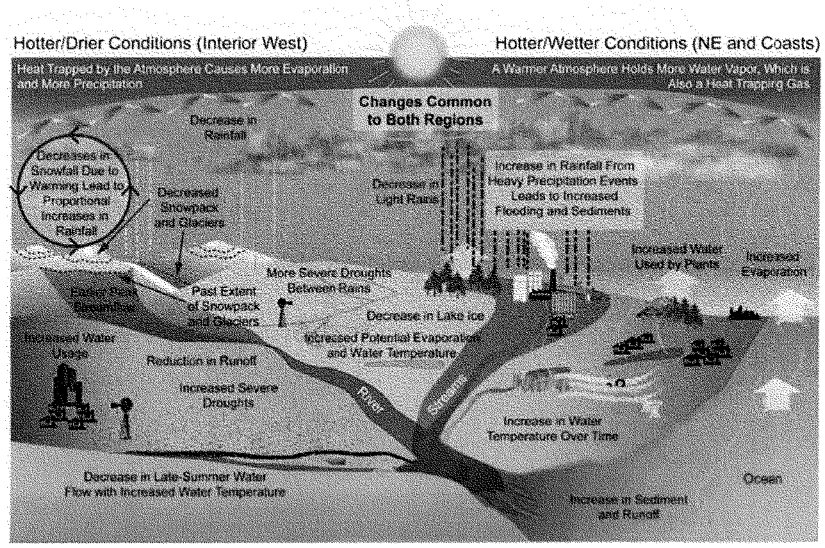

Figure 1. Graphical representation of the ways climate change will affect freshwater resources.
Source: United States Global Change Research Program. 2009. Global Climate Change Impacts in the United States.

Water Availability and Timing Are Changing

Precipitation Patterns Are Changing

Plant water requirements vary throughout its various life stages. Generally crop water requirements are low during the early vegetative period, but increase over the course of the growing season as the plant matures and temperatures increase. Consequently, the timing of precipitation is important for plant production. Too much or too little water during the plant's development could reduce yields.

Rainfed agriculture, which accounts for 94% of the nation's farmland, is particularly vulnerable to changes in precipitation patterns. Current climate models project that global precipitation will increase over the next century. Changes in precipitation patterns, however, are subject to significant regional variation and are not yet well understood. As a result, impacts on crops are not well known. In general, warmer temperatures combined with *reductions* in precipitation will increase plant stress and may reduce yield and quality, whereas warmer temperatures combined with *increases* in precipitation may improve plant yield and quality.

In response to changing precipitation patterns, farmers may shift to supplemental irrigation, if water is available and if it is economically feasible. This shift will increase tensions over surface and groundwater resources that are, in many parts of the country, already over-allocated. In fact, this tension is already occurring. In Georgia's Flint River Basin, farmers are rapidly shifting from rainfed to irrigated agriculture; the fraction of harvested cropland that is irrigated has nearly doubled in the last 20 years, from an estimated 40% in 1985 to 70% by 2002. This is one of the factors fueling the ongoing tensions between Georgia, Alabama, and Florida, and these types of conflicts may become increasingly likely in the future.

Surface Water Availability May Decline During Summer Months

Models are in general agreement that climate change will affect the timing and volume of runoff. In rain-dominated basins, found throughout much of the eastern United States, studies suggest that changes in runoff will mirror changes in precipitation patterns. In snow-dominated basins, which are found throughout the western United States, warmer temperatures will create major problems. Hydrologic models suggest that with warmer temperatures, more precipitation will fall as rain, increasing winter flows and reducing the total snowpack. In California, for example, scientists forecast that warming will reduce total snowpack by as much as 70% by the end of this century (Figure 2). Similar kinds of changes are likely for the Rocky Mountain States and the Pacific Northwest. The winter snowpack acts as a natural reservoir, storing water during the winter and releasing it throughout the summer. A reduced snowpack, then, will reduce summer stream flows.

Changes in the volume and timing of surface water will have important consequences for irrigated agriculture. Agricultural water demand is highest during the hot summer months. Yet, most climate models agree that in both snow- and rain-dominated basins, water supply will be lower during the summer months. Thus, surface water supplies will be increasingly out-of-phase with agricultural water demand. An inadequate water supply weakens the plant, making it more susceptible to disease and infestation, and in severe cases, can lead to total crop failure.

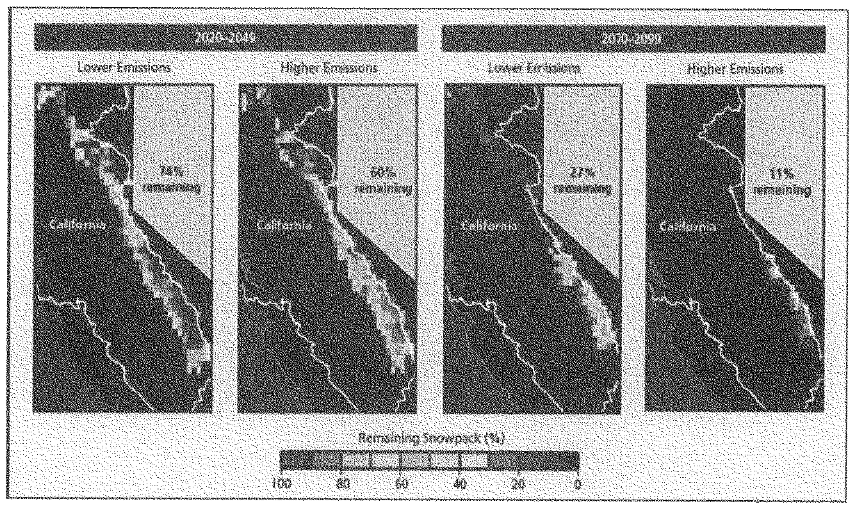

Figure 2. The loss of California snowpack under two climate scenarios by mid- and late-century.
Source: Proceedings of the National Academy of Sciences. 2004.

Groundwater Resources May Decline

The potential impacts of climate change on groundwater resources are not well understood. Recent studies, however, suggest that climate change will affect the availability and quality of groundwater resources. Groundwater recharge rates will change, increasing in some areas and decreasing in others. Groundwater will likely become more saline as a result of higher evaporation rates and, in coastal aquifers, rising sea levels.[2]

Groundwater is an important source of water for agriculture in many parts of the United States, accounting for about 40% of all irrigation withdrawals. The Ogallala aquifer, for example, provides water to nearly 30% of the nation's irrigated land, yet it is already being pumped ten times faster than it can be naturally recharged. During drought years, when surface supplies are limited, groundwater becomes an increasingly important stop-gap measure for farmers. Thus, as the frequency and intensity of droughts increases, agriculture's dependence on limited groundwater resources may also increase.

Agricultural Water Demand is Expected to Increase

Agricultural water demand is sensitive to climate. Warmer temperatures tend to increase plant transpiration rates, thereby increasing crop water requirements. Higher atmospheric carbon dioxide concentrations, however, can reduce water requirements under some conditions as plants close their stomata. While few studies have explicitly evaluated the relative importance of these processes, most suggest that the temperature effect will be more important and overall crop water requirements will increase, particularly with greater levels of warming. As described above, the supply of water will become more variable. Greater reliance on what could very well be a diminishing resource will spark conflict among users.

Floods and Droughts Threaten Agricultural Productivity

New research suggests that changes in extreme weather events will have a greater effect on crop production than changes in average conditions, particularly if the extreme events

[2] Kundzewicz, Z.W., L.J. Mata, N.W. Arnell, P. Döll, P. Kabat, B. Jiménez, K.A. Miller, T. Oki, Z. Sen and I.A. Shiklomanov, 2007: Freshwater resources and their management. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 173-210.

occur during sensitive plant developmental stages.[3] According to Reddy et al., "unexpected late spring and early frosts and periodic episodes of heat and drought stress are predicted to occur more frequently in the changed weather environment, and these could exacerbate climate change effects on many aspects of crop growth and development, reducing crop yield and affecting quality."[4]

Droughts have serious implications for agriculture. The Federal Emergency Management Agency estimates that the average cost of drought in the United States is $6-8 billion annually. Much of this cost is due to crop loss and other direct and indirect losses.[5] Drought conditions are often favorable for many insects, including grasshoppers and locusts, which damage crops further. Drought-stricken crops are also more susceptible to infestations and disease. Wind erosion associated with excessively dry soils can permanently destroy productive agricultural land, as the U.S. experienced during the Dust Bowl. In severe cases, agricultural losses, combined with a lack of food reserves or limited access to aid, can lead to widespread famine.

Floods, on the other hand, can either benefit or harm agricultural production. Floodwaters deposit nutrient-rich sediment on the floodplains, thereby creating fertile soil. These benefits are sometimes offset by the vulnerability of agricultural production to floods that destroy farms and crops. Floods may also cause significant damage to water infrastructure, further affecting the availability and reliability of water resources. A massive levee failure in the Sacramento-San Joaquin Delta, for example, could produce what is often referred to as the Big Gulp, where salt water rushes into the Delta. The massive water export pumps would be shut down, as levees are repaired, which could

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[3] Easterling, W.E., P.K. Aggarwal, P. Batima, K.M. Brander, L. Erda, S.M. Howden, A. Kirilenko, J. Morton, J.-F. Soussana, J. Schmidhuber, and F.N. Tubiello, 2007: Food, fibre and forest products. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 273-313.
[4] Reddy, K.R., G.H. Davidonis, A.S. Johnson, and B.T. Vinyard. 1999. Temperature regime and carbon dioxide enrichment alter cotton boll development and fiber properties. Agron. J. 91(851-858).
[5] Federal Emergency Management Agency. 1995. National Mitigation Strategy; Partnerships for Building Safer Communities. Mitigation Directorate, p. 2. Federal Emergency Management Agency, Washington, D.C.

take months to complete. Shutting down these pumps would cut off a major source of water to the region and in particular to agriculture.

Water Quality May Be Compromised

The connections between climate change and water quality are not understood as well as climate change's impact on quantity, although the literature on these connections is growing. Climate change is expected to increase water temperatures in lakes, reservoirs, and rivers, leading to more algal and bacterial blooms and lower dissolved oxygen concentrations. More intense precipitation events could increase erosion rates and wash more pollutants and toxins into waterways. Along the coast, rising sea levels could push salt water further into rivers, deltas, and coastal aquifers, threatening the quality and reliability of these systems. Groundwater quality is also expected to decline as it become saltier, as described above.

Water quality concerns may have both direct and indirect impacts on agriculture. The increasing salinity of groundwater will pose a problem for farmers in some areas. In California's San Joaquin Valley, for example, shallow saline groundwater already threatens the productivity of an estimated 2.5 million acres of farmland. According to California Department of Water Resources, "this marginal to poor quality groundwater has mounded up to reach crop root zones in this area and is threatening the viability of agriculture there."[6] In addition, agricultural runoff may exacerbate water quality concerns in rivers and streams that are already impaired as a result of climate change. To protect human health and ecosystems, water quality regulations affecting the agricultural sector may need to be strengthened.

[6] California Department of Water Resources. (2005). The California Water Plan Update. Bulletin 160-05. Sacramento, California.

What Can We Do to Reduce the Risks to Agriculture from Climate Change? Adapting to a Changing World

Many of the impacts of climate change are now unavoidable. Adaptation "is essential to complement climate-change mitigation, and both have to be central to an integrated strategy to reduce risks and impacts of climate change."[7] The good news is that adaptation can substantially reduce the risk of climate change for the agricultural sector. Scientists estimate that agricultural losses could be reduced by up to 50% as a result of farmer adaptation to climate change.[8] We already know that anticipatory or preventive adaptation measures that predict and respond to vulnerabilities before damages occur are often far less costly than reactive measures.[9]

There is no single adaptation strategy for the agricultural sector. As noted in the 2000 U.S. National Assessment:

> "The wide uncertainties in climate scenarios, regional variation in climate effects, and interactions of environment, economics, and farm policy suggest that there are no simple and widely applicable adaptation prescriptions. Farmers will need to adapt broadly to changing conditions in agriculture, of which changing climate is only one factor."[10]

Farmers implement a variety of technologies and practices to adapt to current climate and weather-related risks. For example, farmers already shift the timing and types of crops grown according to seasonal weather forecasts. In addition, farmers install irrigation systems in response to periodic droughts. These response measures should serve as a starting point for developing comprehensive adaptation strategies. It is important to build upon existing risk mitigation measures, but we cannot assume that existing approaches are sufficient to adapt to future climate conditions.

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[7] Fischer, G., M. Shah, and H. van Velthuizen. 2002. Climate Change and Agricultural Vulnerability. International Institute for Applied Systems Analysis. Vienna, Austria. Prepared for the United Nations for the World Summit on Sustainable Development, Johannesburg, 2002.
[8] Mendelsohn, R. and J.E. Neumann. 1999. *The Impact of Climate Change on the U.S. Economy*. Cambridge University Press. Cambridge, UK.
[9] Repetto, R. 2008. *The Climate Crisis and the Adaptation Myth*. Yale School of Forestry and Environmental Studies. Working Paper Number 13.
[10] Reilly, J., F. Tubiello, B. McCarl, and J. Melillo. 2000. Climate Change and Agriculture in the United States. In U.S. National Assessment of the Potential Consequences of Climate Variability and Change. U.S. Global Change Research Program. Washington, D.C.

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Action is needed now. As noted by Dr. Repetto, "saying that the U.S. *can* adapt does not imply that it *will* adapt, at least not in the efficient and timely way needed if major damages are to be avoided."[11] The United States must become a global leader in smart preparation and adaptation to climate change. Below, we offer a set of recommendations, focusing on those that reduce agriculture's vulnerability to changes in water resources. We also provide some specific thoughts about possible legislative action.

Recommendations

(1) Adaptation Efforts Must be Encouraged and Expanded

- **Improve management of surface and groundwater resources**

Water managers and policymakers must start considering climate change as a factor in the operation of existing facilities and systems. Existing state, federal, and local water systems should be tested under a range of potential future climate conditions to see how they respond and the extent to which they are vulnerable to expected changes. Water managers must re-evaluate engineering designs, reservoir operating rules, contingency plans, and water-allocation policies. Specifically, the federal government should

- Require the Bureau of Reclamation and Army Corps of Engineers, which operate many of the nation's reservoirs and water-related infrastructure, to revaluate their operation of these systems and develop new operational rules in light of climate change.
- Based on the experiences of the Bureau of Reclamation and the Army Corps of Engineers, provide guidance and oversight to local and state agencies to do similar assessments.

[11] Repetto, R. 2008. *The Climate Crisis and the Adaptation Myth.* Yale School of Forestry and Environmental Studies. Working Paper Number 13.

An estimated 40% of irrigated agriculture relies on groundwater. Because groundwater use increases during a drought, an increase in the frequency and intensity of droughts will likely increase our dependence on groundwater resources. Throughout much of the United States however, groundwater basins have been mismanaged and overdrafted. While overdraft certainly creates challenges, it may also provide an opportunity. In particular, we may be able to store excess surface flows, including storm water, during wet years for use during dry years. This option can improve supply reliability and flexibility, reduce land subsidence, and minimize the impacts of excess runoff on local steams and the marine environment. In particular, the federal government should

- Require all states to design and implement comprehensive local groundwater monitoring and management programs.
- Encourage use of groundwater basins to store excess surface water.

- **Capture water conservation and efficiency potential**

There is significant potential to reduce agricultural water use, thereby reducing vulnerability to drought and other water supply constraints. In California, for example, the Pacific Institutes estimates that widely available technologies and management practices can reduce agricultural water use by 10% and probably by substantially more. Aggressive efficiency improvements implemented in Australia as a result of their ongoing severe drought has increased agricultural water efficiency by as much as 25%. By improving agricultural water use efficiency, farmers reduce their vulnerability to water supply constraints. In addition, adopting many of these practices, including drip irrigation and improved irrigation scheduling, can increase crop productivity through higher yields and better quality. Many conservation practices, however, require substantial investment. EQIP, as described above, provides one means to defray these initial investment costs. Additional mechanisms are needed to support water conservation and efficiency improvements. Specifically, the federal government should:

- Provide greater emphasis on water conservation and efficiency improvements within the federal Environmental Quality Incentives Program and expand funding for these initiatives.
- Provide tax exemptions or rebates on efficient irrigation equipment to help offset capital investments for these systems.

- **Eliminate Federal Policies that Inadvertently Increase Vulnerability to Climate Change**

The U.S. Farm Bill contains vitally important federal agricultural policies. The 2002 Farm Bill authorized $619 billion in crop subsidies, of which $53 billion was provided in direct payments to support field crops. In some cases, direct payments make the production of certain field crops economically viable. These incentives, however, may encourage farmers to grow crops that are not appropriate under future temperature and precipitation regimes in some locations. Thus, direct payments may hamper the ability of farmers to adapt to changing conditions and thereby increase their vulnerability to climate change.

New policies that promote climate change adaptation should be introduced into the Farm Bill. The Environmental Quality Incentives Program (EQIP), for example, provides up to a 75% cost share for structural and vegetative practices that promote agricultural production and environmental quality. The 2008 Farm Bill includes a new stipulation that prioritizes water conservation and irrigation efficiency measures that reduce total water use for those producers that agree not to use the conserved water to bring new land under production. The 2008 Farm Bill authorizes EQIP funding at $1.2 billion in 2008, accounting for less than 0.2% of the overall Farm Bill budget. In 2009, Congress has threatened to reduce funding for this program. In order to capture potential efficiency improvements and to reduce our vulnerability to climate changes, the federal government should

- Reduce or realign subsidies from low-value, water-intensive crops to less water-intensive crops.

- Provide greater emphasis on water conservation and efficiency improvements within the federal Environmental Quality Incentives Program and expand funding for these initiatives.

(2) Information Must be Communicated to the Agricultural Community

- **Expand outreach efforts**

It is critical to communicate information on climate risks and adaptation strategies to the agricultural community. Farmers and local communities will ultimately be responsible for implementing adaptation strategies. While impact studies have been conducted at universities and research centers across the country, in most cases, this information has not been adequately conveyed to farmers. There is a significant gap between top-down analysis and bottom-up implementation. Additional outreach is needed to convey what information is available to farmers so that they can begin developing adaptation strategies.

Outreach efforts would be best accomplished by building on existing institutions. In particular, cooperative extension services and the Natural Resource Conservation Service (NRCS) have long-standing relationships with farmers and agricultural organizations throughout the nation. A University of Vermont Extension professor notes that "extension work is also about building trust and mutual respect with clients so they will be receptive to the information you have to offer."[12] Because cooperative extension agents and the NRCS have already established these important relationships, these organizations would serve as ideal conduits for outreach efforts. To encourage these efforts,

- The United States Department of Agriculture, in association with the NRCS, should develop trainings and provide guidance to extension agents about climate change impacts and adaptation strategies for the agricultural sector.

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[12] Grubinger, V. Climate Change and Agriculture: Challenges and Opportunities for Outreach. Climate and Farming.org. http://www.climateandfarming.org/

(3) Additional Research and Development is Needed

- **Expand impact assessments to include all regions of the United States**

Although climate change is a global problem, its impacts are local. Accordingly, detailed assessments of climate change risks require thorough analysis at the regional level. While climate change impact studies have been done in some areas, such as California, good assessments are lacking in others. Additional analysis is needed at the regional level to better understand climate change impacts. Without significant investment to generate the information needed to understand projected impacts, climate change will remain a vague and unwieldy threat.

- **Improve Weather Forecasting**

Short- and intermediate-term weather forecasts provide important information to farmers, allowing them to alter their planting regimes and implement other management practices in response to changing weather conditions. Improved forecasting would provide farmers with better information to make more informed decisions. Additional research is needed to improve weather forecasting. Funding for research programs to support this research, however, is declining. Congress should restore and expand this funding to support improved weather forecasting.

Ms. HERSETH SANDLIN [presiding]. Thank you, Ms. Cooley.

It is now a great pleasure of mine to be able to introduce the next witness to members of the select committee. He is a fellow South Dakotan and a friend, Mr. Tom Troxel.

Tom is the director of the Black Hills Forest Resource Association. Mr. Troxel brings a deep understanding of forestry and the forest industry, gleaned from over three decades of experience as a forester, working with the forest product companies in South Dakota and Wyoming for about 10 years, or longer than that, but 10 years in the U.S. Forest Service before then.

He has been an invaluable resource to my office on issues related directly to the Black Hills National Forest and forest practices and policies more generally. His expertise is well known at home, but also recognized and respected nationally.

On a personal level, I would like to publicly thank Tom for sharing his advice and counsel with me for many years now, and I strongly commend his testimony to my colleagues today.

Mr. Troxel, you are now recognized for 5 minutes.

STATEMENT OF THOMAS A. TROXEL

Mr. TROXEL. Thank you very much, Representative Herseth Sandlin and members of this committee, for this opportunity to discuss climate change and forests.

Many climate experts are predicting a warmer, drier climate in the coniferous forests of the Western United States. If correct, based on the last decade of drought conditions over much of the West, our forests will be increasingly susceptible to insect epidemics and forest fires, both of which have significant effects on air quality, water quality, stream flows, wildlife habitat, infrastructure, recreation, and rural communities.

Sustainable management of forests can, to a substantial degree, mitigate global climate change, and there appears to be substantial overlap between climate change goals and proper forest management. Forests are unique in that no other means of sequestering or offsetting carbon has the added benefits of providing clean air, clean water, biodiversity, wildlife habitat, aesthetics, and wood products.

Federal policies that invite and encourage sustainable use of our Nation's forests can help produce low carbon energy and sequester carbon through management strategies for sequestration, reducing fires and insect epidemics, substitution of biomass for fossil fuels, and utilization of wood products. Forests can either be a sink or a carbon source. A carefully managed forest can both prevent and reduce greenhouse gas emissions.

Emphasis must be placed on maintaining forest health by thinning overstocked stands to reduce the risk of insect epidemics and wildfires. When catastrophic events do occur, dead trees should be salvaged, the area regenerated to restore forest cover and allow young trees to start absorbing carbon dioxide through photosynthesis.

Emissions of greenhouse gases can be reduced through the substitution of biomass for fossil fuels to produce heat, electricity, and transportation fuels. The Congressional definition of renewable biomass in the RES is critical for cogeneration plants to be financially feasible. Forest biomass from Federal lands must be eligible, and all sustainably managed forests, public or private, should be equally eligible to supply biomass.

I would like to show several slides, if we can have the slides, please. I am going to go through these quickly in the interest of time.

This is the result of a mountain pine beetle epidemic in the Black Hills. These dead trees are a carbon source and a fire risk.

This is a mountain pine beetle epidemic in Colorado. These dead trees are also a carbon source and fire risk. All the stands in this entire landscape are lodge pole pine. They are the same age, and they are overstocked. This was a mountain pine beetle epidemic waiting to happen, and increased temperatures pulled the trigger.

This is the smoke column from the Jasper fire in the Black Hills. Fires are a huge source of greenhouse gases and particulates.

This is the Jasper fire area. It is now a carbon source as the trees decay. There is a risk of reburn. And the burned area needs reforestation to restart the sequestration cycle.

This is an unthinned stand of Ponderosa pine in the Black Hills. A stand like this is very susceptible to fires and forest insects.

This is a thin stand of Ponderosa pine in the Black Hills. This is a healthy stand with low susceptibility to fires and insects. This is a carbon sequestration factory. There is strong public support for thinning like this in the Black Hills, because residents understand the link between overstocked forests and fires and mountain pine beetles.

This is a slash pile. The Forest Service burns thousands of these each year. These are a source of greenhouse gases and particulates. These should but do not meet the RES definition of renewable biomass.

My last slide is a picture of the Case Number 1 area. This is the site in the Black Hills National Forest where the first timber sale from the entire national forest system was sold in 1899. This area has been thinned and harvested several times since 1899. Since then, approximately 6 billion board feet have been harvested from the Black Hills National Forest, and at the same time, the standing volume has increased from about 1.5 billion board feet to almost 6 billion board feet. Sustainable forest management really does work.

Including forestry in the climate change equation offers an opportunity to have our cake and eat it, too. We can make our forests healthier, reduce the risk of wildfires and insects, better utilize slash in small trees, create new jobs in rural communities, and produce renewable energy from American resources.

In conclusion, thank you very much for allowing me to testify today. I appreciate your time and attention, and I offer my full assistance to the committee, to Chairman Markey, and also to you, Representative Herseth Sandlin.

Thank you.

[The statement of Mr. Troxel follows:]

Testimony of

Thomas A. Troxel

Director, Black Hills Forest Resource Association

Before the House of Representatives Select Committee on

Energy Independence and Global Warming

June 18, 2009

Chairman Markey, Ranking Member Sensenbrenner, Representative Herseth Sandlin, and members of the Select Committee, thank you for the opportunity to give testimony on the important topic of forests and climate change. My name is Thomas A. Troxel, and I am here today representing the Black Hills Forest Resource Association, a trade association representing forest products companies in the Black Hills region of South Dakota and Wyoming.

Background

I'm testifying today, not as an expert on global climate change, but as a forester with 35 years of experience in the Intermountain West. I currently work primarily with the Black Hills National Forest, which lies in western South Dakota and northeastern Wyoming, and with the other national forests in Wyoming and Colorado, which comprise the Forest Service's Rocky Mountain Region. These forests are comprised primarily of ponderosa pine, lodgepole pine, Engelmann spruce, true firs, and aspen, each of which occupy specific habitats and require individual management strategies.

How will changes in temperatures, precipitation and weather patterns affect forestry?

Forests have evolved over millions of years in association with many past changes in climate. For instance, the current forests of the Black Hills are a remnant of a boreal forest that covered all of South Dakota only 10,000 years ago. Looking ahead, climate change will have varying effects on forestry depending on the specific change and the particular species of trees. Most scientists now predict a warmer, drier climate. To the extent that climate change will cause a warmer, drier climate, it will likely stress forests, making them more vulnerable to insect and disease outbreaks. Similarly, in a warmer, drier climate, wildfires will likely become more frequent and intense, cost more to suppress, and have greater impacts on air and water quality, wildlife habitat and infrastructure.

To understand how this would affect forests in the future, consider the effects of below average precipitation for most of the last 10 years over much of the western United States. Since 2000, forest fires have burned 184,000 acres of the Black Hills NF, including the Jasper Fire, the largest fire in the recorded history of South Dakota. In August 2000, with hot, dry weather conditions, and record low vegetation moisture, the Jasper Fire burned 83,500 acres (including 50,000 acres in just a few hours on August 26th) and cost $11.5 million to suppress. In 2002, the Hayman Fire burned 138,000 acres southwest of Denver, Colorado, making it the largest fire in the recorded history of Colorado, and cost $39 million to suppress. Also in 2002, the Missionary Ridge fire burned 70,000 acres in southwest Colorado, at a cost of $90 million to suppress and another $9 million in rehabilitation costs.

Since the late 1990s, a mountain pine beetle epidemic has affected over 200,000 acres in the Black Hills, and is still killing over 100,000 new trees each year. During the same period, a massive mountain pine beetle epidemic has exploded in Colorado and Wyoming, killing nearly 2 million acres of forests. Forest entomologists predict that by the time the beetle has finished, it will have killed 80-90% of the mature lodgepole trees in Colorado. Mature trees account for 90% of the lodgepoles. While beetle infestations are part of the natural order of these forest, the current epidemic has exceeded anyone's prediction.

In addition to the effects on the forests themselves, fires and mountain pine beetle epidemics will have significant effects on water quality, water quantity, wildlife populations and habitat, recreation, critical infrastructure, and the safety of people and communities.

How will threats by pests change or grow due to climate change?

Climate is one of the most important factors affecting mountain pine beetle populations. Typically, higher elevation and northern latitude forests experience extreme cold periods where air temperatures hover at minus 30-40°F for several or more weeks in winter. Under such temperatures over-wintering beetles or larvae experience significant mortality. Similarly, cool moist summers can inhibit beetle activity and larval development and increase the effects of fungal pathogens. Under warmer and drier climatic conditions, beetle populations respond with less winter mortality and faster, more efficient reproductive cycles.

Under the "average" climatic conditions of the past century, mountain pine beetles exist as an endemic population within pine forests, colonizing and killing trees that are unable or incapable of defending themselves due to a variety of physiological, genetic or environmental factors. Trees that are not growing vigorously due to old age, competition, poor growing conditions, drought, fire or other damage are the trees most likely to be attacked by bark beetles.

The availability of suitable host trees is an equally important factor that influences mountain pine beetle populations. Susceptibility to mountain pine beetles is closely related to tree vigor, which is related to stand density. As stand density increases, the amount of competition between individual trees within the stand for water, sunlight and nutrients, will also increase. A warmer, drier climate will cause additional stress to forests, making them even more vulnerable to insect and disease outbreaks.

A combination of mild winters, early springs and longer summers present perfect conditions for mountain pine beetle survival and reproduction. When combined with a landscape dominated by stands of mature host trees, which are stressed from overstocking and drought, the conditions for an epidemic are present. If the climatic conditions that favor bark beetles persist, this epidemic will last as long as there are host trees available to eat. When epidemic populations develop, trees that originally exhibited resistance to pest attack can succumb to the sheer numbers of beetles. That is exactly the scenario now playing out in forests in the Black Hills, Wyoming, Colorado, and across the West.

How can forestry help produce low carbon energy and sequester carbon?

Forestry can help produce low carbon energy and sequester carbon through 1) Management Strategies for Sequestration, 2) Reducing Fires and Insect Epidemics, 3) Substitution of Biomass for Fossil Fuels, and 4) Utilization of Wood Products.

1) Management Strategies for Sequestration - Forests play a crucial role when considering ways to address the increase in atmospheric carbon dioxide levels and potential climate change. Forests are better at storing carbon than any other land cover. It is estimated that U.S. forests sequester about 200 million metric tons of carbon per year, which offsets about 10% of the industrial emissions of greenhouse gases.

Although there is debate on this issue, it seems clear from modeling studies that, in the long run, properly managed forests that incorporate a sequence of harvests result in more carbon sequestered than a forest left unmanaged. This is because rapidly growing young forests are more efficient in carbon sequestration. Old forests store more carbon, but as they age and are taken over by insects and disease the net uptake of carbon can diminish to zero as carbon lost in respiration and decomposition becomes similar to the rates of carbon uptake. Harvesting results in an immediate decline in carbon storage, but the significance of this depends on the fate of carbon in the various harvested products, and the environmental and carbon costs of using alternative products, such as steel, concrete, or aluminum, whose manufacture is energy intensive and produces substantial emissions.

There is no "best" approach to managing forests for carbon sequestration as the type of management used depends on ownership objectives, tree species, and site productivity. Any forest carbon strategy must seek to maintain forest ecosystems with a diversity of age classes at the landscape level. Emphasis must be placed on maintaining forest health by thinning overstocked stands to reduce mortality from drought, insects, disease, and wildfire. When catastrophes do occur, dead trees should be promptly salvaged, where allowed, and the area regenerated to ensure rapid restoration of forest cover to allow young trees to absorb carbon dioxide from the atmosphere through photosynthesis.

2) Reducing Fires and Insect Epidemics – Forests can be either a sink for CO2 or a source of CO2. Reducing the number and severity of wildfires may be the single most important short-term action we can take to lower green house gas emissions. One wildfire, the July 2007 Angora Fire, which burned 3,100 acres in South Lake Tahoe, released an estimated 141,000 tonnes of carbon dioxide and other green house

gases in the atmosphere, and the decay of trees killed by the fire could bring total emissions to 518,000 tonnes. This is equivalent to the green house gas emissions generated annually by 105,500 cars. Active forest management to improve forest health and reduce hazardous fuels can dramatically reduce CO2 emissions, while simultaneously enhancing wildlife habitat, recreational and scenic values, reducing the threat of wildfires to communities and critical infrastructure, and contributing to the health of rural communities by providing family-wage jobs.

On the national forests alone, between 60 and 80 million acres of forestland is classified as densely stocked and at risk for catastrophic wildfire. As a result, wildfire is burning large amounts of forests across the nation. In recent years fires have burned about eight million acres each year, and management predictions for the next decade indicate that fires may well burn in excess of ten million acres annually.

The annual growth the Black Hills NF, and the entire National Forest System, is significantly higher than the annual harvest (see Attachment 1). On the Black Hills NF, the volume of standing sawtimber has increased from 1.5 billon board feet in 1897 to more than 5 billion board feet today, while nearly 6 billion board feet of timber was harvested during that same period. Consequently the overstocking and mountain pine beetle risk are compounded each year by new growth, ultimately leading to even higher risks of mountain pine beetles and fires. Further, the lack of age class diversity puts entire landscapes at risk. In Colorado and Wyoming, almost the entire lodgepole pine landscape is mature (see Attachment 2), the result of settlement, logging, and fires 100 years ago.

A healthy forest products industry is critical to reducing risks of wildfires and mountain pine beetles. The single most important factor for the viability of existing industry infrastructure is a consistent, predictable supply of timber sales from the national forests. Losing infrastructure will harm all landowners and make the task of managing the national forests extremely difficult. Millowners need consistency and predictability in the Forest Service's long-term management programs. Similarly, the Forest Service faces the challenge of planning their programs each year without certainty about Congressional funding levels.

As a step toward addressing this issue, I applaud the overwhelming passage of the FLAME Act by the House of Representatives, and hope the Senate will follow suit soon.

3) Substitution of Biomass for Fossil Fuels - Emissions of green house gases can be reduced through the substitution of biomass for fossil fuels to produce heat, electricity, and transportation fuels. Currently, one of the forest products companies in the Black Hills is seriously exploring a partnership to construct and operate a $50 million, 19 MW electrical co-generation facility adjacent to their existing sawmill. The benefits of this facility include:

a) Increasing our nation's supply of renewable energy, thus decreasing our dependency on foreign oil.
b) Increased utilization of forest biomass from forest management projects on the Black Hills NF and private timberlands, including mill residues, slash piles, and small diameter thinnings. About 5,000 large slash piles are created each year, and most of those are burned during the winter months, generating huge volumes of smoke and carbon, and wasting a resource.
c) Creation of 40 to 50 additional jobs for families in local communities.

One of the important considerations is the RES (Renewable Electricity Standard) definition of Biomass. The RFS (Renewable Fuels Standard) definition inexplicably excluded nearly all federal fiber from counting toward renewable biofuels. This restrictive definition serves as a disincentive to restore forest health in many areas and hampers efforts to reach renewable fuels mandates. Unfortunately, HR 2454, the American Climate and Energy Security Act just approved by the House Energy and Commerce Committee is on the verge of repeating this mistake by disqualifying any fiber from Federal lands if it comes from a "mature" forest stand. This provision would have the effect of prohibiting much of the fiber from the national forests from being counted as renewable biomass. Considering the unhealthy state of much of the Western forests, and the pressing need to develop additional capacity of renewable energy, this would be a mistake of historic proportions.

Forest biomass from federal lands must be eligible and all sustainably managed forests, public or private, should be equally eligible to supply biomass. More specifically, slash and other biomass from national forest timber sales that conform to the applicable laws governing the national forests, and the applicable Land and Resource Management Plan, should qualify as renewable biomass under the RES, and the RFS.

4) Utilization of Wood Products - Forests have added value in providing a renewable source of wood products upon which our standard of living depends. Use of wood should be enhanced because life cycle assessments show that using wood for construction and housing uses far less energy and has a much lower "carbon footprint" than structures built with steel, plastic, or aluminum. These alternatives require more energy to produce than an equivalent amount of wood product, and they are not renewable. America's forest businesses are leading the way to embracing environmental standards in business. We grow and harvest timber to manufacture wood and paper products used by every American, and are an essential part of our nation's economy.

Conclusion

Sustainable management of forests can, to a substantial degree, mitigate global climate change. Forests are unique in that no other means of sequestering or offsetting carbon has the added benefits of providing clean water, biodiversity, clean air, wildlife habitat, aesthetics, and wood products. Federal policies that invite and encourage a growing forest business sector and sustainable use of our nation's forests are the right policy for the future. Finally, I am honored to be asked me to testify today, and I would be very pleased to work with Chairman Markey, Representative Herseth Sandlin, and the Committee to explore solutions to the issues discussed here today.

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Thomas A. Troxel
Intermountain Forest Association

Tom Troxel was born and grew up in Virginia. He received a Bachelor of Science in Forestry from the University of Montana in 1973, and worked for the U.S. Forest Service in Idaho, Montana and California from 1973 to 1989 with responsibilities in reforestation, silviculture, timber sales, and fire management.

Since 1989, Tom has been the Director of the Rocky Mountain Division of the Intermountain Forest Association based in Rapid City, SD. In this capacity, Tom represents forest products companies in Colorado, South Dakota and Wyoming, primarily on issues related to national forest timber programs, including forest planning, project analyses, timber sale contracts, and legislative affairs.

Tom currently serves as the Director of the Black Hills Forest Resource Association, the Executive Director of the Colorado Timber Industry Association, and the Executive Secretary of the Black Hills Regional Multiple Use Coalition. He is a member of the Board of Directors for the Rapid City Chamber of Commerce and of the Black Hills National Forest Advisory Board. He is also a member of the Society of American Foresters, and was previously Chair of the Libby, MT Chapter of the Society of American Foresters and Chair of the Dakotas Society of American Foresters.

Amount and Source of Federal Grants or Contracts in FYs 2007, 2008, and 2009

Thomas A Troxel, 22905 Rimrock Court, Rapid City, SD 57702

Representing: Black Hills Forest Resource Association (BHFRA)

Federal Grants or Contracts received by Thomas A. Troxel in FYs 2007, 2008, 2009

None

Federal Grants or Contracts received by BHFRA in FYs 2007, 2008, 2009

None

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Thomas A. Troxel

Ms. HERSETH SANDLIN. Thank you, Mr. Troxel.

Our next witness joining us today is Mr. Ford West. He is president of The Fertilizer Institute. Mr. West brings 30 years of experience with The Fertilizer Institute, representing the association before Congress, Federal agencies, and the media.

We thank you for being here today, Mr. West. You are now recognized for 5 minutes.

STATEMENT OF FORD B. WEST

Mr. WEST. Thank you, Madam Chairman. I appreciate the opportunity to be here.

The fertilizer industry supplies nutrients, such as nitrogen, phosphate, and potash, to farmers who grow food for America's dinner table. Fertilizer is a strategic commodity in food production, because 40 to 60 percent of the world's food supply is tied to the use of fertilizers.

Now, all sectors of our industry will be impacted by climate change policy, but I am going to focus on the nitrogen sector this morning, which is most vulnerable to the impacts of the cap-and-trade system. And it is our goal at the end of the day, if Congress passes cap-and-trade, that it will not place our industry in a serious competitive disadvantage compared to our global fertilizer producers that we compete with, such as China, Russia, Venezuela, and will not force the domestic fertilizer industry overseas to countries with no carbon reduction policies.

The nitrogen industry uses natural gas as a feedstock or an input required to make nitrogen. We use natural gas as an ingredient in a fixed chemical process that combines nitrogen from the air and hydrogen from natural gas to produce nitrogen fertilizer, ammonia, and we produce CO_2. And outside of changing the laws of chemistry, there is nothing we can do to change this process, and 90 percent of the cost of producing a ton of ammonia is tied directly to the price of natural gas. And so this makes the nitrogen industry one of the most energy-intensive, greenhouse-gas-intensive, and trade-intensive sectors of our economy.

Now, the industry has worked hard to be as energy efficient as we can. We have cut the amount of natural gas used to produce a ton of ammonia by 11 percent. Not only does that save energy, but it also reduces CO_2 emissions, and the U.S. EPA estimates that we have cut about 4.5 million tons of CO_2 equivalent per year out of our production process. We want to be more efficient, but the chemical nature of our process limits our ability to find much more efficiency gains in our production process.

One of our big concerns here is fuel switching. We don't have a very good history with fuel switching when Congress repealed the Fuel Use Act in 1987 and allowed utilities to burn natural gas to produce electricity. As the utilities began that process and went from zero to about 20 percent of our electricity produced by burning natural gas, the price of natural gas went from like $2 to about $8, and we shut down 26 nitrogen plants in that process. We were the poster child of leakage in that public policy, and it is a challenge we have.

Currently, we have 29 nitrogen plants operating in the U.S.; we import about 55 percent of our nitrogen; and 82 percent of that nitrogen comes from countries that are not necessarily eager to regulate carbon and reduce CO_2 emissions.

So I would hope you can understand that we have some concerns with our remaining domestic nitrogen production as the utilities again will turn to natural gases and alternatives to generate electricity. And I know that we are trying to go to the solar and wind to produce electricity, but the backup, when the sun is not shining and the wind is not blowing, is natural gas.

So it is important to understand that fertilizer is a gold commodity traded in the world market. We are not only having to compete against those countries that are not interested right now in climate change policy, but we also have got to be concerned with those governments who are signed on to Kyoto who are looking for ways to protect their energy-intensive industries. And we just hope that this American policy that we develop on cap-and-trade doesn't cause us more plant closure and raise the amount of imported nitrogen that we have.

The average nitrogen plant that we have today employs 150 to 200 people. These are good jobs. The average salary is about $75,000. They are located in rural communities. They are good jobs, good benefits, and these facilities give a great deal back to the communities.

I think you can see that the price of energy is a major concern in agriculture. We did ask the Doane Advisory Service to do an analysis of energy costs and what that may mean to farmers. It is somewhere around $6 billion to $12 billion dollars based on the Lieberman-Warner bill. And that is why you find agriculture so concerned about having an offset program that they could participate in to help recover some of their costs.

We are very supportive of that. We have been working with fertilizer best management practices in Alberta, the province of Alberta, to develop a protocol based on the 4R nutrient stewardship system. And we think the best management practices have a potential to not only increase ag yields, as we are called on to increase agriculture production 50 percent by 2025 and double it by 2050, but we can also enhance fertilizer use, significantly reduce emissions of greenhouse gas, and improve our water quality.

I thank you and look forward to your questions.

[The statement of Mr. West follows:]

The Fertilizer Institute

Nourish, Replenish, Grow

Testimony of Ford B. West
President, The Fertilizer Institute
Before the
U.S. House Select Committee on Energy Independence and Global Warming
June 18, 2009

Good morning Chairman Markey, Ranking Member Sensenbrenner and members of the committee. I am Ford West, President of The Fertilizer Institute. The Fertilizer Institute is the leading voice for the nation's fertilizer industry and I am pleased and appreciative of the opportunity to provide you with our industry's perspective on climate change policy.

Fertilizer helps feed the world by increasing farmer's yields by as much as 40 to 60 percent. Specifically, the fertilizer industry supplies nitrogen, phosphate, and potash to farmers who grow food for America's dinner tables. Nitrogen is made using natural gas for which there is no substitute. This means that the nitrogen fertilizer industry is highly dependent on a reliable and reasonably priced supply of natural gas. Phosphate and potash are minerals mined from the earth and these processes also require a great deal of energy.

The fertilizer industry has gone to great lengths to advocate environmental stewardship and many of our members participate in voluntary climate change markets. We believe that it is important to implement a climate change policy that preserves our ability to compete as manufacturers while reducing green house gases to protect the environment.

All sectors of the fertilizer industry will be impacted by any climate policy, but I will focus today's comments on our nitrogen sector which is most vulnerable to the impacts of a cap and trade system. As I will explain, any cap-and-trade proposal will place our industry at a serious competitive disadvantage compared to global fertilizer producers in countries like China, Russia and Venezuela and likely will force the domestic fertilizer industry overseas to countries with no carbon reduction policies.

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All crop producers rely on our products to produce food, feed, and now fuel, with corn being the nation's largest fertilizer consuming crop.

The nitrogen industry will be impacted by a cap and trade system because it is uniquely sensitive to the price of natural gas as it is a feedstock or input required to make nitrogen. We use natural gas as an ingredient in a fixed chemical process that combines nitrogen from the air and hydrogen from the gas to produce nitrogen fertilizer, in a form that the plant can take up. Outside of changing the laws of chemistry, there is nothing we can do to change this process and, consequently, as much as 90 percent of the cost of producing a ton of ammonia, the building block for all other nitrogen fertilizers, can be tied directly to the price of natural gas. This makes the nitrogen industry one of the most energy intensive manufacturing process that exists.

Between 1983 and 2006, the industry reduced the amount of natural gas used to produce a ton of ammonia by 11 percent. With that energy efficiency came carbon reductions. The U.S. EPA estimates that between 1990 and 2006, U.S. nitrogen producers reduced their greenhouse gas emissions by 4.5 million tons of CO_2 equivalent. While our member companies are committed to additional energy efficiency projects, there will soon come a point where, due to the constraints of chemistry, the efficiency gains will be limited.

Historically, the cost of natural gas has exacted a heavy toll on America's nitrogen fertilizer producers and the farmer customers they supply. The resulting impact on the American fertilizer industry has been unprecedented and threatens to irreversibly devastate the U.S. nitrogen fertilizer manufacturing industry. The U.S. industry now supplies a little less than one-half of U.S. farmers' nitrogen fertilizer needs – a very notable departure from a domestic nitrogen fertilizer industry which typically supplied 85 percent of farmers' nitrogen needs during the 1990s.

Specifically, since 2000, the U.S. nitrogen industry has closed 26 nitrogen fertilizer production facilities, due primarily to the high cost of natural gas. Currently, only 29 nitrogen plants are still operating in the U.S. and presently 55 percent of the U.S. farmer's nitrogen fertilizer is imported. Of this imported fertilizer, 82.7 percent is made up of countries without climate change policies in place to regulate carbon and a majority of these countries are those from whom we are striving for energy independence.

U.S. farmers are becoming increasingly dependent on foreign sources of fertilizers from places that offer cheap natural gas like the Middle East, China, Russia and Venezuela. In 2007, U.S. farmers imported 314 thousand tons of nitrogen materials from Libya; 477 thousand tons from Egypt; 1.8 million tons from the Middle East; and over 3 million tons from countries of the former Soviet Union. These countries have discovered the opportunities associated with offering an attractive combination of reduced manufacturing, labor, natural resources, and environmental costs compared with that of the United States.

The fertilizer industry has grave concerns that our remaining domestic nitrogen production will not stay operational through any transition period of a cap and trade system where utilities turn to natural gas as an alternative for generating electricity and fertilizer producers are forced to buy emission credits on the open market. It is important to understand that fertilizer is a global commodity traded in a world market. In addition to the nitrogen producing countries I listed earlier, which are already at a competitive advantage over U. S. producers thanks to their easy access to supplies of natural gas and reduced manufacturing costs, U.S. fertilizer producers are also competing against producers in the European Union and Australia, whose governments have adopted or drafted policies that aim to fully protect their energy-intensive/trade-intensive industries. American policy that would increase demand and thus drive the cost of natural gas up will further handicap our domestic production and lead to more plant closures. This should be of concerns, because in the rural areas where our plants operate, the fertilizer industry is usually the highest paying employer. The average nitrogen plant employs 150 – 200 people with an average salary of $75,000. These are good jobs and these facilities give a great deal back to their communities.

Moreover, reduced domestic production of fertilizer will only increase costs to American farmers since they will be more exposed to price volatility and product availability resulting from importing such a great deal of our plant nutrient needs.

Increased input costs for farmers are another concern under a cap and trade system. Last year, TFI commissioned a study on the impacts of high energy costs resulting from a cap and trade system on American farmers. Using the Lieberman Warner bill as a baseline and EPA's moderate economic analysis of the impacts to energy prices resulting from the legislation, Doane Advisory Services measured the production cost increases for eight farm commodities. Doane economists found that any such cap and trade system would add $6 to $12 billion to total crop production costs leading to a significant decline in farm income. If a cap and trade system is enacted in the United States, it is imperative that American farmers are able to offset these additional crop production costs with the ability to earn soil carbon sequestration credits through science-based best management practices.

Farmers should get credit for their very important role in the reduction of climate change related emissions. Not only can low till and no till farming techniques help increase the carbon content of soils and reduce erosion, there are also practice based approaches such as the Alberta Protocol, which is based on fertilizer best management practices, that demonstrate farmers' capacity to reduce nitrous oxide emissions from the field. The Alberta Protocol is a peer reviewed set of fertilizer best management practices based on the 4R nutrient stewardship system, which promotes the use of the right product applied at the right rate, right time and right place. These best management practices have the potential to not only increase agricultural yields but they can also enhance fertilizer use efficiency, significantly reduce emissions of GHGs and improve water quality.

Congress must tread cautiously and consider all ramifications and unintended consequences. Fertilizer is a strategic commodity and U.S. food security cannot be attained without the use of commercial fertilizers. We have already witnessed the impact reliance on foreign sources of oil have had on U.S. consumers and it is frightening to imagine the uncertainties that could result if U.S. policy made us completely reliant upon some of the same foreign sources for our food production.

I would like to thank you for the opportunity to present the fertilizer industry's concerns related to climate change legislation. I appreciate your interest in our industry's needs and I am happy to answer questions at the appropriate time.

Ms. HERSETH SANDLIN. Thank you, Mr. West.

Our next witness is Dr. Johannes Lehmann, associate professor of soil fertility management and soil biogeochemistry at Cornell University, and the world's expert on biochar. Dr. Lehmann has conducted research around the world, recently studying nutrient and carbon management in the Central Amazon for the Federal Research Institution of Forestry.

Dr. LEHMANN, welcome to the select committee. You are now recognized.

STATEMENT OF JOHANNES LEHMANN

Mr. LEHMANN. Thank you, Chairwoman Herseth Sandlin and members of the committee. Thank you for the opportunity to discuss biochar for sustainable climate change mitigation and global soil.

Biochar is a fine grain light material that is produced through heating of biomass under fire conditions. Upon such heating to relatively low temperatures, the chemical properties of biomass carbon changes to form structures that are much more resistant to microbial degradation.

Ms. HERSETH SANDLIN. Sir, could you make sure your microphone is on.

Mr. LEHMANN. Through this so-called pyrolysis, biomass can be transformed from materials that are subject to rapid decomposition to material that decomposes much more slowly, thereby creating a long-term carbon sink. Such thermally altered material is about 1.5 to 2 orders of magnitude more stable in soils than uncharred organic matter, thus creating solar carbon pools with a mean resident time of several hundreds to thousands of years.

Biochar production and its application to soil provides several additional important value streams beyond direct climate change mitigation. These include waste management, energy production, and soil improvement. Biochar can be produced from a variety of feedstocks that would otherwise constitute a financial and environmental liability. Examples include animal manures in agricultural regions with high phosphorus and nitrogen loadings, green waste that might generate nitrous oxide or methane during landfill, or biomass from forest thinning for fire prevention.

The second value stream arises from the bioenergies generated during biochar production. Between 2 and 7 units of energy can be produced for each unit of energy invested during the life cycle of various biochar systems.

The third value stream is the improvement of soil quality upon biochar additions. Crop yields and many less productive soils can be significantly increased, and losses of agro chemicals, such as fertilizer nutrients, herbicides, and pesticides, can be decreased.

Taken together, these three sources of value can enhance food and energy security while also combating climate change.

Delivered biochar additions to soils have a number of implications for carbon trading. Additionality can be demonstrated because biochar is currently not added to soil to any appreciable extent. Monitoring of biochar sequestration is facilitated by the fact that we can easily record the carbon that is added at any time, and its sequestration impact does not need to develop over time.

Verification of sequestration is possible because biochars bear a chemical signature that can be distinguished from other organic matter and soil.

The national and global potential of biochar to help mitigate climate change is only theoretical at this point because too few biochar systems exist at scale of implementation. Conservative modeling of the technical potential place biochar as an approach to contribute on the order of 1 gigatron carbon removal annual by 2050.

Such widespread adoption of biochar systems will require sustainability criteria. Biochar must therefore be integrated into existing food production systems and not be an alternative for food production; make use of already developed best management practices such as conservation agriculture; and build on residue†collection systems that are already in place.

While few fully implemented modern biochar systems exist worldwide, the necessary engineering and science capacity is available to evaluate a diverse set of biochar systems at scale of implementation in the near term. In fact, biochar has rapidly evolved even over the past 12 months. Evaluation does not rely on a fundamental advance in science, but on application and adaptation of existing science. The underlying technology is robust and sufficiently simple to make it applicable to many regions globally.

Current hurdles to implementation are availability of pyrolysis units at sufficient maturity to allow all necessary research and development and as a direct consequence a lack of demonstrated carbon trading activities, a sufficient development of best biochar practices and of demonstration of soil health benefits for the full spectrum of agro ecosystems.

The distributed nature of biochar systems and the potential for variability between systems creates significant opportunities for sustainability, but also hurdles to widespread adoption, regulation, and financial viability.

Establishment of policies at national and international levels is required to remove hurdles to implementation and support full evaluation of biochar systems.

Mechanisms for carbon trading need to be put into place that recognize biochar soil carbon sequestration. Methodologies must include full lifecycle accounting of emission balances to deliver net climate benefits.

The entire value chain of mitigation approaches must be recognized to reward those activities that have multiple environmental and societal benefits.

Biochar must not be an alternative to making dramatic reductions in greenhouse gas emissions immediately, but it may be an important tool in our arsenal for combating climate change.

Thank you, Madam Chairman.

[The statement of Mr. Lehmann follows:]

Testimony of Dr. Johannes Lehmann
Cornell University, Ithaca, NY, USA

Before the
House Select Committee on
Energy Independence and Global Warming

Thursday, June 18, 2009

2175 Rayburn House Office Building
Washington, DC

Biochar for sustainable carbon sequestration and global soil enhancement

Chairman Markey, Members of the Committee:

Thank you for the opportunity to provide scientific information about biochar carbon sequestration for sustainable climate change mitigation and global soil enhancement. Biochar is a fine-grained charcoal-like material that is produced through the heating of biomass under air-deprived conditions. This process is called pyrolysis. A wide variety of organic matter sources can be used as a feedstock for this process, including residues from forests or crop production, from animal production (manures), and from green waste streams, such as yard wastes. Upon pyrolysis at relatively low temperatures of 300-600°C, the chemical properties of biomass carbon change to form structures that are much more resistant to microbial degradation in comparison to the original organic matter. Thus, materials that would rapidly release carbon dioxide and other potent greenhouse gases as they decompose, are transformed into a material that degrades much more slowly, thereby creating a long-term carbon sink (Figure 1). Such thermally altered material is about 1.5 to 2 orders of magnitude more stable in soils than uncharred organic matter.[1,2] Biochar has mean residence times of several hundreds to several thousands of years in soils.[3,4]

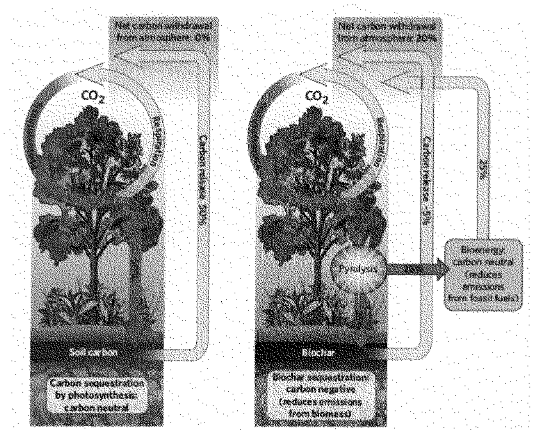

Figure 1: Schematic showing how biochar would achieve an increase of soil carbon stocks by decreasing the carbon dioxide return to the atmosphere.[5]

The mechanism behind carbon sequestration through biochar in soils is very straightforward because stabilization is to a large extent a function of its intrinsic chemical stability. This is in contrast to uncharred organic matter, where soil carbon accrual primarily relies on a range of interactions between the mineral matrix and the organic matter.[6,7] Therefore, the level at which soil carbon stores saturate[8] and cease to sequester additional carbon is greater for biochar than for uncharred crop or forestry residues.

Biochar is a familiar substance in soil. Most soils already contain char that was generated during vegetation fires throughout the past several thousand years. These chars are estimated to make up several percent of total soil organic carbon worldwide,[9,10] which, in turn, is about twice the size of the atmospheric carbon pool.[11] Biochar soil management increases the amount of such naturally existing chars, which have been found to provide beneficial health and productivity properties to soil.

Biochar production and its application to soil provide several additional important value streams beyond direct climate change mitigation. These include waste management, energy production, and soil improvement (Figure 2). As a waste management strategy, biochar can be produced from a variety of feedstocks that would otherwise constitute a financial and environmental liability.[12] For example, in agricultural regions with high phosphorus and nitrogen levels in the soils and water, animal manures could be pyrolysed as a waste management strategy to prevent eutrophication. In many situations, compost, landfill or animal manure operations often generate large amounts of methane and nitrous oxide. By pyrolysing materials such as lawn clippings or biomass from forest thinning for fire prevention, the production of these even more potent non-CO_2 greenhouse gases would be effectively mitigated at the same time as the carbon is sequestered in soil.

A second value stream arises from bioenergy generated during biochar production. Between 2 and 7 units of energy can be produced for each unit of energy invested during the life cycle of various biochar systems.[13] Biochar production can be paired with local heat generation such as a system where poultry manure is pyrolysed on-farm to heat barns and the resulting biochar is applied to fields.

The third value stream is the improvement of soil quality upon biochar additions. Crop yields can be significantly increased in soils that have productivity constraints. These may arise from degradation of soil organic matter or years of nutrient extraction through cultivation. The resulting losses of agrochemicals such as fertilizer nutrients, herbicides and pesticides can be mitigated by biochar's ability to retain these compounds.[14,15,16,17,18] Subsequently, fertilizer use efficiency is increased.[19] In its ability to improve several key properties of soils, biochar is particularly effective not only because it delivers these values for a longer period of time, but also because it has a greater effect per unit of carbon added to soil.[20] Improved soil fertility also provides better resilience against climate change. Taken together, these three sources of value have the potential to enhance food and energy security while also combating climate change.

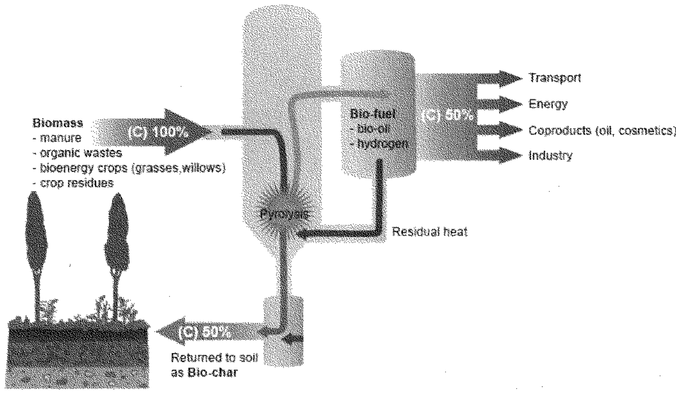

Figure 2: Biochar value streams including biomass use, energy generation and soil enhancement.[21]

Deliberate biochar additions to soils have a number of implications for carbon trading. Additionality can be demonstrated because biochar is currently not actively produced or added to soils to any appreciable extent (less than 1% global penetration). However, it would still be critical to determine what the carbon stocks and flows would have been under the baseline system and to ensure that no greenhouse gas "leakage" would occur. For example, the land-use effects of large-scale biofuel-style plantations[22] for biochar production or the removal and use of crop residues necessary to protect soil from erosion would likely make such systems inappropriate for biochar production to achieve net carbon sequestration. Measurement and verification of biochar sequestration is facilitated by the fact that the amount of carbon added at any one time is easily measured or calculated, and does not need to accumulate over time. Verification of lasting sequestration is possible because biochars bear a chemical signature that can be distinguished from other organic matter in soils. Furthermore, sequestered biochar carbon would not be released to the atmosphere due to changes in land management, fires, or deforestation, making it a strong candidate as a reliable carbon sequestration agent, with a mean residence time of several hundred to thousands of years.

The national or global potential of biochar to help mitigate climate change is only theoretical at this point, because too few biochar systems exist at scale of implementation. Conservative modeling of the technical potential place biochar as an approach to contribute on the order of 1Gt carbon removals annually by 2050 (considering only limited biomass feedstock availability and only carbon sequestration impacts).[23] Such widespread adoption of biochar systems will require sustainability criteria, since the climate change mitigation value of biochar arises from several connected sources including energy and agriculture. The potential for climate mitigation is highly variable from one biochar system to the next due to different feedstocks, scales, and applications[13,24] which requires careful evaluation. Biochar must be integrated into existing food production systems and not be an alternative to food production, make use of already developed best-management practices such as no-tillage or conservation agriculture, and, for efficiency, build on residue collection systems that are already in place.

While few fully implemented modern biochar systems exist worldwide, the necessary engineering and science capacity is available to evaluate a diverse set of biochar systems at scale of implementation in the near term. In fact, biochar science has rapidly evolved even over the past 12 months.[25] Evaluation does not rely on a fundamental advance in science, but on the application and adaptation of existing science. The underlying technology is robust and sufficiently simple to make it applicable to many regions globally.

Current hurdles to implementation are: availability of pyrolysis units at sufficient maturity to allow all necessary research and development, and, as a direct consequence, a lack of demonstrated carbon trading activities; of sufficient development of best biochar practices at scale of implementation, including farm scale; and of demonstration of soil health benefits for the full spectrum of agroecosystems. The distributed nature of biochar systems and the potential for variability between systems create significant opportunities for sustainability, but also hurdles to widespread adoption, regulation, and financial viability.

Establishment of policies at national and international levels is required to remove hurdles to implementation and support full evaluation of biochar systems. Mechanisms for carbon trading that recognize soil carbon sequestration, including biochar sequestration, need to be put into place. Methodologies must include full life cycle accounting of emissions balances to deliver net climate benefits. The entire value chain of mitigation approaches must be recognized, to reward those activities that have multiple environmental and societal benefits. Biochar must not be an alternative to making dramatic reductions in greenhouse gas emissions immediately, but it may be an important tool in our arsenal for combating dangerous climate change.

Thank you, Mr Chairman.

Summary

What is biochar?

- Biochar is a fine-grained charcoal-like material produced through pyrolysis.
- Pyrolysis is the heating of biomass to temperatures of 300-600°C under air-deprived conditions.
- Through pyrolysis, the feedstock changes chemically to form structures that are much more resistant to microbial degradation than the original material.
- Many different sources of organic matter can be used as a feedstock for this process, including residues from forests or crop production, from animal production (manures), and from green waste streams, such as yard wastes.
- Biochar-like materials produced through forest fires are already a significant part of the global soil carbon cycle.

How does biochar sequester carbon?

- Because biochar is much more stable than other forms of biomass-derived carbon in soil, it remains in the soil for much longer.
- Biochar is 1.5-2 orders of magnitude more stable in soils than uncharred material and has mean residence times of hundreds to thousands of years.
- The "saturation point" for biochar additions to soil would be significantly greater compared to other additions from organic matter.

Why is biochar valuable?

- Biochar is a very stable form of carbon and can thus be used to sequester CO_2.
- Biochar can be made from waste materials, including those (e.g., manure or green wastes) that may otherwise produce even more potent non-CO_2 greenhouse gases.
- Biochar production results in energy generation, which can also be integrated into sustainable local-scale operations such as the heating of farm buildings.
- Biochar's addition to soils can enhance soil fertility and retention of agrochemicals.

What do we need to know/do?

- The technology and scientific knowledge is ready to implement the necessary steps to thoroughly develop biochar systems at a meaningful scale.
- This will be necessary in order to understand biochar best practices, demonstrate field-scale soil health benefits for different agroecosystems.
- Soil carbon sequestration, including biochar carbon sequestration must be recognized under carbon trading schemes.
- Robust guidelines must be developed to ensure that any integration of biochar into carbon trading schemes is truly additional, sustainable, and does not result in the "leakage" of greenhouse gas emissions.
- Biochar must not be seen as a replacement for dramatic reductions in our greenhouse gas emissions.

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Ms. HERSETH SANDLIN. Thank you, Dr. Lehmann.

I thank all of our witnesses for their testimony. I will go ahead and start out the first set of questions.

And, Mr. Troxel, I want to spend a few minutes focusing on your testimony regarding the substitution of biomass for fossil fuels to produce heat, electricity, and transportation fuels.

If you could discuss what impact the Federal definition of renewable biomass in the renewable electricity standard and the renewable fuels standard has on developing wood-based sources of energy; and, how would including woody biomass from Federal lands in the RFS and RES impact Federal forest land management?

Mr. TROXEL. Thank you, Representative Herseth Sandlin. The definition of renewable biomass in both the RFS and RES would make a great deal of difference in the financial feasibility of plants that would either produce electricity or cellulosic ethanol because of the financial incentives that are associated with both of those pieces of legislation.

In the case of the RFS definition of renewable biomass, woody biomass from the national forest was completely excluded. Most of the forest in the Black Hills are Federal Black Hills National Forest, and so that whole stream of biomass is taken off the table.

In the current version of the RES, there are really three components of woody biomass that would go into any of those facilities. There are mill residues. There is slash from the slash piles that we saw the picture of, and there are precommercial thinnings.

In the RES definition, the mill residues would be included. But the way I read and understand the definition is that the precommercial thinnings and the slash piles would be excluded from the renewable biomass because of a specific phrase that excludes timber from mature forest stands. And that is a term, it is a fairly generic term. There is not a definition for it. I think it is open to debate or challenge, and especially when we get into the Federal process of making decisions that could be subject to appeal or litigation, and it just opens a lot of uncertainty.

The other part of the current RES definition that is problematic is the requirement that it be harvested in environmentally sustainable quantities as determined by the appropriate Federal land manager. As foresters, I am completely supportive of sustainable quantities and management, but I don't know, and this is open to speculation, about what the process would be to make that determination and what kind of analysis or decision would be required to get there.

Ms. HERSETH SANDLIN. Thank you, Mr. Troxel.

As you may know, we are deep in negotiations as it relates to altering the definition that currently exists in the bill that was marked up in the Energy and Commerce Committee, and we hope to be able to make the changes that you suggest so that we are able to utilize precommercial thinnings and other woody biomass through current forest management practices on Federal forests. But would you like to speak for a minute or two about the importance of how this affects private forest owners as well?

Mr. TROXEL. Most of the timber lands in the Black Hills are Federal. I think it is important, though, to include private timber lands and make sure that those private landowners do have a chance to contribute toward production of renewable energy. And I would encourage you to continue your efforts to make sure that that definition does adequately include both private and Federal lands.

Ms. HERSETH SANDLIN. Thank you, Mr. Troxel.

I will reserve some of my other questions for the second round of questioning and would now recognize the gentlewoman from Tennessee, Mrs. Blackburn.

Mrs. BLACKBURN. Thank you, Madam Chair.

And thank you to our witnesses for taking the time to be with us today. We all appreciate it.

I am sorry I was late to the hearing, but as you have learned probably from others, today we have three hearings; Energy and Commerce has three hearings that are going on. And, of course, trying to step into those and then be here is tricky. But we have the opportunity to make them all and appreciate it.

Agriculture is a very vital part of the economy in Tennessee, which is where my district is found. And we are hearing quite a bit about the Waxman-Markey bill and the effect it is going to have on agriculture.

And, Madam Chairman, I have two pages that one of our constituents sent over. These are just ag facts. I would love to submit those into the record for this hearing if that is possible.

Ms. HERSETH SANDLIN. Without objection, so entered.

[The information follows:]

AGRICULTURE CONTRIBUTES $44.2 BILLION TO THE TENNESSEE ECONOMY

DIRECT AND TOTAL EFFECTS OF AGRICULTURE ON THE TENNESSEE ECONOMY*

	Direct Effects		*Total Effects*
Total Industrial Output	$26.2 billion	Total Industrial Output	$44.2 billion
Employment	177,461	Employment	341,738
Labor Income	$3.5 billion	Labor Income	$9.7 billion
Value-added	$8.1 billion	Value-added	$18.1 billion

DIRECT AND TOTAL EFFECTS OF AGRICULTURAL PRODUCTION ON THE TENNESSE ECONOMY

	Direct Effects		*Total Effects*
Total Industrial Output	$2.8 billion	Total Industrial Output	$4.5 billion
Employment	107,488	Employment	130,291
Labor Income	$0.3 billion	Labor Income	$0.9 billion
Value-added	$1.5 billion	Value-added	$2.4 billion

DIRECT AND TOTAL EFFECTS OF PROCESSING ON THE TENNESSEE ECONOMY

	Direct Effects		*Total Effects*
Total Industrial Output	$21.4 billion	Total Industrial Output	$36.1 billion
Employment	65,913	Employment	194,148
Labor Income	$3.0 billion	Labor Income	$8.1 billion
Value-added	$6.1 billion	Value-added	$14.3 billion

DIRECT AND TOTAL EFFECTS OF AG INPUT SUPPLY INDUSTRIES ON THE TENNESSEE ECONOMY

	Direct Effects		*Total Effects*
Total Industrial Output	$2.0 billion	Total Industrial Output	$3.6 billion
Employment	4,061	Employment	17,299
Labor Income	$0.2 billion	Labor Income	$0.7 billion
Value-added	$0.5 billion	Value-added	$1.3 billion

**Direct effects are the economic impacts due to industry activity. Total effects also include impacts due to supplier industries and the impact effects household income have on the economy.*

AIM-AG/AGRI-Industry Modeling & Analysis Group: (Dr. Burton English, Dr. Kim Jensen, and Mr. Jamey Menard), Department of Agricultural Economics, University of Tennessee Institute of Agriculture. For more information, please contact the group at 865/974-7231 or visit the web site at http://web.utk.edu/~aimag/. Data generated for this report from IMPLAN pro, Minnesota IMPLAN Group, 1999. Additional information in publication E11-1215-004-07 entitled "Economic Impacts of Agriculture and Forestry in Tennessee, 2003".

Tennessee Agriculture Facts

AIM-AG

Agri-Industry Modeling & Analysis Group

Agri-Industry Modeling & Analysis Group

- Agriculture in Tennessee includes farming and related industries, as well as value-added food and fiber products, processing and manufacturing.
- Agriculture accounts for 11.4 percent of the state's economy and generates $44.2 billion in economic activity.
- About 342,000 Tennesseans work in agriculture, with over 130,000 employed in agricultural production.
- Agriculture input supplying industries — agriculture machinery and chemical products — generate nearly $3.6 billion in economic activity annually.
- Over 43 percent of Tennessee's total land area is in farms, with cropland accounting for close to 60.0 percent of farmland.
- Tennessee farmers earn more than 66.1 percent of their cash receipts from cattle and calves, broilers, greenhouse/nursery, soybeans, and cotton.
- The most common types of agri-tourism attractions in the state are on-farm retail markets, on-farm restaurant/eating establishments, on-farm tours, pick-your-own farms, farm festival and fairs, pumpkin patches, cut-your-own Christmas trees, and on-farm petting zoos.
- Major markets for Tennessee's exports of agricultural and livestock products include China, Mexico, Turnkey, Indonesia, and India.
- Tennessee's equine population is the second largest in the United States (based on number of head). Of the state's estimated 210 thousand head of equine, over half are walking or quarter horses.
- Cash receipts for the leading commodities for crops and livestock and livestock products totaled close to $1.3 billion and $1.1 billion, respectively, in 2003.

AGRICULTURE CONTRIBUTES $44.2 BILLION TO TENNESSEE'S ECONOMY ANNUALLY

Mrs. BLACKBURN. Thank you. I appreciate it.

This is all about agriculture in Tennessee, and it is $44 billion of our state's economy. That is 11 percent of our state's economy. And we have 79,000 farms that are employing more than 300,000 people in our state, and over 40 percent of our state is actually farmland. So the issues that we are discussing today are of vital importance to us on so many different levels. And, as I said, people are very concerned about what Waxman-Markey is going to do to their livelihood, their ability to earn a livelihood.

The estimate that has come out so far is that the farmers' net income would decrease by $23 billion annually over the next 25 years. We have got a lot of farmers that live off that income. And also, the increase in construction costs to farm buildings and equipment is expected to be a 5 percent to 10 percent increase added to whatever the inflationary rate is. So when you look at what the farmers are up against with the cost of buildings and construction and equipment and maintenance, and then you get into actually dealing with the crop itself—and, Mr. West, fertilizer is a big part of that.

And when I am in West Tennessee, and we are talking about not only the row crops but the soybeans and the cotton, fertilizer is a huge component of that.

Mrs. BLACKBURN. And what I would like to hear from you, what my constituents are asking from me, if cap-and-trade, if Waxman-Markey is passed into law, what is it going to do to the fertilizer industry? What is it going to do to your prices? And equally as important, what is it going to do to the availability of the product?

And you touched on nitrogen. And you touched on the offshore competition. And I would like for you to drill down on that just a little bit.

Mr. WEST. I think the issue for us is availability.

Mrs. BLACKBURN. Okay.

Mr. WEST. Because, we see the price of natural gas going up, and that will affect our agriculture across the board. Every $3 increase in natural gas is $1 billion to our industry. That is how much gas we use in producing ammonia. And so the question becomes are we going to produce a nitrogen fertilizer, for example, in the United States? Are we going to import the majority of our nitrogen fertilizer?

Now we import 55 percent today. So we don't set the price of nitrogen fertilizer in the United States. It is set in the world market. And a year ago, the demand for fertilizer around the world as we had a food scare and as you know, we had a big conference in Rome in June of last year about scarcity of food, we had countries around the world hoarding food. We had countries hoarding fertilizer, keeping it off the world market. The price of fertilizer went off the charts. And, of course, the worldwide drop in the economy has changed that and the prices have come down. But if we raise our input costs, the world price of fertilizer stays the same, we will shut down our production facilities.

Mrs. BLACKBURN. I don't want to interrupt you, but I do have one other question I want to go to before my time expires.

Dr. Hatfield, you mentioned that some of the studies show that the optimum range of temperature for the crop harvest actually increases as CO_2 in the atmosphere increases. So very quickly how do you see this affecting our Southern States like Tennessee?

Mr. HATFIELD. I don't know that we made a statement that said that. Would you repeat that?

Mrs. BLACKBURN. That the optimum range of temperature for crop and harvest increases as CO_2 in the atmosphere increases.

Mr. HATFIELD. Actually, there are two different processes that are going on. Temperature requirements for plants is really not linked to the CO_2. If we said that, that is a misinterpretation. The temperature plays a real role and CO_2 is really that basic building block in terms of taking CO_2 through the atmosphere through the process of photosynthesis, it grows that. It is temperature mediated. And when one of the pieces of that occurs in this is not the photosynthetic process but actually the respiration process that is affected as well which is entered by temperature.

Mrs. BLACKBURN. Thank you for that. And my time is expired. I will yield back.

Ms. HERSETH SANDLIN. I thank the gentleman. I now recognize the gentleman from Colorado, Mr. Salazar.

Mr. SALAZAR. Thank you, Madam Chair. Mr. Troxel, about 50 years ago there was a severe insect infestation across the West and some of the forests. We find that same problem here today. It is significant in Colorado, we have seen many of forests, the pictures you have shown today are quite telling.

Many people actually blame climate change for being the sole factor. I mean, this thing has happened. It is kind of cyclical. It has happened in the past. Could you comment on that?

Mr. TROXEL. Thank you, Representative Salazar. I believe the underlying problem is the condition of the forests. And as I described the picture in Colorado, it is a single species. They are all the same age, and they are in overstocked stands. And it seems like this is one of those cases that we have to keep relearning the same lessons. And managing a forest is a lot like managing a stock portfolio. Diversity is good. Our forests in Colorado, our Lodgepole Pine Forests are roughly the equivalent of having an entire stock portfolio in Enron several years ago. And when it goes south, it all goes south. And that is what has happened to our forests.

Looking ahead what we need to do is concentrate on diversity of age classes, diversity of species and keeping those stands thin and vigorous and healthy going forward so that they are better able to resist and withstand stress and not be as susceptible to fires and insect epidemics.

Mr. SALAZAR. Thank you very much.

Dr. Lehmann, to a layman like myself, explain biochar. I don't understand it.

Mr. LEHMANN. Thank you, Mr. Salazar. Biochar is very much like charcoal in the sense that the organic structures change entirely when you heat biomass. For instance, a wood log, you cover it in modern pyrolysis units. This is achieved in so-called reactors where air is excluded from the process. And the biomass is heated to about 300 to 600-degrees Celsius.

At that temperature, the properties of the biomass change and there forms so-called charcoal. Charcoal is a substance that has been produced throughout the history of humanity at all stages. It has been one of the earliest industrial processes. So the process is very similar, identical almost, as producing charcoal. What it differs is that biochar is produced for the purpose of soil amendment. And that means, several charcoals may make good biochars but there have been found to be a lot of different biochars made from feedstocks that would not make a very good fuel, which is what we usually produce charcoal for.

And this biochar material has remarkable properties that enhance soil fertility, soil quality. It is like a sponge. It is like a substrate where nutrients can hold on to where micro organisms can find a habitat. And it has also been dubbed as a microbial reef in soil.

The chemical changes that happen through these so-called thermodecomposition, this thermal treatment, is so profound that the stability of the organic matter is dramatically increased. What was a leaf or a grass that would have decomposed within a few days or weeks or months, is now a charred leaf that is stable for many decades, hundreds of years, even thousands of years.

Mr. SALAZAR. So is it like a sponge, then, for example if you apply nitrogen fertilizer to the soil, will that actually hold the nutrient and release it as the plant needs it?

Mr. LEHMANN. Yes, very similar to, we are all very familiar with the value of soil organic matter. Every farmer, every gardener will agree that when we increase soil organic matter, we hold nutrients in the soil. We improve soil plant growth ability.

And very much the same is happening with biochar. The interesting aspect is that biochar is more effective in providing these attributes, these desirable attributes of soil organic matter than, for instance, other organic material because it is more stable and it has a higher surface area, it has a certain structure that provides this ability.

Mr. SALAZAR. Thank you. My time is expired.

Ms. HERSETH SANDLIN. Thank you. I thank the gentleman. The Chair now recognizes the gentlewoman from California, Ms. Speier.

Ms. SPEIER. Thank you, Madam Chairman.

Dr. LEHMANN, let me ask you. There is great exciting news coming from companies like yours that suggest that if we pursue biofuels, we are going to see a reduction in greenhouse gases of some 70 percent. A company in my district called Solazyme that is using algae to produce aviation fuel right now and has the potential of producing it for cars as well. Its big problem, and I am wondering if it is yours, as well, is the fact that it needs to gear up. It needs the resources to be able to create a large facility so that it can, in fact, produce the products in large volumes. I guess my question to you is what do you recommend that Congress do to focus on the technical and economic challenges that many of you are facing in your efforts to scale up?

Mr. LEHMANN. Thank you, Ms. Speier, for the question. Just for the record, I am not a representative of a company, but I am a university professor and have no company affiliations.

You are asking about the fuel production ability of bio in the energy stream using pyrolysis. And that is correct, pyrolysis is able to generate fuels and so are other bioenergy streams that you mentioned, fermentation, even combustion. Bioenergy, as a whole, needs to deliver net climate and net environmental benefits. And we need to look at the full life cycle impact both economically as well as from a carbon footprint point of view, that I think we have learned the hard lesson with the current ethanol debate.

Biomass in itself is a, in many instances, a commodity that is distributed in the landscape, and that means that when they need to be gathered, carbon needs to be invested to achieve that. It is a handling issue. It is a storage issue. And so we need to look hard at those opportunities where we can harness the most environmental and climate benefits.

Colleague Troxel has already shown us a few examples where biomass actually constitutes, or biomass burning, the decomposition and die-back of forests constitute an environmental and economic liability. These are opportunities that can be harnessed first.

There needs to be very judicious discussion and very judicious observation of biomass bioenergy to be sure to develop net climate and net economic benefits. Thank you.

Ms. SPEIER. Let me further ask you. We make the mistake from time to time of picking winners and losers, whether it is in health or, in this case, choosing ethanol over other potential alternative fuels, and finding out that, in fact, there are huge repercussions.

Do you have any recommendations to us on how we go about being somewhat more neutral in allowing those that are in the area of producing new alternatives to be able to do so in a way that don't create a winner or a loser and yet also gives the opportunity for the entities that are out there to gear up?

Mr. LEHMANN. That is a very good question. And it is indeed important to not pick winners or losers because there will likely be opportunities for many different avenues and they need to be geared to the local conditions. And what is worse probably they will change over time even during the course of the year which biomass streams are viable. So we need to look at integrated concepts of bioenergy.

And there are initiatives underway by companies as well as by academic institutions and research organizations to look at bioenergy as an integrated concept not as just a one side track for dealing with biomass. And that is very important.

Ms. SPEIER. Thank you. I yield back.

Ms. HERSETH SANDLIN. I thank the gentlewoman.

The Chair now recognizes the gentleman from Washington, Mr. Inslee.

Mr. INSLEE. Thank you.

Mr. West, I have read your testimony. I am sorry I didn't get to hear it. But I have read your testimony. And I want to ask you a couple of questions about this important subject. In the underlying text of the bill that has passed the Commerce Committee, we have a provision that is called the Doyle-Inslee amendment that has free allowances to trade-sensitive, energy-intensive industries, and it is my understanding that the fertilizer industry would qualify for that, both as trade sensitive and energy intensive.

Is that your understanding?

Mr. WEST. That is my understanding, yes, and thank you for doing that, putting it in there.

Mr. INSLEE. I appreciate that.

How would you quantify the benefits to the industry in that regard? Have you put a dollar figure on it or a percentage of cost?

Mr. WEST. Well, we are subject to those free allowances. As you know, 15 percent of the total allowance is set aside for energy-intensive energies. We are probably one of what, 45, 50 sectors that would be eligible for that.

Right now I don't know exactly how many allowances we are going to be able to receive from that because, as you know, we have going to through the rulemaking and let EPA and everybody report. My gut tells me that there is probably not enough in there.

And I would love to see the nitrogenous sector with a set amount so that we can plan a little bit more about what that means to us and can we survive in the global economy over say that 10 years that that is going to be available.

Mr. INSLEE. When Mr. Doyle and I were doing this, we wanted to be fairly aggressive in protecting these sectors. And I think it is a pretty good slug of allowances that we have come up with. But your concern is that your natural gas increases would be larger than the value of those allowances? Is that your concern?

Mr. WEST. That is correct. Your provision deals with as you know direct and indirect costs. And then we have this big old boogie man out here of what is the cost of natural gas, $3.5 today. We seem to have a lot of natural gas, but everybody seems to be turning to natural gas and natural gas is the environmental fuel of choice. And if we don't get this right, our allowances will be eaten up by the price of natural gas. And we won't be competitive in the world market.

Mr. INSLEE. The EPA, I am told, and I haven't read this in detail, but I am told that the EPA did an assessment of this and found that there really, they didn't feel there would be natural gas price spikes associated with this that you fear. Have you looked at their assessment?

Mr. WEST. I don't know if I have looked at their assessment. But natural gas has spiked above $10 three times since 2000. So it is going to be very difficult not to put, with the demand for natural gas, that natural gas prices will not increase as everybody turns to it.

Mr. INSLEE. I am told that their assessment suggested that, and I am not saying there won't be spikes in natural gas and they are not saying that either. It is spiked without this bill. There have been big spikes in natural gas without this legislation of course. The question is what this legislation would do.

And my understanding of their conclusion is that the combination of the free allowances, the fact that we have got considerable natural gas supplies still subject to development, the fact that we have got significant efficiencies we are all still working on, the fact that there are other alternatives besides natural gas, it is not the only one, they have concluded that they didn't see a probability—we are all dealing, you describe it as the boogie man, maybe that is the right way to look at it, we deal with possibilities and probabilities here. But they felt that the probability was that we wouldn't experience that. And if you have any critiques of that assessment, send it by. We would love to see it. And thank you for your testimony.

Mr. WEST. Thank you.

Ms. HERSETH SANDLIN. We have less than 5 minutes remaining in a very long series of votes. If this were normal series of votes, we would recess for a period of time and come back for additional questions that I and others have. But there are at least 28 votes in this series. And so I would encourage my colleagues to submit any additional questions that they have for the record. I have a series as it relates to incentives and tools for agriculture to employ to adapt and what H.R. 2454, how it addresses those incentives or tools as well as sufficiently robust offsets program that Mr. West explained.

But I want to emphasize to our panelists today the importance of your testimony. As I stated previously, negotiations are intense and ongoing as it relates to possible changes to the draft that was marked up in the Energy and Commerce Committee. And the upcoming days and possibly few extra weeks are immensely important. And the issue of agriculture and forestry is a primary focus of those negotiations.

So we appreciate your testimony.

We will submit our questions to you in writing and hope that you will have time to get back to us as quickly as possible based on the impact that your responses could have for those negotiations that are ongoing. So I want to thank all of our witnesses today.

I thank my colleagues for their participation.

And the hearing now stands adjourned.

[Whereupon, at 10:50 a.m., the committee was adjourned.]

PACIFIC
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Research for People and the Planet

July 20, 2009

Honorable Members of the Select Committee on Energy Independence and Global Warming,

Thank you for the opportunity to testify about the impacts of climate change on agriculture. Below, I have provided brief responses to your questions. If you would like additional information, please do not hesitate to contact me.

Thank you,
Heather

1. How would significant increases for farming inputs (for example, fuel and fertilizer costs) affect profitability of farms?

The impacts of rising farm inputs depend on a number of factors, including productivity, crop prices, and farmer response. Rising farm input costs could reduce profitability if all other factors are held constant. If, however, crop prices also rise, then profitability may be maintained or even increase. In the medium- to long-term, increases in inputs may encourage farmers to develop ways to reduce the quantity of inputs they require. This was most recently seen with rising petroleum costs, which spurred consumers to purchase more fuel-efficient vehicles and farmers to find ways to use less petroleum-based products, like fertilizers

2. Given that climate change uniquely affects different parts of the US, shouldn't each region approach this issue based on its experiences, rather than involve the federal government, which may implement a plan of action that could help one sector of the US to the detriment of another?

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I agree that climate change warrants a regional response, but that does not preclude the federal government from playing a role in developing climate change adaptation and mitigation strategies.

Numerous federal agencies play an active role in resource management, including the Bureau of Land Management, the Forest Service, the Fish and Wildlife Service, Bureau of Reclamation, Army Corps of Engineers, and the National Park Service. Climate change will affect all of the resources that these agencies manage, and it is critical that they begin to understand potential climate change impacts and develop mitigation strategies. A recent Government Accountability Office study reports that many federal agency officials have not yet incorporated climate change impacts into their planning processes - this is a critical missing link. The Bureau of Reclamation and Army Corps of Engineers, for example, operate many of the nation's reservoirs and water-related infrastructure. These agencies should revaluate their operation of these systems and develop new operational rules in light of climate change.

Climate change impacts will ultimately occur at the local level but local agencies may vary in their capacity to address this threat. The federal government should provide guidance and oversight to state and local agencies in developing adaptation policies. In addition, the federal government should take the lead in providing climate change data at a relevant scale for policy making and planning. In particular, global climate models need to be down-scaled in order to be relevant at the regional or local level. The federal government should be coordinating efforts to extract these data.

3. You propose a lot of programmatic suggestions for the federal government without addressing the financial aspects of your suggestions. What sort of revenue mechanisms are necessary to fund your programs?

The costs can be defrayed by a variety of innovative funding mechanisms, including pricing, fees, and redirecting funding of existing conservation programs within the federal Farm Bill. Below, we provide some examples:

- Irrigation districts and state and federal water managers should implement new water rate structures that encourage efficient use of water. Additional revenue generated by heavy water users can be used to finance district-wide and on-farm efficiency improvements.

- Irrigation districts and the State should provide sales tax exemptions or rebates on efficient irrigation equipment to help offset capital investments for these systems. Funding for these rebates could be provided by new water rate structures that charge higher rates for those who use more water.

- Redirect commodity payments in the U.S. Farm Bill to conservation programs, especially the Environmental Quality Incentives Program (EQIP). EQIP, which accounts for less than 1% of the Farm Bill budget, provides cost-shares to agricultural producers who make water conservation and efficiency improvements. In many areas, however, EQIP funds are fully allocated only days after they become available. Funding should be increased substantially for this program and more emphasis should be placed on water conservation and efficiency projects.

4. How do you see technology assisting adaptation efforts to climate change? For example, are you aware of any projects being developed right now that will help manage water supply and increase crop resiliency?

Many technologies offer advantages in both water savings and in climate adaptation. For example, better weather forecasting capability will allow water managers to adjust reservoir operations in response to changing weather conditions. Efficient irrigation methods can reduce evaporative losses (which will increase as the temperatures rise) and also help manage water scarcity overall. Many of these technologies make sense with or without climate change because of their economic and water savings potential. But we cannot rely on technology alone. We must also evaluate how we manage our resources. The Pacific Institute recently analyzed potential water savings in California's agriculture sector and found that the majority of these savings were from improvements in management, including more precise irrigation scheduling and practices like regulated deficit irrigation, where irrigation water is not applied during the drought-tolerant growth phases of some crops.

5. What responsibilities do the state governments have to designate flood plans? Could the state governments require certain high risk properties to have flood insurance?

State and local agencies should develop appropriate response plans for all types of disasters, i.e., floods, droughts, hurricanes, etc. Effective disaster management integrates the concept of risk management. It involves both structural and non-structural measures that must be taken before, during, and after the hazard event.

The federal government already requires flood insurance for those areas at risk of coastal and riverine floods. While flood insurance is one part of the puzzle, we must also implement measures to reduce our vulnerability to floods. Land-use management is among the most effective mitigation measure available. Land-use management for flood-risk reduction consists of locating appropriate land uses, such as parks, wildlife, and recreations areas, in flood-prone areas. While parks and recreation areas may sustain damage during a flood, the damage and potential loss of life is small when compared to flooding in an urbanized region.

Proper land-use management can increase the benefits of floods. Floodwaters, and the sediments they contain, provide an important resource for maintaining agricultural productivity. For example, the Yolo Bypass was established as a flood conveyance channel around communities in the Sacramento River watershed in California. While the Bypass is an effective flood control method, it also provides a number of other benefits, including essential upland and wetland habitat for wildlife, as well as productive agricultural land for a variety of farm uses.

6. Isn't it prudent for farmers to buy flood insurance to protect their crops?

Purchasing flood insurance may reduce the short-term **impacts** of floods, but it does not reduce the **risk** of floods. In fact, it may actually increase long-term risks because it encourages farmers to plant in flood-prone areas.

7. Increasing technology has long increased the productivity of our agriculture industry. Won't technology continue to improve the resiliency of our crops?

Technology will certainly play a role, but we cannot rely on technology alone. In many instances, the technology is already available, but it has not yet been employed. Drip irrigation, for example, has been shown to lower input costs and increase production value. Despite these benefits, millions of acres of farmland are still irrigated by flooding the field. We must identify and overcome a series of informational, financial, legal, institutional, and educational barriers in order to build a more resilient agricultural sector.

8. Depletion of water is a growing issue on the Missouri River. The US Geologic Survey estimates the amount of water in the MO River has already been depleted by about 28 percent. The majority of the water is consumed by western states upstream on the River. Can you elaborate on climate change effects on the Missouri River how Missouri and other downstream states will be impacted?

In general, climate change projections suggest that the Midwest can expect more extreme heat days. Changes in precipitation patterns remain uncertain, but there is potentially a greater risk of flooding along the Mississippi and Missouri Rivers. The Midwest is an important agricultural producer and changes in temperature and precipitation are projected to result in greater variability in crop production due to drought and heat stress. Please see the U.S. Global Change Research Program's recently updated report on the impacts of climate change on the Midwest for more detailed information (http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/regional-climate-change-impacts).

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9. We are already seeing shifts in timing of runoff in Colorado. This year our snowpack was over average in early April and less than average by late April. I'm concerned about flooding early and drought late in the season. One of the suggestions you have is to store excess water in groundwater basins.
   a. What specifically do you mean by this?
   b. Has it been done?
   c. What are the results and challenges of doing that?

Surface water and groundwater are hydrologically linked. "Conjunctive use" takes advantage of this connection by storing excess surface water, including storm water and recycled water, in groundwater aquifers for later use. In this sense, the groundwater aquifers acts much like a surface reservoir. Conjunctive use provides a number of important benefits, including reducing the risk of floods, improving water-supply reliability and flexibility, reducing land subsidence, and minimizing the impacts of urban runoff on local streams and the marine environment.

Conjunctive use is already being implemented in many parts of the West. I have not seen an analysis of the number of entities currently using this approach but its use is expanding. In Orange County, California, for example, the water district is recharging the groundwater aquifer with highly treated recycled water. Water agencies in Kern County, located in the southern part of California's San Joaquin Valley, have built large spreading basins to recharge groundwater with water during wet years. The Imperial Irrigation District, located in Southern California, operates a 25 foot deep sand and gravel lined pond that collects rainwater to recharge the utility's field wells.

If you think of it like a bank, in wet period water is deposited into the bank, and during dry periods users can withdraw that water. However, users must be careful not to withdraw more than what was stored and run the risk of overdraft. Challenges related to conjunctive use include little measurement or monitoring of groundwater use in many states. In order for a groundwater bank to work properly, we must know what is going in and what is coming out, therefore careful measurement and reporting is necessary to ensure sound management.

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THE SELECT COMMITTEE ON
ENERGY INDEPENDENCE AND GLOBAL WARMING

Dear Mr. Troxel,
Following your appearance in front of the Select Committee on Energy Independence and Global Warming, members of the committee submitted additional questions for your attention. I have attached the document with those questions to this email. Please respond at your earliest convenience, or within 2 weeks. Responses may be submitted in electronic form, at aliya.brodsky@mail.house.gov. Please call with any questions or concerns.

Thank you,
Ali Brodsky

Ali Brodsky
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1. What impact does the federal definition of renewable biomass in the Renewable Electricity Standard and the Renewable Fuels Standard have on developing wood-based sources of energy? How would including woody biomass from federal lands in the RFS and RES impact federal forest land management? Please elaborate on the importance of fixing the RES and RFS definitions of renewable biomass in addressing climate change.

a. By design, the RES and RFS will increase demand for, and supply of, renewable energy. The Congressional definition of renewable biomass will dictate the extent to which wood-based sources of energy will contribute to that increased demand, both as a function of 'credit' toward renewable energy mandates and the financial incentives available through RES and RFS legislation. In much of the Intermountain west, where the majority of timber comes from federal lands, exclusion of federal biomass from the RES or RFS definitions of renewable biomass will sharply reduce the prospect of wood-based energy production.

b. Including woody biomass from federal lands in the RFS and RES would benefit federal forestland management in two ways. First, it would provide incentives for increased utilization of slash piles (limbs, tops, and unmerchantable pieces of trees from timber harvest operations) instead of burning the piles in the woods. Burning piles in the woods produces high volumes of smoke that impacts air quality, costs a lot of money, carries a risk of escaped fire, and wastes a resource that could be utilized. Second, it would provide an additional source of revenue for proactive management projects to remove small, low value trees to reduce the risk of catastrophic wildfires, and reduce the cost of those projects to taxpayers.

On public lands in the West, many of the silvicultural treatments prescribed to reduce the risk of catastrophic wildfire and improve forest health will generate large volumes of forest biomass. Increased utilization of forest biomass can improve forest conditions in the eastern and southern states as well, where additional markets for low-quality and small-diameter trees also will enable forest managers to improve forest health. On other forests, both public and private and across the country, forest health and restoration treatments are needed to control insects and disease and to improve wildlife habitat and watersheds. This type of management can be costly, as much of the biomass removed has little to no value. A RFS or RES, structured appropriately, would help to create a market for woody biomass. This, in turn, could encourage much-needed forest health or fuels reduction projects by offsetting some of the cost of biomass removal. The current RFS with a restrictive, one-size-fits-all definition, encourages the opposite.

Sustainable management of forests can, to a substantial degree, mitigate global climate change. Forests are unique in that no other means of sequestering or offsetting carbon has the added benefits of providing clean water, biodiversity, clean air, wildlife habitat, aesthetics, and wood products. Federal policies should invite and encourage a growing forest business sector and sustainable use of our nation's forests.

c. "Fixing" the RES and RFS definitions to include woody biomass from federal lands will also help combat global climate change and improve the nation's energy security by providing an abundant, renewable fuel resource as a substitute for imported fossil fuels in both public utility and industrial power generation facilities.

2. Both public forests and private forests can sequester carbon and play important roles in mitigating climate change. When looking for ways for domestic forest owners can participate in carbon reduction efforts, we often focus on private forest owners' ability to participate in carbon offset markets. I am interested in exploring additional options that can work alongside offset programs to incentivize carbon sequestration. For example, H.R. 2880, Rep. Pingree's Buy American Carbon Incentives Program Act of 2009, would direct the Secretary of Agriculture to establish a carbon incentives program to achieve supplemental greenhouse gas emissions reductions on private agricultural and forestland of the United States. In addition to agriculture and forestry offsets, what additional options should the federal government consider to incentivize private landowners to increase carbon sequestration?

   Many small, non-industrial landowners may not have the ability to participate in forest offset projects. They can, however, improve forest management to sequester more carbon and aid with adaptation. Rep. Pingree's bill is a positive step towards realizing this benefit and encouraging good forest management on private lands. The bill would also provide an additional revenue stream to landowners and hopefully help to keep their land forested rather than developed.

3. What are the consequences of excluding federally-harvested timber from the renewable fuel standard as it is currently defined by the American Climate and Energy Security (ACES) Act? Without inclusion of federal biomass in an RFS, what would happen with the thinned biomass from national forests?

   The Energy Independence and Security Act of 2007 did not include federally harvested timber in the Renewable Fuel Standard definition of Renewable Biomass. Consequently, renewable fuels produced from trees, slash, thinnings or other woody biomass from federal lands will not count toward the RFS mandates.

If not utilized for renewable energy, most slash (limbs, tops, and unmerchantable pieces) from federal timber sales is piled and burned. This in-woods burning produces much more smoke than burning in a bioenergy plant; studies have shown that woody biomass diverted for use in a bioenergy plant can reduce carbon emissions by 90 to 99 percent compared to open burning. Further, there would be an opportunity lost to offset the costs of removing small or low-value trees to reduce fire risk.

Removing biomass and thinning forests are often a component of projects needed to improve wildlife habitat, watershed function and forest health. Excluding federally harvested biomass, which has virtually no value, increases the cost of these projects for federal land management agencies. This, in turn, greatly limits the projects that can be implemented due to constrained budgets. On the other hand, if federal biomass were allowed to contribute to biomass markets, land management agencies could offset more of the cost of removal.

4. Do you support the carbon emissions reductions certification process set forth in the ACES Act? Does the EPA have the necessary expertise to measure certifiable greenhouse gas reductions that result from forest management techniques?

   Currently, the USDA has the expertise to measure and certify greenhouse gas reductions in forestry. USDA has played an active role in forest carbon sequestration since the passage of the 1992 Energy Act. As a result of the law, the Department of Energy, USDA and the Environmental Protection Agency worked with stakeholders to develop standard methods for measuring, monitoring and reporting carbon sequestration and emissions reduction capabilities of forests (these are known as 1605(b)). USDA also has the experience of working with landowners through extension, technical assistance and other USDA agencies and programs. While EPA should have a role, USDA should have the lead role in the certification process.

5. You state, "reducing the number and severity of wildfires may be the single most important short-term action we can take to lower greenhouse gas emissions." How do

proper forest management techniques, specifically thinning crowded stands, reduce the possibility of wildfires? Should forest management be a part of our portfolio to mitigate carbon emissions?

Thinning can reduce the intensity and severity of potential wildfires by a) reducing the vertical fuel continuity, i.e., 'ladder fuels', that fosters initiation of crown fires, b) decreasing crown density and continuity, and c) increasing the proportion of fire-resistant tree species. Thinning at a landscape scale is much more likely to be successful than thinning individual stands in isolation. Forest Service researchers indicate that thinning forests and removing surface and ladder fuels to improve resistant to insects, disease and wildfire can lead to at least a 50-60 percent reduction in wildfire. (Personal Communication, Forest Service Researcher Mark Finney).

Two good references are:

Graham, Russell T., McCaffrey, S., Jain, T.B. 2004. Science Basis for Changing Forest Structure to Modify Wildfire Behavior and Severity. Gen. Tech. Rep. RMRS-GTR-120. USDA, Forest Service, Rocky Mountain Research Station. 43 p.

Finney, 2001. Design of Regular Landscape Fuel Treatment Patterns for Modifying Fire Growth and Behavior. Forest Science 47(2).

Yes, forest management should be an integral part of our portfolio. Domestic forests, both public and private, can make positive contributions now to help us meet emission reduction goals. Sustainable management of forests can, to a substantial degree, mitigate global climate change. Forests are unique in that no other means of sequestering or offsetting carbon has the added benefits of providing clean water, biodiversity, clean air, wildlife habitat, aesthetics, and wood products. Federal policies should invite and encourage a growing forest business sector and sustainable use of our nation's forests.

6. How good is the scientific data on how much carbon is sequestered by forests, by the various types of forests, and on how changes in forestation affect the global climate?

The quality of scientific data on how much carbon is sequestered by forests, and by various types of forests in the US, depends on the state of forest inventories. Considerable, accurate data are available on above-ground biomass based on traditional and extensive forest timber inventories that have been conducted over the past 75 years of forest management. Less extensive and less accurate estimates are available of carbon in the other forest carbon pools (above- and below-ground biomass, standing dead trees, forest floor and litter, down wood, and soil) in each of the numerous forest types in the United States.

The standard inventory base used to estimate forest carbon stocks is from the USDA Forest Service's Forest Inventory and Assessment Program (FIA). This base is used by some forest carbon protocols (e.g., the California Action Reserve). The FIA inventory program should be strongly supported.

The following references provide information on the FIA program:

Smith, J.E., L.S. Heath, K.E. Skog, and R.A. Birdsey. 2006. Methods for calculating forest ecosystem and harvested carbon with standard estimates for forest types of the United States. USDA Forest Service, Gen. Tech. Rep. NE-343, 216p. http://www.fs.fed.us/ne/durham/4104/papers/ne_gtr343.pdf

Smith, J.E., L.S. Heath, and M.C.Nichols. 2008. US Forest Carbon Calculation Tool: Forest-land carbon stocks and net annual stock change. USDA Gen. Tech. Rep. NRS-13, 33p. http://www.nrs.fs.fed.us/pubs/gtr/gtr_nrs13.pdf

Birdsey, R.A. and G.M. Lewis. 2003. Carbon in United States Forests and Wood Products, 1987-1997: State by State Estimates. USDA Forest Service, Gen. Tech. Rep. NE-310, 43p. http://www.fs.fed.us/ne/global/pubs/books/epa/

The life cycle analysis of carbon sequestered by forests is well documented in the literature (see www.CORRIM.org).

Changes in the forestland base have direct effects on carbon sequestration and storage. The first principle is to keep forests as forests. This is critically important globally as deforestation has been estimated to contribute 30 percent of global GHG emissions. In the US, it is critical to limit converting forests to other land uses such as development -- each year about 1 million acres of forestland is converted. Secondly, it is critical to maintain forest health, and manage forests (primarily by selective thinning) to limit losses due catastrophic wildfires, windstorms, and insect/disease outbreaks. Thirdly, it is important to foster the expansion of urban forests (about 70 million ac in the US), which provide a more livable urban environment while sequestering and storing a significant proportion of carbon dioxide. Fourthly, it is important to recognize the importance of using harvested wood products, which are renewable and an important offset to the use of more energy consumptive products and as potential sources of biofuels.

7. A 2008 article in *Science Journal* discussed a study that suggested that the large increase in bio-fuels will have negative greenhouse gas impacts worldwide when incorporating land-use changes, particularly from deforestation to plant more crop land. What role do you think bio-fuel mandates play in rainforest degradation? Do you support inclusion of land-use changes in assessing life-cycle greenhouse gas emissions of bio-fuels?

I'm sorry, but I don't have the expertise to answer this question.

8. What methods are there to contain the pine beetle epidemic in trees?

The mountain pine beetle is a native insect that attacks several species of pine trees, including ponderosa pine, which grows in the Black Hills, along Colorado's Front Range, and other lower elevation, dry sites in the West, and lodgepole pine, which grows in higher elevation areas in Colorado and Wyoming and other similar sites in the West. At endemic population levels, mountain pine beetles kill small numbers of already weakened trees each year. Periodically, populations grow to epidemic levels, and large acreages of both stressed and healthy host trees are attacked and killed.

The most effective long-term policy is to implement proactive silvicultural strategies. In ponderosa pine forests, the most effective strategy is thinning to reduce tree density and increase tree vigor. In lodgepole pine forests, the most effective strategy is to create and maintain a diversity of age classes through a planned sequence of harvest and regeneration. The current imbalance in age class distribution of lodgepole pine in the national forests in northern Colorado and southern Wyoming (see Attachment 2 from my June 18, 2009 testimony) has contributed heavily to the size and intensity of the current mountain pine beetle epidemic in those forests.

Two good references are:

Schmid, J.M., Mata, S.A., and Obedzinski, R.A. 1994. Hazard Rating Ponderosa Pine Stands for Mountain Pine Beetles in the Black Hills. Research Note RM-529. Rocky Mountain Forest and Range Experiment Station. 4 p.

Amman, Gene D., McGregor, M.D., Cahill, D.B., and Klein, W.H. 1977. Guidelines for reducing losses of lodgepole pine to mountain pine beetle in unmanaged stands in the Rocky Mountains. General Technical Report INT-36. Intermountain Forest and Range Experiment Station. 19 p.

9. The 2007 renewable fuels standard banned most wood from both federal lands and privately owned natural forests from qualifying as forest biomass. Some want to expand the definition to include woody biomass and claim it will help decrease wildfires by providing an end-use for the materials collected from forest thinning. Opponents say expanding the definition could increase demand to the point that too much forest land is clear-cut and sensitive lands won't remain protected. What is your opinion on this issue and your recommendation for the best policy to pursue in regards to woody biomass?

Every national forest is required by the National Forest Management Act to have a Land and Resource Management Plan, or forest plan, and all projects on a national forest must conform to that forest plan. Forest plans are required to analyze and make strategic decisions about allowable levels and types of timber harvest, and management requirements to protect sensitive lands, meet wildlife habitat objectives, maintain desired levels of old growth, and protect soils and water quality. Further, national forest management must also comply with the National Environmental Policy Act (NEPA), Endangered Species Act, and a host of other laws. Forest Service decisions are also subject to administrative appeals and litigation. If anything, the existing laws and regulations contribute to "analysis paralysis" that all-too-often prevents the Forest Service from being able to implement needed management programs promptly and efficiently.

Attachment 1 to my June 18, 2009 testimony displays comparative annual growth and removals from national forest timberlands since 1953. Annual growth has been increasing since 1953, but annual harvest has declined sharply since 1987. The result of this trend is more overstocked stands that are at higher risk from insects, disease and fire. The real problem today isn't too much timber harvest; it's not enough timber harvest. Including woody biomass from the national forests in the RES renewable biomass definition will help to address these forest health issues.

In my opinion, the current network of laws and regulations provides ample protection for our national forests, and there is no need for the Congress to enact further restrictions on management of the national forests or, specifically, the removal of woody biomass.

10. As you know Colorado has been heavily impacted by the mountain pine beetle. There are more than 2 million acres of dead trees. We need to remove many of these trees to protect our communities and watersheds from the destructive effects of wildfire.
    a. What does the forest products industry need to thrive so we can utilize these dead trees?

b. What does the forest products industry need to thrive into the future so we can manage the forest for diversity and vigor?
c. What difference would it mean to your industry to make biomass from federal lands available? Would it matter if you could derive some of that material from mature forests?

a. and b. – Today's sawmills or other forest products companies operate sophisticated, state-of-the-art computerized equipment to achieve the highest possible utilization from each log. This requires major capitalization and a long-term planning horizon. The single biggest challenge for forest products companies in the Intermountain West, where the federal government owns the majority of timberlands, is a reliable and predictable supply of timber sales from the national forests. Timber harvest and management by forest products companies is more cost-effective and more precise than alternative management tools. Maintaining the necessary forest industry infrastructure, i.e., mills, loggers, mill workers, suppliers, etc, requires stable, sustainable forest management programs with predictable levels of timber sale volumes.

c. Utilizing biomass from federal lands would increase the ability of sawmills to produce renewable energy to supply their own electrical, heat and steam and sell the excess. The ability to derive some woody biomass from 'mature forests' is a very important consideration. Most national forest timber sales harvest trees from 'mature forests', subject to requirements in the forest plans, the National Forest Management Act, and other applicable laws. The merchantable logs are hauled to a mill and manufactured into a variety of wood products, and the slash (limbs, tops and unmerchantable pieces) is typically piled for later burning in the woods. My recommendation is that all of that slash should be available for utilization as woody biomass instead of burning it in the woods. Burning piles in the woods produces high volumes of smoke that impacts air quality, costs a lot of money, carries a risk of escaped fire, and wastes a resource that could be utilized. Plus, utilizing slash as woody biomass would provide an additional source of revenue for proactive management projects to reduce the risk of catastrophic wildfires, and improve the health of our forests.

11. I like your explanation of how and when a forest sequesters the carbon. I also understand that a forest may meet many different objectives. If carbon sequestration was your only objective what would your forest look like?

That would depend on the species of trees and the site productivity, but in general, a forest managed to maximize carbon sequestration would have a diversity of age classes from young regenerated stands to mature stands, it would be periodically thinned to maintain optimum growth rates and to remove hazardous fuels, dead trees would be promptly salvaged following fires, and harvested or burned areas would be quickly reforested, either by planting or natural regeneration.

12. Within your area of expertise; If you could do one thing to reduce our carbon footprint, what would that be?

My highest priority would be to implement forest management strategies to reduce the number and severity of forest fires.

Forests can either be a sink for CO_2 or a source of CO_2. Reducing the number and severity of wildfires may be the single most important short-term action we can take to lower green house gas emissions. One wildfire, the July 2007 Angora Fire, which burned 3,100 acres in South Lake Tahoe, released an estimated 141,000 tonnes of carbon dioxide and other green house gases into the atmosphere, and the decay of trees killed by the fire could bring total emissions to 518,000 tonnes. This is equivalent to the green house gas emissions generated annually by 105,500 cars. Active forest management to improve forest health and reduce hazardous fuels can dramatically reduce CO2 emissions, while simultaneously enhancing wildlife habitat, recreational and scenic values, reducing the threat of wildfires to communities and critical infrastructure, and contributing to the health of rural communities by providing family-wage jobs.

The Fertilizer Institute

Nourish, Replenish, Grow

Select Committee on Energy Independence and Global Warming
Ford West
President, The Fertilizer Institute
Answers to Committee Questions

1. **In the last decade, approximately half of the nitrogen industry has shut down as a result of high natural gas prices and foreign competition. American farmers import 55% of their nitrogen as a result of this leakage. Do you see this trend continuing? How will this reliance on foreign sources of fertilizer affect American agriculture?**

   A: Cap and trade policy has the potential to have a devastating impact on the remaining U.S. nitrogen fertilizer industry. Since the introduction of the American Clean Energy and Security Act of 2009 (H.R. 2454) in the House, The Fertilizer Institute has been expressing serious concerns with the impact of this legislation on the fertilizer industry, its farmer customers and the U.S. food supply. During the past decade, high natural gas prices had a devastating impact on the U.S. nitrogen fertilizer industry. We are particularly concerned that a consequence of this legislation will be higher energy prices which will drive the remaining U.S. nitrogen production offshore. In this event, U.S. food production would rely solely upon our ability to secure fertilizers from the countries of the Arab world, Venezuela, China and Russia.

2. **In your written testimony, you discussed how fuel switching threatens the nitrogen industry. What other costs would a cap and tax system create for the industry? Considering that fertilizer is traded in a global commodity market, how would these additional costs impact the domestic fertilizer's ability to stay competitive?**

   A: In 2008, the nitrogen fertilizer industry spent $3 billion on natural gas. Each $3 MMBtu increase in the cost of natural gas raises nitrogen fertilizer production costs by over $1 billion. These are not costs we can pass on to our customers as our industry is a price taker in the global fertilizer market.

   Historically, the cost of natural gas has exacted a heavy toll on America's nitrogen fertilizer producers and the farmer customers they supply. Specifically, since 1999, the U.S. nitrogen industry has closed 26 nitrogen fertilizer production facilities, due primarily to the high cost of natural gas. Further volatility and price increases in the natural gas market threaten the continued operation of the remaining U.S. nitrogen production plants.

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3. **We have heard a lot of discussion on the need for energy independence from foreign oil. American farmers import over 55% of our nitrogen. How will cap and trade impact our reliance on foreign sources for American food production and what does this mean to our food security in the U.S.?**

   A: Fertilizer is responsible for 40 to 60 percent of our food supply. Currently, only 30 nitrogen plants are still operating in the United States and over 55 percent of the U.S. farmer's nitrogen fertilizer is imported. Of this imported fertilizer, 82.7 percent comes from countries without climate change policies in place to regulate carbon and a majority of these countries are those from whom we are striving for energy independence.

   Further, last year, TFI commissioned a study on the impacts of high energy costs resulting from a cap and trade system on American farmers. Using the Lieberman Warner bill as a baseline and EPA's moderate economic analysis of the impacts of the legislation on energy prices, Doane Advisory Services measured the production cost increases for eight farm commodities. Doane economists found that any such cap and trade system would add $8.5 - $17 billion to total crop and livestock production costs, resulting in a significant decline in farm income. U.S. Department of Agriculture (USDA) data shows that energy costs are already dramatically impacting farm income and this legislation could further negatively impact U.S. farmers' ability to make a living.

4. **Mr. West, as I mentioned in my opening statement I am a farmer, and so am very familiar with fertilizer and your industry. As a farmer, how much more do you think it will cost me to buy fertilizer for my farm under a cap and trade system as it's currently described?**

   A: The fertilizer industry makes an essential contribution to our food supply and thus to our nation's security. TFI member companies supply nitrogen, phosphate, potash and other plant nutrients to farmers who grow food for America's dinner tables. Fertilizers replenish our soils in harvest after harvest to promote healthy and abundant crops for food production. Those nutrients are removed with the harvested crop and help provide nutritional value to the foods we eat. These nutrients must be replaced to ensure each year's crop grows a nutritious supply of food.

   Because the price of fertilizer is determined by many supply and demand factors related to both the U.S. and global market, it is impossible to predict future prices. Last year, TFI commissioned a study on the impacts of high energy costs resulting from a cap and trade system on American farmers. Using the Lieberman Warner bill as a baseline and EPA's moderate economic analysis of the impacts of the legislation on energy prices, Doane Advisory Services measured the production cost increases for eight farm commodities. Doane economists found that any such cap and trade system would add $8.5 - $17 billion to total crop and livestock production costs, resulting in a significant decline in farm income. U.S. Department of Agriculture (USDA) data shows that energy costs have already dramatically impacted farm production expenses and income. As energy costs increased, U.S. production costs of corn, soybeans, wheat, cotton, rice, sorghum, barley and oats exhibited their largest increase in history, in both absolute and percentage terms, over the period 2000-2007. This legislation will further negatively impact U.S. farmers' ability to make a living.

5. **You mention that farmers should be able to offset additional crop production costs with the best management practices? What are those best management practices you refer to? How do you see those being institutionalized?**

The challenge for agriculture today is to produce more food on limited arable resources. In fact, the Food and Agriculture Organization has indicated that agriculture must increase food production by 50 percent by the year 2025 and double it by 2050. If a cap and trade system is enacted in the United States, it is imperative that American farmers are able to partially offset these additional crop production costs. Farmers should get credit for their very important role in the reduction of climate change related emissions. However, it is equally important that farmers aren't burdened with significantly increased input costs that would far exceed any offset credits they receive under the bill.

It is also crucial that the language regarding commercial fertilizer in the House passed bill be revised in the Senate bill. TFI is extremely disturbed that the House passed bill incentivizes several agricultural practices that will likely have little impact on reducing GHGs and in some cases may increase GHG emissions. We urge the Senate to act quickly to ensure that science is the basis for any grower incentives. GHG emissions can come from all types of nitrogen sources applied to the soil, regardless of whether these are applied as commercial fertilizer or manure. Whether a farmer chooses to use commercial or organic fertilizer sources, BMPs are key to managing climate related emissions.

Not only can low till and no till farming techniques help increase the carbon content of soils and reduce erosion, there are also practice based approaches such as Canada's Alberta Protocol, which is based on fertilizer best management practices (BMPs), that demonstrate farmers' capacity to reduce nitrous oxide emissions from the field. The Alberta Protocol is a peer reviewed set of fertilizer BMPs based on the 4R nutrient stewardship system, which promotes the use of the right product applied at the right rate, right time and right place. These BMPs have the potential to not only increase agricultural yields but they can also enhance fertilizer use efficiency, significantly reduce emissions of greenhouse gasses (GHGs) and improve water quality. Social responsibility and sustainability are permanent features of the fertilizer industry's goals and we believe that using practices that increase the profitability and productivity of U.S. farmland while benefiting the environment makes sense.

Johannes Lehmann
Associate Professor

Cornell University

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Ithaca, July 24, 2009

RE: Follow-up from testimony to the House Select Committee on Energy Independence and Global Warming – June 18 2009

Dear Ms Brodsky:

Thank you for the opportunity to clarify outstanding questions. You will find my answers below.

Sincerely,
Johannes Lehmann

Follow-Up Questions for the Record

Testimony of Dr. Johannes Lehmann
Cornell University, Ithaca, NY, USA

Before the
House Select Committee on
Energy Independence and Global Warming

July, 2009

1. Do you support EPA's accounting for international land-use changes in calculating lifecycle greenhouse gas emissions for biofuels?

   In principle, yes. However, the tools and information to account for such land use change are still to be improved through a thorough scientific discourse that considers the full spectrum of issues[1,2], which is beyond the scope of this testimony. Perceived or actual lack of information should not be seen as an excuse to disregard the issue. Proper accounting for indirect land use will guide appropriate development of sustainable biofuels which is a desirable step forward.

2. How energy intensive is the pyrolysis process? How would significant increases in energy prices change the cost structure of biochar?

   The pyrolysis process is maintained by the energy contained in the biomass itself. In practical terms, heat or gases generated from the pyrolysis are recycled to continue the process. Therefore, the pyrolysis is self-sustaining after it has been initiated[3]. For the start-up of the pyrolysis, either biomass itself or fossil fuels such as natural gas can be used. Over the entire life cycle including biomass production, harvesting, transportation and energy conversion, the pyrolysis process is net energy positive, and current estimates indicate that between two and 9 times more energy is generated than invested[4,5].

   Biochar as a product for soil improvement and sequestration will from a certain level onwards increase in value as energy prices rise, because many biochars have an energy value. Many types of biochar can be used as charcoal to be used as the sole energy source or co-fired in coal power plants. In addition, the pyrolysis process can be adjusted to produce more energy and less biochar. At current energy prices, however, the value of the biochar as a source of energy is less than the cost of producing it. The total costs are mainly a function of the pyrolysis process itself and of the biomass collection. Our current estimates indicate that less than 30% of the costs of producing biochar are a function of energy prices; labor and capital costs account for a larger total share of biochar production costs. Therefore, costs of biochar generation are only to a small degree dependent on energy prices.

3. Is your process commercially deployable at this time? What steps are necessary to take advantage of using biochar in the farming process?
   Biochar production is in a pre-commercial stage. Companies exist that have developed pyrolysis units that are mostly at prototype stage and must demonstrate their long-term viability in a full commercial environment. Demonstration projects of a variety of biochar systems designed for specific biochar platforms should be initiated. Individual farmers have taken the initiative to develop biochar systems, but pioneering the technology is typically out of reach without financial assistance by foundations or government programs. A serious effort is required by the US government to critically evaluate and develop demonstration projects, concurrent with international efforts including governments and non-governmental organizations. The International Biochar Initiative is a non-profit organization in the US seeking to assist and coordinate such efforts, and to help commercialize biochar production and utilization systems at all scales as a means to combat climate change while enhancing the earth's soils.

4. You note that biochar can demonstrate additionality due to the lack of existing global deployment of the technology and further highlight that sequestration can be measured and verified. How would you suggest verifying the amount of biochar in a field? What process would be most effective and who would pay to verify the additionality and measured emissions reductions resulting from using biochar?
   Biochar systems offer a high degree of control over the sequestered carbon, as the added carbon in biochar can be monitored. Verification of biochar presence can be done by analyses of soils. Currently, several approaches are possible that go beyond quantification of an increase of total organic carbon in soils, but include attribution of the carbon that is specific to biochar additions. Biochar has a unique chemical signature that can be distinguished from carbon originating from decomposed plant material already present in soil[6]. While direct quantification in soils is expensive, indirect approaches have recently been developed that are both inexpensive and rapid. Those include mid-infrared analysis calibrated to direct quantification[7].

For routine assessment of biochar sequestration, however, modeling approaches should on the medium term be used that are much cheaper than routine direct measurements and help to address the spatial heterogeneity in any soil environment (though some verification will always be possible and necessary). These may be sufficiently reliable, because biochar properties are well reproducible with modern pyrolysis units. In comparison, the relatively complex interactions between plant litter quality, plant growth, and stabilization of plant residues is already relatively well constrained to provide viable strategies for carbon accounting[8]. Biochar decomposition in soil is less dependent on environmental properties than crop residues for example, as its stabilization relies less on interaction with soil minerals[9]. However, this needs to be demonstrated in practice, and price structures for monitoring and verification need to be developed with a deployment of the first biochar systems at scale of implementation. Before sufficient demonstration projects exist, confidence in the practicality and cost effectiveness is low. Supporting demonstration projects is a critical role that government can play at this initial phase of evaluating deployment of biochar systems.

5. How much additional cost per acre would be required to utilize biochar in farming techniques? What economies of scale exist with pyrolysis that could drive down that cost?

   The question about the cost of biochar production can not be answered with any confidence at present, since no commercial biochar plants exist in the US that provide biochar in sufficient quantity. Some companies are starting to develop the capacity. For individual farmers, large-scale distributors may not be the answer to their request for biochar to sequester carbon, as transportation costs (and from a certain distance also energy investments) are prohibitive. In many situations, the biochar may need to be generated locally. However, since biochar systems are in theory able to connect multiple value streams, such as waste management, energy generation, climate change mitigation and soil fertility enhancement, the revenue from all of these value streams has to be considered[10] and established for biochar production and utilization systems at various scales. These include on-farm systems that can generate biochar for local utilization, and larger-scale, cooperative systems that could generate biochar for sale. If biochar is able to address a soil fertility constraint on farms, the costs will be born by the increase in crop productivity[10]. Waste management through pyrolysis may reduce costs to a farm or community, and the resulting biochar may constitute added value.

6. In your testimony you wrote, "The distributed nature of biochar systems and the potential for variability between systems create significant opportunities for sustainability, but also hurdles to widespread adoption, regulation, and financial viability." What are the existing hurdles and what steps can be taken to reduce those hurdles?
   The large number of different feedstock types available in the US, the variety and scale of pyrolysis conversion technologies, the combination of value streams as outlined above, and the large number of possible applications to different soils and plants generate a significant number of different options to implement biochar systems. A concerted endeavor is necessary to establish the benefits and constraints for each of those combinations. Moving forward, individual biochar platforms are likely to be developed and demonstrated with certain types of biochars generated from feedstocks under conditions where sufficient information exists or can be generated for replication, and applied to soils and crops for which the agronomic benefits have been tested. This methodical development may initially constrain the number of biochar systems, but would enable identification of viable and sustainable application of the technology in a timely fashion.

7. Are there any long-term issues or concerns with biochar remaining in the Earth's soils for hundreds of years?
   So far, no adverse effects have to my knowledge been found for char-type materials that reside in soils for long periods of time. In fact, many if not most soils globally already contain some portion of char. This information stems from a global analysis of all soils archived at the World Soils Information Center (ISRIC) in The Netherlands[11], and a continental analysis of Australian soils[12]. However, these chars have been generated from a certain range of feedstocks largely including grasses and trees. It must be critically evaluated whether feedstocks that lie outside these better-known materials are also

suitable for biochar production, such as animal manures, a wide range of crop residues, food residues or municipal and industrial byproducts.

8. A contentious issue currently being discussed around the climate bill is the possibility of carbon offsets in the agriculture industry and the sequestration of carbon in the land and plant life. Can you say how credible these types of projects are as offsets and if there is a reliable way to measure how much carbon actually rests in a farm plot or an animal burp, for example?

   The measurement of carbon in farmland and soils is very reliable. Adequate methods and expertise exist to perform these measurements with confidence. The challenge lies in the financial viability of performing such measurements with sufficient frequency and spatial intensity. Methods for monitoring changes in vegetation are available and are sufficiently inexpensive. Monitoring of soil using traditional measurement methods is likely to remain too costly for widespread utilization in an offsets regime, and is not able to detect the small changes in concentrations likely to occur over short periods of time. However, there are credible efforts under way to demonstrate that a combination of process modeling and verification using novel, inexpensive and rapid techniques may indeed be feasible[8]. For individual types of changes in practice (e.g., implementation of minimum tillage, biochar conversion of crop residues, compost management etc.), greenhouse gases balances beyond carbon dioxide have to be quantified using a life-cycle approach. Such a comprehensive view will ensure that carbon sequestered in soils or vegetation is not compensated by emissions at a different location or time (e.g., through changes in energy requirements, fertilizer use, nitrous oxide emission etc.). In my opinion, the collective expertise and tools exist to address these challenges, even if the framework for implementation still has to be refined, and supporting policies developed. As we gather information about carbon flows and changes in agriculture, these tools can and should be improved.

9. Where would you put Biochar? What uses do you see in addition to agricultural use? Is there a problem with such long residence times in the soil? Does it build up to levels that would alter plant growth or cause farmers problems?

In addition to the use of biochar as a soil amendment, it has been shown to potentially possess value in composting or digestion processes. Beyond agricultural use, biocarbons produced at low temperatures similar to biochars may also enter markets as a substitute for activated carbons that require more energy in its production and are therefore more expensive.

The long residence time is primarily seen as an advantage of biochars. As outlined earlier in this document, historic accumulation of natural chars over the past millennia have not revealed any negative effects on soil functions, but rather beneficial effects.

Similar to any soil amendment such as composts, animal manures or mineral fertilizers, we would expect that below a certain quantity, the optimum response is not achieved. The same will be observed for a quantity that is above the optimum amount of application. And we would expect that optimum to depend on soil, crop and biochar type. Biochar-like materials have been quantified in soils to make up over 50% of soil organic carbon or 5-10% by soil weight (over 100 tons per hectare) and dated to several thousand years before present[13], without detrimental effects on soil health. However, it would be premature to generalize these results. Rather it is necessary to conduct due diligence analyses on relevant soils and crops before wide-spread application of biochar. Such testing is straightforward and agricultural services and academic institutions have the tools and knowledge to provide the required information within a relatively short period of time.

10. Where are the existing Biochar production facilities and what are the findings for production and use?

    Fully commercialized facilities for the production of biochar do not exist in the US. Several companies are making considerable efforts to fill this gap, but have not fully reached a demonstration stage. Therefore, the amounts and types of biochar necessary for full evaluation are not yet available. Research institutions are working together with the nascent commercial sector to evaluate and critically examine the available biochar products under a range of soil and crop conditions. The results from these investigations are communicated through conferences[14] and scientific publications. Since biochar research has emerged only a few years ago, the existing record in scientific publications is not a good indication of the current research activity. A small number of biochar demonstration projects on farms exist in the US and several are under development[15], showing promising results and providing optimism that, with the proper policies and development assistance, these systems will prove valuable to a range of goals and environmental and agronomic benefits. In moving forward, there is a critical need for coordination and support. Only the International Biochar Initiative has been efficient in providing a platform for communication and development in the US, and institutional leadership is required to develop biochar into a viable and sustainable environmental management option.

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[14] The next conference co-sponsored by the International Biochar Initiative and organized by the Center for Energy and Environmental Security (CEES) at the University of Colorado is the North American Biochar Conference, Boulder, CO, August 9-12, 2009; the upcoming international biochar conference is planned for mid-2010 in Rio de Janeiro, Brazil, organized by EMBRAPA. Special symposia at society conferences have become routine events by now.
[15] At the IBI website under www.biochar-international.org, many of the projects are featured and a registry is under development, both for the US and world-wide.