HEARING TO REVIEW THE FUTURE OF OUR NATION'S FORESTS

HEARING

BEFORE THE

SUBCOMMITTEE ON DEPARTMENT OPERATIONS, OVERSIGHT, NUTRITION, AND FORESTRY

OF THE

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HOUSE OF REPRESENTATIVES

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HEARING TO REVIEW THE FUTURE OF OUR NATION'S FORESTS

WEDNESDAY, JUNE 3, 2009

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON DEPARTMENT OPERATIONS,
OVERSIGHT, NUTRITION, AND FORESTRY
COMMITTEE ON AGRICULTURE
Washington, D.C.

The Subcommittee met, pursuant to call, at 1:36 p.m., in Room 1300 of the Longworth House Office Building, Hon. Joe Baca [Chairman of the Subcommittee] presiding.

Members present: Representatives Baca, Kagen, Schrader, Dahlkemper, Childers, Fortenberry, and Lummis.

Also present: Representatives Herseth Sandlin, Markey, Thompson, and Goodlatte.

Staff present: Adam Durand, John Konya, John Riley, Lisa Shelton, April Slayton, Rebekah Solem, Patricia Barr, Brent Blevins, and Jamie Mitchell.

STATEMENT OF HON. JOE BACA, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA

Mr. BACA. I would like to call the meeting to order. The Subcommittee on Department Operations, Oversight, Nutrition, and Forestry to review the future of our nation's forests will come to order at this point. We will begin with opening statement by myself and then other Members that are present will have opening statements if they wish. There will be 5 minutes provided for each of the opening statements. We may have other Members—if there is no objections to non-Members of this Subcommittee who to come and be here—we will allow them to sit here with us and then ask questions. Is there any objection? Hearing none, then we will proceed and we will allow that.

Good afternoon. I am pleased to welcome everyone to this hearing examining the future of our nation's forests and forest policy. Thank you all for being here, particularly the new Deputy Undersecretary, Mr. Jensen. Thank you very much. And our second panel of witnesses as well. Before we begin the hearing, I have a few comments. It is my pleasure to Chair the Subcommittee that has jurisdiction and duties over the U.S. Forest Service. I know firsthand about the values of the national forest to a community. The beautiful San Bernardino National Forest borders in my district, and of course everyone can say theirs is better and beautiful, but I think all of ours are pretty good within our area.

The recreational opportunities, economic benefits, plus the natural enhancement to our environment contribute to a higher quality of life for not only my residents but throughout the areas where many residents have forests in their area as well. It is not only our responsibility but also a personal interest of mine to help create and maintain policies that protect and promote our forests; and we are here to talk and to hear how we can protect our forests and enhance our forests too as well as developing a kind of partnership in collaboration. Forests are dynamic entities, ever changing environments that respond to the effects of weather. Climate change and other factors similarly are policies that must be flexible enough to meet these changes.

I am sure that today's hearing will provide a good overview of the major issues affecting the current forestry policies and we have to look at those current policies that we have. I and other Members of the Subcommittee have many questions surrounding the forest health, wildfires prevention, and the role a forest can play in solving climate change. For example, how do we best limit the devastating impact of bark beetle, another invested pest in our forest. What balance do we strike between the development in our forest because as we all know there is a lot of development of homes in our area. And what forest land preservations to ensure that we do not lose more communities to wildfires and mud slides.

How can we better equip our brave men and women who fight fires on the ground to ensure both they have continued protection and success? Do we need to look at those policies? Do we need to modify those policies? In addition, there ways that we can be cost effective in the type of equipment that we have as well with our forestry firefighters out there, and how can we best work with the businesses and labor communities to ensure the survival of timber related to industries during these times of economic difficulties and how can we utilize America's forest to better protect the health of our water resources. As a Californian, water conservation is an issue of particular importance to me because of the state's continued drought problem, and as a father and grandfather, I know it is critical that we protect America's forests for all our future generations to enjoy.

We must find workable solutions to the hazards facing the future. Ultimately, we must have better legislation to serve these forests and many dedicated people who work for the forest as it relates to the industry that we are all working together. So today we will listen, learn from an excellent panel of witnesses about the future forestry policies, and I hope this hearing will build an important body of evidence so that we can continue to work together collaboratively in partnership to preserve our forests, our nature, and our environment and create that healthy quality of life for all of those that are impacted by it or its surroundings. I now yield to our Ranking Member, Congressman Fortenberry, for his opening statement.

STATEMENT OF HON. JEFF FORTENBERRY, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEBRASKA

Mr. FORTENBERRY. Thank you, Mr. Chairman, for holding this hearing. I apologize for running behind. As you know, Mr. Chairman, the future of forestry is an essential issue for all of us, all Members of this Committee, regardless of how much forest we might actually have in our respective districts. Forestry has been a vital component of this country and its economy for more than 400 years. Timber-related fields employ more than 1 million people, interestingly more people than are currently employed by the automobile industry. Forest land comprises roughly 750 million acres of Federal and private land across the country which is 33 percent of the total land area of America. There are many issues facing the future of forestry in the United States, and I would like to address a few of those, Mr. Chairman, if I could.

Like the economy at large, forestry has suffered a recent downturn. Demand for lumber has dropped more than 50 percent since 2005. New housing starting this year will be only 20 percent of 2005 levels, the lowest level in 50 years, and roughly 20 percent of jobs in this field have disappeared. We must examine ways that we can help this important sector of our economy weather the storm. The Conservation, Credit, Energy, and Research Subcommittee of the Agriculture Committee held a hearing last month on the current definition of renewable biomass and the renewable fuel standard. The consensus from the testimony that day was that the definition needed to be amended to include more sources of wood.

I am sure everyone on our panel, or I hope everyone on our panel, will agree wood is the original renewable energy resource. Our nation's timber, furniture, and paper factories have been using wood chips as a source of renewable energy long before the term biofuel became popular. I would also like to take this opportunity, Mr. Chairman, to mention a bill that I introduced earlier this year, H.R. 2170, to promote the use of biomass as a renewable energy resource. Specifically, this legislation creates a revolving loan to be used by schools and other institutions for capital costs needed to convert to the use of biomass for energy generation. The legislation addresses the major obstacles facing schools and other institutions seeking to convert to woody biomass as an energy source, namely, capital cost. By creating a revolving fund with zero or low interest loans, these public institutions could then take the next step forward in creating and utilizing this sustainable energy source.

These institutions could then pay back the loans with their savings and energy cost. Another issue, Mr. Chairman, invasive species represent an ongoing threat to our health of our nation's forests. Federal, state, and private landowners must work together to ensure that these species do not further damage to our nation's treasured forest. I am aware that this is an issue facing several members here today. Wildland forest fires are also an increasing problem. As the Forest Service continues to devote a larger share of its budget to fighting these fires, it is able to devote fewer resources to other programs that are meant to assist state and private landowners. These fires threaten communities and property and Congress must work with the Administration to see that these issues are addressed in the future.

I want to welcome Mr. Jensen and our witness from the private sector on the second panel as well. I look forward to hearing from our witnesses about the current state of forestry in the United

States and what actions they recommend to ensure that forestry remains a vibrant integral component of our nation's economy. With that, I yield back, Mr. Chairman.

Mr. BACA. Thank you very much.

At this time, I will recognize the individuals in order that they came in with the exception of going back and forth between the Democrat and the Republican.

At this time, I would like to recognize Mr. Schrader for 5 minutes.

STATEMENT OF HON. KURT SCHRADER, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF OREGON

Mr. SCHRADER. Thank you, Mr. Chairman, and Ranking Member Fortenberry, for holding this very important hearing on current and future policy in our American forests. I value the Committee's willingness to address these critical issues relating to forest health, including the wildfire prevention, forest restoration, and enhancing access to woody biomass. Our Federal and private forests have served as an economic and social cornerstone in American history, and I appreciate the Subcommittee's willingness to address critical issues to ensure their health and viability for future generations. Frankly, I am very concerned over the current state of our forests. Our forests are under extreme duress from drought, insects, diseases, wildfire, and, frankly, poor management due to lack of funding.

Our rural forest counties are facing historic unemployment and the forest industry, a significant institution critical for good jobs in rural Oregon, is struggling just to stay alive. While urban areas are in one of the worse recessions in their history, rural America has been in one since the 1980s. They have had longstanding double digit unemployment that is only now coming home to roost in some of our urban environment. I hope this Congress understands that our forests, the backbone of these rural counties, can be part of the economic and environmental solution. This is not the 1970's or 1980's timber management anymore. This is a cleaner, smarter, environmentally friendly, and sustainable industry that is part of the global climate change solution and creating much needed jobs in rural America. If properly managed, our forest can be a key resource toward economic revitalization, through job creation, construction of new homes, bio-product manufacturing, and a positive market influence while all being one of the world's greatest carbon sequesters known to man.

Our forests through the use of woody biomass has the ability to help us become more energy independent as we strive to utilize more forms of renewable energy. This not only decreases our dependence on foreign energy, it increases and ensures the energy produced at home in our communities creates good jobs. And I hope as we begin discussing the Clean Energy and Security Act of 2009, this Congress recognizes the benefits of adopting a workable, pragmatic biomass definition like the one in the 2008 Farm Bill that the Chair and Ranking Member and others here have worked so hard to put in. Once again, I really appreciate the opportunity to have this hearing and recommend we adopt good policies as a result of what we hear today.

Mr. BACA. Thank you very much.

Next, I would like to recognize the gentlewoman from Wyoming, Ms. Lummis, for 5 minutes.

STATEMENT OF HON. CYNTHIA M. LUMMIS, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF WYOMING

Ms. LUMMIS. Thank you, Mr. Chairman. I join the gentleman from Oregon in applauding you for holding this hearing today. It is a very important hearing, and I appreciate your doing it. I am aware of your commitment understanding how Federal policies affect the nation's forests, and so I am so pleased that you have invited Jim Neiman from my home State of Wyoming to testify today, and I am very much looking forward to his testimony. I know of no one in my state that knows forestry better than Jim Neiman so thank you so much, and thank you, Jim, for coming to Washington.

This hearing is broad in scope covering many aspects of forestry policy. That is how it should be for the first hearing of the year on the subject. I do want to renew my invitation to the Chairman to hold a field hearing to explore the issue of bark beetle destruction in greater detail. I would be pleased to host such a hearing in Wyoming so we can visit the vast swaths of forest destroyed by beetles in my state. In addition to the beautiful forests that make up our national parks in Yellowstone and Grand Titan, Wyoming is home to nine national forests encompassing about 8.8 million acres of land. Put into context, national forests in Wyoming cover about a million acres more than the total land areas of Maryland, Delaware, and the District of Columbia combined. Add the vast tracts of state and private forests, and you begin to understand the monumental task of maintaining healthy forests in my state.

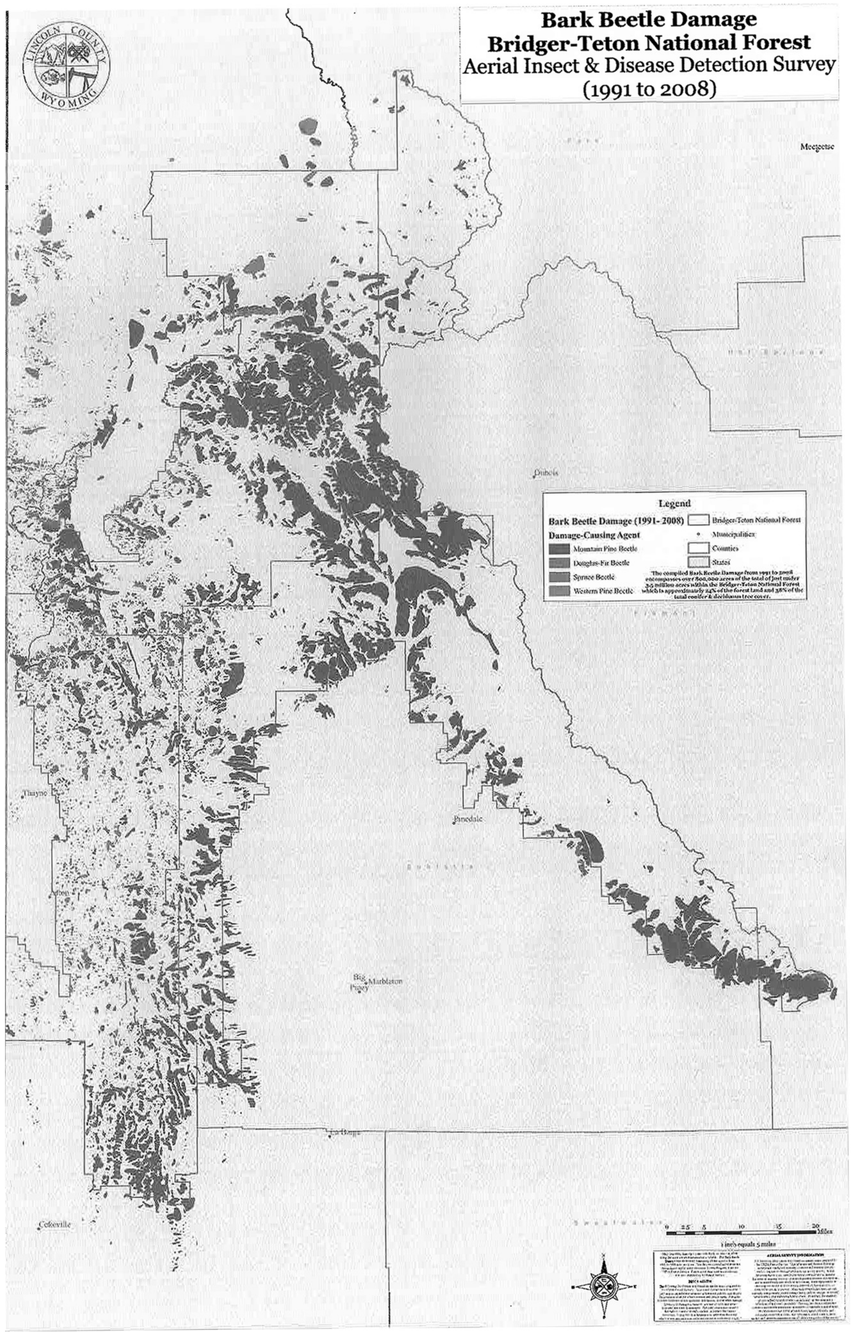
To some, forestry policy is an academic exercise, a way to experiment with grand theories about the role of fire, disease, and the management of forests. To citizens of Wyoming, Federal forestry policy is so much more. Decisions about fuel reduction, beetle prevention and mitigation, prompt harvesting of dead and dying trees, and the overall health of our forests have real tangible effects on our livelihood. We live near or even in these forests. We base entire industries off them. We recreate and enjoy them and we count on these forests to attract thousands of tourists every year. In fact, while I was home over the break in one county 79 percent of forest users reported just driving through to enjoy the scenery as their favorite use of forest lands.

Healthy forests are integral to our lives and livelihoods. That is why I am so concerned about the current state of our forests. The bark beetle epidemic in Wyoming has already destroyed millions of acres of adult forests. I ask unanimous consent to enter into the record a map of the Bridger-Teton National Forest that illustrates this damage. The blue areas mark the beetle kill which had destroyed about 40 percent of that forest since 1991. As vast as that seems, 40 percent earns only a silver medal for the highest rate of destruction in Wyoming. Forest managers estimate that by 2012 every single adult lodgepole pine in southern Wyoming and northern Colorado will be destroyed by bark beetle. This is devastating to our forests and our forest economies. It is also downright dangerous as we enter another wildfire season.

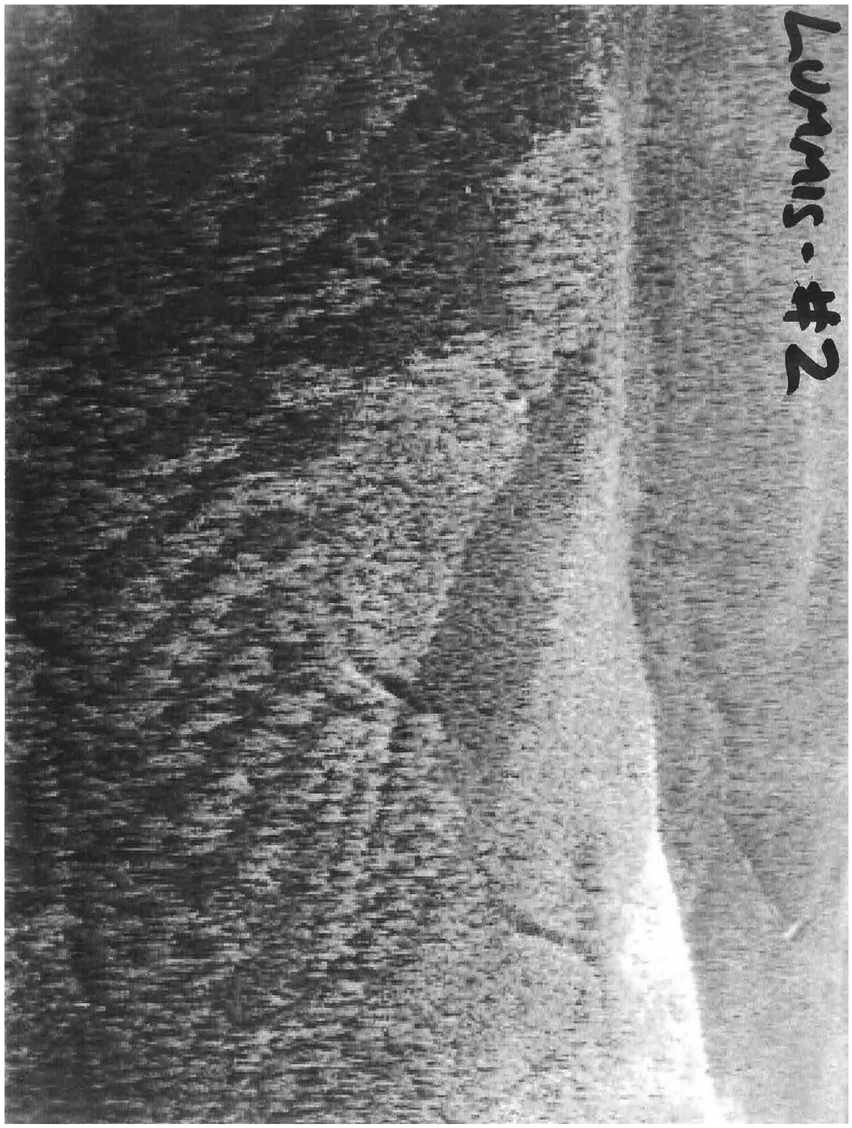
I am eager to hear the steps that the Forest Service intends to take to mitigate the beetle epidemic and to reduce the fuel load that has continued to grow year after year. For Wyoming's forests, we can no longer wait. Our forests are crying out for help in the here and now. I yield back. Thank you, Mr. Chairman.

[The submitted material of Ms. Lummis follows:]

SUBMITTED MAP AND PHOTOS BY HON. CYNTHIA M. LUMMIS, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF WYOMING



Lumis - #1


Lummis - #2

Mr. BACA. Thank you very much for your statement. And I know the minority Ranking Member and I just discussed that maybe we can go in the near future and have that kind of hearing in Wyoming since I look forward to going back there. I have relatives in that area and, of course, the Ranking Member says he has never been to Wyoming so it gives him an opportunity to go there as well.

Ms. LUMMIS. Thank you, Mr. Chairman. Consider yourselves invited. We will fall all over ourselves to make your trip enjoyable and informative.

Mr. BACA. Thank you.

Next, I would like to recognize Mr. Kagen from the State of Wisconsin for 5 minutes.

STATEMENT OF HON. STEVE KAGEN, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF WISCONSIN

Mr. KAGEN. Thank you, Mr. Chairman, for calling this hearing, and thank you for everyone who is about to testify. In the great State of Wisconsin, we are an agricultural state. We have a great deal of forest land. Nearly 70 percent of that land is owned by private industry by private families, and we take good care of our forests. But at the same time, we have all the same challenges as other people across the country. It is an economic issue, and with the downfall of our housing markets we have also lost much of our lumber industry. In the State of Wisconsin nearly 300,000 people are employed because of our forests in the lumber industry and others. We have about 1,800 employers who are directly linked to the lumber industry and the forest industry.

So we have an economic reason to be very keenly interested in the testimony we are about to hear today. We also have an environmental concern. You know, we are Wisconsin, the source of Earth Day, Aldo Leopold, Gaylord Nelson, so in that Wisconsin tradition about caring not just about people's health but the health of our environment and how they are interrelated, I look forward to hearing your testimony. In particular, we have experienced recently some wildfires, and, Mr. Jensen, I look forward to hearing how you are addressing that and what the Forest Service intends to do, and more particularly throughout the state and the region the emerald ash borer is becoming an increasing economic pest.

So I look forward to your testimony and working with you to fashion some solutions that make sense, not just for Wisconsin but for forest owners and landowners and recreators all across the country. I yield back my time.

Mr. BACA. Thank you very much, Mr. Kagen.

Next, I would like to call on the gentlewoman from Pennsylvania for 5 minutes, Ms. Dahlkemper.

STATEMENT OF HON. KATHLEEN A. DAHLKEMPER, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF PENNSYLVANIA

Ms. DAHLKEMPER. Thank you, Mr. Chairman. I am from Pennsylvania, and Pennsylvania means Penns Woods, so obviously our forest in Pennsylvania is very near and dear to us, and I am from the Northwest part of Pennsylvania, still very much of a forested area. I also have a special interest in the fact that 12 years ago, I founded and then ran an arboretum until I came to Congress. I actually miss my arboretum and learned a lot about trees over that time, but I just will concur with everyone's opening statements so far. Certainly, the economic and environmental impact of trees is great in my district as it is throughout this country, and we are dealing with emerald ash borer and we are surrounded in my district by it and just the southern part of the district, we think it has actually entered that part of the district at this point.

So these are all issues that I am looking forward to hearing from our different witnesses from today. And just lastly, I am going to end with a quote that we put in the arboretum, and it is that a society grows great when old men plant trees under whose shade they know they shall never sit.

Mr. BACA. Thank you very much. Next, I have the gentlewoman from South Dakota, Ms. Herseth Sandlin, for 5 minutes recognized.

STATEMENT OF HON. STEPHANIE HERSETH SANDLIN, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF SOUTH DAKOTA

Ms. HERSETH SANDLIN. Thank you very much, Chairman Baca, and Ranking Member Fortenberry for allowing me to join you at this Subcommittee hearing. I appreciate your commitment to our nation's forests, and I look forward to hearing from our witnesses today about the challenges facing our forests and the forest industry. I would like to extend a welcome to all of our witnesses today, but like Ms. Lummis, I would like to extend a special welcome to Jim Neiman, who I would like to count as an honorary South Dakotan given all the great work that he does in the western part of my state. This hearing is especially timely given the consideration in the Energy and Commerce Committee on their approval of the energy and climate change legislation we have been hearing so much about.

Acre by acre, healthy forests can sequester more carbon than any other land use, and furthermore forests can serve the key source of woody biomass, an important energy source. I strongly believe that forests must be fully recognized in any energy and climate change legislation for the essential role they play in reducing carbon emissions and in generating renewable energy. According to one 2005 U.S. Government study often referred to as the billion ton study each year our nation's forests are capable of generating about 368 million dry tons of woody biomass and our agricultural lands can produce almost 1 billion dry tons.

Unfortunately, given these unprecedented opportunities, our forests and related industries and the rural communities they often sustain are facing a startling set of challenges. Forest products companies provide crucial tools for managing our national forests, but these companies must make multi-million dollar investments in equipment and mills in order to be competitive nationally and internationally. Thus, when the economy is faltering and when Federal forest policy is uncertain, it becomes difficult for private companies to make the long-term investments that are needed for healthy rural economies and sustainable forest management. At the same time, in addition to the economic difficulties facing mills and related service providers, many of our public and private forests are also experiencing significant stress from droughts, development, disease, and other factors. Like too many forests across the west, South Dakota is witnessing significant threats from wildfire and mountain pine beetles in the Black Hills National Forest, both of which point to the need for up front preventive management.

Mr. Neiman's experience and insights from his work in the Black Hills of Wyoming and South Dakota will illustrate the interconnections among forest health, forest management, and the forest products industry. In particular, I applaud his interest in construction of electrical coal generation facility near the Spearfish, South Dakota sawmill. This co-gen proposal is exactly the type of innovative project that we need to expand our clean, renewable energy sources as we bring on line new low carbon sources of energy and seek to create opportunities for rural states to fully participate in the new energy economy.

It is exactly projects like Mr. Neiman's that may be stymied if we don't correct the flawed definition of renewable biomass contained in the renewable fuels standard enacted as part of the 2007 Energy Bill and in any renewable electricity standard that Congress seeks to pass this year. As noted by among others the Society of American Foresters on whose behalf Mr. Smith is testifying today, the definition of renewable biomass contained in the energy and climate change legislation approved in the Energy and Commerce Committee needs to be improved in important ways. I have introduced H.R. 1190, which would correct the mistakes made in the 2007 Energy Bill, where nearly all federally sourced biomass was excluded from the RFS.

I am also an original co-sponsor of Chairman Peterson's new bill, which would implement the similar farm bill definition of renewable biomass for the RFS. I am strongly committed to ensuring that H.R. 2454, the American Climate and Energy Security Act, includes a definition of renewable biomass for the RES and RFS that adequately recognizes the role federally sourced slash, mill residue, and other materials should play in meeting our renewable energy goals. The current definition in the bill is incomplete and inadequate. An overly narrow definition will continue to hinder responsible forest land management and slow our nation's movement toward energy independence, as well as to lead to shortfalls in cellulose fuel production under the RFS and hurt many rural communities' ability to participate in the new energy economy.

Thank you again, Mr. Chairman, for this very important hearing, and again I commend you for the foresight and the timeliness of the issues we will be discussing today.

Mr. BACA. Thank you very much for your statement, Ms. Sandlin.

The Chair would request that other Members submit their opening statements for the record.

[The prepared statement of Mr. Peterson follows:]

SUBMITTED STATEMENT OF HON. COLLIN C. PETERSON, A REPRESENTATIVE IN CONGRESS FROM MINNESOTA

Thank you Chairman Baca for holding this hearing today to educate Committee Members about forestry policy and the Agriculture Committee's role in ensuring that Federal policy preserves and improves the health of our nation's forests.

Forest fires, insect epidemics and other threats to the health of our nation's forests must be addressed with proper management and planning. The Agriculture Committee has jurisdiction over forestry on federal lands, forestry research and forestry assistance to states and to private landowners, which means that we have an important role to play in protecting forestry resources.

Forests are an important feature of our national landscape, but they also have the potential to play an important role in the future of renewable energy production in the United States. Unfortunately, provisions included in the 2007 Energy Bill prevent forestry resources from playing a meaningful role in renewable energy. I have fought for two years now to expand the definition of renewable biomass included in that law to include woody biomass from public land. This woody biomass has little economic value and often ends up in landfills or pile burns. The technology needed to convert woody biomass into biofuels has been demonstrated on a pilot scale, and allowing that wood waste to be used for energy production would create an incentive to continue these activities. This is a win-win situation - removing wood waste that can fuel forest fires and using it for renewable energy, but for some misguided reason, provisions added at the last minute to the bill passed by Congress are preventing this from happening. Many of this Subcommittee's members joined me in co-sponsoring legislation that will fix this and other problems with the Renewable Fuel Standard, and we are united in the belief that we need to pass legislation to fix these major problems if we are ever to see a second and third generation of biofuels in this country.

Chairman Baca, thank you again for holding this hearing, and I look forward to the testimony from our witnesses.

We would like to begin with our first panel. We would like to call on Mr. Jay Jensen, who is the Deputy Undersecretary for Natural Resources and the Environment U.S. Department of Agricultural, here in Washington, D.C. Each of the panelists will have 5 minutes, but in your case since you are the only panelist, we will allow you to go the 6 minutes that you have indicated at this point. Mr. Jensen.

STATEMENT OF JAY JENSEN, DEPUTY UNDERSECRETARY FOR NATURAL RESOURCES AND ENVIRONMENT, U.S. DEPARTMENT OF AGRICULTURE, WASHINGTON, D.C.

Mr. JENSEN. Thank you, Mr. Chairman. I hope I can add to the wealth of knowledge and understanding that is clearly on this panel here right now, so hopefully I will add a little bit of insight into that. I am truly honored and humbled to be here. This is my first hearing in this new role, and I take it as an auspicious sign that, Mr. Chairman, I am here before you because as a child growing up in Los Angeles, my first exposure to forests was up in San Bernardino. Mr. Chairman and Members of the Subcommittee, thank you for this opportunity to appear before you today to provide the Department's view on the future of our nation's forests. We are blessed with some of the most diverse, beautiful, and productive forests on the planet. We are a great country, in part, because we have great forests.

The mission of the U.S. Forest Service is to sustain the health, diversity, and productivity of the nation's forests and grasslands for the needs of present and future generations. This mission extends to assisting both public and private forests nationwide. As we look to the future today, I would like to have our conversation focus as much as we can on the values our forests provide more than on any specific output. It is clear that we have our challenges ahead of us, yet I believe we need to rethink our relationship with our forest lands in terms of their long-term values, not just their short-term uses if we are all to get to the best solutions to these challenges.

Our forests are owned privately by individuals, families, and companies, we have already heard this, 420 million acres on that side of the ledger, 56 percent, and publicly by counties, states, and the Federal Government, about 330 million acres, about 44 percent of the ledger. One can find these forests in the back country far from cities, around communities, and sometimes in our own backyards. Our challenge is to reconnect urban and rural Americans to these forests and to focus on how we can work together to deliver all these important and essential values.

As part of this delivery, we must have a clear assessment of the current condition of our nation's forests. Our forest scientists, located at universities and research stations throughout the nation, are continually gathering and analyzing this data, primarily through the forest inventory and analysis program to help us better understand the conditions we are facing. Here are some specifics. Insects and disease, while tree mortality caused by insects and disease tend to be cyclical, it is currently at the highest level in 50 years. Eight percent of the forested area in the U.S. is at risk of attack or mortality. Beetle killed trees cover areas of the Northern Rockies, the Southwest, and the dry forests of the Northwest, estimated around 8 million acres over the past few years.

Similarly, areas of the Lake States are being ravaged the emerald ash borer, as we have heard from a number of folks here today, and it is threatening to move into the plains states. Around 137 counties in 12 states reported that Asian long horned beetles are destroying trees in the Northeast, and right here in our backyard of the nation's capitol five major cities in New York, New Jersey, Massachusetts, and others. Water, 53 percent of our nation's demand for water comes from forested watersheds. Protecting those forested head waters is going to be key. Wildfire, public and private forests have built up excess hazardous fuels due in large part to a century of fire exclusion. On the nation's forests alone, just alone, between 60 and 80 million acres of forest land is classified as densely stocked and at risk of catastrophic wildfire.

Further, over the past 10 years fires have burned on average around 7 million acres per year. This is a size nearly twice the size of the State of New Jersey. Management predictions for the next decade indicate fires may well burn in excess of 10 million acres per year. Last year we lost 2,000 homes, about 4,000 buildings total. In 2009, we are on trajectory to surpass that number right now, and for all Federal, state and local fire agencies, the cost of fire suppression continues to grow. Forest land conversion, over the next 10 years we anticipate that almost 22 million acres of forest within 10 miles of existing cities and towns will be further subdivided and developed into non-forest uses.

In addition, many of the owners of larger tracts of these lands are growing in age. Right now there is 100 million acres owned by people at age 65 years or older, and they are beginning to contemplate how to pass on those lands to the next generation, who may have different ideas for the forest lands. Considering that the majority of forest land in the country is owned by private family forest land owners, around 280 million acres, 10 million plus people, change is coming and it may be significant. Urban forests, today over 80 percent of the population lives in urban settings where the average canopy cover is around 27 percent with trees. These trees help clean our air, minimize flooding, cool our neighborhoods and offset demand for energy. One million tons of pollutants were scrubbed last year and over 800 million tons of carbon were either stored or offset as estimated.

The right tree in the right place can save homeowners big money and help to mitigate climate impacts. And we can't forget climate change. It is estimated that the U.S. forest offset approximately 11 percent of the gross U.S. emissions each year. With wildland fires and loss of forest land increasing forests as carbon sinks are not a given. Lastly, community vitality. In addition to these resource challenges the forest products industrial infrastructure is in decline right now in many places since 2006, our numbers we have are around 127 mills have closed. Accompanying that decline is a loss of jobs and a decline in community vitality. More often than not, these mills are a huge part of the fabric of these rural communities, and while much of this is a result of the current recession and the associated decline in housing starts that does nothing to soften the blow. And for forest managers, this loss of the strategic infrastructure makes resource management more difficult and costly.

These are numerous challenges ahead but every set of challenges also offers opportunity. I am particularly excited about opportunities related to the development of new markets around ecosystem services and bio-energy, which amongst other things helps to maintain, reconnect, and renew the bond between communities and their forests. We can deliver the many values we have come to appreciate and want if we invest the time and energy to work together. There is no doubt that people and interests will have differing ideas on how to tackle these issues and leverage opportunities, yet it has been my experience that people on opposite sides of the forestry table often have the same values. They just differ on how they want to see those values expressed on the land. While for one person protection is eliminating human influence on the ecosystem for another protection is aggressive treatment. Both want the forest to exist and thrive.

So if we can focus on values and focus more on the outcomes of our actions, meaning we focus more on what we leave behind in our forests rather than on what we take away from our forests, we can enlarge the dialogue and arrive at a better solution. Collaborative dialogue, a means to an end, is the path forward here. Currently, collaborative efforts are flourishing across the nation creating increased understanding between citizens of diverse backgrounds. This is a notion we are very supportive of. Our intention will be to provide the means to multiply these successes across the country. As an example, on a national and local scale, collaborative efforts of the past few years have revolved around the development of community wildfire protection plans. There are over 56,000 communities at risk and right now around 4,700 communities have completed these plans. There is more work to do. These plans prioritize fuel reduction areas across the landscape. A perfect example of this notion is what the Mountain Area Safety Task Force in San Bernardino, California has accomplished.

Taken further, in Arizona, this is another example, through former Governor Janet Napolitano's Forest Health, Oversight, and Advisory Committee, they have worked at the same concept at multiple levels of Government to the point where interests are now agreeing on how much biomass can sustainably be taken off of Federal lands on the scale of millions of acres, perhaps a lesson for the energy bill debate that we have been talking about here today. And while these examples deal with in large part with wildfire the notion of communities getting together to chart a course and make a statement of what is most important to them can reap rewards on almost any issue and on any scale, be it kudzu eradication in Mississippi or forest restoration work in Montana, so we have much restoration work ahead to accomplish.

Fortunately, the U.S. Forest Service is staffed by some of the best trained, hardest working professionals in the world, but it won't be one entity alone. We know we cannot achieve these objectives without the active participation and collaboration of citizens, other Government resource management agencies, elected officials, conservation interests, the forest products industry, and the general public. Simply put, our belief is that healthy forests equate to healthy communities. We must conserve, protect, and enhance our forests. We welcome your involvement and assistance in that effort. This concludes my prepared statement, and I would be pleased to answer any and all questions that you have. Thank you.

[The prepared statement of Mr. Jensen follows:]

PREPARED STATEMENT OF VAY JENSEN, DEPUTY UNDERSECRETARY FOR NATURAL RESOURCES AND ENVIRONMENT, U.S. DEPARTMENT OF AGRICULTURE, WASHINGTON, D.C.

CONCERNING THE FUTURE OF OUR NATION'S FORESTS

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear before you today to provide the Department's view on the Future of Our Nation's Forests. We are blessed with some of the most diverse, beautiful, and productive forests on the planet. We're a great country in part, because we have great forests. The mission of the U.S. Forest Service is to sustain the health, resilience, and productivity of the nation's forests and grasslands to meet the needs of present and future generations. Our mission extends to assisting both public and private forests nationwide.

Over 100 years ago, the forests of the east and south were significantly cut over, as were some in the west, largely due to the primary objectives of the time, the conversion of forests to crop land, and the use of wood for building railroads, mining and fuel. The National Forests and the United States Forest Service were created over a hundred years ago in the initial stages of the American conservation movement, in part, to stop rampant deforestation and to begin the practice of scientific and sustainable forest management. Eventually, national forests were established in the east primarily for the purpose of healing cut over watersheds. The goal of stopping and reversing the deforestation crisis of 100 years ago was largely achieved. Today, our nation's forests cover about one-third of the country, provide 51 percent of the nation's demand for water (US Forest Resource, Facts and Historical Trends, 2005), provide wood and paper products, provide habitat for threatened and endangered species and other wildlife, and offer beautiful settings for billions of recreation visits (RPA, 2005).

Today I'd like to focus on the values our forests provide, rather than on any specific output. I believe we need to rethink our relationship with these lands in terms of their long-term values, not just their short-term uses. These values include everything from clean drinking water to hardwood for furniture to grizzly bear habitat to an experience of solitude as a respite from urban life to biomass that can help solve some of our nation's energy challenges. To protect and maintain the values the nation's forests provide requires much vision, planning, and work. Our forests are owned privately by individuals, families, and companies, and publicly by counties, states, and the federal government. One can find these forests in the backcountry far from cities, around communities, and sometimes in our own backyards. Our challenge is to reconnect urban and rural Americans to these forests and to focus on how we can work together to deliver all these important and essential values.

As part of delivering those values, we must have a clear assessment of the current condition of our nation's forests. Our forest scientists, located at universities and Research Stations throughout the nation, are continually gathering and analyzing data to help us better understand the conditions we are facing. In addition, our Forest Inventory and Analysis division has been gathering on-the-ground data on the condition of our nation's forests for the better part of a century. These assessments point to the challenges our nation's forests are currently facing due to changes caused by insects, disease, noxious and exotic weeds and fire, and the conversion of forest land for development. Here are some specifics:

- While tree mortality caused by insects tends to be cyclical, it is at its highest level in fifty years. Eight percent of the forested area of the US is at risk of attack and potential mortality (RPA 2005). Beetle killed trees cover large areas of the Northern Rockies, the Southwest, and dry forests in the Northwest. Similarly, areas of the Lake States are being ravaged by the Emerald Ash Borer and the Asian long horned beetle is destroying trees in New England and right here in the backyard of the nation's capitol. The impact of insects and disease is not limited to the back woods. Cities and towns throughout the Northeast are witnessing the death of their beloved trees along streets and within community parks.
- Public and private forests have accumulated a significant amount of excess hazardous fuels (brush and woody materials) due, in large part, to a century of fire exclusion. On the National Forests alone, between sixty and eighty million acres of forest land is classified as densely stocked with small diameter trees and at risk for a catastrophic wildfire (Budget Director re: Congressional testimony provided in 2009). 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 of forest and grassland. This is an area nearly twice the size of the State of New Jersey. Management predictions for the next decade indicate that fires may well burn in excess of ten million acres of forest and grassland annually (Quadrennial Fire Review). In addition, more homes are being burned each year. For many federal, state and local agencies, the cost of suppression continues to grow.
- Forested lands are being invaded by noxious and exotic weeds. On the National Forests alone, our management estimates indicate that to be six to eight million acres annually (Invasive Species Threat to America's Forested Ecosystems, Ielmini).
- Over the past fifty years urban areas have increased in size by 60 percent. During that same period, forested acreage has shown little change. The actual picture is somewhat more complex than the simple statistics alone would suggest. The amount of forest area is generally shrinking in the eastern and western states due to urbanization and fragmentation, while the amount of forest area is increasing in the interior of the nation as some of our cropland reverts to forest. Over the next ten years we anticipate that almost 22 million acres of forest within ten miles of existing cities and towns will be further subdivided or developed (Forest on the Edge, Stein, McRoberts, and Alig, 2006). In addition, many of the owners of large tracts of forest are senior citizens, indicating vast tracts of forested land will be transferred to new owners who may or may not maintain them as large forested tracts. Considering that the majority of forestland in this country is owned by private family landowners, change is coming and it may be significant.
- Today, over eighty percent of the population lives in urban settings (cities and towns with a population greater than 2500). The average canopy cover in these cities and towns is 27 percent. These trees have many environmental benefits in the urban ecosystem including cleaning the air and actually cooling neighborhoods which reduces our energy needs. Open space also provides areas for filtering surface water and helps mitigate potential flooding. Management estimates indicate that there are 3.8 billion trees in these settings (Forest Resource Facts and Historical Trends, 2009). As noted, the impact of insects and disease is also a major concern in these urban ecosystems.
- We continue to demonstrate our appreciation for forest settings in large numbers. Last year, we estimate that Americans made several billion visits to forest

settings. On the National Forests, our survey data indicates that the Forest Service hosted approximately 186 million visitors. These forested settings are critical to the quality of life for many of us and our communities. (Forest Resource Facts and Historical Trends, 2009)

In addition to resource challenges, the forest products industrial infrastructure is in decline in many places. Accompanying that decline is a loss of jobs and a decline in community vitality. Much of this is a result of the current recession and the associated decline in housing starts. This makes resource management, where needed, more difficult.

There are numerous challenges ahead, but every set of challenges also offers opportunity. There are significant opportunities to begin addressing these challenges by maintaining, reconnecting, and renewing the bond between communities and their forests. We can deliver the many values we've come to appreciate and want if we invest the time and energy to work together.

We look forward to working with the Congress to address many of the challenges facing America's forests. Some of those challenges include:

- private forests and development,
- insect, disease and noxious weed epidemics in both rural and urban settings,
- hazardous fuels reduction near communities, municipal watersheds and critical infrastructure,
- moving towards more fire resilient forested landscape,
- balancing sustainable wood products and the biomass industry which helps restore healthy ecosystems,
- managing roadless areas,
- supporting such values as clean water, clean air, and fiber and carbon sequestration and storage,
- protecting and enhancing wildlife and fish habitat, and
- providing opportunities for citizens to choose forest settings to recreate, refresh, and renew themselves.

Another challenge our forests face is the deep divide that persists in the wake of decades of debate about how to best manage for the desired multiple uses. Some of our forests need restoration work and sustainable active management to remove hazardous fuels, to ensure clean water flows; all while maintaining forest health and resiliency in a changing climate. It is important to note that not every acre needs active management. We must move beyond the all or nothing ideas of competing interests by focusing on shared values and how they can overlap and come together. This requires intelligent, collaborative planning, smart, scientific based management, and inclusive decision-making.

It's been my experience that people on opposite sides of the forestry table often have the same values. They just differ in how they would want to see those values expressed on the land. While for one person, protection is eliminating human influence on an ecosystem, for another it is aggressive treatment. Both want the forest to exist and thrive. If we can focus on values, we can enlarge the dialogue and arrive at a better solution.

Currently, collaborative efforts are flourishing across the nation, creating increased understanding between citizens of diverse backgrounds. Here are several recent examples where people have been working together to accomplish this vision:

1. The town of Woodland Park, Colorado, working with the Front Range Fuels Treatment Partnership Roundtable, of which the Forest Service is a member, was the recipient of the Community Demonstration Project Award. The project already has attracted $100,000 to help treat fuels in high-risk areas. One hundred percent of the project is in the Wildland Urban Interface (WUI). Funding from the Governor's Energy Office, the Colorado Forest Restoration Institute, and the Office of Smart Growth will be matched with funding from national foundations and local organizations to make the Woodland Park Healthy Forest Initiative a reality. This collaborative project of various federal, state, local government, nonprofit, and individual partners is dedicated to the improvement of the resiliency and health of forests in and around the Woodland Park area, and the implementation of the Teller County Community Wildfire Protection Plan. Current funding for this project from the grant and from other partners exceeds $350,000.

2. The National Forests of Mississippi produced a nearly completed draft Land and Resource Management Plan that was a result of excellent collaboration with all interested parties. The collaborative process clarified the wide support for prioritizing native ecosystem restoration and habitat improvement for threatened and endangered species as core components of the plan. This collaborative process demonstrates how active forest management is a tool for meeting ecosystem restoration goals, sustaining healthy, resilient forests while also supplying desired goods and services to the local communities.

3. The Mississippi Forestry Commission is leading a collaborative effort to address the kudzu problem. Utility companies, federal, state and local officials spend thousands of dollars each year to control kudzu. Kudzu contributes to the intensity of woodland fires because it is highly flammable and provides a fuel ladder from the forest floor to the forest canopy. The purpose of this collaborative and comprehensive approach between state and federal agencies and non-governmental organizations is to address the threat and destruction that kudzu poses to farmers, ranchers, and foresters on both public and private lands.. The coalition intends to facilitate a voluntary and cooperative effort in educating the public, researching this pest species, and providing a means of control, suppression, or selective eradication of kudzu. As a partner in these efforts, Secretary Vilsack recently approved $1.6 million for American Recovery and Reinvestment Act invasive species projects on the Holly Springs National Forest.

Our intention is to provide the means to multiply these successes across America. We are committed to a vision where Americans will sit down to not only address impacts, but more importantly, to protect and promote the full range of forest values that are important to all of us.

On a national and local scale, one particularly successful collaborative effort over the past several years has been the development of Community Wildfire Protection Plans (CWPPs). The National Association of State Foresters estimates that there are over 56,000 communities at risk. To date, more than 4,700 at-risk communities have completed (CWPPs). These plans prioritize fuels reduction areas across the landscape. Federal and state agencies have found CWPPs to be very useful in helping prioritize agency fuel treatments via these collaborative mechanisms.

The Administration is increasing support for the Forest Legacy Program as well as the Land and Water Conservation Fund, both of which will help Americans protect important forested landscapes for future generations.

We have much restoration work to accomplish on the nation's forested landscapes. Fortunately, the U.S. Forest Service is staffed by some of the best-trained, hardest working professionals in the world. They know we cannot achieve these objectives without the active participation and collaboration of federal and state resource management agencies, elected officials, residents living in and close to forested areas, the forest products industry, environmental interests, and the general public. We look forward to working together with the Congress and our partners to, among other things: 1) conserve working forest landscapes, 2) protect our nation's forests from harm - wildfire, invasive species and the ravages of insect and disease outbreaks, and 3) enhance benefits associated with trees and forests; e.g., water quality as well as sustainable communities and landscapes.

I am convinced that with the help and continued engagement of the Congress and our state and local community partners, we can improve upon these successes by restoring our forests, public and private, consistent with the values we cherish. Simply put, healthy forests equal healthy communities. We welcome your involvement and assistance in that effort.

This concludes my prepared statement, and I would be pleased to answer any questions you may have.

Mr. BACA. Thank you very much for your testimony. And we all agree that we have all got to work in partnership and got to collaborate if we are really looking at where we are at today and where we need to be in terms of the future. With that, I would like to begin by yielding myself 5 minutes and then we will ask each of the other individuals if they have any questions. They will be given 5 minutes to ask questions. Again, thank you very much, Mr. Deputy Undersecretary Jensen. As California, I am too well aware of the devastating effects that recent wildfires have had on our national forests. I also know the terrible impact the shift of Forest Service funds to fire suppression activities has on many of our other important programs that safeguard the environment and health of our forest. Do you see any other feasible answer to the constant underfunding problem besides increasing the budget of the USFS?

Mr. JENSEN. I do. I am glad you are asking this. This is probably one of the most immediate challenges we have right now. There are going to be some discussions. I know discussions are ongoing right now within Congress about looking at the budget structure and restructuring that. I think you have noted in the President's 2010 budget there is also a notion of creating a contingency fund to try to help get ahead of that problem and that curve because currently right now we are looking at other program areas to fund our fire suppression efforts, and that is not something that is acceptable.

What I would put on the table in answer to that is this issue has been debated and discussed for more than 10 years, and there are some pretty good efforts out there that if we turn to what some of the states have been doing in the past, notably the Western Governor's Association developed back in 2001, along with the help of multiple other collaborators, a 10-year comprehensive wildfire strategy. I would encourage the panel to look closely at that document as I believe it is a pretty good blueprint as to where we might want to look forward.

Mr. BACA. Along the same lines as we look at, is there enough funds in the emergency or reserve in conjunction with other states too as well because the states also have to pick up a certain portion of it, and is there anything that we need to do or to begin to look at in how we can look at that budget especially under emergency situations that are unexpected, whether it is wildfires in our areas, where it is mud slides or diseases or water or even endangered species or any other act?

Mr. JENSEN. We currently feel that we are more than prepared for this wildfire season and going into the next budget cycle and prepared with the President's budget to handle these issues right now. The season itself will certainly dictate the reality of that, but right now we feel we are prepared. But as the season unfolds, we will look forward to connecting with you and working with other agencies and departments at the Federal, state, and local levels to try to figure out what we need to ensure that we have the resources that are needed out there to protect our communities and for our wildland firefighters.

Mr. BACA. Thank you. I know that we all agree that the men and women who are firefighters are remarkable for their ability and bravery and they do an outstanding job in protecting us down at the bottom, and then also protecting our forestry too as well, but one aspect of firefighting that is rarely discussed is the science of firefighting. Are we providing firefighters with the most up-to-date equipment to make sure they are adequately protected?

Mr. JENSEN. We believe right now that we have, and do have, the right resources in place. And we would look forward to hearing from you if there are certain areas and interest where you see otherwise but the way we structured and prepared for the season otherwise feel like our firefighters are prepared for the season.

Mr. BACA. Well, it is not just about having the resources for them. It is looking at if we can be cost effective and get other kind of equipment that are just as protective and better in handling and fighting fires. And that is one of the things that I have heard from a lot of the firefighters is that we need to update the kind of equipment that we have that is more modernized, that it is even more cost effective than some of this heavy equipment that they are constantly carrying right now. And so we have the resources but we are spending on outdated equipment, and we need to look at what is it that we need to do now scientifically and still get the same kind of results to preserve cancer presumption and other things. And I know the doctor knows a lot of this because he is involved with a lot of the patients and others. But to see what needs to be done, we need to explore that as well, and hopefully you can begin to look at the equipment that we have.

Do we need to make changes? Is it cost effective for us? Because, you know, if we can save money there and buy equipment and still be safe, then we have to look at other alternatives. And there isn't one set of policy that is in place, and part of the problem is that every state, every area has its own policy in terms of their own equipment. And do we need to standardize it so this way we can be more cost effective or do we still allow the autonomy of each state? That is something that we need to begin to look at as well. And being cost effective and looking at what resources we have and what we will have in the future.

Let me ask you the other question, regarding the stimulus package, many of the projects will receive funding. Can you tell us the criteria that were used to select Forest Service projects?

Mr. JENSEN. Certainly. Currently we are about halfway through the release of the Recovery Act funds that have been allocated for the Forest Service, and the way the products are selected are through a competitive criteria based process of looking at jobs both near term and longer term chronic unemployment, as well as the impacts and outcomes that those projects would have on the ground.

Mr. BACA. Thank you. My time has expired, so at this time I would like to recognize Mr. Fortenberry for 5 minutes.

Mr. FORTENBERRY. Mr. Jensen, congratulations on your new position and obviously you have a passion for it given your testimony. I would like to return to the subject though of changing the definition of the renewable fuel standard to include more sources of wood renewable biomass. It wasn't uncommon when I was young to see large piles of trees pushed up as development from occurring, pushed into piles and simply burned. That is a vivid image I have of growing up. Recently on my way home, going down the interstate, probably coming back from here, and that memory from childhood was evoked again as I saw a large pile of woody trees pushed up and simply burning. It is rare to see that now but the thought crossed my mind, what a waste.

Now it is not always practical, clearly, in certain clearing situations to move wood to a renewable type of energy conversion, but at the same time a growing sensitivity to allow for waste wood products and other forms of biomass to be converted and the technology allowed to be developed to regularize woody biomass as a part of our renewable fuel strategy. We have to build a big book with multiple strategies in order to build a sustainable energy future, and I think renewable woody biomass has an important role to play there. I also think none of this should be wasted. So as a representative of the Administration, is this a directive that you would like to see? What are your thoughts and ideas on how we make progress in this regard?

Mr. JENSEN. Secretary Vilsack has been very clear on his desire and support of creating wealth and the health of rural communities across this country and part of that equation is trying to find uses, sustainable uses, that protect fish, water, and wildlife habitat along the way. When that can be done in conjunction, I am very much in support of.

Mr. FORTENBERRY. So again place it though in terms of a priority within the Administration. How are you going to develop and unpack that as one—it is a small chapter, we understand, but a lot of small chapters have to be built in order to create a renewable, sustainable energy future.

Mr. JENSEN. Working landscapes are going to be a key component of the agenda that we are starting to put together right now, and what that means is trying to knit the connections between the urban landscapes and the rural landscapes, protecting the head waters in the forest down to the urban forests where a lot of the population gets its first exposure to these sorts of issues and what the glorious benefits of trees and forests are. We are going to work to make sure that that knitting of the working landscapes is done sustainably, which means it takes into account the ecologic, the economic, and the social aspects of that coming together.

Mr. FORTENBERRY. Is there any resistance to changing the definition of the renewable fuel standard to include more sources of wood—renewable sources of wood?

Mr. JENSEN. I think that debate is ongoing right now, and it is pretty clear that there is a certain amount of resistance or discussion points that are happening right now. The Department and the Administration are still figuring out its exact position on that matter.

Mr. FORTENBERRY. Well, I think we can help you.

Mr. JENSEN. It is safe to say that the Secretary feels that the definition, an overly narrow definition, would not be of benefit to that objective of——

Mr. FORTENBERRY. What do you see as the drawbacks from pursuing this more aggressively? What is your hesitation?

Mr. JENSEN. It is around the sustainability of use of that materials. We have to make sure that the systems that get put in place are done in a sustainable manner and that is the——

Mr. FORTENBERRY. You heard my comments. I qualified it by saying renewable woody biomass. Thank you, Mr. Chairman.

Mr. BACA. Thank you very much. Next, I have Mr. Schrader for 5 minutes recognized from Oregon. By the way, it is next to the state that just won the World Series women's softball from Washington State.

Mr. SCHRADER. We take pride with our Oregon State Beavers having done pretty well in the World Series for the men too, so men and women are doing great up in the Northwest. Thank you, Mr. Chairman. I appreciate you being here, and apologize for the tenor of my questions because I agree with the Ranking Member that we need the Administration and the Forest Service to step up in a big, big way on the biomass discussion. You have the expertise. You have the knowledge. You need to impart that, frankly, to the rest of the Administration and make sure they understand that our forests are part of the solution, not a part of the problem, so I really would urge you to get on with that. Why is it that the Forest Service is not implementing HFRA? I mean basically why are we being held hostage by the extreme environmental organizations that sue at every opportunity and not implementing the goals of the Congress and this nation under HFRA?

Mr. JENSEN. I don't have all the numbers in front of me right now, but I think I would put on the table right now that the agency has pursued projects under the Healthy Forest Restoration Act to the tune of hundreds of thousands of acres right now. If there are specifics or there are some concepts and ideas that you would like to pursue in earnest, we look forward to some conversations with you on how we can get at more.

Mr. SCHRADER. Well, I would hope some of the panelists might discuss and see how well we are implementing that. Certainly in my part of the world it is not working at all. I would also take issue, you said that we have the equipment, we are prepared to deal with the fire season and such. We have the right resources. How can you say that without the air tanker fleet being in the air? Basically without that air tanker fleet, we have hamstrung, frankly, the Forest Service ability to fight these fires, and they are just going to rage out of control and it falls to the states to step up with resources they just don't have.

Mr. JENSEN. I will look to get more information for you on this, but my understanding is that our air tanker fleet and helicopter fleet is in the air right now. The status and briefing I had this morning, I think had 10 active tankers out there. There has been in the past some grounding of the air tankers, and some of those issues have been worked through. It had to do with the safety certificates of those planes. We are currently looking to the future to make sure that our fleet is exactly what we need and currently right now we feel that the resources we have to come to bear are adequate to deal with the situation at hand.

Mr. SCHRADER. I pleasantly disagree. I am glad your attention is on it though and hope we do a little more. One of the strategies that my state has adopted that I don't see the Forest Service adopting is an early intervention strategy. By getting into these fires early with resources up front you not only save money, you burn less carbon into the atmosphere, you protect homes, you protect trees. Why is the Forest Service not adopting an initial attack strategy like has been used very successfully—as a matter of fact, with that strategy my state is actually able to buy insurance from Lloyd's of London to help defray the cost of excessive catastrophic wildfires because we have a strategy they believe in.

Mr. JENSEN. Oregon has got some interesting and unique abilities in that regard. The agency shares that objective. Our goal and our direction as well is to have early and aggressive initial attack done safely. So we hope that it is clear that there may be some challenges in Oregon right now in front of you but we definitely share, and that is a key part of our strategy, is that you have to catch these fires early before they move into the larger conflagrations that cost us the larger dollars than we currently are implementing as a few strategies to help with that. I would be happy to discuss with you further.

Mr. SCHRADER. I appreciate the response and look forward to working with you on that and the rest of the Committee. And I apologize again for the tenor of my questions, but I am just really interested in making sure that the Forest Service is shown to advantage and our healthy forests remain healthy or get healthier. Thank you, sir. I yield back.

Mr. BACA. Thank you very much. Before I recognize the next person to ask a question, I just wanted to recognize Glenn Thompson from Pennsylvania, who has been with us since the very beginning of the hearing and then also I would like to welcome Ms. Markey from Colorado who are sitting here too as well. I would add—I would like to recognize Ms. Lummis for 5 minutes.

Ms. LUMMIS. Thank you, Mr. Chairman. In light of both the Ranking Member and the gentleman from Oregon's comments and the gentlelady from South Dakota in support of changing the RFS standard to include renewable woody biomass, I won't ask the same question. However, I would ask unanimous consent to insert for the record a photo that shows a huge slash pile much as you described, Mr. Fortenberry, that could be used as woody biomass under the renewable fuels and renewable electric standards, but otherwise could and would go to waste. So I want to ask unanimous consent to introduce that, Mr. Chairman. As well, I would like to ask unanimous consent to enter into the record a second photo that shows the type of destruction that we are seeing in the west of adult lodgepole pines due to bark beetle. This particular photo is from the Frazier Forest in Colorado.

And, Mr. Chairman, with all due respect to my beloved Jackson Hole Mountain Resort, I do occasionally sneak down to Steamboat Springs and Winter Park to ski in Colorado because I am closer to the Colorado border than to Jackson. And it is just devastating there. You would be stunned if you saw Winter Park, Colorado, absolutely stunned. It is devastating for these economies, and the fuel loads are very dangerous. So my question is this. What specific steps do you anticipate the Forest Service undertaking to reduce the hazardous fuel load in areas like this?

Mr. JENSEN. Right now we are looking at a very unique and unfortunate circumstance in the sense that we have the Recovery Act. It is in response to some terrible times that are out there right now, but it is also providing some amazing opportunities to get ahead of some of these problems. And I don't have specific numbers in front of me right now but we are using some of those monies to get ahead of this to do exactly the types of things that you are talking about. We are not going to have ever enough money to throw at this to get at the problem, but we have some pretty unique opportunities right now, and we are going to be doing our best.

Ms. LUMMIS. Mr. Chairman, another question. This is with regard to HFRA. When projects include road closures or wildlife protection in addition to HFRA requirements the Forest Service seems to be hesitant to use HFRA. Do you agree with that assessment and, if so, why is that the case?

Mr. JENSEN. I would have to know the specifics of the case. As with most forest management decisions, the tool you use is usually driven by the types of circumstances on the ground and every choice and decision looks different in different parts of the country, so the HFRA tool while it may be appropriate in some places may not be the one solution in all, and I would hope that our forest managers and our rangers in the field are using the right tool for the right place.

Ms. LUMMIS. Well, Mr. Chairman, just to comment, and that is that I would ask you, almost plead with you, to look at the Bridger-Teton Forest management in Wyoming. I am tremendously concerned about that forest in terms of its management. It is my personal opinion that the Shoshone Forest is better managed than the BT. And, furthermore, this devastation that is occurring on its northern Colorado and southern Wyoming border is beyond the pale, and I strongly encourage you to visit, Mr. Jensen. You will be stupefied. Thank you.

Mr. BACA. Thank you very much, Ms. Lummis. Next, I would like to call on Mr. Kagen from Wisconsin for 5 minutes.

Mr. KAGEN. Thank you, Mr. Chairman. Than you again, Mr. Jensen, for being here and coming under fire, so to speak, but it isn't so hot in here that you can't take it. I would like to know exactly, and you don't have to report this now, but this Committee as an oversight Committee is very interested in knowing the total number of dollars that you have received through the stimulus funds, the name of every program that you originated, the name of the director of that program, how many jobs you have created through those specific programs, and the economic impact on the communities in which you are investing those hard-earned Federal tax dollars. I think these are the questions that the people in Northeast Wisconsin are very interested in.

You don't have to provide it today, but through each and every one of those programs, we would like to see how that is moving. And if you don't mind giving us a report month by month, we would really appreciate it. Could you do that? That is a yes?

Mr. JENSEN. We will certainly follow up with you and get you the details you need.

Mr. KAGEN. I am going to interpret that as, yes, we will.

Mr. JENSEN. Very good.

Mr. KAGEN. So that is a yes. That is a very good thing. It is unanimous. The other question I have for you is a real easy one. What are the top three complaints you are getting from people you are working for, from state agencies, from foresters, from private landowners, from people trying to make a living, what are the three most common complaints that you are getting through the Forest Service, and what are you responding, what are you doing in response to those problems that they are presenting to you?

Mr. JENSEN. I would put that in the context right now of dealing with economic recovery, wildfire, and then generally the discussion right now around forest management and the utilization of the forests and the biomass themselves.

Mr. KAGEN. Have you given any consideration—I appreciate what you are hearing, and I would appreciate a more in-depth response in writing as to how you are responding to their demands, and perhaps more importantly have you taken any time to study your own department to decide how you could become more lean in your functioning, more rapid in your respond? We understand how long it takes to grow a crop of trees. We all agree here on this Committee that every tree should be reclassified as an agricultural product. But we don't want your department to take as long as it takes to grow trees to harvest them to respond to these problems, so have you taken a look or do you have an in-house report or an active person that is looking at how to become more lean within your own department?

Mr. JENSEN. The most important thing for us is to make sure that these dollars get to the ground and to the people that need them. We have been looking and we are still early in this Administration right now, but we have been looking at certain efficiencies to do just that, and we will be happy and look forward to further discussion.

Mr. KAGEN. Very good. Then with your saying yes, we will stop over, a number of us on the Committee are interested in stopping over at the USDA to take a look personally at how you are doing and maybe you can give us some response in writing before we get there. We will be there in about 4 weeks.

Mr. JENSEN. I look forward to that.

Mr. KAGEN. Very good. I yield back my time.

Mr. BACA. Thank you very much. Now I would like to recognize the gentleman from Pennsylvania for 5 minutes, Mr. Thompson.

Mr. THOMPSON. Thank you, Chairman. Thank you, Ranking Member, for putting this hearing together. Mr. Jensen, congratulations on the new position, and I was real pleased to hear in your opening remarks about recognition or the partnership and community vitality surrounding our forests and national forests. And I have to tell you, I am very pleased with the fact that we have an individual such as yourself with your experience as a forester and a wildland firefighter in that position. I think that is very good. Just to start out, I am going to change course just a little bit in terms of discussion.

The Forest Service web site has a statement many of the communities most affected by the economic downturn are located near national forests, and that has been my experience. I have the Allegheny National Forest, 513,000 acres that were organized 86 years ago. I am fortunate to serve a district that includes that treasure. Unfortunately, the economic downturn in and around the Allegheny National Forest in my district has been really brought about more by the actions of the Forest Service recently than the state and national economy. For example, the recent agreement between the Forest Service and out-of-state environmental organizations will in fact close down oil and gas production in the Allegheny. Ninety-three percent of the Allegheny National Forest sub-service mineral rights are privately owned. The United States Government made a decision to leave those in private hands when it formed the forests, and oil and natural gas has been produced there for a century under strict control of the Pennsylvania Department of Environmental Protection.

Another example of Forest Service policy shift is reduction in timber harvesting. Under the 1986 forest plan the Allegheny could be producing 90 million board feet a year, and this year we will be lucky to hit 25 million even though the ANF is, I believe, the only national forest which actually turns a profit because of the value of the cherry hardwood specifically. The continuously declining timber harvest and natural gas and oil production brought about by policy decisions of the Forest Service, not the economic downturn, really are killing the economy of the ANF region and fly in the face of the President's policy of job preservation and creation. I wanted to get your opinion on that. Is there an explanation why there is a contradiction between the words of what the President is calling for in terms of job preservation and creation and, frankly, the action of the Forest Service related specifically to overseeing in the Allegheny National Forest?

Mr. JENSEN. First, I would say we very much share the sensitivities around this current economic climate, particularly in the districts around the Allegheny National Forest, and the need to look at this nation's energy needs and what those lands can potentially provide for that. We are hoping that our actions to date from what little I know right now on that are moving forward with those two items in mind, but also being mindful of the protection responsibilities that the forest has for the surface and the forests that are on there right now. We will look forward to having some conversations with you further to learn more about what is happening in your district and get a little better sense for the details.

Mr. THOMPSON. Again, I quote from the Forest Service web site. The Forest Service has always risen to the great conservation challenge of our time and with this in mind Abigail Kimball, the Chief of the Forest Service, has identified three times in particular that have stood out, climate changes, water issues, and the loss of connection to nature, especially for kids. The phrase climate change appears on the main page of the Forest Service web site 15 times, yet there is no mention of timber or harvesting, the historic reason that the Forest Services in the Agriculture Department, not the Interior Department. And I guess I would just ask, this is really just a core principle question, what your belief is are the core functions of the Forest Service, and what role does timber harvesting play in its future.

Mr. JENSEN. I guess I would turn back to the mission of the agency, and that is to protect the health, diversity, and productivity of the nation's forest lands. And turning again back to my testimony a little bit, I think the focal point on this is there is a place for timber. There is a place for oil and gas. We want to focus on what is being left behind, not so much on what is coming off.

Mr. THOMPSON. In the Allegheny National Forest with the issues going on there in a recent meeting with Chief Kimball, she was kind enough to come into the office and we talked about the crisis there and the Forest Service agreement with the out-of-state environmental groups to apply NEPA to future gas and oil production. I asked Chief Kimball for copies of the studies done by the Service demonstrating the necessity for NEPA application, and she said that there were none and that the Service relied on pictures of environmental damage, and so my question, I guess, is do you believe that such an important decision should be based on photographs and opinion rather than thorough analysis and documentation?

Mr. JENSEN. I just don't know enough about the details of that. I will commit to work with you to find out a little more about that.

Mr. THOMPSON. I look forward to that, and I appreciate your presence here today.

Mr. BACA. Thank you very much. At this time, I would like to call on the gentlewoman from South Dakota for 5 minutes, Ms. Herseth Sandlin.

Ms. HERSETH SANDLIN. Thank you, Mr. Chairman. Just to follow up, Deputy Undersecretary, and again I echo the congratulations of others on the panel for your position. I look forward to working with you. But I do want to delve into some follow-up questions based on the line of questioning of Mr. Thompson and Mr. Fortenberry. More specifically, can you describe the steps that USDA is taking to provide more stability and predictability in the annual timber sales volume, and more specifically what is the Forest Service doing to address the shortfalls in meeting allowable sales quantity levels established by forest management plans throughout the United States?

Mr. JENSEN. Our current efforts right now are focusing and being drive a lot by the current economic recession, and so the active efforts that we are in right now are looking around the timber sale program and making rate adjustments around some of those timber sales to make sure that when these contracts were signed some years ago, they may have been signed when the markets looked at a lot different than now when they are actually moving towards action on the ground. The prices look a whole lot different, and that is the focal point right now of where we are trying to make sure that these timber sales go forward in an economic, viable fashion.

Ms. HERSETH SANDLIN. So the focal point is on adjusting rates, but not necessarily addressing the shortfalls in the ASQ?

Mr. JENSEN. We are going to need to have some more discussions around that, and I would look forward to hearing what your vision for those are right now. As I come on board, there is a real strong focus on the immediacy of the near term implications of the economic recession and that is where the focal point is.

Ms. HERSETH SANDLIN. And I think that is an appropriate focus, but I will look forward to talking with you about our experience in the Black Hills National Forest. Are you familiar with the Ponderosa Pine in the Black Hills and how quickly it regenerates?

Mr. JENSEN. The most productive.

Ms. HERSETH SANDLIN. And you are familiar with some of the problems we have had over the course of the last decade as it relates to meeting ASQ levels to sustain our industries but also to manage the forest in a much more effective way?

Mr. JENSEN. I have heard from some of the constituents in that area and will look forward to a lot more detailed conversations from here.

Ms. HERSETH SANDLIN. Great. And then on the biomass issue, are you familiar with the recent assessment, I believe it was by the Energy Information Administration, that we are in danger of not meeting the targets set forth for cellulosic ethanol development and the renewable fuel standard?

Mr. JENSEN. I am not familiar with that.

Ms. HERSETH SANDLIN. I would point you to that report, and again it will follow up. If it is not the EIA, but I am fairly certain that it was the EIA that did the assessment. And you are familiar with the President's recent comments of last week in terms of his commitment to achieving advanced biofuels while maintaining the sustainability of the current corn ethanol industry, but clearly a demonstration of his commitment to cellulosic biofuels? You are familiar with his comments that he made last week?

Mr. JENSEN. I have not seen them most recently, but I am very familiar with the commitment of the Administration towards advanced biofuels and cellulosic ethanol.

Ms. HERSETH SANDLIN. And so with that, the Secretary nor the President has yet to put forward a position on the definition of renewable biomass for either the RFS or the RES?

Mr. JENSEN. That is my understanding, correct.

Ms. HERSETH SANDLIN. What role, in your opinion, can utilizing woody biomass on Federal lands play in accomplishing our goals for bioenergy?

Mr. JENSEN. I think there is a huge role. Starting from a community standpoint, I think the obvious one of trying to reduce fuel loads out there on the landscape to protect those communities, and then also trying to tie that into the economic possibilities done sustainably to those communities is a huge one to get that going.

Ms. HERSETH SANDLIN. You have mentioned sustainable, sustainability a couple of times in your opening testimony and responses to questions. Do you feel that more information is necessary as it relates to sustainability even as it concerns utilizing slash and other materials coming off the forest under current management practices?

Mr. JENSEN. I would say yes. It is clear that to make good decisions we need to have the best information we possibly can, and we are trying to—we want to make sure that the programs and capacities that we have in place give us the answers we need to make the best decisions on the ground.

Ms. HERSETH SANDLIN. Well, how long do you anticipate that that will take and in the interim are we just going to continue to burn or let rot existing slash piles in our national forests?

Mr. JENSEN. We are prioritizing our works to make that they are done in areas that are of highest risk and where there is energy within the communities to get at those situations. That is not to say that it is enough. We need to double our efforts and get in front of this instead of behind it and reactive to it, but we are definitely trying to work to target our resource with the best information and best science we have to make sure it is done in the right way.

Ms. HERSETH SANDLIN. Well, I appreciate your responses to my questions, and I would implore you and the Secretary and the President to weed into the debate on biomass and to take a position in light of the over arcing goal to meet the targets that we set forth in 2007 and get these answers to some of the lingering questions that some may have as to sustainability so that we can achieve our energy independence goals as well as sustain our rural communities that rely on our Federal forests as well as our private forests across the country. Thank you, Mr. Chairman.

Mr. BACA. Thank you very much, Ms. Sandlin. At this time, I would like to call the gentlewoman from Colorado, Ms. Markey, for 5 minutes.

Ms. MARKEY. Yes. Thank you, Mr. Chairman, for the opportunity to speak at this Subcommittee hearing. Mr. Jensen, I want to elaborate on what my colleague from Wyoming was talking about with the devastation of the bark beetle in southern Wyoming and northern Colorado. Two weeks ago, Secretary Vilsack was in Fort Collins, Colorado with me. We visited Colorado State University, and we were talking to some of the researchers looking at the bark beetle problem, and they said that in 5 years 90 percent of the lodgepole pines in Colorado will be dead, 90 percent in 5 years. It is well over 2 million acres. You know, of course, this has an enormous increase in the risk of wildfires. And I know that there is some stimulus money coming but there is just really not going to be enough funds for the magnitude of the problem that we are dealing with in southern Wyoming and northern Colorado.

Some of our county commissioners have come to me and said we know the Forest Service is doing other programs like prescribed burns on our grasslands in the eastern part of the state, can some of that money at all be shifted to fighting wildfires as a result of the bark beetle problem. So can you tell me, is there any discussion, I know we passed the FLAME Act. We hope to have more money for fire suppression. There is stimulus money as well. But are you looking at shifting any money within the existing Forest Service budget as well?

Mr. JENSEN. Most certainly, and I think the region has received a good amount of money to date and obviously this is a priority in the future as well. I would note that this is exactly the type of issue why it is important that we have these sort of public and private partnerships that are inclusive of traditional and new industries that are out there to be able to get out all the work because as you just said 2 million acres is a lot. And it is not going to be solved alone by the public dollar. We need to move forward in partnership where we can work with communities and work with existing and new industries to find solutions.

Ms. MARKEY. Thank you, Mr. Chairman.

Mr. BACA. Thank you very much, Ms. Markey. At this time, that concludes the questions of our panel. I would like again to congratulate you on your position, Mr. Jensen, and thank you very much for appearing before us. And if there are any additional questions that Members may have had that they didn't have an opportunity, they may submit them for the record and hopefully you will be able to respond back to those particular questions. Again, thank you very much.

Next, I would like to call our next panel up front. Would they please come to the table? Thank you. I think at this time everybody has sat down, but we would like to welcome our second panel to the hearing. I would like to begin by again reintroducing our Member from Oregon to introduce our guest from Colorado, Mr. Schrader, would you please introduce the Member from Oregon?

Mr. SCHRADER. Thank you, Mr. Chair. It is my pleasure to introduce the representative from Oregon Tree Farm System and American Forest Foundation, Mr. Clint Bentz. Clint is known as a major leader and advocate for family forestry in our Northwest. He is the Chairman of the American Tree Farm System, the first Family Forest Landowner President. He was recognized in 2002 along with his father as the Western National Tree Farmers of the year. Also, a graduate of the Master Woodland Manager Extension Program based out of Oregon State University, the best land grant institution in the country. He is also an author and recently wrote "Ties to the Land, Your Family Forest Heritage" in partnership with OSU. Clint manages a 25-acre tree farm and 700-acre family tree partnership at the Blue Den Ranch in Scio, Oregon. He is also an avid trout fly fisherman and recently honored by Governor Kulongoski for his work as President of the Oregon Aquaculture Association in aiding salmon recovery efforts, a big deal in my state, and showing fish and forestry are not incompatible.

In his spare time, he works as a certified public accountant. He also helped rewrite Oregon's property tax program for small woodland owners, and in Scio he lives with his wife, Maureen, and their six children, so he does have some spare time. And I thank Mr. Bentz for making a long trip to Washington and commend his dedication of aiding forestry and fishing in our great state. I look forward to your testimony.

Mr. BACA. Thank you very much for that introduction. Next, I would like to have the gentlewoman from Wyoming, Ms. Lummis, to introduce her guest from Wyoming.

Ms. LUMMIS. Thank you, Mr. Chairman. It is really an honor for me to welcome Jim Neiman to Washington, D.C. He is in the middle of a very busy season for his business, but he dropped everything at our request to join us today, and there is no one more knowledgeable about forest industry or just forestry in general in Wyoming. Jim Neiman has served on the University of Wyoming board of trustees. Jim Neiman is a steward of the land and the natural resources in Wyoming. I served a brief stint as the Director of State Lands and Investments to which forestry is tied in Wyoming, and also 8 years on our Board of Land Commissioners, and no one was more helpful in terms of providing advice with regard to good stewardship of the State of Wyoming's forested lands than Jim Neiman.

You will learn a great deal from him today. Jim Neiman is also involved in Devil's Tower Forest Products in Hulett, Wyoming, and it is the last remaining sawmill in the entire State of Wyoming. So the survivability of this industry is at risk in spite of their best efforts to employ good stewardship. And so I am so excited to hear your testimony today about cogeneration, about renewable resources, and the great stewardship that you provide. Thank you for being a wonderful Wyoming citizen and looking forward to your testimony today, Jim.

Mr. BACA. Thank you very much. Next, I would like to have Mr. Childers recognize his guest from Mississippi.

Mr. CHILDERS. Thank you, Mr. Chairman. I would like for the Committee to join me in welcoming Dr. Tom Monaghan here. Mr. Monaghan has had a long career with Mississippi State University, which I will take issue that another college that was mentioned was the best land grant institution in the country. We have one that we think is the best. He is from Starkville, which is technically not in my district but he and I have a lot in common in that we are both tree farmers and have a great respect for the land and what it produces. I welcome you here today. He has also worked with the Mississippi Forestry Association, the National Association. I am looking forward to hearing from you today. Dr. Monaghan, thank you for being here, sir. Welcome.

Mr. BACA. Thank you very much. Then I would like to have Ms. Markey introduce her guest from Colorado.

[The prepared statement of Mr. Childers follows:]

SUBMITTED STATEMENT OF HON. TRAVIS W. CHILDERS, A REPRESENTATIVE IN CONGRESS FROM MISSISSIPPI

I want to thank Chairman Baca and the other Members of this Committee for holding this essential hearing. I also want to thank Mr. Monaghan for taking the time to testify today and for representing the Forests Owners of my home state.

Mississippi's forests have been a vital a part of the cultural fabric of our state for over 200 years. The Forestry industry provides 8.5% of all jobs in Mississippi. Mississippi State University is both a premier research institution in forestry and an important educational resource for forest owners. The state's 6 National Forests provide residents and tourists alike with some of the most pristine hiking, camping and fishing areas in the entire country. Mississippi is also a leader in forest conservation as the first state to implement a comprehensive state-sponsored forest resources inventory and finally, over 65% of Mississippi's land is in forests.

on energy, conservation, and agriculture policies it is important that we recognize the vital role forestry can play in all of these issue areas. I am pleased to participate in this hearing and I am looking forward to listening to the testimony of all of the witnesses and I hope to learn more about the ways we as Members of Congress can help bolster our National Forests and our forest industry.

Ms. MARKEY. Yes. Thank you, Mr. Chairman. And I want to thank all of our speakers today, and I want to thank Mr. Brian McPeek for being with us today from Colorado to speak about the great work of the Nature Conservancy and what you do in North America. The previous speaker today highlighted the bark beetle epidemic in the Rocky Mountain region. The Forest Service expects the bark beetle epidemic will kill most of the mature lodgepole pine covering 2.2 million acres in Colorado and southern Wyoming over the next 5 years. The epidemic can be seen by the large swaths of red trees and is now spreading to the eastern slope and the Ponderosa Pines on the front range.

While these beetles are native to Colorado, the increase in numbers over the past several years has been attributed to increased temperatures leaving large areas of dead wood and increasing the risk of wildfire. While some forest areas are growing back, these younger, smaller trees also increase wildfire risk. Infestation prevention techniques in Colorado are very labor intensive and do not guarantee the trees will survive. Therefore, it is important to focus on our wildfire prevention efforts. For the future of our forests in Colorado, it is imperative that we provide a stable source of funding for emergency wildfire suppression such as provided in the FLAME Act.

Finally, I would like to stress the importance of providing the USDA Animal and Plant Health Inspection Service with the resources that they need to update the quarantine 37 regulations for the importation of plants into the U.S. Without these updated regulations our forests are prone to invasive species. Updating these regulations will ensure that we are not unnecessarily exposing our forests to destructive and invasive plants. Thank you again for being here, Mr. McPeek, and we look forward to your testimony.

Mr. BACA. Thank you very much. And we have two other panelists that are here. We have Mr. Steve Koehn, Maryland State Forester, on behalf of the National Association of State Foresters, Parkton, Maryland. Thank you, and welcome to the panel. We also have Matt Smith, on behalf of the Society of American Foresters from Falconer, New York. I would like to welcome all of you to the panel, and thank you very much for agreeing to be out here and giving us your expert testimony. We will begin with Mr. Koehn at this time. Again, you have 5 minutes. Each of the speakers will have 5 minutes and then at the conclusion of the panelists, we will ask questions. But there may be a time that I believe that the bell may be ringing for votes at 3:00. What we will do is go as far as we can and then break for recess and then come back and reconvene. So, Mr. Koehn, you may begin.

STATEMENT OF STEVE KOEHN, MARYLAND STATE FORESTER, ON BEHALF OF THE NATIONAL ASSOCIATION OF STATE FORESTERS, PARKTON, MARYLAND

Mr. KOEHN. Thank you. Chairman Baca, Members of the Committee, thank you for the opportunity to appear today on behalf of the National Association of State Foresters. My remarks today will highlight the role of the nation's forests as a strategic national resource. I also want to address the importance of markets for ecosystem services and traditional forest products in ensuring the nation's forests provide environmental benefits today and for future generations. All the nation's forests face numerous threats from changes in forest ownership and land use to wildfire, climate change, insects and disease. These threats will inevitably impact their ability to deliver essential environmental services like clean air and water and may provide these services at no cost or very little cost to the American public.

Water quality has emerged as one of the most important and public environmental issues of our time. In the United States, well over half of our population depends on water supplied through areas that are originating on or protected by forest lands. Forests increase the resilience of watersheds through water storage, soil protection, nutrient buffering, and filtering of sediment and other pollutants. Increasing the ability of private forest landowners, public forest managers and communities to manage, protect, and enhance forests is one of the greatest challenges to ensuring the future sustainability of clean drinking water and our waterways and our water dependent ecosystems.

State level best management practices have become widely accepted and understood tools to help reduce non-point source pollution by providing forest buffers and limiting soil disturbance, sedimentation, and leaching of fertilizers into our waterways. BMPs have relied on both regulatory and voluntary mechanisms for their implementation and have been found to be very effective in controlling non-point source pollution. New regulatory requirements will impact the ability of private forest landowners to realize value from a working forest. They also are often unnecessary given that BMP implementation and compliance rates are consistently quite high.

Forest practice regulations threaten to place additional burdens on private forest landowners and serve as a disincentive in many cases to maintain forest land cover.

Land conservation of non-forest uses such as urban and industrial development pose greater risks to impairing water quality. Legislative efforts should target and encourage the development of private and more diverse force markets. These will help landowners hold on to their forest land in the face of increasing development pressures. Fundamentally, sustainable force management is not possible without diverse, viable, and robust markets. The absence of markets deprives landowners of financial incentives for them to keep forest as forest. In other words, no markets, no management, no cash flow, no conservation. Markets for traditional forest products have typically done the heavy lifting as far as providing economic returns to landowners. Today, however, global competition has created a situation where U.S. imports of forest products have grown at a faster rate than American exports.

The current economic downturn and housing slump have also reduced the demand for paper products and lumber and led to a 15 percent decrease in the forest product industry's work force. State foresters are well positioned to work with Federal partners to correct these declines, support new markets, and help create jobs at the local level. In the meantime, emerging carbon markets have been making important progress. Carbon is projected to become one of the largest commodity markets in the world. However, water quality protection, forest and habitat conservation programs are also critical ecosystem services and should have a place in an active market place. State foresters believe that it is important to reestablish effective programs that maintain and diversify markets even in difficult budget times and particularly when the nation's forests are being called upon to address national climate and renewable energy priorities.

The renewable electric standard in the proposed American Clean Energy and Security Act, better known as H.R. 2454, adds yet another dimension of the role of forests as a strategic national resource. State foresters believe that the forest biomass will be essential in meeting the goals of producing 15 percent of the nation's energy from renewable sources by the year 2020, particularly in states such as my home State of Maryland where wind and solar and other renewable energy options are less viable. Including a broad biomass definition in an RES like the one found in the 2008 Farm Bill will be essential in attracting new investment in renewable energy facilities. Including a restrictive biomass definition in H.R. 2454, would severely constrain the ability of new projects to generate renewable electric credits under a Federal RES.

Our nation's priorities for renewable energy are underscored by global efforts to address a changing climate. NASF supports a national cap and trade program that includes forest carbon offset projects that guarantee reductions in atmospheric greenhouse gases. Forestry projects offering quantifiable emission reductions but cannot meet higher standards for offset markets should be eligible for incentives beyond offsets. Although they may not be able to qualify for offset payments support for these incentives and other programmatic efforts could some from the sale of allowances for carbon emissions as well as other sources.

Mr. BACA. Your 5 minutes are up, but if you can conclude real quick, and if I can ask the other panelists to look at the light and try to stay within the given time limits because we have quite a few witnesses and the bell has just rung for us to vote.

Mr. KOEHN. I will wrap up immediately.

Mr. BACA. Thank you.

Mr. KOEHN. As long as public values continue to be derived from private forest lands, there is an undeniable role for Federal investments in order to achieve cooperative conservation on state and private forest lands. NASF asks that this Committee give favorable consideration to appropriate allocations for these important services, and with that I conclude my remarks.

[The prepared statement of Mr. Koehn follows:]

SUBMITTED STATEMENT OF MR. STEVEN KOHEN, MARYLAND STATE FORESTER, ON BEHALF OF THE NATIONAL ASSOCIATION OF STATE FORESTERS, PARKTON, MARYLAND

Chairman Baca, Members of the Committee, thank you for the opportunity to appear today on behalf of the National Association of State Foresters. NASF represents the directors of the state forestry agencies of all fifty states, eight territories and associated states, and the District of Columbia. State Foresters manage and protect state and private forests across the U.S., which encompass two-thirds of the nation's forests, as well as support our federal partners in their efforts.

Private forest lands in the U.S. encompass approximately 495 million acres and provide significant environmental benefits at little or no cost to society. All forests face myriad threats from changes in forest ownership and use, wildfire, climate change, as well as insects and disease. These threats will inevitably impact the ability of the nation's forests to deliver any number of environmental services.

In today's discussion, I will highlight the vital role our forests play as a strategic national resource that will continue to ensure water quality and quantity, provide renewable energy, mitigate climate change and allow wildlife to adapt to new habitats. I will also address the importance of markets for traditional forest products as well as for ″ecosystem services″ in ensuring that the nation's forests provide environmental services today and for future generations.

Water Quality and Quantity

Water quality has emerged as one of the most important public environmental issues of our time. The availability of sufficient amounts of clean water is critical to communities, agriculture and industry, fisheries, wildlife, as well as wetland and estuarine habitat. In the U.S., well over half of our population depends on water supplies that originate on or are protected by forestlands. Forests are essential in increasing the resilience of watersheds through water storage, soil protection, nutrient buffering and filtering of sediment and other pollutants.

Water quality is an important indicator of how well land is managed. Increasing the ability of private landowners, public forest managers and communities to manage, protect and enhance forests is one of the greatest challenges to restoring and ensuring the future sustainability of clean drinking water and healthy waterways and ecosystems.

State-level Best Management Practices (BMPs) have become widely accepted and understood tools to help minimize soil disturbance, limit sedimentation and leaching of fertilizers and pesticides into nearby streams, provide forested buffers around streams and other water bodies, and provide guidelines for proper road and water crossing construction. BMPs have relied on both regulatory (i.e. through state forest practices acts) and voluntary (e.g., landowner education and technical assistance programs, third-party certification) mechanisms for their implementation and have been very effective in controlling non-point source pollution when they are properly implemented. Overall implementation and compliance rates are consistently to be quite high.1A[1]

Because regulatory requirements impact the ability of private forest owners to realize value from a working forest, policymakers must consider the economic implica-

[1] NCASI. 2008. Compendium of State and Provincial Forestry Best Management Practices.

tions whenever new environmental requirements are entertained. Without considerable forethought, new regulations which place additional burdens on private forest landowners may serve as a disincentive to maintain forest cover and could encourage conversion to non-forest uses (e.g., urban or industrial development) which-in many cases-pose greater risks to impairing water quality in rivers, lakes, streams, ponds and other waterways. Conversely, regulation that helps to establish private and more diverse markets can be an important way of helping forest landowners hold onto their forestland in the face of increasing development pressures.

Renewable Energy

The House Energy and Commerce Committee recently passed their version of the American Clean Energy and Security Act (i.e. HR 2454) on May 21. The bill included a Renewable Electricity Standard (RES) that would require the nation's utility providers to supply as much as fifteen percent of their power from sources such as wind, solar and biomass by the year 2020. Reaching this goal will hinge on whether Congress can craft an RES that does not interfere with the ability of the nation's forests to contribute to renewable energy. Forest biomass will be essential in meeting national goals for renewable energy, particularly in states-such as Maryland-where wind, solar, and other renewable energy options are less viable. Including a broad biomass definition-such as the one found in the 2008 Farm Bill-in an RES will be essential in attracting new investment in renewable energy facilities. In Maryland, for instance, two wood-based bioenergy facilities are planned on the Eastern Shore to meet increased energy demands imposed by an ever-increasing population.

The first anticipated project is Fibrowatt's FibroShore facility which would utilize a projected 50,000 tons of forestry residues alongside 300,000 tons of poultry litter to deliver 40 MW of power to as many as 50,000 homes. FibroShore's sister power plant is FibroMinn located in Minnesota, the first of its kind biomass-fueled facility in North America.

The second project - which is under consideration by the Maryland Environmental Service (MES), a quasi-public entity -is envisioned to need an estimated 80,000 dry tons of forest residues (i.e., bark, chips, tops, limbs, unmerchantable small trees) to produce as much as 10 MW of power annually at the Eastern Correctional Institution (ECI). Given a biomass-fueled facility is a base-load operation - compared to intermittent production, like wind and solar -- it is possible to realize excess generation that could be fed to the PJM grid.

In addition to renewable energy, these two projects will also generate green jobs in areas of Maryland which are experiencing unemployment rates higher than the state average and median incomes below the state average.

New markets will provide Maryland-as well as other parts of the nation-with the infrastructure needed to improve forest health and productivity while creating incentives for families and individuals to maintain their forests in forests. Both would also produce measurable environmental benefits including a reduction in harmful greenhouse gas emissions and reduced non-point source nutrient pollution in the Chesapeake Bay.

Limiting the availability of forest biomass by including a restrictive biomass definition in HR 2454 could severely constrain the ability of the FibroShore and ECI projects (as well as other similar projects across the country) to generate renewable electricity credits (RECs) under a federal RES. Removing the possibility of RECs would serve as a disincentive to investment, would likely have a detrimental effect on the economic viability of the projects, and would likely contribute further to the erosion of energy reliability at a time when PJM predicts rolling brownouts and blackouts throughout Delmarva by 2011 and 2012, respectively.

Climate Mitigation & Wildlife Adaptation

National priorities for renewable energy are underscored by global efforts to address a changing climate. Our forests will serve as a strategic national resource in our collective climate mitigation and adaptation efforts. NASF supports a national cap-and-trade program that includes forest carbon offset projects that guarantee reductions in atmospheric greenhouse gases (GHG). Forest carbon offsets offer one of the quickest means of reducing carbon emissions, are highly cost-effective, and provide valuable co-benefits such as clean water, wildlife habitat, clean air and recreational opportunities. State Foresters recommend that eligible offset project types should include afforestation, reforestation, improved forest management, and others such as avoided deforestation to be added at a later date. Early adopters participating in existing regulatory and voluntary carbon markets should be rewarded in order to maintain their current and future interest in supplying emissions reductions.

Forestry projects offering quantifiable emission reductions-but that cannot meet higher standards for offset markets-should be eligible for incentives beyond offsets. Although they may not be able to qualify for offset payments, support for these incentives or other programmatic efforts could come from the sale of allowances for carbon emissions as well as from other sources. We recommend that legislation offer these kinds of incentives to reward forest project types with quantifiable climate benefits-including avoided deforestation-and would designate Forest Legacy, EQIP and other Farm Bill programs as part of a ready delivery system.

NASF supports legislation that includes new and expanded funding for adaptation activities across the nation's federal and non-federal forests. Past proposals have focused climate adaptation funding on federal lands and have omitted opportunities to help fund adaptation activities on state and private forest lands. State forestry agencies-in coordination with state fish and wildlife agencies-help provide forest-based habitats for fish and wildlife (among many other forest-related benefits) in the face of changing climates. Cooperative Forestry Assistance programs can play an essential role in implementing forest adaptation strategies on private forestlands. Yet, with the exception of a very small allocation for the Forest Legacy Program, HR 2454 makes no provision for funding these programs as part of the Natural Resources Climate Change Adaptation Fund. NASF asks that this Committee ensure that adaptation funding be allocated to support nonfederal forests as well as federal forests and wildlife needs.

Importance of Markets for Sustainable Forestry

Sustainable forest management is not possible in the absence of diverse, viable and robust markets. The absence of markets results in passive management and deprives landowners of financial incentives for keeping forests as forests. In other words: no markets - no management; no cash-flow - no conservation. Today, markets exist for traditional forests products and for the ″ecosystem services″ forests provide. Both have important roles in providing incentives which encourage conservation and for implementing sound forest management and stewardship practices.

Markets for Traditional Forest Products

Markets for traditional forest products (e.g., lumber, pulp, piling, poles) have done the bulk of the heavy lifting as far as providing economic returns to landowners and have helped reward them for keeping forests as forests. Currently, the nation's forest products industry faces significant global competition creating a situation where U.S. imports of forest products have grown at a faster rate than American exports. Further, the current economic downturn and housing slump have reduced the demand for paper products and dimensional lumber resulting in a loss of traditional markets all across the country. Over the past three years alone, 15 percent of the forest products industry's workforce-found mostly in our rural areas-has been left without a job as a result of mill closings.

Ecosystem Service Markets

Ecosystem services are the values that forests provide above and beyond the traditional products like lumber and pulp. Important progress has been made in regard to carbon and renewable energy markets under the high-profile urgency of climate change. In fact, the market for carbon is projected to become one of the largest commodity markets in the world. But water quality protection, forest conservation, and habitat conservation programs are also critical ecosystem services that should also have a place in an active marketplace.

In Maryland, the ″Bay Bank″ is attempting to provide innovative solutions to bridge the gap by offering a basic online market infrastructure to help landowners determine what markets and programs they are eligible to participate in and then generate and market credits for various ecosystem services. Landowners can place different practices on their land; see what types of credits those practices are capable of generating; and the costs and benefits of implementation and potential income from credits. The multi-state nature of the registry will also assist the development of regional markets.

Programs Needed to Facilitate Diverse & Robust Forest Markets

NASF strongly supports the new Office of Ecosystem Services and Markets, led by former USDA Forest Service Associate Chief Sally Collins. The leadership role of USDA through this office will be critical in developing markets which will compensate landowners for the wildlife, water, clean air and carbon storage benefits their forests provide.

State Foresters and the USDA Forest Service should also be involved in efforts to support new markets-particularly for low value materials-and thus helping to correct declining markets particularly at a time when unprecedented global competitive pressures confront the forest products industry and as the nation's forests are being called upon to address national priorities related to renewable energy and climate mitigation. State Foresters believe it is important to reestablish effective programs that maintain and diversify markets even in difficult budget times. Past programmatic efforts in these areas were not clearly articulated and have lost sight of their intended purpose. New programs could help identify and fund the most innovative projects from around the country which address priority issues in each state, ensure longevity of benefits, maintain and create jobs, and promote the overall goal of improving the prospects for practicing sustainable forestry.

It is also important to recognize the important role of Farm Bill programs in achieving these national goals. NASF sincerely appreciates the leadership of Chairman Peterson and Members of the House Agriculture Committee in crafting the Forestry Title of the 2008 Farm Bill. The State Assessments and Strategies specified in that title are critical in developing direction and future appropriations for Cooperative Forestry Assistance programs. Similarly, State Forestry agencies anticipate improved services and cost-share capabilities through the enhanced forestry provisions contained in the Environmental Quality Incentives Program.

I would like to commend Chairman Baca and Ranking member Fortenberry for holding this hearing today and thank the Committee Members for allowing us to offer our views on the future on the nation's forests.

Mr. BACA. Thank you very much. Mr. Bentz.

STATEMENT OF CLINT BENTZ, ON BEHALF OF THE OREGON TREE FARM SYSTEM AND AMERICAN FOREST FOUNDATION, SCIO, OREGON

Mr. BENTZ. Thank you, Chairman Baca, Ranking Member Fortenberry, and Members of the Committee. My dad brought our property in 1964, and we were like most family forest landowners trying to figure out how to pay the mortgage. We bought it originally to run cattle on. It was a cutover stump ranch. There really wasn't a whole lot happening on the property. And so we ran cattle. We created a fish hatchery. We built some lakes. We had private recreation. We were just kind of doing anything we could. And in the late 1970's a stewardship forester, our local stewardship forester, Mike Barsoti, started talking to my dad about managing for the timber resources. And so we had some cost share funds that were available at that time, and we started pushing brush and planting trees. And over the last 20 years, we have re-planted and re-started about 400 acres of forest.

I moved home about 20 years ago, and we realized we were making all these investments in the land. We were going to create a state tax problem for our family. We started talking also about generational transfer issues that this work that my dad was doing and that I came back to help him with, we would not live long enough to see through to completion, and so if we were going to be successful, we needed to engage our children and our grandchildren in this process so they had as much passion about it as we did. And out of that resulted this ties to the land curriculum that is now being used nationally by family forest landowners across the country connecting inter-generationally to the land.

As a result of all of our work, we were named the 2002 National Outstanding Tree Farmers of the Year by the American Forest Foundation. America's Forest Foundation has a tree farm program, which was founded in 1941 in Oregon. We were the first tree farm Committee. And we work basically doing education and outreach and recognition of family forest landowners. There is 91,000 of us across the country. We have 24 million acres under internationally third party certified green management of the property so sustainably managed for wood, water, wildlife, and recreation. I just finished a three-term chair as the chairman of the organization. I am continuing as a trustee. Oregon has produced four National Tree Farmers of the Year over the last 60 years so Oregon actually has the largest number of tree farmers that have received that award.

Small forest landowners in the United States are defined as being under 1,000 acres. There are 10 million of them, and they own more than a third of the forests in the United States. Average holding is under 100 acres. If we compare that to family farms there is roughly the same number of acres, about 250 million acres of family farms. There is 2-1/2 million family farmers. There is 10 million family forest landowners, but basically the same land base that they are controlling. In Oregon, the forest products industry is the largest forest products industry in the United States. We produce more than 18 percent of the total U.S. softwood lumber production, so timber still is a big deal in Oregon. We are the Persian Gulf of timber, we like to say out there, so even though we have the Silicon Forest growing up near Portland.

Ninety percent of endangered species rely on our forest land. We are facing all kinds of issues with multi-generational issues. Our loss of markets, we are being left out. Many of the renewable building standards that are coming out don't recognize wood at all or if they do they don't recognize our wood as a part of the standard. We have development pressure. I know in Oregon forest land goes for about $1,000 an acre. If you can put a house on it, it is worth $30,000 an acre. That is a huge differential that makes it very hard to talk family forest landowners into keeping the land in that use. Of course, we have generational change. One in five owners is over 75 years of age. We are going to have 44 million acres of this land change hands in the next 5 years.

So we have this climate change bill in front of us. We want to make sure that family forest landowners qualify for carbon offsets, that the work we are doing can be in there. We are now trading—we have pilot projects American Forest Foundation has set up to help family forest landowners aggregate and trade carbon in the voluntary markets. We want to make sure that whatever new rules get written coming out of Congress don't throw those people under the bus, that they are able to continue to trade their carbon and aggregated. Again, most of our landowners are small, so a lot of times economies of scale aren't there so we still need incentives. We need cost share, we need other help to help them get through. I think the bottom line for me is that family forest landowners really care deeply about their land. We own the land but really it owns us. Stewardship is a natural part of that ethic. We don't live long enough to see the fruit of our labors.

Our success, the success of American Forest Foundation is built on engaging the hearts and minds and the creativity of these folks, and I know that if you recognize and reward these landowners for the hard work that they are doing, they will give back to you far more than you ever give them. Thank you.

[The prepared statement of Mr. Bentz follows:]

PREPARED STATEMENT OF CLINT BENTZ, ON BEHALF OF THE OREGON TREE FARM SYSTEM AND AMERICAN FOREST FOUNDATION, SCIO, OREGON

Tanking member Fortenberry, Members of the Subcommittee, thank you for the opportunity to appear before you today on behalf of America's family forest owners. I'm a family forest owner in Oregon, where my siblings and I own 700 acres and manage it as a certified property under the American Tree Farm System - a program of the American Forest Foundation. ATFS certification means that my forest, like that of the 91,000 other family forest landowners in the system, is managed in a way that ensures the continuation of clean water, wildlife, recreational opportunities, and renewable wood products.

We were honored by the American Forest Foundation as the National Outstanding Tree Farmers of the Year in 2002 for our conservation and outreach efforts. We were also honored by Oregon's governor, Ted Kulongoski, for our conservation efforts on behalf of the Oregon Salmon Plan. I just completed my 3-year term as Chairman of the National Operating Committee of the American Tree Farm System - the first family forest landowner to hold that post in the organization's 65-year history. I currently serve as a Trustee and Treasurer of the American Forest Foundation.

As a Certified Public Accountant, I speak, write and work with family forest landowners around the nation on the issue of maintaining family ownership of farm and forestland across the generations. I'm also a member of the Oregon Small Woodland Owners Association, which represents over 3,000 family forest owners in Oregon. I'm here today on behalf of the American Forest Foundation and the 91,000 family owners in the American Tree Farm System.

Why Forests Matter

In Oregon, families own 4.7 million acres, or around 15 percent of the forested landscape. Nationally, 56 percent of the 751 million acres of forestland is privately owned. Of this private forestland, 62 percent, or 264 million acres is owned directly by individuals and families. This family forestland is owned by roughly 10 million individuals, with an average land holding of less than 100 acres. The forest industry in Oregon is the largest in the nation, accounting for 18 percent of total U.S. softwood lumber production. Our soils and wet climate have made Oregon the "Persian Gulf" of timber in the U.S. Voluntary efforts by private forest landowners in Oregon over the last 10 years under the Oregon Salmon Plan have restored over 3,700 miles of stream banks and have made 3,100 miles of stream accessible to fish by improving culverts and stream crossings.

Securing the future of the nation's family-owned forests is a priority we should all be concerned with, whether we own forests ourselves, work in the forestry sector, or simply live in an urban environment. Family forests that are sustainably managed are critical to our daily lives.

Across the nation, these family forests supply the bulk of the wood for wood products, clean water and air, wildlife habitat, and recreational opportunities. Ninety percent of our nation's endangered species rely on family-owned forests for some part of their critical habitat. If these lands aren't managed sustainably and families are not able to hold onto their lands, we will lose a vast part of our nation's natural infrastructure, the jobs and economic value that forests provide for rural communities, the hunting, fishing, and other recreational opportunities, and the scenic beauty we all enjoy.

Ensuring Clean Water Supplies. Safe drinking water is pretty much taken for granted in the U.S., but in fact more than 50 percent of the freshwater flow in the lower 48 states depends on forested watersheds for purification. Forests protect water quality by stabilizing soils, slowing runoff, preventing erosion and floods, and filtering pollutants. The US Forest Service estimates that 180 million Americans depend on forests for their drinking water.

A Green Building Material. Wood itself is increasingly recognized as one of the best "green" building materials for many reasons-it is renewable, forest products store carbon, and it takes far less energy to provide than other building materials like steel and concrete.

Mitigating Climate Change. Since trees absorb carbon, our nation's forests are effectively reducing 10 percent of all harmful carbon dioxide pollution in the U.S. every year. Without forests, we would be sliding even closer and faster into climate change.

The US EPA predicts, with the right incentives to encourage good forest management practices (planting trees, replanting cut trees or trees damaged by disasters, lengthening cut rotations, and avoiding deforestation), forests could actually do much more to combat climate change-capturing and storing up to 20 percent of all U.S. carbon emissions.

This is important-we have 20 percent of the solution to our nation's climate challenges right here in our back yard today-in the nation's forests. This is a climate mitigation tool that we can put to work immediately.

Providing Renewable Energy. Forests can also supply significant amounts of renewable energy, for both fuels and electricity. As we strive to reduce the nation's reliance on foreign sources of oil and fossil fuels, we should turn to the nation's forests, where we have 50 percent more biomass today than we did in 1950. If these lands are managed sustainably, we can meet our wood fiber and our renewable energy needs.

The thing I love about being a Tree Farmer is that I don't live long enough to see the fruit of my own labors. Everything I do on our Tree Farm is for the benefit of generations yet to come. Anything I do on our land that generates income is due to something that the previous generations created. We care about these lands and our goal is to leave them to the next generation better than we found them.

My father purchased our property in 1964 to provide summer pasture for our cows. At the time it was a "cut-over stump ranch" that had been significantly degraded by the prior owners. In the 1980's we began to manage for timber, and in one generation a forest that had been gone for over 50 years began to re-emerge. When he passed away seven years ago, the task of management fell to me. I am working hard to ensure that my children acquire the passion and vision to continue the work of restoration Dad and I started on this property 30 years ago and see it through to completion.

As a professional, I have worked with several families who have owned their forestland for 6 to 10 generations. Imagine the sense of heritage and pride these families have in their lands. They are true stewards and while they own the land, in many ways the land owns them. With the many challenges in family life today, these properties can become a unifying force keeping families working together for a common purpose. They can also be a source of division and frustration if the families do not work to keep this sense of heritage alive.Clearly, there is a lot at stake with this essential aspect of our nation's natural infrastructure. Unfortunately, the news isn't all good. These family forests are at grave risk for a number of reasons. When I get family forest owners together to talk about why we are so passionate about out lands in the face of the risks of fire, insects & disease, a rapidly changing regulatory environment, declining markets, the estate tax and climate change, the only answer we can come up with is Brain Damage! We love these lands. The dirt gets under your skin and you become a part of it.

Development Pressures

Family forest owners are faced with tremendous development pressures, as urban areas grow, and the cost of owning their land rises. The US Forest Service predicts that by the year 2030, roughly 44.2 million acres of forests will experience substantial increases in housing density. When forests are converted to other uses, the US Forest Service reports that these negative impacts are common:

- Decreases in native fish and wildlife and their habitats
- Changes in forest health
- Reduced opportunities for outdoor recreation
- Poorer water quality
- Greater loss of life and property to wildfire
- Decreases in production of timber and other forest products.

While development pressures have certainly slowed due to the economic slump, we are sure to see it pick back up. Annually, we lose about 1.5 million acres, an area about the size of the state of Delaware. What does this mean? Well, the slide? We lose the ecological services like water and air filters and these lands become much harder and more costly to manage for economic and ecological purposes.

Climate Change and Forest Health

Scientists around the globe predict that as our climate changes, we'll see drastic changes to our forested ecosystems. Many predicted changes will negatively impact America's forests-increased catastrophic wildfires and insect and disease outbreaks, shifts in forest species compositions, and major drought.We are already seeing the affects of the changing climate today. Take, for example the massive mountain pine beetle outbreak in the Rocky Mountain region, where millions of acres of forests are dying from the outbreak. Scientists believe the severity of this outbreak is due to a number of factors, one of which is the fact that earlier warming in spring and a longer growing season have allowed the beetles to increase their rate of reproduction to a level we did not think was possible. Earlier spring warming is already causing alarm in southern Vermont where folks have seen the harvest time for maple syrup consistently starting earlier and earlier until it is now a whole month earlier.

We also have a growing collection of invasive forest pests and pathogens that threaten the nations forests, whether it's the emerald ash borer in the Lake States, Sudden Oak Death in my neighborhood, Asian longhorned beetle in the Northeast, or the European wood wasp in New York, or cogongrass in the south, it seems that every forested region is facing more threats from pests that arrive from overseas due to our increasingly global economy.

Declining Traditional Markets

One risk to our family forests is the changing economics of forestry. In the West, most of our lumber goes into the housing market. The decline of new housing starts from 2.1 million to fewer than 500,000 in two years has decimated the forest products industry and sent timber prices to historic lows. Contributing to this problem is the fact that we are importing logs and lumber from countries whose environmental regulations are not as strict as our own.In the South and East, we see paper production moving offshore for a variety of reasons with a resulting loss of pulpwood markets. Markets for wood products of all kinds are declining, and without cash flow to the landowners, there can be no conservation of the land. While the economic downturn is magnifying this, we have seen dramatic declines in market opportunities for traditional wood products from family forests for more than a decade. This is due in large part to the global economy and rising competition from places like South America and Asia. We are quickly losing our ability to compete with other countries, as manufacturing and environmental costs rise here in the U.S. and the regulatory climate for forest owners continues to grow more burdensome.

Forest owners, who previously may have done some cuts to generate revenue each year, have had to hold off the last couple of years because of the weak market. One of our Tree Farmers in Louisiana, Judd Brooke, was only able to get about ten cents on the dollar when clearing down trees from Hurricane Katrina, compared to the pre-Katrina prices. In Oregon, log prices are currently at or below the cost to harvest and transport the logs to the mill. I didn't harvest any timber last year and won't harvest any this year either.

As a result, many saw mills have been closing down, making it more and more expensive (especially with higher gas prices) to ship timber to farther-away saw mills. Loggers and truckers are going out of business and young people are choosing other careers. Together, these types of market trends have put tremendous pressure on rural communities that have long been dependent on timber production. This is happening at the same time that we are importing 35 percent of our lumber from other countries.

Aging Population of Forest Owners

It's of course a fact that the U.S. population is aging. However, this issue is much more pronounced in the population of family forest owners where most family forest owners are above the age of 55. Generational change is a huge issue for family forestlands. With nearly 20 percent of the acres are owned by individuals over 75 years of age, and half owned by someone of retirement age, we expect over 40 million acres of family forests to change hands in the next five years. In many cases, these families have not begun engaging the next generation to prepare them for the handing over of the baton. For certain, the average size of these holdings will decrease as this land is further fragmented, and this is likely to have impacts on how these lands are viewed and managed by the new owners. Eighty percent of family forest owners list as a top priority the passing of their lands to the next generation. Surprisingly, less than a third of the current generations of landowners inherited their land from the previous generation. Almost 80 percent of forest landowners have purchased at least some of the lands they manage.

Raising timber is a multi-generation project. In Western Oregon, it takes 40-80 years to raise a tree from seedling to harvest. In Eastern Oregon and the Inland West, it takes on average 80-120 years to raise a tree to maturity. Hardwoods in the Midwest and East can take up to 150 years to produce high quality hardwood lumber. That is 3 to 6 generations of owners for one harvest cycle. If families fail to prepare for generational change, this is a point where we see a lot of forests shift into non-forest uses, become fragmented, or developed, never to return to a working forest.

Another impact is the effect of the estate tax on family forestlands. When the land gets valued and taxed at fair value 3 to 6 times between planting and harvest, it often results in the premature harvest of the timber, followed by the sale of the land. For many families, after they pay estate bills, there is not enough of the property left to make it worthwhile to keep it.

So, now that I've laid all this depressing information on you, we have some policy solutions to address these threats, capture the tremendous value of family forests for climate mitigation, renewable energy and other ecosystem services like clean water, and help keep this essential element of our rural economies intact. This is how we will truly secure the future of the nation's forests.

Expanded Market Opportunities

While the primary motivation for ownership among most family forest owners is not timber production (it is a top 10 reason, but not a top five reason for owning the land), financial incentives are an essential element for keeping them on the land-no cash flow, no conservation.

Maintaining and improving traditional wood products markets. These markets have and will continue to be a strong source of income for family forest owners, if the appropriate policies and incentives are put in place. This includes ensuring that wood grown on family forest lands is considered "renewable" in new and emerging green building markets. Unfortunately, some green building standards, including the Standards used by our very own General Services Administration, exclude the use of wood from most family forests, including the 30 million acres certified under the American Tree Farm System.

Emerging renewable energy markets. This Committee has been at the forefront of the debate over emerging energy markets for biomass. This new market has the potential to offset revenue streams lost by the declining timber market. Unfortunately, family forest owners are essentially left out of the renewable fuels market due to an unduly limited definition in the Renewable Fuels Standard. Emerging carbon markets. Carbon markets represent another minor, yet important, emerging income stream for family forest owners. However, it is critical that the policies are structured to reflect the needs of family owners; otherwise, the vast climate mitigation potential in these forests will go untapped. Right now, there are still many questions and uncertainties present in the House climate bill, HR 2454, that could make or break this market opportunity for family forest owners. The American Tree Farm System already has pilot programs in place where family forest landowners are aggregating and selling their carbon on the existing voluntary markets. We want to see these efforts encouraged and expanded under whatever regulatory structure is adopted by Congress.

Emerging Ecosystem Service Markets. In addition to carbon markets, markets for other ecosystem services, like clean water and endangered species habitat are emerging. The 2008 Farm Bill took a step in the right direction, requiring the development of standards and guidelines for ecosystem services and the establishment of the USDA Office of Ecosystem Services and Markets. We must have policies in place that encourage the development of these markets, to secure the continuation of these services in the future.

Investments in Conservation

In addition to market opportunities, we also need incentives for family forest owners to continue managing their land sustainably and stay on the land. These incentives help add to revenue streams from markets and are by far preferable to a regulatory approach. Again, no cash flow-no conservation.Tax Incentives. Tax policy can serve as either a major incentive or a major deterrent to family forest owners who wish to keep their land in the family and manage their forests sustainably. This is especially true as development pressures and land values escalate, often putting forest land owners in a situation where they may feel forced to sell in order to pay property, estate or other taxes. Forest land is a unique, risky, investment, often requiring significant upfront expenditures that can take 30-150 years to yield favorable returns. In many cases, there is a 10-fold or more difference in the value per acre as forest land or development land.

Tax incentives can take the form of lower income taxes for forest revenue, an estate tax system that encourages rather than discourages intergenerational ownership of family forestlands, tax credits or deductions for conservation activities such as conservation easements or endangered species conservation. Congress will have an opportunity this year to tackle several of these issues, including the estate tax and tax credits for conservation easements.

Conservation Incentives. Tax policy is just one way to create incentives for forest conservation and sustainable management. Other incentives, like those provided in the 2008 Farm Bill through programs like the Environmental Quality Incentives Program, also help spur sustainable forest management. We also need better safe harbor agreements so that when a landowner creates habitat for an endangered species, they are not punished by losing the ability to continue the active management of their lands.

This year, with climate legislation moving, Congress has a unique opportunity to create incentives for climate mitigation activities on family forests. While carbon offset markets are one way to do this, they won't work for every forest owner. Pilot projects underway at the American Forest Foundation indicate that while family forest landowners can effectively aggregate their carbon for sale in carbon offset markets, the economic feasibility drops precipitously for forests at or below 80-100 acres.

Because the vast majority of forest owners own less than 100 acres, we need other ways to capture the carbon benefits of these forests-if we are going to double the sequestration in forests from 10 to 20 percent. Incentives will do the job, provided the legislation includes them. Unfortunately, the current Waxman-Markey climate bill only includes incentives for international forestry projects, and leaves out America's forest owners and farmers. Congress can rectify this and provide an incentive for carbon sequestration that can start happening immediately.

Research Investments. Today, more than ever, we need cutting edge research to face the challenges before us. Whether it's figuring out how forests can help solve climate problems or finding a way to control increasing number of invasive forest pests, there is no shortage of questions that need answers in order for our forests to continue to thrive. Unfortunately, forest research funding has drastically declined over the past decade, due in large part to a decreasing investment from the private sector. Investments in research at our federal agencies and our universities are essential to getting the right information in the hands of those making decisions about forests.

Federal Forest Policy. The problems that plague our national forests have made them bad neighbors to the family forestland owners that live on their borders. In the Pacific Northwest Region over the last 10 years, the average size of a wildfire on the national forest was 133 acres. On state and private lands the average size was 24 acres. In 2007, more than 500,000 acres of national forests in Oregon were damaged as a result of bark beetles and other insects and disease problems caused largely by stress from drought and historically overstocked stands.

Wildfire and insect and disease issues do not honor property lines, and the federal forests need to be funded and actively managed to restore the health of this vital ecosystem and national resource. In 2007 in Oregon alone, less than 7 percent of the annual growth in the federal forests was harvested. Nearly 20 percent of the annual growth was lost to fire, insects and disease, and the remaining 73 percent of the growth is still there, increasing the stress on these already overstocked stands. This is a recipe for disaster.

By comparison, on private forest lands in Oregon in 2007, 75 percent of the annual growth was harvested, 4 percent was lost to fire, insects and disease, and 21 percent of the growth is still there in the woods.

The US Forest Service concluded in 2007 that forest health could be restored by thinning these stands, burning after thinning, harvesting insect-infested trees, and selected harvesting which restores the forest to healthy, historical stocking levels. Private landowners in these same areas have adopted these practices and have seen great improvements in the health of their forests. This was vividly brought home to Oregonians in the recent B & B fire where national forestlands were devastated and the adjoining private forests escaped relatively unharmed.

Education Investments. All the market opportunities, incentives or other policies we enact will have little effect if the next generation of landowners, conservationists, and general citizens do not have the awareness and skills to tackle our environmental challenges. Investments in education about the environment, science, math, and other areas, that help prepare our children to meet these challenges in essential. There are several opportunities through USDA, including through the US Forest Service's conservation education programs, to increase these investments. This should also be a priority as we seek to secure the future of the nation's forests.

This Congress and decisions made over the next several years will have a dramatic impact on the future of the nation's family forests. Right now, the future is looking good, family forest owners have tremendous potential to help solve some of our toughest environmental challenges and Congress is poised to help see this happen. We must make the right decisions about our nation's forests, ensure adequate market opportunities and provide incentives that will help us address our pressing challenges and secure the future of this precious natural resource.

I believe that families have the ability to hold and manage land sustainably over the generations. However, if we don't help them succeed, we will lose a vast part of our nation's natural infrastructure, the jobs and economic value that forests provide for rural communities, the hunting, fishing, and other recreational opportunities, and the scenic beauty we all enjoy.Forests have long provided traditional benefits like wood, wildlife, and recreation. Now, we are also depending on forests to provide ecosystem services like clean drinking water, carbon sequestration, and biomass for clean fuel. Family forests will play an essential role to help our nation with its most pressing environmental issues-climate change and the demand for renewable energy. But family forest owners need supportive policies and market incentives if their forests are going to do all they can to survive as healthy forests, providing all the ″free″ benefits the public now enjoys.

Thank you again for the opportunity to speak to you. I'm happy to answer any questions you may have.

Mr. BACA. Thank you very much. Mr. McPeek.

STATEMENT OF BRIAN McPEEK, NORTH AMERICA CONSERVATION REGION DIRECTOR, THE NATURE CONSERVANCY, DENVER, COLORADO

Mr. MCPEEK. Thank you, Mr. Chairman, and Members of the Committee. I appreciate the invitation to testify today. First, Mr. Chairman, I want to thank you and the Subcommittee for your great leadership and support on farm bill conservation programs. Thank you for that. As you know, The Nature Conservancy is a leading conservation organization working in all 50 states and 30 countries around the world. Our mission is to preserve the plants, animals, and natural communities that represent the diversity of life on earth by protecting the lands and waters they need to survive. Forests in the United States provide extensive habitat for many of the plants and animals that the Nature Conservancy is committed to protect and made profound contributions to the ecological health of our lands and waters.

From our first acquisition of a 60-acre hemlock gorge in New York State in 1955 to the 310,000-acre purchase of Plum Creek forest lands in western Montana last year, the Conservancy has more than 50 years of experience in developing strategies to conserve forest habitats. Forests in the United States and around the world have many values from improving air quality to providing clean drinking water to storing carbon and sheltering an incredible diversity of plants and animals. Forests have an immensely positive impact on the American economy and the quality and character of the American way of life.

Despite their economic and environmental importance, forests in the United States are threatened on many fronts and are showing severe signs of stress. Another 44 million acres of forest, as someone cited earlier, are predicted to be lost in development by 2030. Wildfires cost us $2 billion a year to extinguish at the same time that overgrown brush and trees are choking lands that are adapted to periodic fire. An astounding array of non-native insects and diseases are found across the continent. These pests can destroy all or nearly all oaks, maples, hemlocks, birches, willows, and bay in the U.S. climate change; specifically, increases in temperature and new patterns of precipitation is beginning to affect our forests in profound ways. The length of the fire season, expanding populations of some native insects like the bark beetle in Colorado are now tied to climate change with dramatic and noticeable impacts.

The country's movement towards renewable energy creates huge opportunities for forests as an alternative energy source. Without sideboards to encourage sustainability, we run the risk that the energy boon could trigger losses of native forests and biodiversity. Finally, budget cuts to Federal and state forestry programs have trimmed back technical assistance to private landowners at a time when shifting markets and the threats I described make information and technical assistance all the more important.

A wide and balanced range of strategies are needed to address these threats. The Nature Conservancy believes that successful forest management must incorporate five overall management strategies. First, we need forest planning and management at the landscape level wherever possible. Second, we need to focus adequate resources to conserve private forests. Third, we need to manage forests for their full range of values and benefits. Fourth, we need to make restoration a key component of forest policy. And, finally, we need forest management to take climate change into account. In our written testimony, we have provided a number of specific recommendations for each strategy, and I will end my comments by focusing on three specific projects that we are involved in that we think are good examples of the programs you might support.

The 25 million acre flood plain of the Mississippi River north of New Orleans was once one of the great bottom wetland hardwood forests on earth. Eighty percent of the delta, however, has been converted to farmland. While most of this land should remain in agriculture, there are at least a million acres of very wet and flood prone soils that should be restored to bottom land hardwoods. This restoration would reduce the impacts of flooding trapped nutrients, provide wildlife habitat, and store carbon. The Conservancy's experience in forest and hydrological restoration in the delta suggests that the wetland reserve program in tandem with a new carbon reserve program, a carbon offset program, and a land and water conservation fund can restore bottom hardwoods over hundreds of thousands of acres on both public and private land.

In the Jemez Mountains in New Mexico, they are a candidate area for the newly created Forest Landscape Restoration Act. This forest supplies water to several towns and cities, as well as recreation, grazing, and modest amounts of timber, burned severely in the 2000 Sierra Grande fire. The green forest that remains is severely overgrown. Partners have been working together to plan and manage the various jurisdictions in this landscape for over a decade. While their approach has received some results were this landscape to receive sustained funding under the Forest Landscape Restoration Act the scale of treatments could increase dramatically. Finally, the Garcia Forest, 24,000-acre Garcia River Forest in Mendocino County, California, is among the first and largest forest to be recognized by the California Climate Action Registry as a verified source of carbon credits.

The Nature Conservancy owns the conservation easement on the property, ensuring protection that makes verification possible. The giant redwoods and Douglas fir in the Garcia River Forest can store more than 77,000 tons of carbon emissions annually, the equivalent of taking more than 14,000 cars off the road every year. The Garcia River Forest is poised to offer the most reliable and valid carbon credits in the country to private companies and public organizations seeking to offset the greenhouse gas emissions while allowing for sustainable harvest activities in the process sustaining water quality, habitat for salmon, forest and wood product jobs in the local economy. As we have outlined in the testimony, forests are critical to the American way of life and are necessary to sustain our water supplies and products we use daily. The Nature Conservancy looks forward to working with this Committee as opportunities emerge to enact forward looking legislation that protects our nation's forests and the benefits they provide to people. Thanks again.

[The prepared statement of Mr. McPeek follows:]

PREPARED STATEMENT OF BRIAN MCPEEK, NORTH AMERICA CONSERVATION REGION DIRECTOR, THE NATURE CONSERVANCY, DENVER, COLORADO

Mr. Chairman and Members of the Committee:

Thank you for your invitation to testify today on the future of our nation's forests. My name is Brian McPeek, and I am Director of the North American Conservation Region of The Nature Conservancy.

Introduction

The Nature Conservancy is a leading conservation organization -- working in all 50 states and more than 30 countries around the world -- with the mission of preserving the plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive.

Forests in the United States provide extensive habitat for many of the plants and animals The Nature Conservancy is committed to protect, and forests make profound contributions to the ecological health of freshwater and estuarine ecosystems. From our first acquisition of a 60-acre hemlock gorge in New York State in 1955 to the 310,000-acre purchase of Plum Creek forest lands in western Montana last year, the Conservancy has more than 50 years of experience in developing strategies to conserve forest habitats.

While acquisition of interests in land, whether outright or by conservation easements, remains an important conservation strategy for us, to address the scope and complexity of today's conservation challenges, we also use other conservation tools: policy advocacy for the management of public and private lands, conservation incentives for private landowners, implementation of payments for ecosystem services, reforestation and restoration projects, learning networks and technical assistance. In pursuing these strategies we partner with many organizations and interests -- from rural communities to large corporations, from municipal governments to federal agencies -- to achieve lasting forest conservation.

The Essential Values of Forests

Forests in the United States and around the world have many values -- they improve air quality, provide clean drinking water, regulate stream flows, maintain water temperatures to improve fish habitat, filter out pollutants, mitigate flooding and erosion, moderate our climate, store carbon, supply wood fiber and wood products, and are a renewable energy source. They are habitat for an incredible diversity of plants and animals, and forests are the setting for outdoor recreation and tourism. Forests have an immensely positive impact on the American economy and on the quality and character of the American way of life.

Forests Are Threatened on Many Fronts

Despite their economic and environmental importance, forests in the United States are threatened on many fronts and are showing signs of severe stress:

Land Use Conversion and Fragmentation.

Relentless conversion of forests to other uses, especially urbanization, is a primary threat with as much as 44 million acres of forest land predicted by the U.S. Forest Service to be lost to development by 2030. In some places, including western lands adjacent to national forests and land along the Appalachians, second home development is the leading cause of fragmentation, while in other places urbanization, along with road and energy development or off-road vehicle use are the primary contributors.

Climate Change

Climate change scientists are continually releasing new information about the impacts of climate change on U.S. forests. Recent studies have documented the effect of warmer temperatures and variability in precipitation on the length and intensity of fire seasons, the life cycle of native bark beetles, and on the viability of a wide range of species.

Altered Fire Regimes

The typical interval between natural fires is every 1-35 years for about 2/3 of the continental United States. More than 80 million acres of these lands are now prone to catastrophic wildfires because fire suppression and other management activities have increased tree density and fuel loads. Fire risks are exacerbated by climate change impacts, such as longer summer weather, higher summer temperatures, early peak snowmelt and faster runoff. Under the drought conditions now present in some places, the woods have become tinderboxes where wildfires are likely to do long-term ecosystem damage.

Invasive Pests and Pathogens

An astounding array of non-native insects and diseases threaten forests across the continent, most acutely in the East, the Pacific Coast, the South, the Rockies and the upper mid-west. These pests could destroy all or nearly all oaks, maples, hemlock, birch, willow and redbay adding to the existing extirpation of the American chestnut and the American elm. Estimates of economic damage for each of several pests run to the tens or even hundreds of billions of dollars, but policies to prevent these pests are out of date and inadequately funded. Climate change appears to be having an impact on native insect species causing them to spread to new areas and interact in new ways with their host trees, producing devastating impacts such as the 15 million acres currently impacted in the Rocky Mountains by the native mountain pine beetle.

Energy Development and Woody Biomass Use

Forests are a renewable resource and can be used as an alternative energy source. However, without sideboards to encourage sustainable use, such activities could lead to huge losses of native forests and biodiversity. When wood-fueled energy facilities are out of balance with wood supplies overcutting of native forests or their conversion to non-native species could result.

Reductions in Funding for State Forestry Programs and Technical Assistance

In recent years, budgets for many state forestry programs have been drastically reduced as have some Federal programs providing technical assistance to private land owners. At a time of shifting markets and increasing threats, the lack of management information and technical assistance presents a distinct threat to privately owned forests.

The Nature Conservancy Recommends Five Overall Strategies to Address These Threats

A wide and balanced range of strategies are needed to address these threats. The Nature Conservancy believes that successful forest conservation must incorporate five overall management strategies:

1. Wherever possible forest planning and management should take place at the landscape scale.

Forest managers have experience working at small scales, whether at the stand level on a large ownership or across small properties in a fragmented landscape. Our experience tells us that we cannot address threats like altered fire regimes or land use conversion unless we are working at a larger, landscape scale. Large blocks of contiguous forest are increasingly more and more important where they exist in the United States, providing critical habitat for an array of endangered and sensitive species that are often confined to forest remnants and rare forest habitats.

2. Focus adequate resources to conserve private forests

Threats to the nation's forests cannot be addressed only by attention to the management of public lands. In the 13 Southern states, for example, more than 85% of the forest land is privately owned. While over time a small proportion of these lands may shift to public ownership, the great majority will not. Private land conservation incentives, including robust funding for the Forest Legacy Program, will be essential to keeping forests in forests.

3. Manage forests for their full range of values and benefits

Traditionally forests have been managed for only a few purposes, such as wood production and recreation. We now realize that forests provide other very important values such as protection of water resources, carbon storage, protection from natural disasters, control of soil erosion and maintenance of stream water temperatures. Market strategies and valuation of the benefits forests are essential if landowners are to have an economic rationale for long-term forest stewardship. Similarly, public land management must achieve a more encompassing balance of uses.

4. Make restoration a key component of forest policy

Many American forests have been lost or degraded over time, compromising their values, and making restoration critically important. While forest management is increasingly targeted at restoration of habitat elements that were once common in forests, it is insufficient to address the scale of the problem. Across the nation many restoration efforts are underway: old timber roads are being decommissioned, culverts removed, fish structures installed, and overgrown brush and trees thinned out by mechanical means or with controlled fire that replicate natural conditions, all demonstrating the efficacy of restoration to forest conservation. In addition, many areas where forests have been removed or significantly altered can, and where appropriate, should be restored back to more natural conditions.

5. Forest management must take climate change into account

The impacts of a warming climate are already being seen in our forests. Long range forest planning should include evaluation of likely climate impacts and adopting measures to help forests become more resilient and more able to adapt to change, whatever the rate and scope of impacts turns out to be.

A Number of Policy Barriers Impede Management that Carries Out These Overall Strategies

On private lands, the current set of funding and incentive programs function effectively at smaller scales, but are difficult to coordinate across agencies and jurisdictions to achieve landscape scale outcomes. State land policies vary widely, but to the extent that they rely on federal funding and programs, they are impeded by similar policy barriers.

Federal land management is inhibited by policies that require longstanding forest management practices be continued into the future, even though public needs and expectations have changed. Legislation that was ground-breaking and innovative in its time - for example the Multiple Use/Sustained Yield Act of 1960, National Forest Management Act of 1976 and Federal Land Policy and Management Act of 1976 - now creates barriers to the development of markets for water and carbon, and management of environmental services from forests that are critical to sustain people and nature.

Specific Actions Are Needed to Conserve America's Forests on Both Private and Public Lands

In conformance with the overall strategies that I have outlined in this testimony, The Nature Conservancy makes the following specific recommendations for conservation of private and public forest lands:

On Private lands:

Increase Funding for and Expand Farm Bill Forest Programs

The 2008 Farm Bill included important steps forward for forest conservation. We are grateful to the Committee for this progress. Given our growing understanding of forest threats, however, the forestry incentives included in the 2008 Bill should be better funded and greatly expanded, particularly to address the water resource and carbon values of forests. While there is much discussion of ecosystem service markets, these have been slow to develop. In the meantime, the reserve and cost share programs in the Farm Bill can become, in effect, surrogates for true markets by paying forest land owners for forest practices that provide additional, significant and quantifiable values to society. Toward that end:

- Increase funding for the reserve and cost share programs included in the 2008 Farm Bill (Wetlands Reserve Program, Conservation Reserve Program, Environmental Quality Incentive Program, and the Wildlife Habitat Incentive Program).
- The Wetlands Reserve Program should be expanded and funded to explicitly address the conservation of forested headwater streams
- A new reserve program is needed to reward landowners for forest practices that increase long term carbon storage on their lands. Such a program would be different from a framework for tradable emissions offsets and designed to be more suited to the needs of small and medium sized landowners.
- Funding is needed to complete the State Forest Resource Assessments required by the 2008 Farm Bill as a guide to the strategic and landscape scale application of Farm Bill incentives. In the past, incentive programs have been so distributed across states that they have not achieved a critical mass of protection

and management in watersheds or landscapes. State Forest Management Plans can be used to better focus these programs.

- Funding should be restored to the State and Private Forestry Program of the Forest Service for state forestry programs to again provide technical assistance to private landowners.

Extend and Expand Tax Incentives for Forest Conservation

Tax policies can be significant incentives and disincentives for forest land stewardship. The Conservancy recommends that:

- Tax deductions for conservation easements be made permanent
- Legislation should increase the tax limitation on the amount excluded from a gross estate for lands covered by a conservation easement

Define Forests Offsets in the Climate Bill to Meet International Standards

A framework for defining tradable forest carbon offsets should be adopted as part of climate change legislation that is robust and credible, including clear principles on additionality, permanence, leakage, measurement, verification, and environmental criteria.

In addition, while strongly supporting market-based approaches, the Conservancy believes that other complementary policies are needed to ensure the full climate mitigation potential of the forest sector.

On Public Lands

Fund the Forest Landscape Restoration Act and Address Wildfire Budget Issues

With passage of the Forest Landscape Restoration Act (FLRA) as part of the Omnibus Public Lands Bill of 2009, a new tool is available for accomplishing large scale forest thinning and restoration over an extended time period. To meet its promise, the FLRA should be funded at $40 million annually, as provided in its authorization. This should be a priority for Congress, along with restructuring the appropriation process for the U.S. Forest Service to provide funding for fighting wildfires that does not compromise other spending by the Service.

Revise Forest Service Organic Statutes to Reflect Additional Forest Values

Revise the Multiple Use Sustained Yield Act of 1960 (MUSYA), to allow for ″ecosystem services and compatible recreation″ that meets the needs of the American people in the 21st century. Reshape the Organic Act to provide a foundation for the definition of ecosystem services and values in authorizing legislation that modifies the multiple use mandate, i.e., managing each acre for all uses, and provides a framework to ensure that the ecological health of federal lands is restored and maintained for future generations. Revise existing targets for products and services to include targets for ecosystem services, and realign the Forest Service budget to support the transition from multiple-use to restoration and ecosystem services. Incorporate mechanisms into Forest Service policies that encourage payment for ecosystem services that directly benefit communities, and use these funds to maintain and expand ecosystem benefits.

For All Lands

Ensure Rules Governing Live Plant Imports Move Forward Swiftly

USDA's Animal and Plant Health Inspection Service (APHIS) needs to move swiftly to implement programs to prevent insects and diseases from entering our country from overseas, and to improve response to those pests that do arrive. Because American trees did not evolve in concert with these pests, they often have little resistance, and devastation can result.

The most critical need is to move forward revision of rules governing live plant imports. These rules have become outdated over several decades as the number of plants imported each year has risen from a few thousand to more than 2 billion plants. APHIS announced its intent to revise them in 2004, but action has been too slow due to a combination of insufficient resources and insufficient leadership attention. For example, putting forward the first phase of a planned three phase rule-making has taken more than four years. The first phase still has not been published in the federal register, although it has been substantially complete for a year. This Committee could help highlight the problem and encourage faster action on the remaining phases of the rule revision via oversight hearings.

Ensure that Renewable Energy Standards Protect Forests from Over-cutting and Conversion

Renewable Energy Standards (RES) should not encourage the large scale destruction of forest resources. While forests can be used to provide renewable biomass for the production of energy (including biofuels), recent studies have shown that if facilities for the generation of energy from woody biomass are not scaled to available wood supplies, and these supplies are not harvested in a sustainable manner, forests in those woodsheds are at risk from overcutting to meet the demand and natural forests may be converted to plantations, often of non-native species, to meet the demand. The Nature Conservancy believes the RES regulations should be developed to avoid these outcomes.

Similarly, while wood and other plant materials from National Forests can provide energy and fuels, it is our view that federal lands should not be expressly harvested for this purpose but rather fuel should come as a by-product of forest restoration.

Provide Funding for the Careful Expansion of Public Forest Lands Including the Conservation of Large-scale Landscapes and Corridors

The Land and Water Conservation Fund and the Forest Legacy Program have been important in securing additions to federal and state forests and, in the case of the Forest Legacy Program, to buying easements over private forest lands. These programs have been greatly underfunded in relation to the demand. The Conservancy recommends that LWCF be funded at the authorized level of $900 million annually and the Forest Legacy Program increased to at least $150 million annually. We are gratified by the President's FY10 budget request of $90 million for the Forest Legacy Program; however, we are concerned that the budget request for the Forest Service's portion of LWCF has been reduced by more than $20 million from FY09 enacted.

These existing programs, however, are not sufficient to create the large and connected forested landscapes needed to sustain critical habitat and other forest values in the face of climate change. To accomplish this we are supportive of a new federal matching program designed to catalyze large landscape conservation through planning and capital funding to create landscape connections. In tandem with such a program, we propose that Farm Bill Programs give priority to these same larger landscapes.

Use a Mitigation Protocol: Avoid, Minimize, and Compensate

Our country is moving into a period of large scale investment in energy, transportation and other infrastructure. This investment has the potential to fragment and otherwise damage forests. Where wetlands, large blocks of unfragmented forest, or endangered species are involved, or on public lands, infrastructure planning should employ the mitigation protocol (avoid, minimize, compensate) to plan the location and design of infrastructure such that it avoids the most significant forest habitat and, where, impacts cannot be avoided, provides compensatory investments that most effectively offset the impacts. Here, too, State Forest Resource Assessments can be important in identifying areas best avoided as well as areas where forest restoration can be most useful.

No Net Loss of Natural Forests

Given the importance, and rapidly diminishing extent, of our native forests, the federal government should consider establishing a national policy goal to maintain and expand the existing ecological benefits of forests. A federal target could be established, to be reached in the near future, e.g. 2020, with the intent that federal forest and other policies be modified, developed and implemented to meet this goal. Attainment of this goal should not preclude periods of time where there may be a decline in stocks (e.g., natural disturbance or restoration of forest health) - the goal would be to drive policies that seek to maintain and/ or expand our forests over time.

Several Projects from Our Work in the Field Exemplify What Needs to Be Done

To illustrate our recommendations I would like to describe three projects in which the Conservancy has been involved with a particular emphasis on the role of forests in the protection of water resources.

Mollicy Farms and the Mississippi Delta

The 25 million acre floodplain of the Mississippi River north of New Orleans was once one of the great bottomland hardwood forests on Earth. 80% of the Delta, however, has now been converted to farmland. While most of this land should remain in agriculture, there are at least a million acres of very wet and flood prone soils that should be restored to bottomland hardwoods for their multiple values, including reducing the impacts of flooding, trapping nutrients, providing wildlife habitat and storing carbon.

In a prototype of such restoration, a 20,000 acre tract on the Upper Ouachita National Wildlife Refuge has been replanted in bottomland hardwoods by the U.S. Fish and Wildlife Service and through the Economic Stimulus Bill the levees separating the tract from the Ouachita River will be breached to allow the Mollicy tract to flood during times of high water. Ecosystem services such as carbon storage, flood mitigation, nutrient removal and wildlife production from these lands will be monitored over time in an attempt to better quantify ecosystem values. The Forest Service has already made investments in the Delta, and would be an excellent location for piloting coordination of a new carbon reserve initiative with an enhanced Wetland Reserve Program. LWCF and new landscape conservation funds might also be used here to expand the chain of National Wildlife Refuges along the region's rivers to better manage flood waters, reduce the flow of nutrients to the Gulf of Mexico, and provide even more wildlife habitat.

The Jemez Mountains

The Jemez Mountains in northern New Mexico are a candidate area for the newly created Forest Landscape Restoration Act. This million acres of forested, mountainous land is truly multi-jurisdictional with lands managed by Bandolier National Monument, Valles Caldera National Preserve, Santa Fe National Forest, Bureau of Land Management, Los Alamos National Laboratory, Jemez Pueblo and Santa Clara Pueblo. The forest supplies water to several cities and towns, as well as recreation for locals and New Mexico's urbanites, grazing for local communities and modest amounts of timber products. The forest sustained one of the first large scale wildfires in 2000, the Cerro Grande Fire, and across the entire region the mid-elevation forests are severely overgrown and in need of fuels treatment. In addition, the low-elevation pinon juniper woodlands suffered a massive infestation of native pine beetles during the drought period 2002-2005, killing 90% of the pinon pines across the entire landscape.

Climate change studies by The Nature Conservancy and others have recently identified the Jemez Mountains as having New Mexico's most extreme temperature increases and precipitation decreases during the recent period of global warming. Partners have been working together to plan and manage the various jurisdictions in this landscape for more than a decade. While their piece meal approach has already achieved some results, designation of this landscape to receive sustained funding for treatments under the Forest Landscape Restoration Act would allow restoration at a much larger scale, boost resiliency of the forest to climate change impacts, and sustain critical water supplies for New Mexico's largest urban areas.

The Garcia River Forest

The 23,780 acre Garcia River Forest is almost 24,000 acres of forest in Mendocino County, California and is among the first and largest forest to be recognized by the California Climate Action Registry as a verified source of carbon credits. The Conservation Fund owns and manages the property as a sustainable working forest that safeguards wildlife habitat, improves water quality and preserves the traditional economic base of the local community. In partnership, The Nature Conservancy owns the conservation easement on the property, ensuring protection, regardless of ownership, that makes verification possible. The redwoods and Douglas fir in the Garcia River Forest have the capacity to store more than 77,000 tons of carbon emissions annually, which is the equivalent of taking more than 14,000 cars off the road every year. By achieving the Registry's high standard of carbon verification, Garcia River Forest is poised to offer the most reliable and valid carbon credits in the country to private companies and public organizations seeking to offset their greenhouse gas emissions, as well as protecting water quality, fish and wildlife habitat particularly for Pacific salmon restoration while also providing forest and wood product jobs in the local economy.

Conclusion

Thank you for your interest in the future of the nation's forests. As we have outlined in this testimony, forests are critical to the American way of life and are necessary to sustain our water supplies and provide products we use daily. Forests are threatened in numerous ways, and we run the risk of losing too much forest land, and of unhealthy forests that are killed by fire, insects, or climate stress. The Nature Conservancy looks forward to working with this Committee, the entire Congress, and the Administration as opportunities emerge to enact forward-looking legislation that protects our nation's forests and the benefits they provide to people.

Mr. BACA. Thank you very much for your testimony. What we will do at this point what we will do is recess and convene after the votes are concluded. And I appreciate the panel's staying here until after we are done voting. So at this time we will recess and we will reconvene right after votes. Thank you very much.

[Recess.]

Mr. BACA. We will reconvene the Subcommittee hearing. We will start with Dr. Tom Monaghan.

STATEMENT OF TOM MONAGHAN, ON BEHALF OF THE NATIONAL ALLIANCE OF FOREST OWNERS, STARKVILLE, MISSISSIPPI

Mr. MONAGHAN. Mr. Chairman, thank you for this opportunity to appear before the Subcommittee. I am here as a private forest land owner, forester, scientist, educator, and conservationist. In 2002 I retired as extension leader of the Department of Forestry at Mississippi State University, and now am employed by the Mississippi Forestry Association. We represent forest landowners and businesses, and we are a member of the National Alliance of Forest Owners, which represents owners in 47 states. My testimony will focus primarily on private landowners, but as you know forest owners are dependent on loggers and manufacturers for markets and vice versa. We are all in a fox hole together. 427 million acres of U.S. forest land are privately owned by 10 million individuals and firms and represent much of the wealth of our country. To sustain these diverse forest and their benefits, we have to know more about those 10 million owners and their diversity.

Their objectives vary from income to recreation, from secluded home sites to long-term investments. Forest owners are people like you and me or they may be farmers, factory workers, professionals, housewives, retirees, widows, blue collar and white collar. Another private ownership group has changed recently. In the past, forest industries owned manufacturing facilities in vast forests to supply their mills with wood. Now most of their forest land has been sold to new companies like real estate investment trust or timber investment management organizations which are owned by individual investors. Some of you may be owners through your pension fund or life insurance company. These firms employ professional foresters and managers and focus on long-term sustainability and profitability. In the past 100 years, our forest land area has remained relatively stable. Unlike the rest of the world the volume of our standing timber has grown by 50 percent in the past 50 years, and this growth has occurred during a time of increased use of forest products. How could that be?

Well, it is through sound forest management by the private owners that I have mentioned. Recently, however, markets have begun to dwindle and the positive trends of the past 50 years may be in jeopardy. Markets are important to sustainability. If trees have no value what is the incentive to pay ever increasing annual taxes. A little widow on Social Security once told me, and I quote, "I can't afford to hold on to this forest land that has been in my family for 100 years. I am being taxed on what they say I should be producing, but I can't afford to do what it takes to help my timber produce." Some forest owners like that little old lady depend on their forest to yield enough income just to pay their taxes and keep their land, but collectively forest owners depend on the value of their forest for a variety of things like retirement, college fund, long-term investment, savings account, collateral for borrowing money, medical emergencies, and for some it is their primary income.

But there is one thing for which forest-related income is essential and that one thing is sustainability. The economic value of forests is the engine that drives our collective ability to sustain our forest resources. Incentives are useful, but there must be a market incentive in order for a practice such as tree planting to be a viable investment. Even if an incentive such as a cost share program reduces the initial investment a landowner still must be able to recover their part of the investment through timber sales or other markets. If not, it is a bad economic investment. Bad investments won't sustain our forests. Good investments will. If forestry is not a good investment, if trees have little or no economic value what is the incentive for a family to incur risk of natural disasters year after year?

Hurricane Katrina was one we won't soon forget. Wildfire, insects and disease, epidemics or others, but there are other threats too. One threat is that public policy can deny owners the opportunity to realize reasonable returns on their investments. Without returns, the land may be converted to other uses that do not provide the benefits of the forest. You will soon consider legislation to tackle renewable energy. Private forests should be able to play a vital role and take advantage of these markets. The national climate policy should allow owners to use carbon credits as a source of revenue. State forestry regulations already protect the environment and ensure sustainability.

We don't need additional regulations that could cause landowners to take their land out of forest use just out of sheer frustration. Tax policies are also important. They should not create disincentives. Believe or not, overpayment of taxes is not uncommon by forest owners. A lack of knowledge is another problem. The extension programs at land grant universities, for example, their mission is to interpret research and design targeted education programs for forest owners, but these programs are woefully underfunded, yet they represent the best opportunity to translate public policy from paper to action. Keeping working forests is the key to sustainability. The private landowners have shown that they can do this, and they will continue to do so if they have a sustainable business environment, viable markets, targeted incentives, freedom from over regulation, and access to new technology and information. Let us work together to design policies that help landowners keep their forest working. Thank you.

[The prepared statement of Mr. Monaghan follows:]

PREPARED STATEMENT OF DR. TOM MONAGHAN ON BEHALF OF THE NATIONAL ALLIANCE OF FOREST OWNERS, STARKVILLE, MISSISSIPPI

I. Introduction

Mr. Chairman, thank you for this opportunity to appear before the Subcommittee on Department Operations, Oversight, Nutrition and Forestry today and to assist you and your colleagues, also of this Subcommittee, in your efforts to chart the future of our nation's forests.

I am pleased to appear before you today as a private forest landowner, a forester and a lifelong steward of our natural resources. In 2002, I retired as the Forestry Extension Leader from the Mississippi State University Extension Service. In that role, I led our state's extension foresters in delivering a variety of educational outreach programs to private landowners and forestry personnel, all designed to promote stewardship and sustainable forest management practices on the land. The day after retiring, I began a second career with the Mississippi Forestry Association (MFA), a statewide membership organization representing private landowners, professional foresters, professional wood suppliers, forest industry manufacturers and businesses and federal and state agency personnel who manage forests to produce clean water, clean air, wildlife habitat and outdoor recreational opportunities for all Mississippians.

The Mississippi Forestry Association is a member of the National Alliance of Forest Owners (NAFO), an alliance that represents forest owners in 47 states, encompassing more than 74 million acres. NAFO is an organization of private forest owners committed to promoting federal policies that protect the economic and environmental values of privately-owned forests at the national level.

My testimony today will focus on the present and future contributions of private forestland in the United States. I will examine the importance of forests to our national natural resources infrastructure; how forests can meet important national objectives, such as clean air, water, energy, climate change mitigation and the demand for forest products in our everyday lives; and the importance of federal policies that support the ongoing efforts of private forest landowners to invest in and be good stewards of their land.

While I will focus on private forest landowners, please keep in mind that all members of the forest products community, including forest owners, resource professionals, loggers and manufacturers play key roles in sound forest management.

II. Private forest owners manage the majority of forestland in the U.S. Forest inventory is generally increasing and ownership patterns are dynamic. Private forest landowners generally seek to keep working forests in tact rather than convert them to other uses.

Nationally, there are 755 million acres of forestland. Of that, 427 million acres, 2.5 times the size of Texas, is private forestland owned by over 10 million people. Unlike much of the rest of the world, the U.S. is expanding its overall forests and standing timber inventory. Over the past 100 years the amount of forestland has remained relatively stable. Additionally, the standing inventory (volume of growing stock) of hardwood and softwood tree species in U.S. forests has grown by 49 percent between 1953 and 2006. This has occurred because of sound forest management and through the increased importance of forests and forest products in our economy and society in general. Recently, however, markets have begun to dwindle, potentially jeopardizing the positive trends of the past 50 years.

Americans own forests in a variety of ways, including family ownership, partnerships, small and large businesses, private investments, such as Timber Investment Management Organizations (TIMOs) and publicly traded investments such as Real Estate Investment Trusts (REITs). The vast majority of forestland owners are families. For them, forests represent a significant family investment as well as a considerable share of their wealth. In Mississippi, the 175,000 individual and family forest landowners who own and manage 10 acres or more of the state's timberland, have long looked to an investment in land and timber as a very significant means of support for their retirement, for college funds, for savings accounts, for medical emergencies or simply as "rainy day" reserves. Others have used the value of their lands and forests as collateral when borrowing money to build homes or pay for college educations.

Of course, much of the value of these family forests comes in benefits without a specific price tag, including family recreation, hunting trips, solitude and aesthetics. To many of these families, their forests represent more passion than profit.

Other private forest landowners include small and large businesses, partnerships and investment organizations such as TIMOs and REITs. These owners have taken on new significance over the last few years. Most Americans still see the forest products industry as a vertically integrated industry that owns forests for specific manufacturing purposes. However, over the past two decades, most of the forests owned by large manufacturing companies have been transferred to businesses that focus solely on responsible long-term forest management with little or no manufacturing interests. Today over 80 percent of the forests formerly owned by large manufacturers is now owned by companies and organizations comprised of professional foresters and land managers who responsibly manage their forests for multiple market opportunities over the long-term. Apart from the inevitable changes in land use that accompany a growing population, the long-term value of these private forest lands comes primarily from keeping them in a working forest condition.

Throughout my testimony today, you will hear me use the term ″working forest.″ A working forest is one that is conserved, not preserved. President Teddy Roosevelt said, ″Conservation means development as much as it does protection.″ He charged our nation with using our natural resources to provide sustained environmental, economic and social benefits over time. Working forests, then, are forests that provide an important base for family-supporting jobs in America's rural communities, that are the source of sustainable building and consumer products, contribute significantly to national priorities, like energy independence and security and climate change solutions and that address human health and quality of life needs, water quantity and quality, essential wildlife habitats, recreation and other important environmental services.

III. Private working forests are an increasingly critical part of our natural resource infrastructure because they are fundamental to a strong economy, a clean and healthy environment and achieving our national objectives for addressing climate change and developing new domestic sources of low-carbon, renewable energy.

Nationally, private landowners own the majority of our forests. This is particularly true in the Southern states where private landowners are the principal stewards of forests and wildlife. In fact, 44 percent of the private forests in the United States are in the South. In contrast, the federal government owns the vast majority of the forests in Western states.

Private forests provide significant economic benefits to society, providing the raw material for a major industry in our country. The forest products industry ranks in the top ten manufacturing sectors in 48 states. It accounts for approximately 6 percent of the total U.S. manufacturing GDP, placing it on par with the automotive and plastics industries. Additionally, it generates more than $200 billion a year in sales and employs more than 1 million people earning $54 billion in annual payroll. Through all of this, the U.S. forest products industry pays approximately $7 billion annually in federal, state and local taxes. The U.S. forest products industry is a world leader in natural resources stewardship by providing valuable consumer goods and services while maintaining the highest standards of environmental stewardship in the world.

In addition to economic benefits, private forests produce a wide variety of environmental services desired and needed by our society, including outdoor recreational opportunities, diverse wildlife habitat, the storage of atmospheric carbon and the production of clean air and clean water. For instance, nationally, private forests provide 53 percent of our freshwater supply. Outside of the Western region of the U.S., state and privately owned forests provide 89 percent of the freshwater supply.

Nationally, forests sequester almost 200 million metric tons of carbon each year, offsetting 10 percent of annual U.S. emissions from burning fossil fuels. This fact has been recognized by the international community and federal regulators. The United Nations' 2007 Intergovernmental Panel on Climate Change (″IPCC″) highlights forest management as a primary tool to reduce GHG emissions. The IPCC states that, ″In the long-term, a sustainable forest management strategy aimed at maintaining or increasing forest stocks, while producing an annual sustained yield of timber, fiber or energy from the forest, will generate the greatest mitigation benefit.″ The EPA has identified responsibly managed forests as one of five key ″groups of strategies that could substantially reduce emissions between now and 2030.″

No other land use comes close to producing the array of environmental, economic and social benefits provided by our nation's private forestlands. They are a vital part of our national infrastructure that shouldn't be lost. Sustaining and enhancing the value of these forests both to society and to forest owners so they can continue to benefit our nation is of vital national importance.

IV. The potential use of wood for renewable energy and to address climate change provides an opportunity to strengthen existing markets and encourage the development of new markets for private working forests.

Congress is currently focused on renewable energy policy that will diminish our nation's dependence on fossil fuels and enhance our country's energy independence. Developing the full contribution our private working forests can make to this national priority will at once help us meet our renewable energy goals and maintain our working forest resources. As existing markets decline, emerging energy markets can provide new opportunities for private forest owners to realize sufficient economic return to continue making long-term investments in their forests.

Wood is the original renewable energy and has been used at the industrial level for decades. Currently, the forest products industry generates approximately 80 percent of all renewable biomass energy, making it the largest industrial renewable energy producer. The current technology for using wood to produce electricity and heat is mature and readily accessible. Emerging technology also holds significant promise for utilizing wood cellulose to produce ethanol. Each of these applications provides a viable future source of domestic renewable energy from a wood resource that is efficient, plentiful, sustainable and beneficial to our climate and overall environment.

If Congress mandates a certain level of renewable electricity generation, it should provide sufficient flexibility to allow renewable forest biomass to make its full contribution. This will help keep our working forests working by promoting new market opportunities for wood that otherwise may have little or no economic value.

Congressional interest in renewable energy is in many ways driven by climate change considerations because of the potential to replace carbon intensive fossil fuel energy with renewable energy that significantly reduces our nation's overall carbon footprint. Private working forests are a fundamental part of the solution to global climate change. Both the United States Government and the international community recognize the value forests provide in sequestering carbon through absorbing CO_2 and storing carbon in trees, soils and forest products.

Our nation will realize these benefits by developing and promoting markets, like renewable energy, that help private forest owners continue managing their forests for long-term economic and environmental benefits .

Just as with renewable energy, as national climate change policy and legislation is considered by Congress, it should explicitly include the positive contributions of private working forests. Such policy should help maintain a robust manufacturing base for working forests to help maintain existing markets that foster long-term forest viability and investment. Any climate change framework should also allow offset credits from forest management and harvested wood products to be generated and traded as a flexible, cost effective way for regulators and other industries to achieve net greenhouse gas reductions.

Renewable forest biomass energy production on a much larger scale and the opportunity to participate in climate change mitigation markets offer two promising new markets for forest landowners. As history has taught us, maintaining existing markets and expanding new market opportunities for working forests help ensure they will remain and even increase over time.

V. New and existing markets should rely on local and state level oversight, third-party certification, and education programs as the most effective means to sustain working forests on the landscape over the long-term.

Sustaining the environmental, social and economic benefits of responsibly managed forests will occur only if governmental policies are aligned with the fundamental economics of forest ownership. Governmental policies must be scientifically based and developed through transparent and inclusive processes. They should recognize the important role played by a healthy, domestic forest products manufacturing base, which enables forest owners to continue to meet their ecological, economic and social responsibilities.

Private forest landowners are diverse and demonstrate sustainable forest management in a variety of ways. These include reforestation of harvested sites to maintain the forest cycle, using Best Management Practices (BMPs) defined through voluntary and regulatory state forestry programs and forest certification standards, supporting training and outreach programs for loggers and family forest owners, using consulting foresters and other natural resource professionals and supporting research and technology development on sustainable forest management.

Additionally, private forest landowners verify their adherence to sustainable forest management principles in many ways, including: compliance with state and federal laws and BMPs; cooperative agreements with government agencies, conservation organizations, and multi-stakeholder partnerships; and transparent data collection and reporting. Forest certification is an especially important method. Credible forest certification systems are designed to integrate social, environmental and economic performance, verified through independent, third-party auditing and communicated through a brand or label on products. Several credible forest certification programs are available in the marketplace.

This robust yet flexible array of tools, in the form of federal, state and local laws, regulations, programs and BMPs have measurably improved the environmental performance of forest operations in the United States over time. They have also worked to promote environmental goals without sacrificing jobs and economic activity. As policymakers consider the imposition of new federal regulations on private working forests or market limitations on the participation of private working forests in emerging renewable energy markets, the implications for the economic viability of working forests must be considered to avoid inviting an unintended result -- compelling private forest owners to consider alternative land uses for working forests that do not provide the environmental services that promote healthy watersheds, wildlife habitat, carbon sequestration and similar benefits that are highly valued by society.

Rather than creating new federal regulatory overlays on effective existing practices at the federal, state and local level, Congress would be well advised to rely on the current framework that has been developed through transparent public processes over decades to strike the right balance between social, economic and environmental benefits. New federal intrusions into the existing framework, particularly in a manner that results in federal pre-emption of current state and local practices, may create powerful market disincentives that will hinder rather than promote our nation's overall energy and environmental objectives.

VI. Conclusion

Keeping working forests working across the landscape as a fundamental part of our nation's natural resources infrastructure is essential to the well-being of our country. Private forest landowners provide unique economic, social and environmental benefits to our nation. While many of these benefits provide direct economic returns to society and to the landowners - the forest products we use every day and the jobs that sustain many communities - many are essential benefits to society that the private landowner provides for free - clean air, clean water and wildlife habitat.

The most effective way to keep working forests working is to promote policies that seek to sustain both the benefits working forests provide to society and to forest owners. This includes viable markets for existing and familiar products and services as well as innovative new markets for wood and the environmental benefits provided by sound forest management.

While oversight is important, it should be based at the state and local level - where environmental stewardship is best understood and practiced. This is the approach that has increased the productivity and extent of our forests in the United States at a time when many parts of the world have seen massive deforestation. By supporting practices that work while seeking new and promising market opportunities, our working forests can continue to provide the many benefits that have made them an extraordinarily valuable part of our nation's past, present and future.

For more information, please contact:
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Mr. BACA. Thank you very much, Mr. Monaghan. At this time, we would also like to welcome to the Subcommittee hearing our past Chair of the Agriculture Committee, Mr. Goodlatte. Thank you very much for being with us. Would you like to make a statement, and then I will just quickly turn it over to——

Mr. GOODLATTE. Yes. Mr. Chairman, I really appreciate you holding this hearing. I wish I were a member of this Subcommittee, and I really thank you for allowing me to sit up here on the dais and after the others have asked questions, if I am given the opportunity, I may have a question or two.

Mr. BACA. Thank you very much.

Mr. GOODLATTE. Thank you, Mr. Chairman.

Mr. BACA. Next, we will call on Mr. Neiman.

STATEMENT OF JIM D. NEIMAN, VICE PRESIDENT AND CEO, NEIMAN ENTERPRISES, INC., HULETT, WYOMING

Mr. NEIMAN. I am extremely humbled and honored, Mr. Chairman. Thank you for the opportunity to testify today. My name is Jim Neiman, and I am the Vice President and CEO of Neiman Enterprises in Hulett, Wyoming. Hulett is in the Northeast corner of Wyoming 8 miles from Devils Tower National Monument, our nation's first monument. The Neiman family has been in the forest products business for three generations. We currently own three sawmills and one pellet operation with 490 employees and 250 independent contractors that we feel are families we need to support. I appreciate your attention to the future of the nation's forests. My comments are focused primarily on the nation's forests, especially the Black Hills National Forest. A health forest products industry is critical to the future of our national forest, and they make it possible for our company to operate on and contribute to management objectives also on private lands.

The single most important factor in existing sawmill infrastructure in the intermountain west is supply raw material from national forests. A year ago there were three sawmills in Wyoming. Now only one remains, and this ours. The biggest reason the other two sawmills closed was historic and unpredictable national forest timber supply. Without a consistent supply of timber, no mill owner can justify the investment to maintain competitiveness in the competitive industry. My company is seriously exploring a partnership to construct and operate a $50 million 19 megawatt electrical co-generation facility in our South Dakota operation that would also produce steam for dry kilns in the adjacent university.

The benefits of this facility would be increased supply of renewable energy, better utilization of forest biomass, and additional local jobs, up to 40. I need two things to make this work. First, a consistent and predictable supply of timber sales from the Black Hills National Forest. The sawmill side of our business has to be financially sound in order for us to make co-generation work. Second, we need a conclusive definition of biomass in the RES. The RFS definition excluded an area all Federal fiber from counting toward renewable biofuels. Unfortunately, H.R. 2454 just approved by the 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. My recommendation to Congress is that all biomass for a national forest timber sale that conforms to applicable law and the forest plan should qualify under the RES. The Forest Service's mission is to sustain the health, diversity, and productivity of the nation's forest and grasslands to meet the needs of present and future generations.

When I look at national forest statistics of acres burned and acres of trees killed by beetle epidemics, I am not sure the Forest Service is achieving that mission. Most of the current timber sales in the Black Hills National Forest respond to the pine beetle epidemic. Instead of always responding to crisis, the national forests should develop and implement proactive strategies to prevent those crises in the first place. In the Black Hills and much of the west, we know what it takes to reduce the risk of mountain pine beetle and fires. Simply put, the problem is primarily a function of tree density. Dense stands have a higher risk of bugs and fires and thin stands have a much lower risk. Annual growth on the national forest timberlands far exceeds the annual harvest. Increasing the national forest timber sale program would have multiple benefits including stabilizing forest products companies, adding green jobs to our local economies, strengthening our nation's manufacturing sector, increasing the health of our forests, and increasing flow of clean water.

Sawmilling has been a challenge, but this recession is worse than anything my father can remember since the Great Depression. We are doing everything we can to maintain our operations, keep our employees and contractors, and help manage the forests. We are not asking for a bail out, but there are contractual steps the Forest Service can take that would make a big difference in maintaining the current infrastructure of forest products companies. However, timing and speed is essential. I want to thank Mr. Jensen for his kind words that he spoke earlier to the industry, and in conclusion thank you for allowing me to testify, I appreciate your time and attention. I offer my full assistance to the Subcommittee and to you, Mr. Chairman, to Congresswoman Herseth Sandlin, and especially to Congresswoman Lummis for the invitation. Thank you very much.

[The prepared statement of Mr. Neiman follows:]

PREPARED STATEMENT OF MR. JIM D. NEIMAN, VICE PRESIDENT AND CEO, NEIMAN ENTERPRISES, INC., HULETT, WYOMING

Introduction

Thank you Chairman Baca, Members of the Subcommittee, and Rep. Lummis, for the opportunity to present testimony today.

My name is Jim Neiman, and I am the Vice President and CEO of Neiman Enterprises, Inc. in Hulett, Wyoming. Our family has been in the ranching business for 5 generations and in the forest products business for 3 generations. We currently own and operate three sawmills and one pellet mill in the Black Hills of South Dakota and Wyoming. Our company directly supports about 750 families through our 490 employees and 250 local independent contractors, and those families live in communities throughout the Black Hills. We produce lumber for wholesale and retail markets throughout the United States, plus shop grade lumber for window and door companies. We also sell sawmill by-products, such as bark, sawdust, shavings, and chips for decorative bark, particleboard, pulp and paper, animal bedding, and wood pellets.

I am currently the Vice-President of the Board of Trustees for the University of Wyoming. I also serve on the Board for the Hulett National Bank, Hulett Airport Board, Black Hills Forest Resource Association and Intermountain Forest Association, and am a member of the Federal Timber Purchasers Committee, which is allied with the American Forest and Paper Association. I have also served in the past on the Wyoming Occupational Health and Safety Commission, and the Wyoming Economic Development and Stabilization Board.

Background

I appreciate the Subcommittee's attention to the future of our nation's forests, and I hope my testimony will be helpful to you. My comments are primarily about the future of our nation's national forests. I'm most familiar with the Black Hills National Forest, which straddles the Wyoming - South Dakota border, since our company relies on the Black Hills NF for approximately 75% of our supply of timber. Similarly, many other sawmill owners across the country also depend on local national forests for an important percentage of their timber supply and share my concerns and anxieties about long-term management and health of the national forests.

Case No. 1, the very first timber sale from the national forests, which was sold to Homestake Mining Company in 1899, was located in the Black Hills NF. Since then, the management of the Black Hills NF has been generally very successful. However, the last ten years have been challenging, to say the least. In 1999, Forest

Service Chief Dombeck remanded the 1977 forest plan revision, a traumatic event that resulted in no new timber sales for most of FYs 2000 and 2001, and required two forest plan amendments and five years to fix the problems identified in the Chief's decision. In total, the Black Hills NF spent 16 years completing a 10 to 15 year forest plan. Since 2000, forest fires have burned 184,000 acres of the Black Hills NF, and a mountain pine beetle epidemic has festered out of control, affecting 200,000 acres to date, and still killing over 100,000 new trees each year.

Many other national forests have experienced similar, or worse, catastrophic forest fires and insect epidemics. A catastrophic mountain pine beetle epidemic has killed 2 million acres of lodgepole pine trees in Northern Colorado and southern Wyoming. These catastrophes have caused great harm to forest ecosystems, and therefore, cause great hardships to family-owned small businesses like mine.

Both the acreage of forest fires and the number of trees killed by mountain pine beetle are a function of numerous variables. However, the most significant variable, and the one over which we have the most control, is the underlying condition of the forest. Simply put, the problem is there are too many trees competing for a limited amount of water. Reducing the risks of mountain pine beetle in ponderosa pine isn't rocket science. Dr. John Schmid, arguably the world's leading researcher on mountain pine beetle has maintained a series of plots in the Black Hills for years. His bottom-line finding is that the duration and intensity of mountain pine beetle infestations are primarily a function of the number of trees in the stand -- the more trees, the higher the risk of mountain pine beetles. Conversely, thinned stands have a significantly lower risk of mountain pine beetles.

Maintaining a Viable Forest Products Industry as a Management ToolA healthy forest products industry is critical to achieving long-term forest health objectives on the Black Hills NF, or any national forest. Further, the timber supply from the national forest makes it possible for our company to exist to manage timberlands for private landowners. We have a diverse, integrated forest products industry in the Black Hills. However, the forest products companies depend on the Black Hills NF selling the forest plan Allowable Sales Quantity (ASQ). Unfortunately, the Forest Service has fallen far behind achieving the Black Hills NF forest plan ASQ, with detrimental effects to both the Forest and the forest products companies.

The single most important factor for the viability of existing industry infrastructure is supply of raw material from national forests. Our company relies on the Black Hills National Forest for approximately 75% percent of our sawtimber supply. Without a consistent supply, I cannot justify the investments necessary to keep these facilities on the cutting edge of technology, and expanding my operation into new product utilization avenues to better accommodate forest health programs, including small-diameter trees, becomes completely out of reach.

We need the Forest Service to make up a significant portion of that accumulated ASQ shortfall. The annual growth on the Black Hills National Forest, and virtually every other national forest, is significantly higher than the annual harvest (see Attachment 1). 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.

This year, the forest products industry is facing the most challenging period since the Great Depression. Last month, the Western Wood Products Association (WWPA) predicted 2009 lumber demand of just 28.9 billion board feet, down from an all-time high of 64.3 billion board feet in 2005. Home construction and remodeling account for nearly 70% of U.S. lumber consumption. The WWPA forecast was for just 432,000 new home starts in 2009, one-fifth of the 2005 level.

Nationally the forest products industry employs more than one million people directly and ranks among the top ten manufacturing employers in 48 states. Lumber, panel, and pulp and paper mills are frequently the economic hubs of their communities, making the industry's health critical to the economic vitality of countless communities in every region of the country. Frequently, forest products companies provide some of the best, if not the only, full time, year round jobs in rural areas where unemployment often exceeds the national average. The overall effect has been to rob the wood and paper industry of economic value, threatening the viability of a key manufacturing sector while potentially threatening the long-term health of our forests. With the near total collapse of the nation's housing market, our industry has suffered a disproportionate blow in the recent economic crisis. Unemployment in the forest products sector is now estimated at 250,000 to 300,000 jobs, or roughly 20% of our workforce. Even in this reduced condition, the 1.08 million people in various segments of the wood and paper industry represent a larger share of U.S. employment than the automobile industry (828,500 as of November, 2008).

The national forests can help sustain the industry through the downturn by being a reliable supplier of fiber, both for areas dominated by national forest timber and places where private landowners are reluctant to sell into fallen log markets. Losing infrastructure will harm all landowners and make the task of managing the national forests more difficult. I struggle constantly to find some measure of certainty and stability in the Forest Service's long-term management programs. Similarly, each year the Forest Service faces the challenge of planning their programs without certainty about the funding levels they will receive from Congress. In essence, we're trying to manage national forests for fifty to one hundred year rotations based on one-year appropriations, two-year Congressional cycles, and four-year Presidential cycles.

Forest Planning

Incorporating long-term forest health strategies into forest plans is essential. There is no excuse for not incorporating long-term forest health strategies into every forest plan, yet many forest plans have been approved with scant attention to long-term desired conditions that will minimize the risks of fires and insect epidemics, especially when the planning was done during periods of above-average precipitation and below-average mountain pine beetle and fire activity. Over the past decade, the States of Wyoming and South Dakota, along with local counties, have prioritized their involvement in forest planning as Cooperating Agencies, and that has been a very positive development.

Even the best forest plan has little real value if the necessary resources are not available for plan implementation. Adequate funding is a perennial issue. Compared to the costs of fire suppression, rehabilitation and restoration, preventative management is a bargain. I did a cursory analysis of the costs and revenues associated with a recent timber sale on the Black Hills NF that was designed specifically to reduce the risk of forest fires west of Rapid City. The net project cost, including NEPA and sale preparation expenses minus timber sale revenues, was $260 per acre. Compared to the $901 cost per acre for suppression and rehabilitation for the 2005 Ricco Fire, that investment of $260 per acre looks pretty smart.

Project Implementation

On average, NEPA compliance represents about 50% of the Forest Service's cost of analyzing, preparing and selling a timber sale. The Forest Service's appeals process is still a cumbersome, time consuming and expensive means of resolving issues. If a decision is appealed and remanded, there is no process for the responsible Line Officer to quickly address and repair the flaws; instead, the process requires a new round of analysis, public review and comment, and another appeal period before the modified project can be implemented. This simply cannot happen in less than 6 months.

I am also concerned about the lack of a process that allows prompt salvage of dead trees following a fire or insect epidemic. Prompt salvage of dead trees is the common-sense response that most private landowners would make to utilize the dead trees and start the process of restoration. Salvage of fire-killed trees will also reduce the risk of a re-burn 10 or 20 years into the future, when dead trees have fallen to the ground and become additional fuel. However, salvage of fire-killed trees following a forest fire on the national forests is no longer a routine ″next step″. In contrast, all of the Forest Service's actions to suppress a fire and implement emergency rehabilitation are designed to move quickly. One suggestion is to allow the Forest Service to consider salvage of fire-killed trees as part of the total response of fire suppression, rehabilitation, and restoration.

The Healthy Forests Restoration Act (HFRA) is working well, although I am concerned that in some instances either the Forest Service is too cautious about using HFRA. The single most helpful feature of the HFRA is the Administrative Review process, which levels the playing field for the Forest Service, and significantly increases the incentives for parties to be a constructive part of the analysis and design process. I would like to see the HFRA Administrative Review process adapted for all projects.

Definition of Biomass

My company is seriously exploring a partnership to construct and operate a $50 million, 19 MW electrical co-generation facility adjacent to our sawmill in Spearfish, SD. The benefits of this facility include:

A. Increasing our nation's supply of renewable energy, thus decreasing our dependency on foreign oil.

B. Utilization of slash from timber sales on the Black Hills NF and private timberlands. About 5,000 large slash piles are created each year, and most of those are burned during the winter months. That generates huge volumes of smoke and carbon, and frankly, wastes a resource.

C. 40 to 50 additional jobs for families in our local community.

I am very concerned about 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. 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 would exclude nearly all trees we harvest in the Black Hills.

Similarly, jack pine and aspen forests in the Lake states, mixed oak stands in the Appalachians, and loblolly stands in the Southeastern US are all generally considered mature when harvested. This provision would be devastating and would have the effect of prohibiting most, if not all, Forest Service fiber 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.

My recommendation to the Congress is that slash and other biomass from a national forest timber sale, which conforms to applicable laws, including NFMA and NEPA, and the forest plan, should qualify under the RES.

Biomass Crop Assistance Program

Title IX of the 2008 Farm Bill established the Biomass Crop Assistance Program to support the establishment and production of crops for conversion to bio-energy and to assist with collection, harvest, storage, and transportation of eligible material, including woody biomass, for use in a biomass conversion facility. This program should help support forest products industries that also produce renewable energy, and these industries should qualify for the harvest and transportation assistance support provided by this program. Currently, USDA is still in the early phases of conducting a NEPA analysis on this program. I encourage the Administration to act quickly to complete the regulations and implement this program.

HFRA Biomass Commercial Utilization Grant Program

Similarly, Section 203 of the Healthy Forests Restoration Act authorized $5 million dollars annually for grants to offset the costs incurred to purchase biomass. That grant program would also be very helpful to my company, and other companies, in expanding utilization of woody biomass, and I urge the Congress to re-authorize and fund that grant program.

Housing

The mortgage crisis and subsequent housing market crash helped create the current economic crash. Historically, rebounds in the housing economic rebounds have led our nation out of recessions and economic downturns. The $8,000 Home Buyer Tax Credit authorized by the American Recovery and Reinvestment Act of 2009 is helpful and important, but I would like to see the federal government do more to help. HR 1119, introduced by Rep Lincoln Davis, would expand homebuyer tax credit to all buyers, not just first time homebuyers, and expands it from $8,000 to 3.5% of the limitation determined under the Federal Home Loan Mortgage Corporation Act. As first time buyers are only about half of the housing market, the credit should be expanded to all purchases of primary residences.

National Forest Advisory Board

In January 2003, the Secretary of Agriculture approved the formation of a National Forest Advisory Board for the Black Hills NF. Fifteen members were subsequently appointed to the Board based on familiarity with national forest issues, ability to represent a particular interest group, and demonstrated skill in working toward mutually beneficial solutions.

The formation of the advisory board was one of the recommendations of an August 2001 Forest Summit, convened by then-Senator Tom Daschle in Rapid City. Since then, the National Forest Advisory Board has become an integral part of the management of the Black Hills NF. The Board's primary duty is to ″provide advice and recommendations on a broad range of forest issues such as forest plan revisions or amendments, travel management, forest monitoring and evaluation, and site-specific projects having forestwide implications.

This Advisory Board has made great contributions to management of the Black Hills NF through public airing and constructive discussion of contentious issues by a group representing diverse interests. I believe it could serve as a model for other national forests.

Reforestation

Finally, I'm concerned about the reforestation backlog on the national forests. In April 2005, the GAO reported that national forest reforestation needs are accumulating because of the increased acreage affected by natural disturbances, i.e., forest fires and insect epidemics. The Congress should require the Forest Service to identify reforestation needs, and then develop a strategy to accomplish that reforestation. Reforestation would yield multiple benefits, including water quality, wildlife habitat, and carbon capture and sequestration.

Conclusion

In summary, I want to thank you for the privilege of testifying here today. Management of the national forests is complex and sometimes contentious, and requires capable leadership. My company is committed to sustainable forest management, jobs, families and communities. As I said earlier, I'm the 3rd generation entrusted with running our business, and I started grooming the 4th generation years ago. Of all the variables I deal with, the one that keeps me awake most at nights is the long-term reliability of a national forest timber sale program. Again, I am honored that you asked me to testify today, and I would be delighted to work with Chairman Baca, Representative Lummis, and the Subcommittee in finding solutions to the many issues discussed here today.

Mr. BACA. Thank you very much, Mr. Neiman. Next, I have Mr. Smith.

STATEMENT OF MATT SMITH, ON BEHALF OF THE SOCIETY OF AMERICAN FORESTERS, FALCONER, NEW YORK

Mr. SMITH. Yes. Thank you. Chairman Baca and Members of the Committee, thank you for the opportunity to testify to you today about something that I am more than a little passionate about. That is our nation's forests. On behalf of the Society of American Foresters, I would also like to take the opportunity to thank you for your tireless work to improve the renewable fuel standard passed in the 2007 Energy Bill. My name is Matt Smith, and for the last 20 plus years, I have been a private forestry consultant in western New York and the Allegheny region of Northwest Pennsylvania. I have also spent the last 4 or 5 years working almost exclusively in the area of forest carbon and the voluntary carbon markets.

It is an interesting point that when I received the call to be here today, which was about 6 days ago, I was in the woods working with a private landowner on a timber harvest, and it is an important point that I will come back to here at the end of my testimony. Forests are inseparably linked to American society and culture. We have heard a lot today about all that forests give us. They give us wood products, jobs, food, fuel, clean air, carbon uptake and storage, recreational opportunities, clean water, and a host of other benefits. The story of America's forest contains many success stories, but it is not all that we hear about. We hear much about the challenges, and we have heard a lot about all of these challenges today.

Catastrophic wildfires, invasive species, changes in land use, and climate change are challenges you may be quite familiar with. Although there are other challenges, the global economic crisis, the housing crisis, and foreign competition, as you have heard, are eroding our traditional wood product markets. The good news is new markets are evolving. However, we are running into regulatory and policy obstacles. We have a renewable fuel standard that needlessly restricts most woody biomass, a cap and trade bill that doesn't recognize domestic forests, and an energy bill with a renewable energy standard that also restricts biomass, woody biomass. All of these provisions we are told are in place to protect forests when in fact if implemented they will harm them in the long run.

In response to the growing concern about anthropogenic climate change and the diverse opinions that have existed and continue to exist on the issue, the Society of American Foresters assembled a team of professionals from across the country under the climate change task force, a group which I was proud to participate in. I think each of you have been provided with a copy of our full report. If not, you will very soon. I would like to just summarize some of the key points that we learn by reviewing the body of available research on forests and climate. Forests and climate are inseparably linked. Dramatic changes to one will inevitably affect the other. Global warming is probable and forest management can mitigate its effects. Also, wood products from sustainably managed forests are not only renewable products, they are products that when used in place of fossil fuel intensive materials such as concrete and steel drastically reduce our countrywide greenhouse gas footprint.

Biomass is a key renewable energy source for the future producing clean energy while increasing the ancillary benefits from forests. Wildland fires and land use change represent significant emissions of greenhouse gases globally, emissions that can be mitigated through sound sustainable management. And, lastly, forests sequester significant amounts of atmospheric carbon, amounts that can increase with delivered management activities. Our current administration stands at a unique opportunity in time. They stand poised to initiate clean energy and climate change programs that will define environmental policies on greenhouse gases for future generations. This opportunity will either embrace forests and its positive impact on the climate change issue or it will leave it behind. Much of what we will have to deal with in this new market opportunity for forests for the future will be determined today in today's policy debate.

We would like to leave the Committee with several action items to think about as you consider the testimonies given today. Regarding the American Clean Energy and Security Act, we would like to encourage the Committee to consider ensuring the role today for forest offsets in cap and trade. Also, ensuring that early actors in today's voluntary markets receive recognition in future Federal programs. Next, to ensure that investments and offsets in clean technology continue by guaranteeing a smooth transition from the voluntary market to the mandatory market. Next, to ensure the future for woody biomass by redefining woody biomass in current regulations. Next, to restore forest health on Federal and public lands. Public lands are destined on a trajectory to become possibly sources of CO2 through fires and decay versus the sinks that they could be. And, lastly, to encourage new and existing markets.

And I just want to make a quick statement on that harvest I was on when I received the call to be here today. That forest was a thinning. Low grade products were removed from that forest to improve forest health. They were low value products in any market. But it was able to yield $14,000 to that landowner 1-1/2 years ago when I sold that timber. Today, if faced with the same management challenge that forest, that treatment, would not be applicable in a commercial setting. There is no market for the material we removed from that forest, a real impact and a real measure of what is happening with the erosion of our traditional forestry markets today.

This is a very important issue for the SAF as well, having now approved the task force on understanding and improving global competitiveness in the U.S. forest sector, and the Society of American Foresters will keep you abreast of the findings. I would like to thank the Committee and the SAF for allowing me to share this information with you on its nation's forests. It has been my extreme pleasure to be here with you today, and I look forward to your questions and comments. Thank you.

[The prepared statement of Mr. Smith appears follows:]

PREPARED STATEMENT OF MATTHEW S. SMITH, CF, ACF, ON BEHALF OF THE SOCIETY OF AMERICAN FORESTERS (SAF)

Chairman Peterson, Chairman Holden, and Members of the Committee, thank you for the opportunity to testify on the important topic of our nation's forests. On behalf of the Society of American Foresters, I would also like to thank you for your tireless work to improve the Renewable Fuels Standard (RFS) passed in the 2007 Energy Bill.

My name is Matthew Smith, I am a Private Consulting Forester, SAF certified forester, Member of the Association of Consulting Foresters, Adjunct Professor of Forestry at SUNY Environmental Science and Forestry in Syracuse, NY, Sustainable Forestry Auditor, Member of the Chicago Climate Exchange Forestry Committee, and Director of Ecosystem Services at FORECON Inc. I am here today representing the Society of American Foresters for which I serve as Western New York Chairman, and member of the SAF Climate Change Task Force.

The Society of American Foresters (SAF) is the national scientific and educational organization representing the forestry profession in the United States. Founded in 1900 by Gifford Pinchot, the first Chief of the Forest Service, SAF was chartered to advance the science, education, technology, and practice of forestry for the benefit of society. Today SAF publishes several scientific peer-reviewed journals, certifies foresters and accredits forestry schools among other things. With over 14,000 members SAF is largest professional forestry society in the world. SAF members include natural resource professionals in public and private settings, researchers, CEOs, administrators, educators, and students.

Our Forests

The United States is blessed with abundant forest resources. In fact the US holds approximately eight percent of the world's forests, placing it among the top 4 countries in the world. The US forest base is estimated at some 755 million acres, and has been stable at this level for about the last 100 years. The US forests are dominated by private non industrial landowners, which combined own roughly 57% of the forests in the country. This forest base is however, dynamic, with about one million acres of forest lost to other land uses annually. Fortunately, these losses are typically offset by new forest establishment, such as abandoned agricultural land, in other regions.

While America's forests are fairly stable in area, they grow in volume, with growth exceeding removals over the past 50 years. Advances in forest management techniques along with natural factors have resulted in increased production from our forest base. In spite of this increased production of wood volume, US demand for forest products still exceeds annual production by 4.2 million cubic feet. As a result, the US imports approximately 36% of its wood products annually. The import of wood products to American shores raises key environmental concerns as much of this supply can come from regions without the environmental and sustainable qualities of wood that is grown domestically.

Forests are inseparably linked to American society and culture. Forests give us innumerable benefits including; wood products, jobs, food, fuel, clean air, carbon uptake and storage, recreation opportunities, clean water, cultural benefits, open space, wildlife, biodiversity, scenic landscapes, and many more. Forests are unique as a natural resource because they can provide these values in concert with one another, on a renewable basis, through sound sustainable forest management.

I'd like to illustrate the critical contribution forests make to America by taking a brief look at my home State of New York. When most people think of New York, they think of Time Square, Broadway musicals, and sky scrapers. Most people have little appreciation for how significant the forest resources in New York are, or how important they are to our state-wide economy. New York State currently has an estimated 18.8 million acres of forests (61% of land area), owned primarily by private landowners. These forests provide NY with over 55,000 jobs in rural communities, and have an estimated net economic impact of almost $12 billion dollars each year. Recently, with the downturn in housing starts, increased energy costs, and depressed wood product markets many of these jobs have been lost, resulting in a significant reduction in the economic contribution realized from the forest economy. The situation in New York is just an example of what is happening across the country. Forests, and the communities that rely on them, are under pressure from both human influence, and natural factors.

Challenges for the Future of America's Forests

The story of America's forests contains many successes, including their abundance, diversity, ecological services, recreational opportunities, and vast array of wood products they produce. Many times, however, it is the challenges to our forest resources that we hear the most about, and understandably so. Catastrophic wildfires, invasive species, changes in land use (deforestation), climate change, global competition, and increased demand for traditional and emerging forest products are just some of the challenges we face.

In the past five years, over 42 million acres of federal forests has burned in the US. In 2006 wildfires in the US burned nearly 10 million acres, cost $1.9 billion to suppress, and were 166% greater in extent than the previous 10-year average. Due to climate change and public land management practices, future fires are likely to be more severe, cost more to suppress, and have greater impacts on air and water quality, wildlife habitat and infrastructure. Current estimates show that 180 million acres of federal forests in the US are at an unnaturally high risk of catastrophic wildfire. At present, harvest levels on national forests are about one-eighth of the growth resulting in forests that are overly dense, unhealthy and prone to unnaturally severe wildfire. In Oregon, tree mortality on federal lands from insects, disease, and fire is reported to be six times the level of harvest. Though there is some debate, it is generally agreed that continuation of this situation will not lead to healthy, sustainable forests that store carbon and serve the national interests. In eastern Washington, federal forests will soon become a source of carbon emissions rather than a sink due to decay from insect and disease infestation and catastrophic wildfires. This picture is true of many of our federal forests, especially those in the West.

In 2006, almost eight percent of US forests (58 million acres) were at significant risk to insects and disease, either natural or introduced. This issue continues to be of significance nation wide, perhaps most significantly with the spread of Mountain Pine Beetle in the Western US. In New York we are also battling infestations of foreign pests such as Sirex Wood Wasp, Asian Long Horned Beetle, Hemlock Wooly Adelgid, and potentially the Emerald Ash Borer in our forests. The impacts of a warming climate on insect and disease pathogens is largely unknown. It is believed, however, that forest pests held in check by winter low temperatures may spread as the average temperature increases.

Perhaps the greatest challenge our forests face is forest loss to alternative land uses. As our US population grows, it is estimated that approximately 44 million acres of private forestland in the US could experience drastic increases in housing density in the next three decades. As has been stated above, the host of values presented by forests are significant, however these benefits are only realized if the forests stay as forests. Frequently, forest loss can be attributed to a failure to recognize all of the values presented by the forested property.

Hand in hand with keeping forests intact is having healthy and integrated markets for forest products and services. Landowners are much more likely to keep and manage their forestland if they have value as forests. This key component to preventing forest conversion is often overlooked and/or misunderstood by Congress.

Emerging markets, such as ecosystem services, renewable energy and carbon offset projects, could also help to keep forests forested by adding an additional revenue stream to landowners. At the moment, however, we have a Renewable Fuels Standard that needlessly restricts most woody biomass, a cap and trade bill that doesn't recognize domestic forests and an energy bill with a Renewable Energy Standard that restricts woody biomass. All of these provisions, we are told, are in place to 'protect' forests. To be perfectly clear, these policies will only harm our domestic forests and leave foresters with fewer options to manage forestland for the benefit of society.

Meeting the needs of a growing global demand for forest values in the face of these challenges is a reality we face for the future. As our population grows and spreads into the rural areas of our country, and as the impacts of a warming climate are realized, these pressures will increase exponentially. These challenges can only be addressed with thoughtful, deliberate, sustainable forest management.

The SAF Climate Change Task Force Report 2009

In response to the growing concern about anthropogenic climate change and the diverse opinions that exist on the impact it would have on forests, the SAF assembled a group of 12 experts from across the country to form the SAF Climate Change Task Force. The group was assembled in 2007 and was charged with reviewing the body of available research on climate change, clean energy, forestry, and carbon sequestration. The objective for this group was to inform its membership and the public by summarizing the most current and best available research in the form of a Task Force report. The report was completed in 2008 and was published early in 2009. The end result is a very comprehensive and current presentation of the science of climate change as it impacts and is impacted by forest resources and the role forests play in the global climate budget. The findings of the report are summarized below.

Forests are shaped by climate. Changes in temperature and precipitation regimes have the potential to dramatically impact forests nationwide. Climate is also shaped by forests. This interrelationship means that dramatic change to one will somehow influence the other. Climate change has the potential to transform entire forest systems, shifting forest distribution and composition.

Wood products from sustainably managed forests can be replenished continually, providing a plentiful and dependable supply of both trees and wood products. Substituting wood for fossil fuel-intensive products can substantially improve environmental performance and store carbon in wood products while also supporting other ecological services, such as clean water, clean air, wildlife habitat, and recreation. Life Cycle Inventory analysis reveals that when wood products in construction are used instead of steel, concrete, brick or vinyl materials, the wood products store more carbon and use less fossil energy.

Green House Gas (GHG) emissions can be reduced through the substitution of biomass for fossil fuels to produce heat, electricity, and transportation fuels. Biomass can also be used to produce a wide range of plastics and chemicals traditionally made from fossil fuels. Product substitution involves the use of biomass to replace products that would emit more GHG per functional unit. While some of the increasing need for sustainable electric power can be met by renewable energy sources such as solar and wind, biomass is the only renewable that can meet our demand for carbon-based liquid fuels and chemicals.

Wildland fires are a major contributor to national and international GHG emissions. The EPA has estimated that wildfire emissions in the lower 48 states and Alaska released an average of 105.5 million metric tons/year (range: 65.3 to 152.8) of carbon dioxide into the air from 2000 to 2005. Active forest management to improve forest health and reduce hazardous fuels can dramatically reduce CO2 emissions while also enhancing wildlife habitat, recreational and scenic values, and reducing the threat of wildfires to communities and critical infrastructure. This management can also contribute to the health of rural communities and economies by providing family-wage jobs.

Land use change from forests to non-forest use releases carbon and other GHG's stored in forests. No other anthropocentric activity, besides energy production, releases more carbon emissions globally: 150 billion tons or 33 percent of the total emissions between 1850 and 1998. While this is mostly an international problem and U.S. forestland area has remained relatively stable since the 1920s, forest land use and carbon policies need to encourage the retention and enhancement of forestland. Again, healthy and diverse markets will play a large role in preventing forestland loss.

Managed forests are unique in that they contribute to GHG reduction while simultaneously providing essential environmental and social benefits including clean water, wildlife habitat, recreation, forest products, and other values and uses. The important metric is net carbon uptake and storage. Forests of all ages and types have remarkable capacity to sequester and store carbon. Enhancement of this capacity depends on active, informed forest management.

Market-based instruments encourage environmentally sound behavior through market signals rather than through explicit directives regarding pollution control levels or methods. When well designed and implemented, these instruments will create incentives that alter the producer's pollution control strategy in ways that benefit the producer while meeting pollution reduction policy goals. Market-based climate change policy instruments provide economic incentives that promote innovation in the development of pollution abatement technologies because it is always in the entity's best interest to do so.

It seems surprising that society currently seems reluctant to embrace forest conservation and management as part of the climate change solution. Time is of the essence and the forestry profession must transmit a clear, urgent message to society that global warming is probable and forest management can mitigate climate change effects. History has repeatedly demonstrated that the health and welfare of human society is fundamentally dependent on the health and welfare of a nation's forests. Society at large, the U.S. Congress, and state legislators must not only appreciate this fact, but also recognize that the sustainable management of forests can, to a substantial degree, mitigate the dire effects of atmospheric pollution and global climate change.

A Unique Opportunity in Time

Ours is an exciting time to be working in the environmental field. The increased environmental focus generated by concerns centered on climate change is creating increased opportunities in the area of forestry. New products such as biomass and bio-fuels, voluntary greenhouse gas reduction (cap and trade) programs for forest offsets, and the development of ecosystem markets for forest based services such as water and biodiversity are transforming how we view and value our forests. The capture and recognition of these new products and services from forests stand to have significant positive impacts on forests and forestry in the US.

The emerging markets for forestry derivatives like carbon credits and biomass are proven to have significant positive impacts on climate change. The realization of income streams from these products holds huge potential to alleviate financial pressures to change forest land use, incentivize the expanded use of sustainable management practices on private lands, create jobs and stimulate economies in rural areas, and also to expand the ecosystem services provided by forests nation wide. It is important however to recognize that these benefits can only be realized if Congress and the Federal Government allow forests to fully participate in these programs and markets.

Our current Administration stands poised to initiate clean energy and climate change programs that will define environmental policies on greenhouse gases for future generations. This opportunity can either result in increased opportunities to embrace forests and their benefits for the future, or create barriers to their contribution to the climate change problem. Much of the future for forests in the realm of climate change programs will lie in how policies for these programs are designed today.

Action Items for the Committee

1. Ensure a role for all forest offsets in Federal cap and trade

Numerous bills have been proposed on climate change over the past few years. Most recently the American Clean Energy and Security Act was approved by the House Energy and Commerce Committee. The Act, however, did not recognize domestic forestry offsets.

As legislation moves forward, attention must be paid to the role of terrestrial offsets from forestry projects. Forest offsets provide low cost, measurable, real carbon reductions to cap and trade systems. Forests provide these climate benefits with unequalled ancillary benefits such as clean water, biodiversity, and recreational opportunities--benefits not realized by any other offset type. Moreover, forests can provide these benefits now. Domestic offset projects allowed in any Federal cap and trade program must include opportunities for afforestation, reforestation, forest management, and harvested wood products (long-lived wood products). Further, the Federal Government must develop credible, accurate, and economically viable opportunities to recognize the important contribution forestry projects make to the climate change program.

2. Ensure that early actors in qualified voluntary programs are recognized

With the development of voluntary GHG reduction markets and programs in the US, has come an age of innovation, investment, and development for terrestrial offsets such as agriculture and forestry. Millions of tons of carbon dioxide have been sequestered in and traded from independently verified terrestrial offsets in the US and abroad. These early actors have not only led the way with early climate change actions, but they have developed innovative new technologies and processes to quantify, produce, and report carbon instruments in this new industry, to the benefit of all. Current language in the American Clean Energy and Security Act would significantly limit the recognition of these early actors.

3. Ensure that investments in offsets and clean technology continue

The American Clean Energy and Security Act includes provisions for a list of approved offsets to be developed at a later date by the Environmental Protection Agency (possibly out as far as 2012). The impact of this provision will likely result in slowed or no investment in the offsets sector as developers and owners of offset projects wait to see if their actions will be recognized in the Federal program. The SAF encourages the Committee to push for a comprehensive listing (including forestry and agriculture) of approved offset types and programs as soon as is possible in order to maintain growth and investments in this industry.

4. Encourage Woody Biomass Energy

As the House Agriculture Committee is well aware, the definition of 'renewable biomass' in the Renewable Fuels Standard passed in the 2007 Energy Independence and Security Act must be corrected. This prescriptive, restrictive definition serves as a disincentive to restore forest health in many areas and only hampers efforts to reach renewable fuels mandates. The SAF recently submitted testimony with the House Agriculture Committee on this problem and that testimony is attached. Further, the most recent version of the American Clean Energy and Security Act includes a Renewable Energy Standard (RES) of which the definition of biomass is overly restrictive, especially on federal lands. Attached to this testimony is the SAF's most recent letter to the House Energy & Commerce Committee explaining the problems with the definition.

5. Encourage existing and new markets

Without markets, whether they're traditional or emerging, foresters cannot manage forest land. With the plethora of challenges facing domestic forests-wildfire, insects & disease, conversion, climate change-forests across the nation will need to be managed by professional foresters to conserve their many values and ensure they provide these values for future generations. Congress must be thoughtful about the laws it passes and must avoid perverse and unintended consequences.

6. Restore Forest Health on Federal and Public Forests

Our vast public forests, much like private forests, can be either a sink for CO2 or a source of CO2. The deplorable state of forest health on public forests, especially in the West, indicates that most of these lands will soon become of a source of CO2 through emissions from wildfires and decay. This problem also adversely affects wildlife habitat, water quality, aesthetic values and costs the Federal Government billions of dollars each year. The current law, regulations and case law governing federal forest management does not allow federal land managers to solve this problem. Congress must act to provide the authorities needed to appropriately deal with this problem.

Closing

I would like to thank the Committee and The Society of American Foresters for allowing me to share with you this information on our nation's forests, its challenges, and opportunities for the future. It has been my extreme pleasure to be here with you today. I look forward to your questions and comments.

Mr. BACA. Thank you very much, Mr. Smith, and I appreciate each and every one of the panelists. I know that we went a little bit longer on the 5 minutes, and the reason I did that is because you were patient enough to wait and so we needed to be patient enough to hear your comments as well, so I appreciate that very much. I want to thank all the panelists for being here and for being patient and waiting until we were done voting. Now we will begin with the process of asking some of the questions. And I will begin myself by asking Mr. Bentz a question first. Thank you for your testimony today. I am intrigued by your findings on energy ecosystem service market, and in my area in southern California we have a significant problem with water, pollution through the form of perchlorate contamination. Perchlorate is a rocket fuel additive that can be found in some of the well heads due to defense constructions that occurred at one time in San Bernardino County. Can you explain for the Subcommittee in greater detail what the role of the forest watershed play in water purification?

Mr. BENTZ. Forests have a huge impact in purifying the water. When the water goes into the soils, first of all, the trees, the root systems, hold the water there and uptakes the chemicals. It helps clean it out. So forests maintain the soils in place so the soils don't move and again provide cover, and so they do contribute tremendously to clean water. Also, they provide shade. They maintain temperature of the water along our streams so that our repairing areas are really critically important for maintaining water quality and having forests in those repairing areas is also very important.

Mr. BACA. Along the same line, is there a feasible way that this type of purification can stop contamination from harmful chemicals like perchlorate?

Mr. BENTZ. I am not aware of that. No, sir.

Mr. BACA. Okay. Under the renewable energy market it seems to be an emerging opportunity to supplement the declining traditional timber market. How do you see this playing out for the family forest owners?

Mr. BENTZ. In the renewable energy component?

Mr. BACA. Yes.

Mr. BENTZ. The renewable energy component allows these lower value woods to find the market. We are seeing markets for pulpwood and some of these other byproducts going away as our paper industry declines, and so having these renewable energy markets available allows landowners to sell these lower value woods into these things, so it is an extremely important economic resource for the family forest landowners.

Mr. BACA. Mr. Koehn, the Federal Government currently requires flood insurance in certain areas, also participation in some agricultural commodity programs require insurance. Do you think the high cost of firefighting suggests that we might want to examine requiring fire insurance in certain fire prone areas?

Mr. KOEHN. I believe that there is some communities in this country that do have the requirement for fire insurance in some of the fire prone communities. I don't think that is a national requirement. I think that is done at the state and local level, so there is, I believe, in some cases an example for that.

Mr. BACA. Okay. Do you believe that the national standards for long-term forest health, even ones that might pre-empt current state laws are necessary?

Mr. KOEHN. It depends on which practice and piece of statute that we are talking about.

Mr. BACA. All right. What can we do at the Federal level to ensure that our states, local governments implement long-term forest health strategies to minimize the risk of fire, insects epidemics, and prevent harmful greenhouse gas emissions?

Mr. KOEHN. Well, on a fire front, as long as we continue to have the support and the resources that we have from partners like the U.S. Forest Service, state fire assistance funds and helps the states provide those kinds of assistance when the fire whistle blows and they need yellow shirts from back east or other states, those things are important. Your other question about, forgive me, help me, beyond the fire was—you had a second part to your question. I am sorry.

Mr. BACA. Okay. The second part, what can we do at the Federal level to ensure that our states and local Government implement long-term forest health strategies to minimize the risk of fire and insect epidemics and prevent harmful greenhouse gas emissions?

Mr. KOEHN. All right. As far as the insect and disease go, and the same thing with fire, well-managed forests are more resilient than forests that are not well managed, so if a forest is growing vigorous and doing well, its potential to withstand catastrophic fires improve, and its potential to withstand insect and disease infestations is improved, so a rigorous, well-managed forest is probably the best preventative way to deal with some of those issues. We also probably could support and would advocate for funding for APHIS for early detection for insect and disease. I am in a state that has been struggling for the last couple of years with emerald ash borer as many other states are, and if we had not had the opportunity for early detection the problem would be much worse.

Mr. BACA. Okay. Thank you. I have additional questions for the rest of you, but I am going to pass and call on the other Members, but I am going to ask one yes or no answer. Based on what I heard today from both the deputy secretary as well and from all of you in some sense or another, do you think that we should have a hearing in biomass?

Mr. KOEHN. Yes.

Mr. BENTZ. Yes.

Mr. MCPEEK. Yes.

Mr. MONAGHAN. Yes, sir.

Mr. SMITH. Yes, sir.

Mr. BACA. Okay. Thank you. With that then, I will go to Ms. Lummis to ask the first question. You have 5 minutes.

Ms. LUMMIS. Thank you, Mr. Chairman. Given the presence of the former Chairman of the Agriculture Committee, I would defer the questions that I have to him for the time being, but I would like to ask a couple later.

Mr. BACA. Mr. Goodlatte.

Mr. GOODLATTE. Thank you, Mr. Chairman. That was very generous. I was prepared to wait on you but if you don't—first of all, I want to thank you all for your testimony. I find it very helpful. I am in concert with most of you who believe that we need to have fair consideration of our forest products in terms of any renewable fuels standard and policy, so I am a supporter of Congresswoman Herseth Sandlin's legislation that would change those provisions to allow woody biomass to be counted in that program.

Mr. McPeek, I am a member of and have been a supporter of The Nature Conservancy for many, many years, and like many of the things that you do. I was concerned, however, about a statement that you had in your statement regarding the biomass putting too much pressure on—I want to quote you directly, but I can't put my finger on it right now, too much pressure on our national forests, and I wonder if you could cite for me some examples of that. Virginia as a whole is 62 percent forested, and my district it is an even higher percentage, closer to 70 percent of all of the land in my district is forested. About half of that is in our national forest, about half of it is in private land ownership. The half that is in private land ownership produces about 96 or 97 percent of the forest products, both for the paper mills. I have four of those in my district, and we have a lot of hardwood lumber production as well.

And the national forest, which comprises 50 percent of the forest land, produces somewhere between 3 and 4 percent of the wood products. Where is it that you see that a program to generate greater biofuel production from forest products would put undue pressure on our national forest land? It seems like right now whatever undue pressure may exist on private forest land. I wonder if you might——

Mr. MCPEEK. First, thanks very much for your support over the years. We greatly appreciate it. We are not against a real energy standard that includes woody biomass at all. It is really just a matter of having the necessary sideboards to not have incentives to clear native forests on private land and have sustainable practices on public land. Sustainable forest management also creates a sustainable industry if we manage the forests. Unsustainably, the industry won't be able to sustain itself either. So in terms of the overall climate change issue the cap on greenhouse gas emissions is the best approach to dealing with that issue. We have not taken a position on the renewable energy standard but if there was one all we would recommend are those sideboards that prevent those kinds of——

Mr. GOODLATTE. But wouldn't putting a cap on greenhouse gas emissions raise the cost of a wide variety of energy sources and those that are potentially more greenhouse gas friendly, and since trees grow by absorbing carbon dioxide presumably they are more friendly than other types of sources of energy. But I am in favor of increasing production of all sources of energy because I think we have a very serious risk that we are already starting to see right now as oil prices start to climb again of pricing ourselves out of being internationally competitive without greater domestic production of energy. But a part of that production to me should be biomass production from forest products. And I wonder if some of the other panel members would like to comment on that. Do you think that simply putting a cap on CO_2 emissions is the best way to address this problem as opposed to increasing the production of energy from forest products?

Mr. MONAGHAN. If energy provides a market to landowners, I think it is proven that landowners will do the right thing and respond to those market incentives by doing a better job of forest management. I don't see it as anything but a win-win situation. I have never seen a situation where you take a market incentive away from someone and they respond by making a positive action in the future. They are more likely to reinvest in sound forest management if they have a market incentive for doing so.

Mr. GOODLATTE. Thank you. Mr. Bentz.

Mr. BENTZ. Right now we think the forests are sequestering about 10 percent of our carbon nationally, and we believe that with active management of our forests that that number could be doubled to as much as 20 percent, so we actually see a lot of room to improve our forest management and our carbon sequestration at the same time providing all these benefits as well.

Mr. GOODLATTE. The current Waxman-Markey bill dealing with climate change makes no mention of domestic forest offsets. I wonder if some of you might comment on the benefits of domestic carbon offsets in a cap and trade system and how do we ensure that these offsets are real? Mr. Koehn, is that something you are familiar with?

Mr. KOEHN. I can speak to that in the sense that some of the things that we do in forestry don't always meet the same kind of rigor that you require for a tradable credit but we do believe that there should be some allowance in programs for credit for landowners who do undertake some of these projects but maybe not have the rigor that is required for something that might be traded on the Chicago climate exchange or something like that, so it is difficult with the accounting to demonstrate that in some cases, but we believe that some of these positive aspects should be recognized in some other forms of programs that we could offer through state and private forestry programs.

Mr. GOODLATTE. Mr. Chairman, I see my time has expired.

Mr. BACA. Thank you very much, Mr. Goodlatte. At this time, I would like to call on the gentleman from Mississippi, Mr. Childers, for 5 minutes you are recognized.

Mr. CHILDERS. Thank you, Mr. Chairman. I guess I am directing this to everyone, and anyone feel free to jump in but specifically, Dr. Monaghan, you are familiar with certainly our district. Northern Mississippi has a lot of sawmills. We have a lot of forest land. And I am a relative new member of Congress. Apparently, the timber sellers in Canada, this is having a negative impact on us, and I have some of the most sophisticated sawmills. They are really remarkable in north Mississippi, specifically one in Tippah and Grenada County that I am thinking about. I take that at face value when they tell me this is happening to them, but what can Congress do to help our timber sellers, if you will, which would ultimately help our mills as well in the market? What can Congress do that they are not doing already?

Mr. MONAGHAN. Well, the Canadian lumber agreement settlement in the past few years looked at that situation very closely with regard to competition or what we would call unfair competition from other countries. So a promotion of fair and even trade is obviously one of the things that was discovered that there were certain situations where the Canadian Government was subsidizing some of the industries up there so it created unfair situations. But as far as what we could do in the future in a situation like that, one of the primary things, of course, is to look at any situation that comes along as an opportunity to provide markets for forest landowners, and because if they have a market that means that somewhere along the line those industries, those sawmills, other buyers of wood products, are in a favorable situation as well.

So I think just fair competition and promoting free enterprise would do the job. If we try to artificially support our forest industries and our forest—the private forest landowners, it is hard to maintain that through artificial incentives, but for certain we need to be fair about any new programs, any new legislation, any new tax policy. We need to be fair and make sure it doesn't create a disincentive.

Mr. CHILDERS. Thank you. The Canadian lumber agreement, if that is its proper name, was supposed to do that, and can I just ask you all this, are we—by the way, Mr. Chairman, I would just like to say that I am proud to have Dr. Monaghan here because very rarely do we have anybody who talks like I talk. He comes in here——

Mr. BACA. I noticed that accent.

Mr. CHILDERS. I appreciate him being here. Are we not doing our part on that agreement? Are we not enforcing our own agreement, do you think?

Mr. MONAGHAN. I honestly can't answer that.

Mr. CHILDERS. Mr. Neiman. I was going to you with that question. I saw you reaching for the mic, so thank you.

Mr. NEIMAN. I have had a real struggle the last number of years watching the whole interaction. It appears to be a one-way street when you look at how we deal with the Canadian Government. I think it has been very unfair. We have watched two judges from Canada picked with one from down here to make decisions. Millions of dollars passed back the year before last to the Canadian Government. I think our Government got $1 billion and they got $5 billion or $6 billion. There has just been a number of issues that really disturbs me. I wish you could just figure out ways to make it fairer and balanced. Canada has a whole different philosophy. They continue to do everything possible, including labor incentives and discounts on their stumpage, just endless benefits. It is a whole different philosophy and in turn it is our responsibility as a Government from my end to hold them accountable and create the tariffs that balance that out. Otherwise, they have an extreme advantage not counting when you look at what the exchange rate has done. We have watched the exchange rate this year drop from our dollar to $1.30 down to $1.18 and back up. They have a lot of advantages that can really hurt our industry.

Mr. CHILDERS. So we are not doing our part?

Mr. NEIMAN. You are correct.

Mr. CHILDERS. My time has expired. Thank you all.

Mr. BACA. Thank you very much. Since Ms. Lummis yielded to the past Chairman, Mr. Goodlatte, I am going to call on Ms. Lummis to ask her questions.

Ms. LUMMIS. Thank you kindly, Mr. Chairman. My questions are for Mr. Neiman, and thank you all for waiting for us during our voting time. As was pointed out earlier, Wyoming being 97,000 square miles, the 9th largest state in the country, one sawmill in the entire state and it is Mr. Neiman's. What are the biggest factors, Jim, in forcing the forest products industry to struggle so much when we have this vast renewable resource?

Mr. NEIMAN. I think you can go to one basic area and the inconsistency or the lack of supply of national forest timber from all forests is the biggest. You can then drop down to a number of different reasons, increased NEPA cost to the forest, litigation, appeals. It just goes on and on, the different things that stymied the Forest Service. It is like our courts have control over our decision making process on the forest. If you look at Wyoming as a whole, you had a mill in Dubois, Wyoming, you had one on Laramie, you had one in Saratoga, you had one in Newcastle, you had one in Riverton, you had one in Sheridan. They are all gone.

The problem goes back to the improper lack of applying true science. A lot of this started in the 1960's and 1970's with the misperception of clear cutting. A lot of those forests were shut down with the perception that clear cutting is bad and lodgepole needs to be clear cut if you study the science. So what does Mother Nature do with fire and with bugs? It clear cuts. It is an even age stand, so we got to allow the foresters—we got to get the science down to the lowest possible level we can to make the decisions.

Ms. LUMMIS. Thank you. With regard to your co-generation facility that is proposed, can you expand on how a co-gen facility at your sawmill would improve forest management in the Black Hills National Forest?

Mr. NEIMAN. If I look at it from the big picture, the Black Hills National Forest produces about 5,000 slash piles a year. That ends up being a hundred and some thousand tons, bone dry tons, of carbon if you want to look at it in terms of carbon, that they burn and it costs them between $1.5 million and $2 million to burn those piles. Then they have to treat those slash piles for weed treatment from 5 to 10 years because it has changed the soil type. We could go in and grind those piles up at no cost to the Forest Service, turn that into energy and have renewable energy in our case, supply steam to Black Hills State University, which is really excited about being a green college. The benefits go on and on. When you look on the private side, private lands, what that can do to help ranchers, it is the same identical benefit.

Ms. LUMMIS. Thank you. I also want to ask what actions are needed at the Federal level to move forest management plans to prompt removal of dead and dying trees from beetle kill or fires?

Mr. NEIMAN. Is that question for myself?

Ms. LUMMIS. Yes, for you, Mr. Neiman.

Mr. NEIMAN. You need prompt action. You need a process, particularly in ponderosa you sometimes have 2 months to get in and remove those before the bugs have got in and bored in. We have less time in ponderosa, so it is critical to take action. But the real solution is to figure out how to get ahead of the bugs within the forest. You can prevent that by getting in and doing proper management.

Ms. LUMMIS. And can the forest products industry help with that?

Mr. NEIMAN. Sure. Right now in the Black Hills, that forest is growing about 150 million a year, the annual growth. The ASQ is about 83. We just got back up. We need a capacity of between 120, 130 million. We are begging for more wood. So, otherwise, we got to go to Montana and Nebraska and the economy will not allow it. We have had to curtail because of the additional cost. Our working circle has shrunk. We would beg to move into higher cuts and move in quickly, remove the bugs, and thin around the area. You got to keep in mind that bugs are endemic to every forest. They don't just appear. The forest becomes unhealthy and creates an epidemic by the multiplication of the bugs, but you got to recognize bugs are endemic to every forest nationwide so by proper forest health we can help and it helps our companies too.

Ms. LUMMIS. And, Mr. Chairman, so slash piles can be either burned and produce more carbon with no benefit to the economy or they can be used to produce products that augment the nation's renewable energy resources, is that true?

Mr. NEIMAN. Yes.

Ms. LUMMIS. Well, I am delighted that we have had this array of testimony today, and, Mr. Chairman, I deeply appreciate your holding this hearing. Thank you so much.

Mr. BACA. Thank you very much. I know that we have gone around. Is there any pressing time on your part because I know that somebody had to leave earlier, and, if not, we would like to ask if there are additional questions. I know I have some additional questions I would like to ask. If there are any other Members that want to ask additional questions, we can turn around and ask, but since we have not completed—hearing that there is no one pressing to leave, we will keep you here a little longer. I have a question for Mr. Smith. First of all, thank you very much for the informative testimony, and thank you very much for the six additional points that we will look at too as well. It is something that I wrote them all down so hopefully we can look at these points.

But as you mentioned earlier, I am well aware of the devastation caused by wildfires, but I was surprised by your testimony to learn about how major contributors they are to greenhouse gas emission. How do you think that we best get across to society and to mainstream America the message that forest conservation and management are critical steps in helping stop negative effects of climate change?

Mr. SMITH. Well, thank you for the question. Forests are part of the answer for climate change, but without management forest can end up being a net source through wildfire and decay. Education and an appreciation for the impacts of our activities on the forest landscape seems to be the knowledge gap that we are missing with the general public. Folks have lost their attachment to the forest and have lost an appreciation for what we look for from the forest and what occurs when we stop management. I have listened very closely to your opening comments, Mr. Baca, about what can we do to safeguard our forest fighters, what can we do about the wildfire issue. The answer to me is clear: Loosen the reins of the U.S. Forest Service and allow them to continue to manage the forest, thin the forest, and maintain it in a healthy condition.

This is the only way to curtail the deep budgets that we need to fight wildfire and the risks we take in the loss of homes and the loss of life through firefighters. But in the climate change issue, this is all tied together, create markets for renewable fuels, create markets for things like carbon credits, do things to strengthen our traditional markets, and you have the tools you need to manage the forests in a way that contributes positively to the issue of climate change.

Mr. BACA. Okay. The next question I have, and, thank you, being from the west I have seen the firsthand devastation of the bark beetle. You mentioned in your testimony several other pests that are attacking the eastern forests. I haven't spent enough time in other areas so could you please compare the pest destruction in the forest to those in the west?

Mr. SMITH. Well, what is happening in the east is not at the scale and not at the magnitude of what is happening with the mountain pine beetle, but what we have are invasive pests that enter our ports, enter our shores from other places. They come in. They have very few natural predators, and unchecked they are allowed to exploit some of our resources. One of the most substantial right now, one of the primary concerns in the Lakes States and western New York, Northwest Pennsylvania is, of course, the emerald ash borer, an insect for which we have no real practical control, but one that is having an enormous economic impact. It focuses on our white ash and green ash resources, and if you are a baseball fan that is important to you. Ash is the primary species that we use to make baseball bats and a variety of other products that are important to every day life.

So we have the same types of things happening throughout the country, in the South, in the West, and in the East, and these are important issues. They are important issues that we need to consider as we have legislation enacted to try to filter these things before they get to our shores because once they are here, they are very problematic to deal with.

Mr. BACA. Thank you very much. I am a baseball fan. In fact, we have our baseball game coming up on June 17, but we use aluminum bats. But for major league baseball that is a concern that we really have right now because all of the bats are wooden bats, and most of the professional baseball players prefer wooden bats. Have they addressed that problem or that problem, has it come to their attention at this point?

Mr. SMITH. Well, one of my clients is——

Mr. BACA. It affects the quality of the kind of bat that you also produce.

Mr. SMITH. Well, there are very few trees that make a major league quality bat. The specifications for a major league quality bat are very high. One of our clients is Louisville Slugger. We have managed some of their lands in Pennsylvania and New York for a very long time. This is, of course, of paramount concern to them, but there is very little right now that we can do about it. There are eradication procedures to try to take the affected white ash out of the environment and destroy it in an effort to curtail the spread of the insect, but right now nothing really has been all that effective. So it is one of very high concern, and something we are working very hard to take care of.

Mr. BACA. That is something that we can look at. The next question I have for you, Mr. Smith, too as well, many critics say that the forestry offset simply pay landowners for some things that are already being done for forest carbon is hard to measure. How can we create forest offset projects that provide bona fide climate benefits?

Mr. SMITH. Thank you very much for going there. I was hoping we would end up in this place. I am very passionate about what should happen in the realm of forest offsets. Private landowners make decisions every day of what to do with their resource. Outside of regulatory requirements, they make free will decisions, free will decisions that are either to the benefit or to the loss of society when it comes to ecosystem services like carbon sequestration. The climate change benefits from a well-managed private sector forest are not guaranteed, so commitments on the part of a private forest landowner specifically to manage their forest sustainably and in a way that accrues carbon over time is additional and is an additional climate change benefit that we have not had to date.

This is the cornerstone argument for why managed forests should be allowed in the Waxman-Markey legislation, but it is very problematic that it leaves the determination to what eligible offset is until later to be determined by the EPA. This is problematic. There have been hundreds of millions of dollars invested in the voluntary carbon market to date, investments that will significantly slow down, if not stop, if this community doesn't know what will be allowed in Federal regulation in 2012 or whenever it decides to take effect. So forests are important, forests are real. Foresters have been measuring the forests and measuring volume change in the forests since the profession began.

We can quantify how much carbon is sequestered by forests, we can make an argument for additionality, and we can make provisions for permanence. They are a real and strong contributor and produce low cost emission reductions and are available today. Not tomorrow, they are available today.

Mr. BACA. Thank you. Ms. Lummis, do you have any additional questions you want to ask?

Ms. LUMMIS. You know, I do have one, Mr. Chairman. Thank you. And I learned this just over the break. I have always thought when it came to NEPA and FLIPMA that local governments were supposed to receive the opportunity to cooperate with the Federal Government with regard to land planning. That is not the word that is used in the law. That is the word that is used in the rules. The law says coordinate with local and state government, not cooperate, coordinate. And so they are supposed to be on equal footing, not have state and local governments cooperating with what the Federal Government wants, and I didn't even know that. I am embarrassed that I didn't know that until now. So my question is for Mr. Neiman. Would you talk about the involvement of state and local governments in forest planning and forest management, and how that is working out?

Mr. NEIMAN. One of the primary reasons we have been at least partially successful in the Black Hills is the attempt both on South Dakota's side and the Wyoming side to get cooperating agency status. That has been instrumental in helping us have a voice at the state level from both states and with local communities, so that has been very, very critical. One other thing that I would suggest that could happen in other areas that could help out a bunch, a number of years ago it was in early 2000, 2001, and this was with the lock-up of our forest. Our first drop was in 1997 and again we went down to zero in 2002 with forest lawsuits. And at that time, Senator Daschle implemented the National Forest Advisory Committee which brought environmental communities and all working groups from around the Black Hills, off-road riders and different interest groups to the table to settle issues instead of it being a national decision. So both cooperating agency status and that national advisory Committee appointed that time that is now a very effective group, working group. If you ever get a chance, I will introduce you to someone if you come up to the Black Hills. The pride they have now sitting down with The Nature Conservancy, different groups that are involved there, it is really rewarding to hear that they take ownership and have an involvement in the success of the Black Hills.

Ms. LUMMIS. Thank you, Mr. Chairman. I wish all of the forests were managed as well as the Black Hills National Forest. I am not saying that there aren't problems there too, but it is certainly an example of how things can be done better than in the BT and some of the other forests that I have seen. Thank you very, very much.

Mr. NEIMAN. Mr. Chairman, we are proud to recognize, as I stated earlier, that over close to Nemal the first U.S. Forest Service timber sale of all the 150 some national forests started there so we are proud to state that we are also the oldest managed forest.

Mr. BACA. Also, thank you. Thank you very much for the statement too. I know that we have all been—I got one more set of questions, and I am going to ask Mr. McPeek. Again, thank for your testimony. As you mentioned in your testimony, the 2008 Farm Bill included important progress in policies related to forestry conservation, access to water and water conservation, the two areas near and dear to my heart, with the ever worsening drought situation in southern California. What is your opinion is the best way for us to expand the progress made in the farm bill so that we can best utilize water resource capacities or capabilities of America's forest?

Mr. MCPEEK. Mr. Chairman, I should probably get back to you if that is okay with a more detailed answer on that. I think we can give you some pretty good ideas about that.

Mr. BACA. Okay.

Mr. MCPEEK. I am not prepared to do that today.

Mr. BACA. All right. What we will do then is for any Members that are here and those that are not here, we will ask them to submit a statement. But at this time, I would like to just basically thank all of you for participating in today's hearing and your thoughtful testimony. Your knowledge and your research will be used by Congress to find out the best policy to preserve, protect, and properly utilize America's forests. And again we have come up with some ideas. I think we all agree that maybe we should have a biomass hearing, so I think we will go in that direction. Again, I want to thank each and every one of you. I want to thank the Members for being here today. With that then, we will adjourn. But before we adjourn, I would like to state under the rules of the Committee, the Committee record of today's hearing will remain open for 10 calendar days to receive additional materials, supplementary written responses from the witnesses to any question posed by Members. This hearing of the Subcommittee on Department Operations, Oversight, Nutrition, and Forestry is adjourned. Thank you very much.

[Whereupon, at 5:34 p.m., the Subcommittee was adjourned.]
[Material submitted for inclusion in the record follows:]

SUPPLEMENTAL MATERIAL SUBMITTED BY MATTHEW S. SMITH, CF, ACF, ON BEHALF OF THE SOCIETY OF AMERICAN FORESTERS (SAF)

Forest Management Solutions for Mitigating Climate Change in the United States

Robert W. Malmsheimer, Patrick Heffernan, Steve Brink, Douglas Crandall, Fred Deneke, Christopher Galik, Edmund Gee, John A. Helms, Nathan McClure, Michael Mortimer, Steve Ruddell, Matthew Smith, and John Stewart

About the Authors

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Malmsheimer has been a professor at SUNY ESF since 1999 and teaches courses in natural resources policy and environmental and natural resources law. His research focuses on how laws and the legal system affect forest and natural resources management, including how climate change and carbon sequestration policies affect forest and natural resources. Prior to becoming a professor, Malmsheimer practiced law for six years. He has a Ph.D. in forest policy from SUNY ESF, a J.D. from Albany Law School, and a B.L.A. from SUNY ESF. He was the 2007 chair of the SAF Committee on Forest Policy and served on the committee from 2005 to 2007. He has served on numerous national and state SAF committees and task forces.

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Heffernan began his career in forestry in 1976 and graduated with a national diploma in forestry from the Cumbria College of Agriculture and Forestry in 1981. He has enjoyed a variety of forestry employment in Great Britain and the United States and is now part owner and manager of an experimental private forest in New Zealand. He has been an SAF member since 1990, served as chapter and state chairs in Montana, and is currently on SAF's National Policy Committee. He was involved during the formative years of what has become the National Carbon Offset Coalition, where his interest in promoting inclusive solutions to forest carbon sequestration posited an approach for scientific net primary productivity calculations as a sound basis for forestry carbon credit markets.

Steve Brink
Vice President–Public Resources, California Forestry Association, Sacramento, California

Brink has been with the California Forestry Association since July 2005. He represents most of the remaining solid wood mill infrastructure and many of the remaining biomass powerplants in the state. His focus is on timber and biomass wood supply from the national forests, which manage 50 percent of the state's productive forestland. Since 2007, Brink has focused on forest carbon sequestration, carbon life-cycle modeling, forestry protocols, and the potential of renewable energy credits for forest landowners, wood manufacturing facilities, and biomass for power generation. He graduated from the University of California at Davis with a degree in civil engineering. Prior to joining the California Forestry Association, he spent 36 years with the US Forest Service.

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Crandall is currently director of Legislative Affairs for the US Forest Service. Previously, for eight years, he was the staff director for the US House of Representatives Subcommittee on Forests and Forest Health, with jurisdiction over most legislation and oversight concerning the Forest Service and Bureau of Land Management. He also served with the Society of American Foresters as policy director, the National Forest Foundation as vice president, and the American Forest and Paper Association as director responsible for national forest issues. Earlier in his career, he spent 10 years managing a lumber company in Livingston, Montana, and four years on the Brazilian Amazon, first as a forester and float-plane pilot, then as a plywood mill manager. Doug graduated with a B.S. in forestry from Oregon State University. He has been a member and officer of numerous forestry, industry, conservation, and community organizations.

Fred Deneke
Staff Advisor, 25x25 Renewable Energy Alliance, Prescott, Arizona

Deneke is forestry staff advisor to the 25x25 Renewable Energy Alliance on woody biomass and biomass energy. He also administers a woody biomass cooperative agreement involving the National Association of Conservation Districts, the US Forest Service, and the Bureau of Land Management. Deneke retired from the US Department of Agriculture in 2005 after 32 years of service with the US Forest Service and USDA Extension Service. Prior to his retirement he was assistant director for the Cooperative Forestry Staff of the US Forest Service in Washington, DC, where he served as national lead for woody biomass utilization for State and Private Forestry on the US Forest Service Woody Biomass Team and the Interagency Woody Biomass Utilization Group (involving the Forest Service, Department of Interior, Department of Energy, other federal agencies, and nongovernmental partners). Prior to his USDA service, Deneke was an assistant professor at Kansas State University. He is a graduate of Colorado State University with a B.S. in forestry science. He also has M.S. and Ph.D. degrees in horticulture from Kansas State University.

Christopher Galik
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Galik currently serves as research coordinator for the Climate Change Policy Partnership, a collaborative project intended to leverage the resources of Duke University to determine practical strategies to respond to climate change. Within this partnership, Galik has primary oversight over biological carbon sequestration, biofuel, and energy efficiency research activities. Previously, he spent several years in Washington, DC, as a policy analyst, specializing in a variety of environmental issues, including species conservation and federal forest management and policy. He holds a master of environmental management degree from the Nicholas School of the Environment at Duke, with a concentration in forest resource economics and policy. He received his B.A. in biology from Vassar College. Galik has been an SAF member since 2001.

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Gee is the national Woody Biomass Utilization Team leader for US Forest Service and the national partnership coordinator for forest management. He oversees the Woody Biomass Utilization Team in the development of sustainable woody biomass strategic planning, policy, and implementation of the plan as it relates to climate change. Gee works directly with the Chief's Office and the Washington Staff Directors Woody Biomass Steering Committee to work across all deputy chief areas as well as with the Departments of Interior, Energy, and Defense, the Environmental Protection Agency, and other USDA agencies. He received his B.S. degree in natural resource management from the University of California at Berkeley, a Certified Silviculturist from Oregon State University and University of Washington, and an M.B.A. from the University of Phoenix. He has been a member of SAF since 1983.

John A. Helms
Professor Emeritus, University of California, Berkeley, California

Helms joined the faculty of the School of Forestry, Berkeley, in 1964 and has M.S. and Ph.D. degrees from the University of Washington, Seattle. At Berkeley he was professor of silviculture and became head of the department. Much of his research was in tree physiology with emphasis on net uptake of carbon dioxide by mature trees in relation to stresses from water availability, temperature, and air pollution. He served SAF as chair of the Forest Science and Technology Board for two terms and as president in 2005. He gave testimony twice before Congress in 2007 on climate change effects on forests and wildfires. He currently serves on the board of the California Forest Products Commission and in 2007 was appointed a member of the Sustainable Forestry Initiative's External Review Panel.

Nathan McClure
Director, Georgia Forestry Commission's Forest Products Utilization, Marketing, and Development Program, Macon, Georgia

McClure currently leads the Georgia Forestry Commission's Forest Products Utilization, Marketing, and Development program and also serves as the director of Forest Energy for the agency. He has worked in a variety of positions over the past 24 years with the commission. McClure is a Georgia Registered Forester and a SAF Certified Forester. He received the SAF Presidential Field Forester Award in 2005. He is a 1983 graduate of the University of Georgia with a B.S. in forest resources management. Recent assignments include creating additional values from Georgia's forests through marketing and new product development, facilitating the development of a forest biomass energy industry, and initiating Georgia's new carbon sequestration registry, as well as working with traditional forest products industries.

Michael Mortimer
Director of Forest Policy, Society of American Foresters, Bethesda, Maryland

Mortimer is currently the director of Forest Policy for the Society of American Foresters. Previously he was on the faculty of the Virginia Tech Department of Forestry, where he carried out research and teaching in the areas of public and private land forest management and regulation and published in the areas of forest and biodiversity conservation. He also served as an assistant attorney general for the Montana Department of Natural Resources and Conservation, where he advised and litigated on behalf of the agency's forestry programs. Mortimer received his Ph.D. in forestry from the University of Montana, his J.D. from the Pennsylvania State University, and a B.A. from Washington and Jefferson College. He has been an active member and officer of various professional, forestry, and policy-related organizations at both national and state levels.

Steve Ruddell
Senior Program Officer, World Wildlife Fund, Washington, DC

Ruddell is the senior program officer of the Forest Carbon Project for the World Wildlife Fund's Global Forests Program. He was previously the director of Forest Investments and Sustainability for Forecon, Inc., a multidisciplinary forest and natural resources consulting company. At Forecon, Inc., he consulted with clients on investments in forest conservation and sustainability initiatives using market-based mechanisms, including carbon asset management strategies for trading forest carbon offset projects. Ruddell also conducted Chicago Climate Exchange (CCX) forest carbon asset management services in North and South America, including forest offset project economic analyses, development, quantification, verification, and reporting for accessing the CCX trading platform. He is a designated trader for CCX carbon financial instruments. He is an officer of SAF's Working Group on Bioenergy, Climate Change, and Carbon; the CCX Forestry Committee; the CCX Crediting Conservation Forestry Projects Committee; and the CCX Verifiers Advisory Committee. Ruddell received his B.S. in forest management from Utah State University, and an M.S. in forestry and an M.B.A. in operations management from Michigan State University. He has completed three years of work toward a Ph.D. in forest resource economics.

Matthew Smith
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Smith, ACF, CF, EMS-A, is the director of Ecosystem Services for Forecon EcoMarket Solutions LLC.(Forecon EMS), an approved aggregator for the Chicago Climate Exchange (CCX), and director of Land Management for Forecon, Inc., a forestry consulting company and CCX verifier. Since the mid-1990s he has managed the Land Management Department for Forecon, Inc., working with large land management clients such as timber investment management organizations and high net worth individuals. In 2004 Smith began working in the area of ecosystem services on behalf of these clients and has conducted forest carbon modeling and analysis, prepared managed forest carbon offset projects for the CCX market, and written about carbon sequestration for national audiences. He has served as a consultant to state and local municipalities, forest owner organizations, carbon registries, professional organizations, private landowners, CCX, and other groups. He also directs a team of ecosystem specialists working on market-based incentives for biodiversity and water resources. Smith serves as the chair of the Western New York Chapter of SAF and is a member of the Forest Carbon Education Group, the 25x25 Carbon Working Group, the Association of Consulting Foresters, and the New York Forest Owners Association. He holds a B.S. in forest resource management from the SUNY College of Environmental Science and Forestry and is an auditor and consultant for sustainable forest certification systems.

John C. Stewart
Biomass and Forest Health Program Manager, Department of Interior, Office of the Secretary's Office of Wildland Fire Coordination, Washington, DC

Stewart, the Biomass and Forest Health Program manager for the Department of Interior, represents the department on biomass utilization for renewable energy under the National Energy Plan and leads its efforts at small wood utilization under the National Fire Plan. Stewart also led an interdepartmental team in writing a joint woody biomass policy for the Departments of Interior, Energy, and Agriculture. Previously, Stewart was a forester with the Bureau of Land Management in Washington, DC. He had 22 years of experience with the US Forest Service throughout California before joining BLM. Stewart received a B.S. degree from the University of California at Berkeley and also worked for Dr. Ed Stone doing basic research in seedling growth response and vegetation descriptions. He has been a member of SAF since 1978 and served as the Bay Area Chapter chair in 1990 and 1991.

Abbreviations

BTU British thermal unit
CCAR California Climate Action Registry
CCX Chicago Climate Exchange
CDM Clean Development Mechanism
CER certified emission reduction
CFC chlorofluorocarbon
CH_4 methane
CO carbon monoxide
CO_2 carbon dioxide
CORRIM Consortium for Research on Renewable Industrial Materials
ERU emission reduction unit
EU ETS European Union Emissions Trading Scheme
FT Fischer-Tropsch (gasification process)
GHG greenhouse gas
Gt gigatonne (1 billion tonnes)
GWP global warming potential (an estimate of the pound-for-pound potential of a gas to trap as much energy as carbon dioxide)
HCFC hydrochlorofluorocarbon
HFC hydrofluorocarbon
HWP harvested wood product
IPCC Intergovernmental Panel on Climate Change
JI Joint Implementation
Mt million tonnes
MtC/yr million tonnes of carbon per year
$MtCO_2$ eq. million tonnes of carbon dioxide equivalents
MW megawatt
N_2O nitrous oxide
NMVOC nonmethane volatile organic compound; also VOC
NO_x nitrogen oxides
OSB oriented-strand board
OTC over-the-counter market
PFC perchlorofluorocarbon
ppb parts per billion
ppm parts per million
REIT real estate investment trust
RGGI Regional Greenhouse Gas Initiative
SAF Society of American Foresters
SF_6 sulfur hexafluoride
t tonne, or metric ton (1,000 kilograms, 2,205 pounds, or 1.10231 short tons)
TDR transfer of development rights
Tg teragram (1,000,000 metric tonnes)
TIMO timber investment management organization
ton short ton (2,000 pounds, or 0.907184 metric tonnes)
UNFCCC United Nations Framework Convention on Climate Change
VER voluntary (or verified) emission reduction
VOC volatile organic compound

Executive Summary

Forests are shaped by climate. Along with soils, aspect, inclination, and elevation, climate determines what will grow where and how well. Changes in temperature and precipitation regimes therefore have the potential to dramatically affect forests nationwide. Climate is also shaped by forests. Eleven of the past 12 years rank among the 12 warmest in the instrumental record of global surface temperature since 1850. The changes in temperature have been associated with increasing concentrations of atmospheric carbon dioxide (CO_2) and other greenhouse gases (GHGs) in the atmosphere.

Of the many ways to reduce GHG emissions and atmospheric concentrations, the most familiar are increasing energy efficiency and conservation and using cleaner, alternative energy sources. Less familiar yet equally essential is using forests to address climate change. Unique among all possible remedies, forests can both prevent and reduce GHG emissions while simultaneously providing essential environmental and social benefits, including clean water, wildlife habitat, recreation, forest products, and other values and uses.

Climate change will affect forest ecology in myriad ways, with consequences for the ability of forests, in turn, to mitigate global warming. This report summarizes mitigating options involving US forests and examines policies relating to forests' role in climate change. It also recommends measures to guide effective climate change mitigation through forests and forest management, carbon-trading markets, and bio-based renewable energy.

Preventing GHG Emissions

Forests and forest products can *prevent* GHG emissions through wood substitution, biomass substitution, modification of wildfire behavior, and avoided land-use change.

Wood Substitution. Substituting wood for fossil fuel–intensive products addresses climate change in several ways. Wood products from sustainably managed forests can be replenished continually, providing a dependable supply of both trees and wood products while supporting other ecological services, such as clean water, clean air, wildlife habitat, and recreation. The use of wood products also avoids the emissions from the substituted products, and the forest carbon remains in storage.

Life-cycle inventory analyses reveal that the lumber, wood panels, and other forest products used in construction store more carbon, emit less GHGs, and use less fossil energy than steel, concrete, brick, or vinyl, whose manufacture is energy intensive and produces substantial emissions.

Although wood product substitution does not permanently eliminate carbon from the atmosphere, it does sequester carbon for the life of the product. Landfill management can further delay the conversion of wood to GHG emissions, or the discarded wood can be used for power generation (offsetting generation by fossil fuel–fired power plants) or recycled into other potentially long-lived wood products. Regardless of the particular pathway followed after a product's useful life, wood substitution is a viable technique to immediately address climate by preventing GHG emissions.

Biomass Substitution. The use of wood to produce energy opens two opportunities to reduce GHG emissions. One involves using harvest residue for electrical power generation, rather than allowing it to accumulate and decay on site or removing it by open field burning. The other is the substitution of woody biomass for fossil fuels.

The use of biomass fuels and bio-based products can reduce oil and gas imports and improve environmental quality. Biomass can offset fossil fuels such as coal, natural gas, gasoline, diesel oil, and fuel oil. At the same time, its use can enhance domestic economic development by supporting rural economies and fostering new industries making bio-based products.

The technologies for converting woody biomass to energy include direct burning, hydrolysis and fermentation, pyrolysis, gasification, charcoal, and pellets and briquettes. Energy uses for wood include thermal energy for steam, heating, and cooling; electrical generation and cogeneration; and transportation fuels.

The United States may need to build 1,200 new 300-megawatt power plants during the next 25 years to meet projected demand for electricity, and coal will likely continue to be a major source of energy for electricity production. Although some energy needs can be met by solar and wind, woody biomass presents a viable short- and mid-term solution: it can be mixed with coal or added to oil- and gas-generated electric production processes to reduce GHG emissions.

Federal funds and venture capital are beginning to support the production of cellulosic ethanol. Substituting cellulosic biomass for fossil fuels greatly reduces GHG emissions: for every BTU of gasoline that is replaced by cellulosic ethanol, total life-cycle GHG emissions (CO_2, methane, and nitrous oxide) are reduced by 90.9 percent. The woody biomass is available from several sources: logging and other residues, treatments to reduce fuel buildup in fire-prone forests, fuelwood, forest products industry wastes, and urban wood residues. Plantations of short-rotation, rapid-growing species, such as alder, cottonwood, hybrid poplar, sweetgum, sycamore, willow, and pine, are another source.

Wildfire Behavior Modification. Reducing wildland fires, a major source of GHG emissions, prevents the release of carbon stored in the forest. One modest wildfire—the July 2007 Angora wildfire in South Lake Tahoe, on 3,100 acres of forestland—released an estimated 141,000 tonnes of carbon dioxide and other GHGs into the atmosphere, and the decay of the trees killed by the fire could bring total emissions to 518,000 tonnes. This is equivalent to the

GHG emissions generated annually by 105,500 cars.

In 2006, wildfires burned nearly 10 million acres in the United States, and virtually all climate change models forecast an increase in wildfire activity. Under extreme fire behavior scenarios, which could be exacerbated by climate change, increased accumulations of hazardous forest fuels will cause ever-larger wildfires. The proximity of population centers to wildlands significantly increases the risk and consequences of wildfire, including the release of GHGs. Wildfires in the United States and in many other parts of the world have been increasing in size and severity, and thus future wildfire emissions are likely to exceed current levels.

Three strategies to reduce wildfires and their GHG emissions can address that trend:

• pretreatment of fuel reduction areas—that is, removing some biomass before using prescribed fire;

• smoke management—that is, adjusting the seasonal and daily timing of burns and using relative low-severity prescribed fires to reduce fuel consumption; and

• harvesting small woody biomass for energy, or removing some larger woody material (over 10 centimeters, or 4 inches, in diameter) for traditional forest products and burning residuals.

Active forest and wildland fire management strategies can dramatically reduce CO_2 emissions while also conserving wildlife habitat, preserving recreational, scenic, and wood product values, and reducing the threat of wildfires to communities and critical infrastructure.

Avoided Land-Use Change. More carbon is stored in forests than in agricultural or developed land. Preventing land-use change from forests to nonforest uses is thus another way to reduce GHGs. Globally, forestland conversions released an estimated 136 billion tonnes of carbon, or 33 percent of the total emissions, between 1850 and 1998—more emissions than any other anthropogenic activity besides energy production.

Forest conversion and land development liberate carbon from soil stocks. For example, soil cultivation releases 20 to 30 percent of the carbon stored in soils. Additional emissions occur from the loss of the forest biomass, both above-ground vegetation and tree roots.

In the United States, a major threat to forestland is the rise in land values for low-density development. Forestland in the US Southeast, for example, has been appraised for forest use at $415 per acre and for urban use at $36,216. Landowners generally convert forestland to residential and commercial uses to capture increasing land values, but when forests are damaged by wildfire, insects, or other disturbances, selling the land for development rather than investing for long-term reforestation can be attractive. Since climate change may increase the prevalence of such disturbances, forestland conversion may increase in the future.

Moreover, conversion of forests to agricultural lands is likely if energy policies favor corn-based ethanol over cellulose-based ethanol. Tax policies that increase the cost of maintaining forestland also promote conversion, as do the short-term financial objectives of some new forest landowners.

Because it is unlikely that publicly owned forestland will increase, efforts to prevent GHG releases from forestland conversion must focus on privately owned forests. New products, such as cellulosic ethanol and new engineered wood products, may add value to working forests. Sustainable utilization of working forests for a combination of wood products, including bioenergy, can improve forest landowners' returns on their land, bolster interest in forest management, and prevent conversion to other uses. Credits for forest carbon offset projects, if trading markets develop, may provide the additional income to encourage private landowners to retain forests.

Reducing Atmospheric GHGs

Forests can also reduce GHG concentrations by sequestering atmospheric carbon in biomass and soil, and the carbon can remain stored in any wood products made from the harvested trees. Because the area of US forests is so vast—33 percent of the land base—even small increases in carbon sequestration and storage per acre add up to substantial quantities.

Sequestration in Forests. The capacity of stands to sequester carbon is a function of the productivity of the site and the potential size of the various pools—soil, litter, down woody material, standing dead wood, live stems, branches, and foliage. Net rates of CO_2 uptake by broad-leaf trees are commonly greater than those of conifers, but because hardwoods are generally deciduous while conifers are commonly evergreen, the overall capacity for carbon sequestration can be similar. Forests of all ages and types have remarkable capacity to sequester and store carbon, but mixed-species, mixed-age stands tend to have higher capacity for carbon uptake and storage because of their higher leaf area.

Enhancement of sequestration capacity depends on ensuring full stocking, maintaining health, minimizing soil disturbance, and reducing losses due to tree mortality, wildfires, insect, and disease. Management that controls stand density by prudent tree removal can provide society with renewable products, including lumber, engineered composites, paper, and energy, even as the stand continues to sequester carbon. Above all, enhancing the role of forests in reducing GHGs requires keeping forests as forests, increasing the forestland base through afforestation, and restoring degraded lands.

Two active forest management approaches to addressing climate change are 1) mitigation, in which forests and forest products are used to sequester carbon, provide renewable energy through biomass, and avoid carbon losses; and 2) adaptation, which involves positioning forests to become healthier. Adaptive strategies include increasing resistance to insects, diseases, and wildfires; increasing resilience for recovering after a disturbance; and assisting migration—facilitating the transition to new conditions by introducing better-adapted species, expanding genetic diversity, encouraging species mixtures, and providing refugia. This last kind of intervention is highly controversial, however, because action would be based on projections for which outcomes are highly uncertain.

Traditional silvicultural treatments focused on wood, water, wildlife, and aesthetic values are fully amenable to enhancing carbon sequestration and reducing emissions from forest management. Choices regarding even-aged and uneven-aged regimes, species composition, slash disposal, site preparation, thinning, fertilization, and rotation length can all be modified to increase carbon storage and prevent emissions. Because forests are the most efficient land use for carbon uptake and storage, landowners with plantable acres and degraded areas that can be restored to a productive condition have a significant opportunity to sequester carbon.

Storage in Wood Products. Harvesting temporarily reduces carbon storage in the forest by removing organic matter and disturbing the soil, but much of the carbon is stored in forest products. The carbon in lumber and furniture, for example, may not be released for decades; paper products have a shorter life, except when disposed of in a landfill. Storage of carbon in harvested wood products is gaining recognition in domestic climate mitigation programs, though accounting for the carbon through a product's life cycle is problematic.

The climate change benefits of wood products lie in the combination of long-term carbon storage with substitution for other materials with higher emissions. Because wood can substitute for fossil fuel-intensive products, the reductions in carbon emissions to the atmosphere are comparatively larger than even the benefit of the carbon stored in wood products. This effect—the displacement of fossil fuel sources—could make wood products the most important carbon pool of all.

Forest Carbon Offset Projects

The role of forests and forest products in preventing and reducing GHGs is beginning to gain recognition in market-based policy instruments for climate change mitigation. Forestry is one category of projects that can create carbon dioxide emission reduction credits for trading to offset emissions from industrial and other polluters. Depending on the program, several project types may be eligible: afforestation, reforestation, forest management to protect or enhance carbon stocks, harvested wood products that store carbon, and forest conservation or protection.

Two types of renewable energy credits are becoming available—for using wood-based building materials instead of concrete, steel, and other nonrenewable building materials; and for using wood-based biofuels, such as wood waste, instead of fossil fuels to generate electric power.

Global carbon markets, however, have not yet fully embraced the potential of forests and forestry to mitigate climate change. The Kyoto Protocol, for example, introduced the concept of trading GHG emissions by sources for GHG removals by sinks, but it limits the role of forestry to afforestation and reforestation. Phase I of the European Union Emissions Trading Scheme allows global trading in carbon dioxide emission reductions to help EU countries reach their targets, but forestry activities are not eligible.

Domestic efforts to date include two regulated emissions trading programs. The Northeast's Regional Greenhouse Gas Initiative, a cap-and-trade program, limits eligibility to afforestation. The other, the California Climate Action Registry, permits credits for afforestation, managed forests, and forest conservation. Voluntary markets for forest carbon include emissions trading transactions through the Chicago Climate Exchange and over-the-counter transactions.

All credit programs must ensure that the net amount of carbon sequestered is additional to what would have occurred without the project. Methods are still being developed to separate the effects of management action on a forest from those of environmental conditions, and determining the net change in carbon stocks must include not only all management actions, such as harvesting, tree planting, and fertilizing, but also the effects of weather, wildfire, insects, and disease.

A forest project must also demonstrate permanence. Ensuring permanence can be difficult, however, since some sequestered carbon might be released through natural events, such as wildfires and hurricanes. Another issue is leakage—the indirect effects that a project might have in, for example, altering the supply of forest products and consequently the total area of forestland.

The current forest carbon accounting principles were developed before forest carbon offsets were recognized as a way for direct emitters of CO_2 to meet emission reduction targets. As a result, they do not adequately address all aspects of using forests to prevent and reduce GHG emissions. Emerging standards for participation in carbon markets may provide consistent rules that are appropriate for managed forests and promote additional and long-term forest carbon sequestration benefits.

Opportunities and Challenges for Society, Landowners, and Foresters

Seven conclusions are apparent from the analyses presented in this report:

1. The world's forests are critically important in carbon cycling and balancing the atmosphere's carbon dioxide and oxygen stocks.
2. Forests can be net sinks or net sources of carbon, depending on age, health, and occurrence of wildfires and how they are managed.
3. Forest management and use of wood products add substantially to the capacity of forests to mitigate the effects of climate change.
4. Greenhouse gas emissions can be reduced through the substitution of biomass for fossil fuels to produce heat, electricity, and transportation fuels.
5. Avoiding forest conversion prevents the release of GHG emissions, and adding to the forestland base through afforestation and urban forests sequesters carbon.
6. Existing knowledge of forest ecology and sustainable forest management is adequate to enable forest landowners to enhance carbon sequestration if there are incentives to do so and if carbon and carbon management have value that exceeds costs.
7. How global voluntary and mandatory markets develop will play a significant role in establishing the price of carbon dioxide and thus creating the incentives to ensure that forests play a significant role in climate change mitigation.

Given those facts, society's current reluctance to embrace forest conservation and management as part of the climate change solution seems surprising. It is beyond argument that forests play a decisive role in stabilizing the Earth's climate and that prudent management will enhance that role. Forest management can mitigate climate change effects and, in so doing, buy time to resolve the broader question of reducing the nation's dependence on imported fossil fuels.

The challenge is clear, the situation is urgent, and opportunities for the future are great. History has repeatedly demonstrated that the health and welfare of human society are fundamentally dependent on the health and welfare of a nation's forests. Society at large, the US Congress, state legislators, and policy analysts at international, federal, and state levels must not only appreciate this fact but also recognize that the sustainable management of forests can, to a substantial degree, mitigate the dire effects of atmospheric pollution and global climate change. The time to act is now.

Preface

In March 2007, on the advice of the Society of American Foresters' Committee on Forest Policy, the SAF Council created the Climate Change and Carbon Sequestration Task Force. Council charged the task force with evaluating the implications of global climate change on forests and forest management, addressing the role of forestry and forests in climate change, offering recommendations for SAF policy activities, and the following tasks:

• briefly assess and summarize the literature on the global climate change implications for forests and their management;

• briefly assess and summarize climate change mitigating options involving forests, including forests' potential as a carbon sink (with cost comparisons to other methods, if information is available), and domestic and international policies relating to forests' role in climate change; and

• recommend possible policy measures to guide effective climate change mitigation through forests and forest management, addressing existing and potential carbon-trading markets, opportunities for renewable energy to contribute to mitigation of greenhouse gas emissions, and strategies to minimize the vulnerability and promote adaptation of forests to impacts from climate change.

Prior to publication, the manuscript of this report was reviewed, in whole or in part, by more than 20 scientists. Members of the task force thank all of the reviewers; their efforts increased the report's accuracy and scope. This report and the task force's other products are the result of hundreds of hours by dedicated SAF volunteers.

Global Climate Change

Global temperatures have fluctuated over the past 400,000 years (Figure 1-1) (US EPA 2007b). Nevertheless, Earth is currently warmer than it has been in its recent past. The Intergovernmental Panel on Climate Change (IPCC) found that "eleven of the last twelve years (1995–2006) rank among the 12 warmest years in the instrumental record of global surface temperature (since 1850)" (Solomon et al. 2007, 5). The National Research Council concluded "with a high level of confidence that global mean surface temperature was higher during the last few decades of the 20th century than during any comparable period during the preceding four centuries" and, with less confidence, that "temperatures at many, but not all, individual locations were higher during the past 25 years than during any period of comparable length since a.d. 900" (NRC 2006, 3).

As Figure 1-1 indicates, changes in Earth's temperature have been associated with atmospheric carbon dioxide levels in the atmosphere. Research indicates that this and other important gases have also increased recently (Solomon et al. 2007). For example, between the preindustrial period (c. 1750) and 2005, carbon dioxide increased from about 280 parts per million (ppm) to 379 ppm; methane increased from about 715 parts per billion (ppb) to 1,774 ppb; and nitrous oxide increased from about 270 ppb to 319 ppb (Solomon et al. 2007).

IPCC, "the preeminent international body charged with periodically assessing technical knowledge of climate change" (Leggett 2007, 3) and the co-winner of the 2007 Nobel Peace Prize, concluded that "the global increases in carbon dioxide are due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture," and that these human activities and their byproducts are causing Earth to warm (Solomon et al. 2007, 2). This report does not evaluate the validity of those conclusions, the certainty of the predictions, or whether natural forces are causing changes in the Earth's climate. Rather, our analysis focuses on how climate change may be affecting forests and how managed forests can decrease atmospheric GHG emissions and prevent GHGs from entering the atmosphere.

Greenhouse Gases and the Greenhouse Effect

The biophysical process altering Earth's natural "greenhouse effect" begins when greenhouse gases in the "atmosphere allow the Sun's short wavelength radiation to pass through to the Earth's surface. . . . Once the radiation is absorbed by the Earth and re-emitted as longer wavelength radiation, GHGs trap the heat in the atmosphere" (Leggett 2007, 22).

Greenhouse gases affected by human activities include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and certain fluorinated compounds—chlorofluorocarbons (CFC), hydrochlorofluorocarbons (HCFC), hydrofluorocarbons (HFC), perchlorofluorocarbons (PFC), and sulfurhexaflouride (SF_6). Other GHGs not directly affected by human activities include water vapor (the most abundant greenhouse gas), plus carbon monoxide (CO), nitrogen oxides (NO_x), nonmethane volatile organic compounds (NMVOCs, or simply VOCs),and particulate matter or aerosols. NO_x, VOCs, and CH_4 contribute to the formation of another greenhouse gas, ozone (smog), in the troposphere. Most GHGs are generally well mixed around the globe and have global warming effects.

GHGs have different atmospheric lives. For example, water vapor generally lasts a few days, methane lasts approximately 12 years, nitrous oxide 114 years, and sulfur hexafluoride 3,200 years; carbon dioxide's atmospheric life varies (Bjørke and Seki 2005).

GHGs also have different global cycles. For example, the carbon cycle (Figure 1-2) includes geologic, biologic, and atmospheric carbon pools and the cycling that occurs among them (Harmon 2006). Human activities release carbon as carbon dioxide by various methods (described below). These releases alter carbon pools; the most important of these alterations is the transfer of carbon from its geologic pool to its atmospheric pool. Forests play an important role in the carbon cycle because of photosynthesis.

Photosynthesis is the basic process by which plants capture carbon dioxide from the atmosphere and transform it into sugars, plant fiber, and other materials. Within a

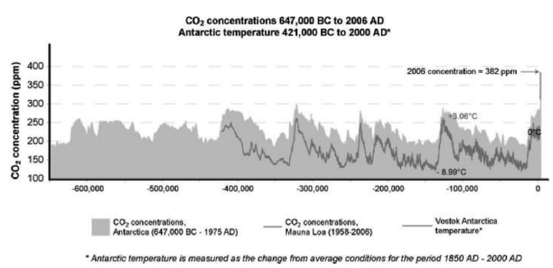


Figure 1-1. Changes in temperature and carbon dioxide (Source: US EPA 2008).

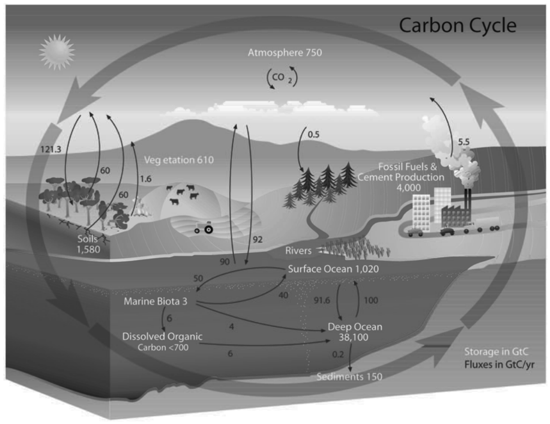


Figure 1-2. Carbon cycle, c. 2004. Black numbers indicate how much carbon is stored in various pools, in billions of tonnes (i.e., gigatonnes, Gt). Purple numbers indicate how much carbon moves between pools each year. The diagram does not include the approximately 70 Gt of carbonate rock and kerogen (oil shale) in sediments (Source: http://earthobservatory.nasa.gov/Library/CarbonCycle/carbon_cycle4.html).

given land area, this process is known as gross primary production. At the same time, plant respiration, which is necessary for plant growth and metabolism, liberates carbon dioxide back into the atmosphere. The resulting net gain of solid carbon compounds in plant fiber, known as net primary production, can be measured using established forest mensuration techniques. The overall accumulation of carbon within the ecosystem is known as net ecosystem production (Table 1-1) and includes other net carbon gains, many of which accrue in the soil and are difficult to measure accurately.

Trees and other vegetation store 610,000 tonnes (Mt, or 610 gigatonnes, Gt) of carbon (Figure 1-2) (1 tonne = 1 metric ton = 1,000 kilograms = 2,205 pounds). In the process of photosynthesis, trees and other plants take CO_2 from the air and in the presence of light, water, and nutrients manufacture carbohydrates that are used for metabolism and growth of both aboveground and below-ground organs, such as stems, leaves, and roots. Concurrently with taking in CO_2, trees utilize some carbohydrates and oxygen in metabolism and give off CO_2 in respiration. Vegetation removes a net of 500 million $MtCO_2$ (i.e., net primary production) from the atmosphere each year. When vegetation dies, carbon is released to the atmosphere. This can occur quickly (in a fire), slowly (as fallen trees, leaves, and other detritus decompose), or extremely slowly (when carbon is sequestered in forest products). In addition to being sequestered in vegetation, carbon is also sequestered in forest soils. Soil carbon accumulates as dead vegetation is added to the surface or as roots "inject" it into the soil. Soil carbon is slowly released to the atmosphere as the vegetation decomposes (Gorte 2007).

Since GHGs affect the radiative balance of Earth in similar ways, they can be compared using two measures, radiative forcing (externally imposed changes in Earth's radiative balance) or global warming potentials (GWPs); Leggett (2007, 23) calls the latter "an easier but imperfect approximation." GWPs are based on the properties of the most important GHG, carbon dioxide, which is emitted from human sources in by far the greatest quantities (US EPA 2007b). GWPs estimate the pound-for-pound potential of a gas to trap as much energy as carbon dioxide; thus a GWP of 23 indicates that 1 pound of this gas traps as much energy as 23 pounds of carbon dioxide (US EPA 2007b). The global warming potentials of the other principal GHGs are methane, 23; nitrous oxide, 296; hydrofluorocarbons, 120 to 12,000; perfluorocarbons, 5,700 to 11,900; and sulfur hexafluoride, 22,200 (Gerrard 2007).

Greenhouse Gas Emissions

Both natural processes and human activities produce GHGs. Here, drawing on Leggett (2007), we address only the human-related sources of the principal GHGs.

• *Carbon dioxide:* combustion of fossil fuels, solid waste, wood, and wood products; manufacture of cement, steel, aluminum, etc.

• *Methane:* coal mining, natural gas handling, trash decomposition in landfills, and livestock digestion.

• *Nitrous oxide:* nitrogen fertilizers, industrial manufacturing, and combustion of solid waste and fossil fuels.

• *Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride:* commercial, industrial, and household products.

Carbon dioxide is the most prevalent of the GHGs produced by human-related activities. In 2000, it constituted approximately 72 percent of human-related GHG emissions. Methane (adjusted for GWP equivalents) constituted 18 percent, and (adjusted for GWP equivalents) nitrous oxide constituted 9 percent (Leggett 2007). Table 1-2 indicates the human-related activ-

Table 1-1. Ecosystem productivity terms.

Term	Definition
Net primary production	Net uptake of carbon by plants in excess of respiratory loss.
Heterotrophic respiration	Respiratory loss by above- and below-ground heterotrophs (herbivores, decomposers).
Net ecosystem production	Net carbon accumulation within the ecosystem after all gains and losses are accounted for, typically measured using ground-based techniques.
Net ecosystem exchange	Net flux of carbon between the land and the atmosphere, typically measured using eddy covariance techniques. The term is equivalent to net ecosystem production but the quantities are not always identical because of measurement and scaling issues.

Source: Birdsey, US Forest Service, pers. comm., January 2008.

Table 1-2. Worldwide GHG emissions (CO_2, CH_4, N_2O, PFCs, HFCs, SF_6) by economic sector, 2000.

Sector	$MtCO_2$ eq.	Percentage[a]
Energy	24,722.3	59.4
Electricity	10,276.9	24.7
Transportation	4,841.9	11.6
Manufacturing	4,317.7	10.4
Other fuel combustion	3,656.5	8.8
Fugitive emissions[b]	1,629.3	3.9
Land-use change and deforestation	7,618.6	18.3
Agriculture	5,603.2	13.5
Waste	1,465.7	3.5
Industrial processes	1,406.3	3.4
International bunker fuels[c]	824.3	2.0
Total	41,640.5	100.1

[a] Percentages add up to more than 100 due to rounding.
[b] NO_2 data not available. Fugitive emissions include the leaking of refrigerants from air-conditioning and refrigeration systems.
[c] Fuels used by aircraft and ships.
Source: Data from WRI 2007.

Table 1-3. Ranking of emitters of GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6), 2000.

Country	$MtCO_2$ eq.	Percentage of world GHGs
1. United States	6,928	20.6
2. China	4,938	14.7
3. Russia	1,915	5.7
4. India	1,884	5.6
5. Japan	1,317	3.9
6. Germany	1,009	3.0
7. Brazil	851	2.5
8. Canada	680	2.0
9. United Kingdom	654	1.9
10. Italy	531	1.6
Top 10 countries	20,707	61.5
Rest of world	12,958	38.5
Developed countries	17,355	52
Undeveloped countries	16,310	48

Note: The total world $MtCO_2$ equivalent is different from that in Table 1-2 because Table 1-3 excludes land-use change, deforestation, and international bunker fuels (see Baumert et al. 2005, 12). This table presents the latest available GHG emissions information; countries' current GHG emissions may differ significantly.
Source: Adapted from Baumert et al. 2005, 12.

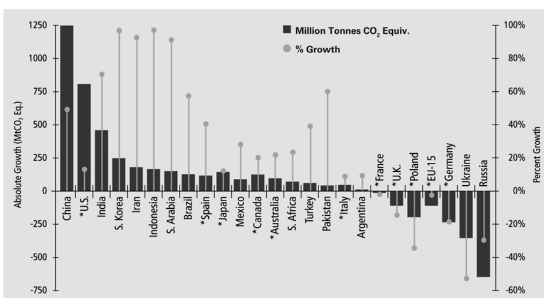


Figure 1-3. Carbon dioxide emissions growth, 1990–2002. * CO_2 plus five other GHGs (Source: Baumert et al. 2005, 15).

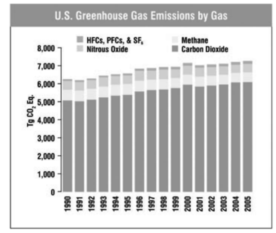


Figure 1-4. US GHG emissions (Source: US EPA 2007b, ES-4).

ities responsible for the 41,640.5 million tonnes of carbon dioxide equivalents ($MtCO_2$ eq.) of worldwide GHG emissions in 2000 (WRI 2007).

Table 1-3 lists the national shares of the world's GHGs. Relatively few countries produce the most global GHG emissions, in absolute terms, but the "largest GHG emitters have large economies, large populations, or both" (Baumert et al. 2005, 11).

Developing countries have the highest emissions growth rates (Figure 1-3). For example, Indonesia's and South Korea's GHG emissions increased 97 percent from 1990 to 2002, Iran's increased 93 percent, and Saudi Arabia's 91 percent (Baumert et al. 2005). China's emissions grew by about 50 percent from 1990 to 2002, but estimates indicate about 35 percent growth for 2003 and 2004 alone (Baumert et al. 2005). Although developed countries' increases are significant in absolute terms, their growth rates are smaller than those of many undeveloped countries.

In 2005, US GHG emissions were 7,260.4 million (7,260.4 teragrams, Tg) $MtCO_2$ equivalents (US EPA 2007b). From 1990 to 2005, US emissions rose 16.3 percent as the US gross national domestic product increased by 55 percent (Figure 1-4) (US EPA 2007b). However, because of the sheer size of US emissions, even this relatively small percentage increase in emissions (compared with other countries) contributed considerably to total GHG emissions. For example, US GHG emissions increases from 1990 to 2002 "added roughly the same amount of CO_2 to the atmosphere (863 $MtCO_2$) as the combined 64 percent emissions growth from India, Mexico, and Indonesia (832 $MtCO_2$)" (Baumert et al. 2005, 13).

Future Greenhouse Gas and Global Temperature Estimates

Since "emissions projections require estimating factors such as population, economic growth, and technological change, they are inherently uncertain. . . . Furthermore, past projections have a weak success record" (Baumert et al. 2005, 18). Nevertheless, all trends point to increasing GHG emissions and global temperatures. For example, the US Energy Information Administration's "midrange" scenario projects that global emissions will rise 57 percent from 2000 to 2025 (Baumert et al. 2005).

The increases are not expected to occur uniformly. For example, China was once expected to surpass the United States as the world's leading GHG emitter in 2020 (Gerrard 2007). However, the country's economic growth has been so fast that the date was moved up to 2009 or 2010. In fact, the most recent reports indicated that China would surpass the United States' CO_2 output by the end of 2007 and that by 2032, "CO_2 emissions . . . from China alone will be double the CO_2 emissions which will come from . . . [the United States,] Canada, Europe, Japan, Australia, and New Zealand [combined]" (Vidal 2007).

IPCC estimates that emissions will result in global warming of about 0.2°C (about 0.36°F) per decade for the next two decades (and even if emissions were held at 2000 levels, a warming of 0.1°C (about 0.18°F) per decade) (Solomon et al. 2007). Longer-term predictions are much less certain, but IPCC scenario projections estimate that global average surface temperature increases (relative to 1980–1999) will range from 1.8° to 4.0°C (3.25° to 7.2°F) for the 2090–2099 decade (Solomon et al. 2007).

Decades after the first generally recognized indications of global warming, the science of climate change remains contentious. While some scientists contend that the Earth's atmosphere is warming, polar ice caps are shrinking, and sea levels are rising because of anthropogenic increases in the concentrations of greenhouse gases, some say that the presumed causes are wrong, the reports overstated, and the predictions mistaken (e.g., Singer 2008; Bast and Taylor 2007; McKitrick et al. 2007). What is not at issue, however, is that forests play a central role in the balance of carbon stocks on Earth, and the policies now being developed and implemented to address climate change will be the more effective the more they incorporate forestry.

Potential Effects of Climate Change on Forests

Forests are shaped by climate. Along with soils, aspect, inclination, and elevation, climate determines what will grow where and how well. Changes in temperature and precipitation regimes therefore have the potential to dramatically affect forests nationwide.

Climate is also shaped by forests. Forest stands act as windbreaks, and forest canopies influence the interactions of soil, water, and temperature. Forests can act as a carbon sink, helping to offset greenhouse gas emissions; in 2003, US forests sequestered more than 750 million tonnes of CO_2 equivalent (US EPA 2005). Alternatively, afforestation in certain areas may reduce surface reflectivity, or albedo, such that any reductions in radiative forcing (warming) gained from increases in carbon sequestration are offset (Betts 2000). The interrelationship between forests and climate means that dramatic change to one will influence the other. In some situations, this feedback is negative, dampening further iterations. In other situations, however, this feedback is positive, building upon and exacerbating the initial change (e.g., Woodwell et al. 1998; Fleming et al. 2002).

The role of climate as a driver in ecosystem function is well established (e.g., Stenseth et al. 2002). A changing climate will affect forests in several ways, ranging from direct effects of temperature, precipitation, and increased atmospheric concentrations of carbon dioxide on tree growth and water use, to altered fire regimes and changes in the range and severity of pest outbreaks. Climate change has the potential to transform entire forest systems, shifting forest distribution and composition. Economically, climate change is expected to benefit the timber products sector (e.g., Irland et al. 2001). Overall harvests in the United States are expected to increase. In terms of lost timber value, suppression costs, and loss of recreation and ecosystem services, however, the costs of wildfire are expected to increase dramatically. Importantly, the specific implications of climate change for forests will vary greatly from place to place.

Ecological Effects

Global mean surface air temperature is expected to increase over the next century, as described in Chapter 1. Temperature minimums are expected to increase faster than maximums, and the growing season is likely to lengthen, especially in the middle and high latitudes (IPCC 2007). Changes in precipitation are likewise expected: tropical and high-latitude areas may experience increases in precipitation, and the subtropics and middle latitudes are expected to experience decreases (IPCC 2007). Heat waves will likely be greater in terms of frequency, intensity, and duration, while precipitation will become more intense but with longer intervals between events.

Climate change and an increased concentration of atmospheric carbon will affect forests on multiple levels. At the individual tree level, an increase in atmospheric carbon dioxide concentrations is expected to lead to increased levels of net primary productivity and an increase in overall biomass accumulation, primarily in the form of fine root production but potentially also through allocation to woody biomass (Ainsworth and Long 2005; Calfapietra et al. 2003; Norby et al. 2002, 2004, 2005). The exact response to elevated carbon dioxide concentrations, however, may vary by species and locale (Norby et al. 2002; Korner et al. 2005; Handa et al. 2005). In forests where photosynthesis is limited by CO_2 concentrations, the degree to which such an increase can be sustained over time will be limited by other factors, such as the availability of nitrogen or water (Kramer 1981; Norby et al. 1999; J.G. Hamilton et al. 2002). Active fertilization may allow for increased productivity under elevated atmospheric carbon dioxide concentrations, especially on nutrient-poor sites (Oren et al. 2001; Wittig et al. 2005). Apart from effects on individual productivity, increased atmospheric carbon dioxide concentrations are also expected to alter leaf chemical composition, affecting herbivore fitness as a result (Saxe et al. 1998). These latter ramifications have been shown to vary across species and other environmental variables, such as temperature (Lincoln et al. 1993; Bezemer and Jones 1998; Zvereva and Kozlov 2006).

Either in addition to or in concert with increased concentrations of atmospheric carbon dioxide, climate change–induced shifts in temperature and precipitation regimes are expected to affect individual trees' fitness and productivity as well (Saxe et al. 1998; Nabuurs et al. 2002; Sacks et al. 2007). Changes in absolute temperatures (e.g., frost, heat stress) as well as changes in the form, timing, and amount of precipitation (e.g., snow versus rain, drought versus flood) can affect forests directly. In boreal, temperate, and Mediterranean European forests, temperatures are expected to increase along with precipitation, raising productivity (Nabuurs et al. 2002). Other regions may experience increasing temperatures along with a decrease in absolute precipitation or a shift in the form of precipitation, possibly changing the seasonal availability of water in the form of snowpack or snowmelt and causing seasonal water shortages (Barnett et al. 2005; Trenberth et al. 2007). A water shortage can also counteract any productivity benefits from increased atmospheric carbon dioxide concentrations or a longer growing season (Wullschleger et al. 2002). Other atmospheric constituents can further exacerbate temperature and precipitation stressors. In particular, nitrogen deposition rates and ozone concentrations, which are expected to rise (IPCC 2007; Nabuurs et al. 2002), can magnify the effects of drought (Schlyter et al. 2006; Eatough-Jones et al. 2004).

The effects of climate and atmosphere on individual trees are borne out at the stand and forest system levels because individual fitness also influences susceptibility to pests, pathogens, and severe weather events (Schlyter et al. 2006). In addition, a warmer climate will likely allow herbivores and pests to expand in both number and range (Logan et al. 2003). For example, milder winters are expected to decrease winter mortality in white-tailed deer, exacerbating browse and forage damage (Ayers and Lombardero 2000). Species such as the rocky mountain pine beetle and the southern pine beetle are expected to expand their ranges, not only latitudinally but altitudinally as well, possibly exposing jack pine (*Pinus banksiana*) and whitebark pine (*P. albicaulis*) to new or increased levels of attack (Logan and Powell 2001; Williams and Liebhold 2002). In northern Europe, the spruce bark beetle, in the past usually limited to a single brood per season, will likely produce multiple broods with increasing frequency (Schlyter et al. 2006). In all, a warmer climate is expected to encourage pest outbreaks of increasing frequency, duration, and intensity (Volney and Fleming 2000; Logan et al. 2003; Gan 2004).

Climate change is also predicted to alter the frequency and intensity of severe weather events (Opdam and Wascher 2004; IPCC 2007). Any change in frequency or intensity, coupled with a change in individual or stand fitness brought about by changes in temperature, precipitation, or outbreaks of pests or pathogens, will affect forests. Species range and distribution may change as a result (Opdam and Wascher 2004).

Increases in the amount of downed or damaged timber, whether caused by weather, pests, or pathogens, combined with the direct effects of shifting temperature or precipitation patterns will strongly influence fire regimes. The effect may be exacerbated by another driver of fire, the increased human presence in the wildland-urban interface. In some areas, such as the Canadian boreal forest, an increase in precipitation may actually lead to a decrease in fire activity relative to historical rates (Bergeron et al. 2004). But in the western United States, climate change is thought to be a primary driver of the recent increase in fire frequency and duration (Westerling et al. 2006). In extreme cases, climate change–induced increases in fire severity and frequency may even facilitate the conversion of forestland into grassland (Flannigan et al. 1998). Although forest management and fuel removal may help counter the increased severity, intensity, and duration of wildfire, such activities may be insufficient to address the full effects of climate change on fire regimes (Westerling et al. 2006).

Under a changing climate, the combined and individual influences of temperature, precipitation, atmospheric carbon dioxide concentration, pests, weather, and fire will have dramatic effects on forest systems. The consequences will be seen in the distribution and composition of forests across entire landscapes. In particular, forest types are expected to migrate both latitudinally and altitudinally (Walther et al. 2002). In the Rocky Mountain zone, for example, a 3.5°C (6.3°F) increase in temperature is expected to shift habitat more than 2,000 feet in elevation or 200 miles north (Ryan 2000). Past episodes of climate change have witnessed forest migration rates of approximately 50 kilometers per century, with some species achieving even greater rates of migration (Schwartz 1993; Noss 2001). The current rate of climate change may exceed the rate at which forests can respond (Woodwell et al. 1998). To match current rates of warming, northward shifts of 500 kilometers over the next century may be necessary—a migration rate up to one order of magnitude greater than that witnessed in the past (Schwartz 1993). Past, present, and future fragmentation of forestland may inhibit dispersal and establishment, significantly reducing potential migration rates (Schwartz et al. 2001; Walther et al. 2002; Opdam and Wascher 2004). As a result, future rates of migration are expected to be at least one order of magnitude *slower* than those seen in the past (Schwartz 1993). Still, evidence does exist of long-distance migration over relatively short time frames (Clark 1998), and disturbance may actually facilitate dispersal by opening canopy (Schwartz et al. 2001). However, an increasing frequency of large-scale disturbances is likely to facilitate the spread of invasive species into forest systems as well (Iverson and Prasad 2002).

Adaptation is another mechanism by which forests can respond to climate change, but it is likely to occur at rates well below what is necessary to respond to expected changes (Opdam and Wascher 2004). A failure to adapt or migrate could result in species extirpation or extinction, or the conversion of forest to grassland or other systems (Iverson and Prasad 2002; Woodwell et al. 1998). This can be counteracted, at least to some extent if not entirely, by active forest management, including facilitated dispersal (Schwartz et al. 2001). Even with active forest management, however, species' ranges may shift enough to result in local, regional, or even national extirpation. For example, models have indicated that under various scenarios accompanying a doubling of atmospheric carbon dioxide concentrations, quaking aspen (*Populus tremuloides*), bigtooth aspen (*P. grandidentata*), sugar maple (*Acer saccharum*), paper birch (*Betula papyrifera*), and northern white cedar (*Thuja occidentalis*) all face potential extirpation from the United States (Iverson and Prasad 2002).

Shifts in forest species composition and range, along with the already-mentioned changes in temperature, precipitation, and fire regimes, will likely have tremendous implications for forest biodiversity. Widespread species response to climate change has already been documented (Parmesan and Yohe 2003). Old-growth forests may suffer increased mortality rates (e.g., van Mantgem and Stephenson 2007), with possible implications for wildlife habitat. Warming trends may lead to mismatches in the timing of once-synchronous events, such as bud burst, moth hatching, and peak food demand by nesting birds (Walther et al. 2002). Range shifts by individual species may alter system dynamics, resulting in new relationships and associations (Skinner 2007). Species with narrow niches will likely face decline or loss (Kirschbaum 2000). Changes in the form and amount of precipitation, along with associated water availability within a forest ecosystem, may directly affect bird, amphibian, and reptile communities by concentrating populations and increasing their vulnerability to parasites and pathogens (Pounds et al. 1999). Protected areas, the boundaries of which are largely static, may cease to protect targeted species, processes, features, or attributes (Halpin 1997; Burns et al. 2003). Some US protected areas may lose up to one-fifth of the species currently found within their boundaries, but expanding northern ranges may result in a net increase in the total number of species these areas contain (Burns et al. 2003).

Appropriate forest management can help reduce the negative effects of climate change on forests. A variety of management options and objectives exist, but recent comprehensive reviews suggest that no single management strategy will satisfy all needs in all situations (Millar et al. 2007). Apart from the aforementioned facilitated dispersal and fuels treatment activities, adjustment of rotation lengths and regional harvesting patterns can likewise mitigate the negative effects of climate change (Easterling et al. 2007). Preemptive harvesting of vulnerable stands, for example, may help contain pest outbreaks (Volney and Fleming 2000), and preventing further forest fragmentation and maintaining gene pools can help ensure that forest function and diversity are preserved (Noss 2001).

Social and Economic Effects

Climate change is expected to affect social and economic aspects of forests as well as forest ecology. The implications for nonwood forest products and services, such as biodiversity, recreation, and edible plants, are difficult to assess, in part because of the high uncertainty regarding the ecological effects.

The effects of climate change on one social aspect of forests, forest-based recreation, are complex. Some activities will witness a net benefit while others will suffer, depending on the type of activity, the seasonal nature of the activity, and the incidence of extreme weather events (Irland et al. 2001). Beach recreation at mountain lakes might benefit as a result of extended seasons, for example, but other uses that are sensitive to average temperatures and climatic variability, such as coldwater stream fishing and snow skiing, could lose (Alig et al. 2004). Lake-based recreation could be negatively affected if lake levels fall because of increased evapotranspiration and changing precipitation patterns (Irland et al. 2001).

Economic effects are likely to vary regionally, but uncertainty over specific impacts remain. Forest productivity is anticipated to continue to slowly rise as demand for industrial wood demand also climbs modestly. Globally, timber production is expected to increase (Easterling et al. 2007). The United States may see a net benefit to the timber products sector, with sawtimber production increasing relative to pulpwood (Irland et al. 2001). Future prices for solid wood and pulp have been examined in at least seven model simulations of climate change (Easterling et al. 2007), and it is expected that supply will meet demand. Most models predict price declines for both solid wood and pulp, which means consumers and mill owners would experience net benefits while landowners and producers would experience net losses (Irland et al. 2001). Harvests are expected to increase across large portions of the United States, especially in the South, where existing infrastructure and lower costs are favorable (Joyce et al. 1995).

Dramatic northern migration of forests accompanied by increasing dryness across the South could result in an opposite outcome, however, shifting increased production to the North (Shugart et al. 2003). Economic effects are predicted to be most sensitive to migration of southern pine northward, which could lead to positive economic outcomes; less optimistic are predictions of no increase in growth or perhaps even a decline in growth for southern softwood timber.

Any economic benefits resulting from changes in mean temperature or precipitation are likely to be outweighed by extreme events of increasing severity and frequency (Easterling et al. 2007). Research indicates that the local economic consequences, positive or negative, of increased extreme weather events can vary. Those events that limit site access may restrict supply in the short term, but events resulting in down or damaged timber and therefore salvage opportunities may increase short-term supply, with different consequences for private landowners and government agencies (DeWalle et al. 2003).

Plant damage from pests, such as the mountain pine beetle in the West and the gypsy moth in the East, will continue to be significant should recent warming trends and drought continue. Although quantitative analyses and modeling of climate change–related pest infestations are somewhat limited, studies have predicted that annual damage from the southern pine beetle alone will increase by four to seven-and-a-half times current levels, or $492 million to $869 million per year (Gan 2004). Furthermore, any pest damage will be amplified by climate extremes. Past research has attempted to capture the effects of interrelated stressors and disturbances (e.g., Fleming et al. 2002), but as yet, few models can fully simulate these interactions (Easterling et al. 2007).

More rain and less snow will mean greatly reduced spring snowpacks; California may see up to a 90 percent reduction in spring snowpack by the end of this century. Smaller snowpacks will lead to longer, drier summers and greatly increase the risk of wildfire and pests. The interactions between pest infestations and wildfire can enhance one another. A recent climate modeling study for the West shows that for Washington State, average annual area burned could expand two to five times by the end of this century (Casola et al. 2006). Modeling in California indicates up to a 55 percent increase in annual average area burned by the end of this century (Cayan et al. 2005). Larger burns would require continued and substantial increases in fire prevention and suppression costs—in just the past 18 years, fire management expenses of the US Forest Service have increased from 13 to 45 percent of the agency's budget (USFS 2007)—and mean an even heavier burden on both federal and state governments. One consequence is corresponding reductions in other resource programs. Moreover, wildfire's economic effects—on timber value, recreation receipts, ecosystem services such as water quality and quantity, human health related to air pollution—all could generate costs and consequences that are many times larger than the fire prevention, preparedness, and suppression costs (Climate Leadership Initiative 2007). Many other substantial economic costs due to wildfire will be felt across much of the nation. One example involves watershed effects: burned areas produce 25 times more sediment than unburned areas, with profound implications for debris cleanup (Loomis et al. 2003), including dredging of reservoirs.

Perhaps the largest economic effect on forests and forest management would come as a result of a cap on carbon emissions. Carbon pricing, considered an essential element of emissions mitigation policy (Stern et al. 2006), could increase the use of fuelwood or forest biomass relative to traditional fossil fuels (Easterling et al. 2007). A carbon price in conjunction with an established offset market could likewise encourage significant increases in domestic carbon sequestration through afforestation and changes in forest management practices (US EPA 2005).

Forest management can play a critical role in minimizing the negative effects of climate change on forests while maximizing positive ones (Shugart et al. 2003; Easterling et al. 2007). Specialized equipment (e.g., harvesters and trucks that achieve high fuel efficiency and minimize soil displacement) can help offset the negatives (DeWalle et al. 2003). Other mitigation or adaptive actions involve changes in gene management, forest protection, forest regeneration, silvicultural treatment, forest operations, maintenance of nontimber resources, and park management (Spittlehouse and Stewart 2003).

Preventing GHG Emissions through Wood Substitution

Wood substitution addresses climate change in several ways. Wood products from sustainably managed forests can be replenished continually, providing a plentiful and dependable supply of both trees and wood products while supporting other ecological services, such as clean water, clean air, wildlife habitat, and recreation (USFS 2005). Substituting wood for fossil fuel–intensive products also avoids the emissions from the substituted products, and what was forest carbon remains stored in the wood products.

Trees remove carbon dioxide (CO_2) from the atmosphere and store it in their roots, stems, trunks, and leaves through the process of photosynthesis. In addition, forested ecosystems store carbon in soil, forest floor, and down dead wood. As forests and their trees mature, their growth slows; however, some studies indicate that as tree growth slows, ecosystem storage of carbon may actually increase as a result of increases in other carbon pools (Zhou et al. 2006; Schulze et al. 2000). Although more definitive research is needed, it appears that both short-rotation management and long-rotation or old-growth management can lead to greater overall carbon sequestration. Intensively managed commercial forests, using short rotations, can sequester significant carbon if the wood products are long-lived (Perez-Garcia et al. 2005). Long rotations and old-growth management mean little or no carbon is stored in wood products but more carbon is stored in the ecosystem. If the only forest management goal is to sequester carbon, both short-rotation intensive management and old-growth management are appropriate; however, if the goal is also to produce wood products, then short-rotation management that leads to long-lived products would be the approach of choice.

Life-Cycle Assessments

Public interest in the environmental impacts of forest management has created demand for strategies and policies to improve environmental performance, some of which can have unintended consequences. Harvest reductions, for example, alter the availability of wood, and in turn, the price of building materials. This increases wood imports from other countries or causes consumers to use nonwood substitutes. The environmental consequences of these changes in material flow and uses are difficult to quantify because of the complexity of tracking materials through market transactions (USFS 2005), but contrary to intuition, the use of nonwood substitutes is often detrimental to the environment.

What exactly are the environmental benefits of substituting wood for steel and concrete? The Consortium for Research on Renewable Industrial Materials (CORRIM) was created as a not-for-profit consortium by 15 research institutions to update and expand a 1976 report by the National Academy of Sciences on the effects of producing and using renewable materials (Lippke et al. 2004). CORRIM developed a complete life-cycle inventory of all environmental inputs and outputs, from forest regeneration through product manufacturing, building construction, use, maintenance, and dis-

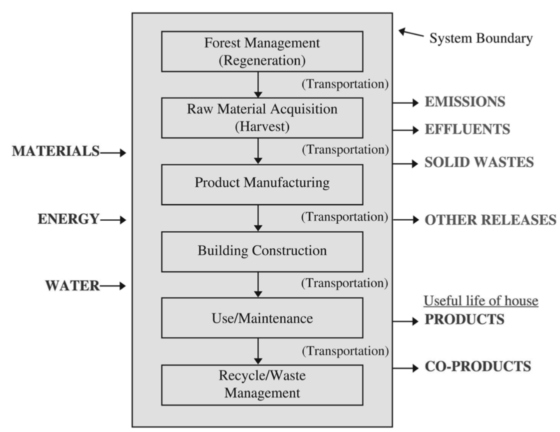


Figure 3-1. Life-cycle assessment from regeneration of trees to disposal of wood materials (Source: CORRIM Presentations, www.corrim.org/ppt/2005/fps_june2005/lippke/index.asp).

Table 3-1. Environmental performance indices for residential construction.

Minneapolis home	Wood frame	Steel frame	Difference	Percentage change
Embodied energy (gigajoules)	651	764	113	17
Global warming potential (kg CO_2)	37,047	46,826	9,779	26
Air emissions index (index scale)	8,566	9,729	1,163	14
Water emissions index (index scale)	17	70	53	312
Solid waste (total kg)	13,766	13,641	−125	−0.9
Atlanta home	**Wood frame**	**Concrete frame**	**Difference**	**Percentage change**
Embodied energy (gigajoules)	398	461	63	16
Global warming potential (kg CO_2)	21,367	28,004	6,637	31
Air emissions index (index scale)	4,893	6,007	1,114	23
Water emissions index (index scale)	7	7	0	—
Solid waste (total kg)	7,442	11,269	3,827	51

Source: Lippke et al. 2004, 13.

posal. It constructed virtual houses (of approximately 2,250 square feet, an average size) and used a life-cycle assessment to determine the associated energy use, air and water pollution, global warming potential, and solid waste production (Lippke et al. 2004). The virtual houses, using framing materials of wood, steel, and concrete, were "built" in two very different locations: Minneapolis (wood versus steel) and Atlanta (wood versus concrete).

Figure 3-1 depicts the life-cycle assessment for a wood-frame house. It includes transportation for each stage from forest management (regeneration) to harvesting, product manufacturing, building construction, use and maintenance, and recycling or disposal. Each stage of processing had different effects, providing insight into where opportunities for improvement could have the greatest overall benefit.

Forest resource management can positively affect climate change. However, implementation of any kind of management treatment requires forest operations, such as harvesting, processing or conversion, and transportation of biomass. These operations affect the GHG profile of forestry activities through the direct emissions of the equipment and the relative efficiency of handling biomass volume (Brinker et al. 2002). Operators employ a wide range of equipment and operational methods, from loggers with chainsaws to highly mechanized mass-production logging systems, to reduce environmental impacts and create economic efficiencies. Power technologies for forest equipment are changing with federally mandated transitions to different fuel types and cleaner diesel engines, and alternative-fuel equipment, including hybrids and biofueled machines, is being tested. Emission reductions must be assessed on a net basis. A low-emissions system may be relatively inefficient at processing carbon volume and thus a poor choice under climate change scenarios (Brinker et al. 2002). However, the energy requirements for harvesting and transportation are substantially lower than for product manufacture, where the energy required for drying is a major factor but can largely be provided by biofuels with negligible net greenhouse gas emissions (Puettmann and Wilson 2005).

Life-cycle inventory analysis reveals that the wood products used in construction store more carbon and use less fossil energy than steel, concrete, brick, or vinyl. Conversely, the manufacture of nonwood products is energy intensive and produces substantial emissions, including global warming potential (GWP) emissions (K. Skog, US Forest Service, Forest Products Laboratory, pers. comm., November 2007).

Table 3-1 presents the summary environmental performance indices for typical Atlanta and Minneapolis houses built to code. With two exceptions (solid waste in the Minneapolis house and water pollution in the Atlanta house), the index measures for the wood-frame designs are considerably lower than for the nonwood frame designs. Notice that for global warming potential, steel has 26 percent higher CO_2 equivalent than wood, and concrete, 31 percent higher CO_2. The difference is particularly significant considering that the framing accounts for only about 6 percent of the mass of the house; the rest of the house's materials are unchanged.

Life-cycle assessment of building systems, like walls and floors, shows that carbon emissions are very sensitive to design and product selection, with steel and concrete walls and floors producing several times more emissions than wood-dominant assemblies (Lippke and Edmonds 2006). Figure 3-2 shows the GWP differences for four floor designs, not including any insulation or floor covering. The concrete floor produces more than four times the GHG emissions of a dimensional lumber or wood I-joist floor. The steel design is much worse, releasing 731 percent more GWP than wood I-joist floors, largely because the horizontal application of steel in a floor requires a high gauge to reduce bending and bounce.

Figure 3-3 shows similar comparisons for an Atlanta wall, including insulation and cladding. The increase in GWP for the concrete wall over a kiln-dried lumber wall is similar to the floor comparison. The calcification process used to produce concrete increases the GWP for the concrete design's block, stucco, and lumber frame 427 percent compared with the kiln-dried lumber design's plywood, vinyl, and lumber (Lippke and Edmonds 2006).

Wood use can substantially alter environmental performance and reduce emissions, especially when wood is substituted for fossil fuel–intensive products and energy. For example, for a Minneapolis steel-stud wall, the steel and its required insulation have 44 percent higher GWP than the kiln-dried wood wall; both walls' cladding and gypsum contribute almost as much to emissions as the framing elements (Figure 3-4, columns 2 and 3). However, substituting wood siding for vinyl siding, wood paneling for gypsum, cellulose for fiberglass, and increasing biofuel use for drying reduces emissions by 75 percent (Figure 3-4, column 1).

Figure 3-5 illustrates the integrated effect of all carbon pools present in a forest as

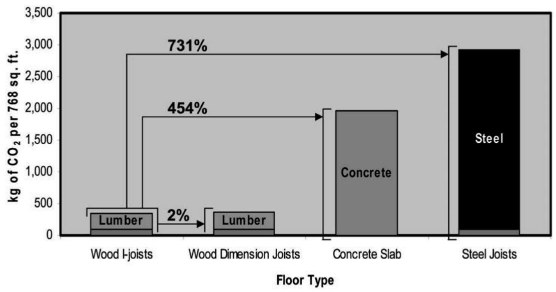


Figure 3-2. Global warming potential of alternative floor materials (Source: Lippke and Edmonds 2006, 63).

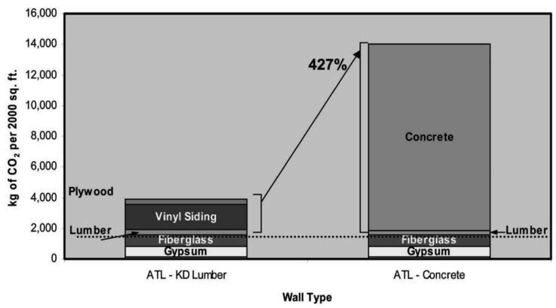


Figure 3-3. Global warming potential of alternative wall-framing materials, Atlanta. Materials below the dotted line are common to both wall designs (Source: Lippke and Edmonds 2006, 61).

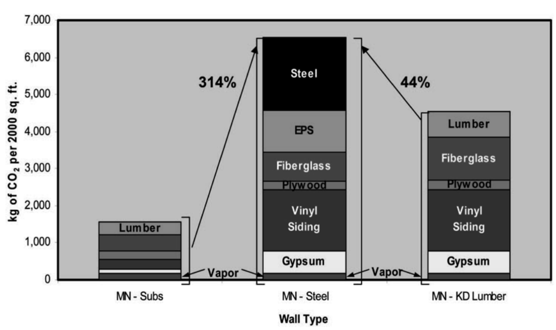


Figure 3-4. Global warming potential of alternative wall-framing materials, Minneapolis (Source: Lippke and Edmonds 2006, 61).

it matures, along with the carbon removed by product pools based on the life-cycle assessment. It shows a modest increase of carbon in the combined forest and product pools over time (lower red line), unlike the steady state that exists in a forest (green line; i.e., when wood products are not removed). More importantly, as wood products are substituted for fossil fuel–intensive building materials like concrete and steel framing (upper red line), emissions are avoided. The combined pools of carbon stored in the forest, forest products (net of processing, including the bioenergy from bark, or hog fuel, from mill waste), and avoided fossil fuel–intensive substitutes increase over time—with important consequences for carbon policy (USFS 2005).

CORRIM has also conducted life-cycle assessments for different kinds of wood products. Plywood sheathing has a 3 percent lower environmental impact in a completed house than oriented-strand board (OSB) (although OSB has fewer water-related environmental consequences, probably because at the time of the research, some OSB mills were in compliance with new, stricter water quality standards) (Lippke et al. 2004). Conversely, substituting wood dimension joists for engineered I-joists results in little difference in the environmental performance indices because the greater material efficiency of the I-joists is offset by the increased use of resins and energy (Lippke et al. 2004). However, material use efficiency is by itself very important, since only half as much fiber is used for engineered I-joists as for the equivalent dimension lumber joints.

Forest Rotations and Conversion

The sooner wood products can be produced from forests, the sooner they can displace the emissions from fossil fuel–intensive products. Thus, intensive, short-term commercial rotations, while storing less overall carbon in the forest, result in lower carbon emissions when life-cycle assessments include forest and product carbon storage as well as the emissions from substitute products. Some estimates indicate that a forest managed for wood production will provide a net sequestration at least double that of an unmanaged forest in the Pacific Northwest (B. Lippke, University of Washington, pers. comm., August 2007). If, however, the goal is to sequester carbon in the forest, management for long rotation and old-growth will lead to significant ecosystem carbon storage (Harmon et al. 1990).

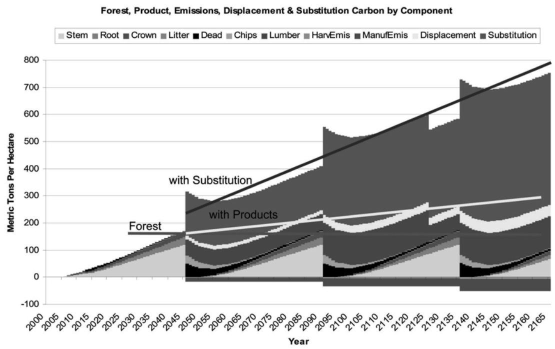


Figure 3-5. Carbon in forest, product, fuel displacement, and fossil fuel–intensive product substitution pools (Source: Perez-Garia et al. 2005).

Carbon stocks are affected by changes in land use. When forestland is converted to nonforest use, the carbon stored both on that land and in its wood products is lost, along with those products' potential to be substituted for fossil fuel–intensive products.

Unnaturally high fuel loads in many forests provide wood substitution opportunities. Thinning heavily stocked stands and using the wood in long-lived products or converting it into biofuel would avoid the carbon emissions associated with fossil fuels and fossil fuel–intensive products. These same areas would thus contribute to reduced GHG emissions and increased carbon storage in wood products, without the risks of GHG releases that overstocking can create if the forest burns (Chapter 5 addresses how GHG emissions can be prevented through wildfire behavior modification). Simulations have shown the reduction in emissions from carbon stored in products and displacement of fossil fuel–intensive products and fuels can be as much as five times larger than the carbon stored in Inland West forests in 100 years (Oneil 2007).

Wood Substitution Climate Change Policy

Policies intended to slow global warming can easily have unintended consequences. A policy that lowers the cost of wood, for example, would motivate builders and consumers to select wood framing and floors in residential construction. As the demand for wood rises, relative to fossil fuel–intensive materials, more investment in growing wood for this market would occur, resulting in further reductions in emissions. However, if a carbon credit is given only to growing trees in forests, it would likely lengthen rotations, reduce the production of wood products, and possibly increase the use of fossil fuel–intensive products, thereby increasing GHG emissions (B. Lippke, University of Washington, pers. comm., November 2007). Developing carbon credit markets that motivate true reductions in carbon emissions must address all carbon pools and their GHG emissions. Such markets will not be successful if they focus only on carbon stored in forests or a single stage of processing.

Measuring the life-cycle inventory of environmental impacts and assessing their effects across all stages of processing are critical to evaluating the consequences of different processes, product uses and designs, and forest management. The values (costs) of these impacts must be accurately reflected in the market if we want to motivate the changes in consumption and investments that will reduce carbon emissions. As an example, the Swedish parliament has recognized an opportunity to reduce GHG emissions by reducing the use of concrete in buildings and has instituted policies, educational campaigns, regulations, and building codes to promote the use of wood (Sathre 2007).

Although wood product substitution does not permanently eliminate carbon from the atmosphere, it does sequester carbon for long durations and can offset the use of more GHG-intensive products. When wood is harvested and used to make lumber, furniture, plywood, or other wood products, carbon is sequestered for the life of the given wood product. Once the wood product has served its useful life, landfill management techniques can further delay the conversion of wood to GHG emissions, or the wood can be used for power generation (offsetting generation by fossil fuel–fired power plants) or recycled into other potentially long-lived wood products. Regardless of the particular pathway followed after a product's useful life, wood substitution is a viable and important technique to immediately address climate by preventing GHG emissions.

Preventing GHG Emissions through Biomass Substitution

GHG emissions can be reduced through the substitution of biomass for fossil fuels that emit more GHG per functional unit. The production and use of biomass fuels and bio-based products is one way to reduce oil and gas imports and improve environmental quality. Biomass can be used as an offset for fossil fuels like coal, natural gas, gasoline, diesel oil, and fuel oil. At the same time, such uses can enhance domestic economic development by supporting rural economies and fostering new industries making a variety of renewable fuels, chemicals, and other bio-based products (California Biomass Collaborative 2005; English et al. 2006; J. R. Smith et al. 2007).

Biomass is the largest domestic source of renewable energy, providing 3.227 quadrillion BTUs (quads) or approximately 48 percent of the nation's renewable energy (EIA 2006). Of the 3.227 quads of biomass energy used in 2005, 2.114 quads (65 percent) came from wood. Of a total of 1.875 quads of industrial biomass energy in 2005, 1.460 quads, almost 88 percent, was used by forest industries, such as sawmills, oriented-strand board mills, and pulp and paper mills (EIA 2006). Most of the renewable energy used by forest industries comes either from their own industrial plant residuals or from wood residues purchased from other wood-using industries. Zerbe (2006) estimates that up to 10 percent of our nation's energy requirement could eventually be produced from wood, compared with the 3 percent we currently produce.

Studies of conversion technologies show that 1 dry ton of forest waste can be converted to 75 to 85 gallons of ethanol fuel or 550 to 650 kilowatt-hours of electricity. If only 30 percent of the estimated 368 million dry tons of forest waste available in the United States each year were in a suitable form and concentration to be converted to energy, these wastes could produce 9.2 billion to 10.4 billion gallons of ethanol or 67 billion to 80 billion kilowatt-hours of electricity (Perlack et al. 2005) (See Table 4-1).

Bioenergy Basics

Technologies for Converting Wood to Energy. The technologies for converting woody biomass to energy include direct burning, hydrolysis and fermentation, pyrolysis, gasification, charcoal, and pellets and briquettes (Bergman and Zerbe 2004; Zerbe 1983, 2006).

Direct burning. The most effective way to use woody biomass for energy is to burn it in a combustion system, such as a boiler, fitted with emissions controls. Net boiler efficiencies range from 60 percent for greenwood at 60 percent moisture content to 80 percent for oven-dried wood. Wood can also be cofired with coal or natural gas.

Hydrolysis and fermentation. In the pulp and paper industry, the hemicellulosic materials from wood can be extracted at the beginning of the process via hydrolysis and then fermented using enzymes to produce ethanol and other products. The remaining cellulosic materials are still available for producing pulp and paper.

Pyrolysis. The heating of wood with limited or no oxygen to prevent combustion, called pyrolysis, produces liquid fuel, char, and gas. Lower temperatures produce higher portions of liquid and char; higher temperatures produce more gas. Another process, "flash pyrolysis," produces liquid bio-oil. In flash pyrolysis, biomass is heated rapidly to 400° to 600°C in the absence of air, with 70 to 75 percent of the feedstock converted into bio-oil. The oil is somewhat corrosive, but it can be used as boiler fuel or, with subsequent treatment, diesel fuel.

Gasification. Gasification uses oxygen and heat to produce a synthetic gas ("syngas") from biomass. This process was used during World War II and earlier, when crude oil supplies were limited. Gasification can be used to power internal combustion engines or gas turbines to drive electrical generators. Energy efficiencies from gasification for generating electricity range from 22 to 37 percent, compared with 15 to 18 percent for steam produced from combustion.

Charcoal. The production of charcoal is a pyrolytic process. Charcoal is made by heating wood in airtight ovens or retorts, or in kilns supplied with limited amounts of air. The heat breaks down the wood into gases, a tar mixture (lignosulfonic acid), and charcoal. The potential fuel yield is only about half of the original energy content of the wood.

Pellets and briquettes. Wood pellets and briquettes are more fully processed and refined than chips, sawdust, chunkwood, and other forms of solid wood and are more uniform in size and physical properties, such as ash content. Wood pellets are easily combusted using sophisticated stoves or burners

Table 4-1. Biomass conversion factors.

1 green ton of chips	= 2,000 lbs. (not adjusted for moisture)
1 Bone Dry Ton (BDT) of chips	= 2 green tons (assuming 50% moisture content)
10,000 lbs. of steam	= 1 megawatt hour (MWH) of electricity
1 Megawatt (MW)	= 1,000 horsepower
1 MW	= power for approximately 750–1,000 homes

Note: A 50 MW biomass powerplant will use 1,200 BDT/day; 100 chip vans/day
Source: Adapted from TSS Consultants 2006.

with automatically controlled feeder systems. Premium wood pellets burn at an efficiency of 83 percent, which offsets the extra energy used in making them (Bergman 2004).

Energy Uses for Wood. Energy uses for wood include thermal energy for steam, heating, and cooling; electrical generation and cogeneration; and transportation fuels.

Thermal energy. Installations for converting wood into thermal energy for space heating and cooling generally involve four size units.

• *Micro scale:* Up to 1 megawatt (MW) for residences or schools. This can involve firewood furnaces or gasification units and the use of a boiler to produce warm air or hot water for pipe heating systems.

• *Small scale:* 1 to 5 MW to produce high-pressure steam for heating or to energize an air-conditioning system.

• *Medium scale:* 5 to 15 MW for larger institutions, such as community colleges or hospitals, involving various types of combustors and boilers.

• *Large scale:* More than 15 MW. These systems are common in the forest products industry, most commonly in dry kilns.

Electrical generation and cogeneration. Wood can be used to generate electrical power from steam-driven turbine generators or gas turbines. Most wood-powered plants in the United States are in the 10 to 20 MW range, but some are larger than 70 MW. The average biomass-to-electricity efficiency of the industry is 20 percent. The nearest-term low-cost option for using biomass in power generation is cofiring with coal (Bain and Overend 2002). Cogeneration or combined heat and power are a more efficient use of wood than for the production of electricity alone. Wood also has the potential to be used for fuel cells; the wood is converted to hydrogen, methanol, or ethanol to power fuel cells.

Transportation fuels. Ethanol and other transportation fuels can be produced from almost any source of woody biomass. Methanol, another liquid fuel, can be made from wood as an alternative to gasoline or diesel. Even gasoline can be made from wood, but this requires gasification of wood and its conversion to syngas. The most direct way of making gasoline and diesel from woody biomass or other organic feedstocks is through what is known as the Fischer-Tropsch (FT) gasification process.

Total Forest Biorefinery Concept. Currently, the Department of Energy and the forest products industry are looking at the potential for pulp mills to become a "total forest biorefinery" (Larson et al. 2006) (Figure 4-1). Some of the hemicelluloses from wood chips would be extracted prior to pulping and converted (by hydrolysis) into wood sugars, which can be fermented into ethanol and produce xylitol and acetic acid. The process would divert hemicelluloses and acetic acid from direct combustion into valuable byproducts without significantly reducing the yield of cellulose pulp.

Preliminary studies indicate that the process may be economically feasible and could add to the output of ethanol as a transportation fuel while enhancing economic returns for pulp mills. Another component of the total forest biorefinery concept is the gasification of spent pulping "black liquor," which is conventionally burned via direct combustion in a Tomlinson recovery boiler in pulp mills. Gasification would be used to produce a syngas (H_2 and CO) that could then be reformed by a catalytic process into various chemicals and transportation fuels (ethanol, methanol, dimethyl ether, and FT diesel).

The latter technology is still being refined and perfected. A recent report showed the potential to displace 2.2 billion barrels of oil annually, with an additional benefit of cutting approximately 91 million tonnes of carbon emissions annually, if the total forest biorefinery concept were adopted by the nation's kraft pulp and paper industry. A fully developed pulp mill biorefinery industry could double or more the liquid fuel production of the current corn-based ethanol industry in the United States (Larson et al. 2006).

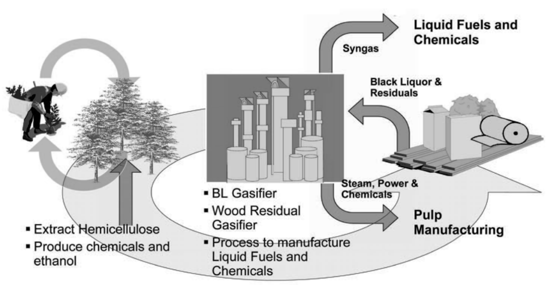


Figure 4-1. Total biorefinery concept applied to pulp and paper industry (Source: Pacheco 2005).

Biomass Energy Production and Greenhouse Gas Emissions

The use of wood to produce energy opens two opportunities to reduce GHG emissions. One involves using forest biomass for electrical power generation, rather than allowing it to accumulate and decay on site or removing it by open field burning. The other is the substitution of woody biomass as an energy source in place of fossil fuels.

Wood Burning and Greenhouse Gas Emissions. Biomass for power generation results in a 98.4 percent reduction in emissions compared with open field burning (Table 4-2) (Darley 1979). These ranged from an 84.8 percent reduction for nitrogen oxides to a 100 percent elimination of hydrocarbons.

Hasse (2007) compared emissions from biomass boilers with emissions from pile burning, prescribed burning, and forest fires (Table 4-3). He found a 99 percent reduction in carbon monoxide emissions, 30 percent for nitrous oxides, 96 percent for volatile organic compounds, and 89 percent reduction for PM10 particulates. Emissions from open burning also include methane (CH_4), which has a global warming potential of 23 (i.e., 1 pound of CH_4 emissions is equivalent to 23 pounds of CO_2).

It is estimated that the United States needs to build 1,200 new 300-megawatt power plants during the next 25 years just to keep pace with projected increases in demand for electricity (Hasse 2007). Coal, the most abundant energy source available in the United States, will likely continue to be a

Table 4-2. Open field burning versus biomass boiler emissions.

Pollutant	Open field burning (lbs./ton)	Biomass boiler (lbs./ton)	Percentage reduction for biomass boiler
Sulfur oxides	1.7	0.04	97.6
Nitrogen oxides	4.6	0.70	84.8
Carbon monoxide	70.3	0.40	99.4
Particulates	4.4	0.26	94.1
Hydrocarbons	6.3	0.00	100.0
Total	87.3	1.4	98.4

Source: Darley 1979.

Table 4-3. Pile burning, prescribed burning, and forest fire versus biomass boiler emissions.

	Pounds of emissions per green ton			
Disposal method	PM10	NO_x	VOC	CO
Pile burning[a]	19 to 30	3.5	8 to 21	54 to 312
Prescribed burning[b]	24	4.0	13	224
Forest fire[b]	15	4.0	21	140
Biomass boiler[c]	2.1	2.8	0.6	1.7
Average reduction (%)	89	30	96	99

[a] Werner (2000), available at http://www.arb.ca.gov/ei/see/memo_ag_emission_factors.pdf.
[b] Environment Australia, Emissions Estimation Technique Manual for Aggregated Emissions from Prescribed Burning and Wildfires, Version 1.0, September 1999.
[c] Based on Chiptec gasifier; other systems are similar.
Source: Hasse 2007.

major source of energy for electricity production. Electricity-generating plants are already the largest stationary source of GHG emissions from fossil fuels. How can the nation meet its energy needs without exacerbating air pollution and GHG emissions?

Although some energy needs can be met by renewable sources such as solar and wind, biomass must play a crucial role. Woody biomass, used as a feedstock to be burned or mixed with coal, presents a viable short- and mid-term solution to low-cost and large-scale alternative energy feedstocks. Cofiring wood with high-sulfur coal reduces sulfur air emissions and problems with mercury and other heavy metals. Cofiring woody biomass with coal on a 5 to 10 percent energy basis and using biomass with coal to produce liquid fuels are two possible clean energy solutions. Cofiring woody biomass with coal could provide a major increase in the demand for woody biomass for energy production. Woody biomass can also be added to oil- and gas-generated electric production processes to reduce GHG emissions (Morris 2007).

Wood-Based Liquid Fuels and Greenhouse Gas Emissions. Annual US gasoline consumption today is 140 billion gallons, and US diesel fuel consumption is 56 billion gallons. Each year the nation uses 6.5 billion barrels of oil but produces only 2.5 billion barrels of oil from domestic sources. That means that 4.0 billion barrels of oil has to come from foreign sources—and often from volatile parts of the world—to meet annual needs (Hasse 2007).

In February 2006, President Bush announced the Advanced Energy Initiative, designed to make cellulosic ethanol cost competitive with corn by 2012. The initiative has two goals:

- *"20 in 10":* replace 20 percent of today's gasoline usage in 2010 with biofuels.
- *"30 in 30":* replace 30 percent of today's gasoline usage in 2030 with biofuels.

In his 2007 State of the Union address, President Bush called for a mandatory 35-billion-gallon renewable fuel standard by 2017. A June 2007 Government Accountability Office report calculated 2006 ethanol and biodiesel production at 4.9 billion gallons a year, or 3 percent of the current US demand. It also estimated that the maximum annual production from corn ethanol would be 15 billion to 16 billion gallons, and from biodiesel, 2 billion gallons (Hasse 2007). This leaves an annual gap of 17 billion to 18 billion gallons of transportation fuels that will have to come from cellulosic and other feedstocks to meet the 35-billion-gallon renewable fuel standard. The gap could be filled by cellulosic ethanol made from wood. Given that 1 dry ton of forest waste can be converted to 75 to 85 gallons of ethanol fuel, 30 percent of the estimated 368 million dry tons of available forest residues could produce 9.2 billion to 10.4 billion gallons of ethanol (Perlack et al. 2005). If 60 percent of the residues were available to make cellulosic ethanol, potential production would be in the range of 18 billion to 20 billion gallons, making the President's mandatory renewable fuel standard of 35 billion gallons of renewable fuels achievable.

At present, increasing amounts of federal funding and venture capital are being channeled into the production of cellulosic ethanol. This is being driven by national security concerns about the increasing US reliance on foreign crude oil, concerns over greenhouse gas emissions and global warming, the realization that corn-based ethanol production will likely peak at 15 billion to 20 billion gallons by 2030, and associated economic development opportunities.

One major challenge in making cellulosic-based fuels is the development of improved technologies to reduce production costs. Another involves supply and demand: the production of renewable transportation fuels from cellulosic feedstocks could affect domestic supplies and costs for existing feed and fiber uses.

The production of cellulosic ethanol has been a subject of studies related to energy conversion efficiency. For the most part, studies show positive energy input-output ratios ranging from 4.40 to 6.61 (Tyson et al. 1993; Lynd and Wang 2004; Sheehan et al. 2004). The only exception has been a study by Pimentel and Patzek (2005), who report a negative energy ratio of 0.69. The difference stems from the assumption by Pimentel and Patzek that industrial process energy is generated by fossil fuel combustion and electricity rather than lignin combustion (Hammerschlag 2006). In most models, cellulosic production generates industrial energy with lignin combustion rather than fossil fuels and electricity, and thus fossil energy inputs are consistently far less than the energy value of ethanol and surplus electricity delivered. Hammerschlag (2006) also notes that cellulosic fuel is a developing industry, and more mature processes with considerably greater ratios of energy outputs to inputs are possible.

The National Renewable Energy Labo-

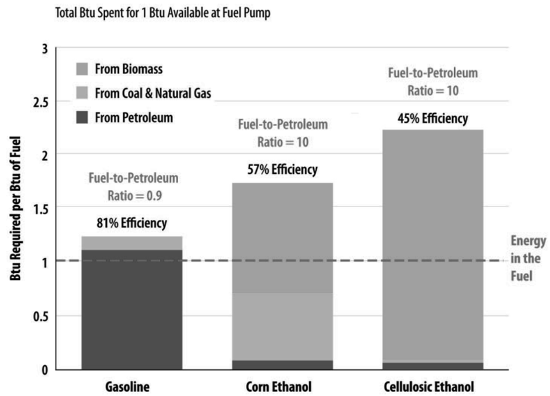


Figure 4-2. Energy required to produce fuels (Source: NREL 2006).

ratory has compared the energy required to produce gasoline, corn ethanol, and cellulosic ethanol, based on data by Wang et al. (2005) (Figure 4-2), and Roj (2005) has compared the energy efficiencies and greenhouse gas emissions from fossil and renewable fuels (Figure 4-3).

In 2007, the Environmental Protection Agency's Office of Transportation and Air Quality estimated the percentage change in life-cycle GHG emissions, relative to the petroleum fuel that is displaced, by a range of alternative and renewable fuels (Figure 4-4). The fuels are compared on an energy equivalent or BTU basis. For instance, for every BTU of gasoline that is replaced by cellulosic ethanol, total life-cycle GHG emissions would be reduced by 90.9 percent. These emissions account not only for CO_2 but also for methane and nitrous oxide. The cellulosic ethanol estimate represents an average mix of feedstock sources (including hybrid poplar, switchgrass, and corn stover) to produce ethanol through two production processes (a fermentation process, and ethanol produced from forest waste via gasification).

Woody Biomass Feedstocks and Their Availability

The research illustrated in Tables 4-1 and 4-2 and Figures 4-1, 4-2, and 4-3 demonstrate that substituting cellulosic biomass for fossil fuels greatly reduces GHG emissions. But is sufficient woody biomass available to address US energy needs?

Woody biomass essentially is any tree or part thereof and any associated woody plant materials. It includes wood from the bole (trunk) of the tree, limbs, tops, roots, and even the foliage. It includes trees that have been killed or damaged by fire, insects, diseases, drought, or wind or ice storms. It can also include trees that have been grown specifically for the production of energy wood—dedicated short-rotation tree or woody crops—and trees removed for fuel reduction, restoration, or other cultural treatments. In its broadest sense, woody biomass also includes raw materials as well as postconsumer recycled paper and wood products.

Nonmerchantable forest wastes and low-value trees can serve as a source for bioenergy feedstock, but there are infrastructure and sustainability challenges associated with the collection of these feedstocks. Collection and transportation costs of woody biomass can be significant and vary greatly from region to region. Although larger trees are generally more cost-effective to harvest and use, such trees usually have a higher value for traditional forest products, such as sawtimber, pulpwood, and manufactured panels.

Perlack et al. (2005) estimated that the United States can produce 1.3 billion dry tons of biomass annually on a sustainable basis. The Department of Energy's National Renewable Energy Laboratory and the US Forest Service estimate that 1.3 billion dry tons would roughly yield an energy heating value of 3.5 billion barrels of oil—equivalent to the US domestic oil production in 1970, the peak year of domestic oil production (Figure 4-5). The woody biomass component of these 1.3 billion dry tons is estimated to be 368 million dry tons. Perlack et al. (2005) note that this annual sustainable biomass estimate is conservative. The calculations exclude all protected wilderness and roadless areas, steep slopes, environmentally sensitive areas, and areas where regeneration would be difficult. Wood considered merchantable for other products was not counted, and the figure also accounts for physical limitations of on-site recovery and leaving sufficient woody debris on site to alleviate potential adverse effects on soil and water quality.

The estimated 368 million dry tons of annual sustainable woody biomass available

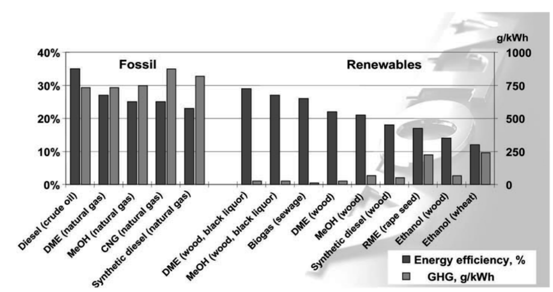


Figure 4-3. "Well to Wheels" analysis of energy efficiency and greenhouse gas emissions (Source: Roj 2005).

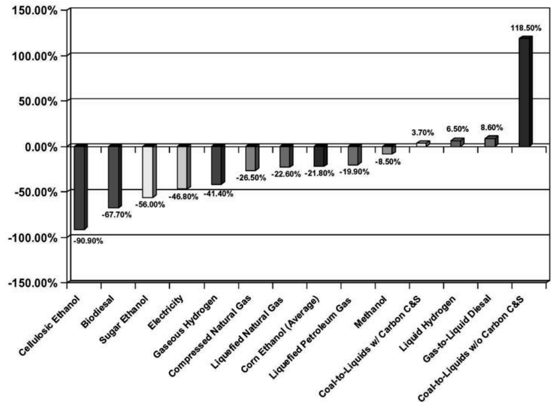


Figure 4-4. Life-cycle greenhouse gas emissions for renewable fuels compared with traditional gasoline (Source: US EPA 2007a).

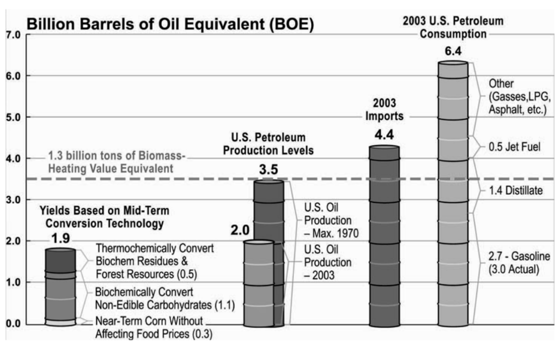


Figure 4-5. Heating value equivalent of biomass compared with oil production and consumption (Source: Pacheco 2005).

in the United States comes from several sources:

- logging and other residues (41 million dry tons);
- fuel treatments (60 million);
- fuelwood (35 million);
- forest products industry wastes (106 million);
- urban wood residues (37 million); and
- forest growth (89 million).

The last category, forest growth, warrants further discussion. The Fifth Resources Planning Act Timber Assessment of the US Forest Service projects the continued expansion of standing forest inventory despite an estimated conversion of about 23 million acres of forestland to other uses (Haynes 2003). The size of the standing forest inventory will increase because annual forest growth will continue to exceed annual harvests and other removals from the inventory. At the same time, the forest products industry will continue to become more efficient in the way it harvests and processes wood products. The demand for forest products is also projected to increase more slowly than in the past because of a general declining trend in the use of paper and paperboard products relative to GNP and the relatively stable forecast of housing starts (Perlack et al. 2005).

The Department of Energy and USDA analyses did not include wood that is currently merchantable at the lower size and quality specifications for conventional products, such as pulpwood and small sawlogs. Depending on local market conditions (e.g., low-price wood and/or high-price oil markets), this wood could be an additional resource for bioenergy and bio-based products. For example, the US South has vast forests that are being commercially thinned to improve stand quality. It is projected that approximately 8 million dry tons could be available annually from these treatments (Perlack et al. 2005). The reduction in pulp utilization in the United States resulting from the globalization of pulp production may make even more such thinnings available for energy in the future.

One forest management option for increasing the production of woody biomass is short-rotation energy crops using rapid-growing species such as alder, cottonwood, hybrid poplar, sweetgum, sycamore, willow, and pine. Perlack et al. (2005) did not count short-rotation tree energy crop production potential or account for possible production increases achievable through genetics or more intensive silvicultural practices. A yield figure of 8 dry tons per acre would add approximately 10 million dry tons annually to the estimated 368 billion dry tons of US woody biomass production.

Preventing GHG Emissions through Wildfire Behavior Modification

Wildland fires are a major contributor to national and international greenhouse gas emissions, adding as much as 126.4 million tonnes of carbon dioxide emissions in the United States during 2005 (US EPA 2007b). Active forest and wildland fire management strategies can dramatically reduce CO_2 emissions while also conserving wildlife habitat, preserving recreational, scenic, and wood product values, and reducing the threat of wildfires to communities and critical infrastructure.

Wildfire GHG Emissions

Smoke from wildfires emits particulates, CO_2, and other GHGs such as methane. The Environmental Protection Agency estimates that forest wildfire emissions in the lower 48 states and Alaska released an average of 105.5 million tonnes (range, 65.3 to 152.8) of carbon dioxide into the air each year from 2000 to 2005 (US EPA 2007b). Another study indicates that annual wildfire CO_2 emissions from 2002 to 2006 may actually average as high as 293 million tonnes per year, a major portion of which comes from forests (Wiedinmyer and Neff 2007).

To take one example, the July 2007 Angora wildfire in South Lake Tahoe affected only 3,100 acres of forestland, yet it released an estimated 141,000 tonnes of carbon dioxide and other GHGs into the atmosphere, and the decay of the trees killed by the fire could bring total emissions to 518,000 tonnes (Bonnicksen 2008). This is equivalent to the GHG emissions generated annually by 105,500 cars. In another example, Bonnicksen (2008) found that four California wildfires emitted an average 65 tonnes of greenhouse gases per acre and that with the release of CO_2 from decay over the next 100 years, the 144,825 burned acres will emit 35 million tonnes of greenhouse gases—equivalent to the annual emissions from half of California's 14 million cars. In 2006, wildfires burned nearly 10 million acres in the United States.

The Intergovernmental Panel on Climate Change describes the global impacts of smoke:

> Destruction of forest biomass by burning releases large quantities of CO_2 and is estimated to create 10 percent of annual global methane emissions as well as 10–20 percent of global NO_2 emissions. Thus, fire can have a significant effect on atmospheric chemistry (IPCC, 1992). The process is well known in terms of general effects, but it has many uncertain parameters in relation to specific fire events because fire effects are related to fuel amounts, arrangements, and conditions as well as weather conditions at the time of combustion—all of which can be highly variable or unpredictable (Goldammer, 1990; Dixon and Krankina, 1993; Price et al., 1998; Neuenschwander et al., 2000). (Sampson and Scholes 2000, 271)

The effect of particulates on climate change is uncertain (Kaufman et al. 2005). Some scientists contend that smoke reflects sunlight and reduces surface temperatures (Pearce 2005); others consider this phenomenon only temporary or transitory and say that long-term warming can result (Cess et al. 1985); still others believe that smoke may provide cooling in lower latitudes but warming in higher latitudes (R. Neilson, US Forest Service, pers. comm., October 2, 2007).

Wildfires in the United States and in many other parts of the world have been increasing in size and severity, and thus future wildfire emissions are likely to exceed current levels. Three strategies to reduce wildfires and their GHG emissions can address this trend:

- pretreatment of fuel reduction areas—that is, removing some biomass before using prescribed fire;
- smoke management—that is, adjusting the seasonal and daily timing of burns and using relative low-severity prescribed fires to reduce fuel consumption; and
- harvesting small woody biomass for energy, or removing larger woody material (over 4 inches in diameter) for traditional forest products and burning residuals.

Removing materials for bioenergy applications (described in Chapter 4) can reduce the threat of catastrophic wildfires and the net smoke and GHG emissions. In addition, active management of forest landscapes has the potential to decrease the area burned in catastrophic wildfires by 50 to 60 percent (Finney 2000). This reduces soil erosion and related watershed problems.

Prescribed fire managers follow stringent air quality and burn plan requirements. In addition to detailed weather and fuel modeling, prescribed burn emissions must comply with federal and state air quality requirements. These requirements include maximum allowable concentrations of the nine pollutants regulated by National Ambient Air Quality Standards (The Nature Conservancy n.d.; see also US EPA 2007c).

To qualify for emission reduction credits for prescribed burns, managers must comply with federal and state emission and smoke reduction standards. The Clean Air Act requires that emission reductions be real, quantifiable, permanent, verifiable, and enforceable. Some states (e.g., California, Florida, and Montana) have developed their own guidelines; however, the Environmental Protection Agency has published only interim federal rules.

Wildfire and Climate Trends

Catastrophic wildland fires in the United States during the past decade have added tens of millions of tonnes of carbon dioxide and greenhouse gases to the atmo-

Table 5-1. Largest fires in state history since 1960

Year	Fire	Location	Size (acres)
2004	Taylor Complex	Alaska	1,305,592
2006	East Amarillo Complex	Texas	907,245
2005	Southern Nevada Complex	Nevada	508,751
2002	Biscuit	Oregon	499,570
2002	Rodeo-Chediski	Arizona	468,638
2007	Murphy Complex[a]	Idaho	464,702
2007	Georgia Bay Complex[b]	Georgia	441,705
2007	Milford Flat	Utah	363,052
2000	Valley Complex (Bitterroot)	Montana	292,070
2003	Cedar	California	279,246
2000	24 Command	Washington	162,500
2002	Hayman	Colorado	137,760
2000	Kate's Basin	Wyoming	137,600

[a] The Murphy Complex burned a total of 653,100 acres in Idaho and Nevada.
[b] The Georgia Bay Complex burned a total of 564,450 acres in Georgia and Florida.
Source: Compiled from National Interagency Fire Center 2007.

sphere each year. Climate change, rural housing development, and human encroachment into wildlands will only exacerbate the problem (Field et al. 2007). Wildfires in the new millennium have even prompted new terms to categorize wildfires that are far beyond the scale of conflagrations in recent human history. "Megafire," for example, refers to one very large fire or a group of fires that burn into a single fire; "fire complex" refers to a series of fires in a short period of time within a specific area that are managed as one large fire.

Since 2000, at least 12 states have experienced the largest wildfires in their modern history (Table 5-1). Six of the worst fire seasons (including 2007) in the past 47 years, based on area burned, have occurred since 2000. Reduced rainfall and changes in seasonal weather patterns—primarily warmer, drier air masses—have influenced wildfire behavior. For example, the 2006 fire season started in January—an unusual time of year for catastrophic wildfires—when more than a million acres burned in Texas and Oklahoma, and extended drought and hot, dry weather in Georgia and Florida caused record fires from mid-April until July 2007.

Figure 5-1 shows the effectiveness of prevention, presuppression, and other efforts in reducing the number of fires since the mid-1980s. However, it also illustrates how increased fuel loads, climate change, and other factors have increased the total area burned, which indicates an increase in megafires. Drought and climate change may increase the risk of insect and disease epidemics, killing or weakening trees and adding to the dead fuel component. This often increases fire intensity and the GHG emissions released. Large-scale insect infestations can affect fire suppression tactics and firefighter safety because fuel loads have changed, increasing spotting potential and altering fire behavior and fireline intensity. Climate and weather influences will further complicate suppression challenges.

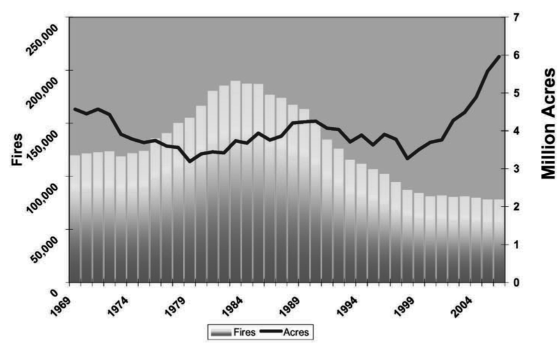


Figure 5-1. Ten-year averages of acres burned and number of fires (Source: Compiled from National Interagency Fire Center 2007).

Virtually all climate change models forecast an increase in wildfire activity, although IPCC cautions that "fire, insects and extreme events are not well modeled" (Easterling et al. 2007, 290). IPCC notes an increase in North American wildfires attributable, with "high confidence," to climate change: "the forested area burned in the western U.S. from 1987 to 2003 is 6.7 times the area burned from 1970 to 1986" (Field et al. 2007, 623, citing Westerling et al. 2006).

Even with a stable climate, the area burned and threats to humans may continue to increase with fuel buildup and human presence in wildlands. Encroachment and development, the proximity of population centers to wildlands, and more human-caused fires (both arson and accidental) all significantly increase the risk and consequences of wildfire, including the release of GHGs. It will take many years to reduce the tremendous fuel buildup in dry forest systems (such as ponderosa pine) whose historic fire regimes, characterized by frequent low-intensity fires, were interrupted by more than a century of wildfire suppression, grazing, logging, and a cooler and moister climate in the middle 1900s. Community wildfire protection planning, as authorized in the Healthy Forests Restoration Act of 2003 (P.L. 108–148) and described by the Society of American Foresters (2004), can address this problem. However, under extreme fire behavior scenarios, which could be exacerbated by climate change, increased accumulations of hazardous fuels will cause ever-larger wildfires.

Not all climate models paint a bleak future for forests. Research by the US Forest Service's Pacific Northwest Research Station indicates that the increase in precipitation associated with climate change may moderate fire behavior, even as the fire season lengthens and temperatures rise. Using the Mapped Atmosphere-Plant-Soil System (MAPSS) computer model, the Forest Service forecasts an increase in western woody and grass fuels (carbon capture) for the 21st century (USFS 2004). The pinion-juniper

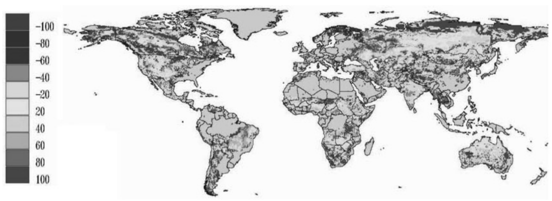


Figure 5-2. Comparison of the percent of biomass burned worldwide from 1951–2000 compared with projections for 2051–2100 (Source: Neilson 2007).

forest type has already expanded its range in the West. MAPSS models predict a dramatic shift to coniferous forests (mostly dry forest types, such as ponderosa pine) over the coming century. The forecasted changes for the East, however, under the MAPSS "moderate" climate scenario—a rise in surface temperature of 4.2°C (7.5°F) and an 18 percent increase in precipitation—reach a "tipping point" in carbon balance. Under the MAPSS "considerable warming" scenario—5°C (9°F) and a 22 percent increase in precipitation—a dramatic decrease in vegetation density is predicted to result in a net carbon loss for the United States. However, climate projections differ; for example, the most recent IPCC scenarios project increasing drought in the US Southwest (IPCC 2007).

Wildfire is not unique to North America, of course. For example, in summer 2007, international attention was focused on Greece when wildfire killed 64 people, burned more than 450,000 acres, and shrouded ancient ruins, such as the site of the original Olympics, in smoke. Though they received more media attention, these fires added much less CO_2 to the atmosphere than the estimated 28.9 million acres (11.7 million hectares) of wildfires that burned in the Russian Federation that same year. Figure 5-2 illustrates how climate change may increase the amount of biomass burned by wildfires (Neilson 2007). A 2002 international assessment estimated the 1998 wildfires in Siberia "released close to 180 million ton[ne]s of carbon to the atmosphere which contributed to the formation of 520 million t[onnes] of carbon dioxide, 50 million t[onnes] of carbon monoxide and other radiatively active trace gases and aerosol particles" (Global Fire Monitoring Center 2003, 8). The Global Fire Monitoring Center predicts that wildfires in Russia may consume 15 million to 20 million hectares (37 million to 49 million acres) per year during the next decade, and that the areas affected by wildfires in the Russian Federation "will increase by at least 50 percent or double over the next three decades" (Global Fire Monitoring Center 2003, 11).

Fuel Treatments

In 2000, in response to catastrophic wildfires, President Clinton convened a team of experts to craft a plan to focus federal efforts in preparing for and responding to wildfires. To protect communities and valued resources, the National Fire Plan recommended the reduction of hazardous fuels, which contribute to extreme fire behavior (SAF 2002). Federal agencies have emphasized fuel treatments under the plan, treating nearly 20 million acres from 2000 to 2006; more than half of these treatments were in the wildland-urban interface (USDI and USFS 2007). Treatments are principally intended to protect communities from catastrophic wildfire losses, but also serve to retain forest habitats across broader landscapes, thus ensuring the watershed, recreational, and economic benefits of forests for future generations.

Recently, federal agencies have shifted funds from land management programs, such as timber, wildlife, and recreation management, to wildfire suppression and hazardous fuel reduction. Federal agencies, especially the US Forest Service, "are compelled to transfer an ever-increasing amount of funds to fire suppression at the expense of other programs. In the past 18 years, the wildfire management portion of the agency's budget has gone from 13 percent to 45 percent" (McMahon 2007, 2).

Despite large fire budget increases, initial fire suppression success has remained relatively stable at around 98 percent; however, if fires escape initial efforts to contain them, large areas often burn. Climate change contributes to this challenge, as do administrative factors like reduced fire staffing, fewer elite crews trained to attack high-intensity wildfires, and inadequate resources for air attacks and logistical support. The Government Accountability Office has recognized the funding challenge: "as wildland fires become more frequent and severe as the climate changes, the costs of firefighting and rehabilitating land [increase]" (GAO 2007, 31).

Mason et al. (2006) see substantial net benefits from fuel removals despite the possibility of very high treatment costs, justifying public investments in reducing the risk of fire. Although hazardous fuel treatments can be costly because the small-diameter material is expensive to remove and has little merchantable value, the future costs of wildfire have been shown to be greater than the cost of treatments if one accounts for the many costs and benefits—not just the savings in firefighting but also the avoided fatalities, property losses, timber and wildlife habitat losses, postfire regeneration and rehabilitation costs, loss in community values, hydrological damage, and carbon emissions.

Forest thinning and fuel reduction treatments often create similar posttreatment stand structures. Forest thinning reduces competition for soil moisture and nutrients, helping trees resist attacks from insects and disease and withstand drought and weather anomalies. Thinning also removes dead trees and increases average tree diameter, providing landowners with increased revenue. The principal objective of fuel reduction treatments is to reduce "ladder fuels" that increase the potential for a wildfire to reach into the crown. Additional objectives are to reduce crown bulk density and to open up the canopy so that fuels are no longer continuous. These actions reduce the potential for wind-driven fires to carry from tree to tree (Peterson et al. 2005). Both treatments typically reduce stand densities from unnatural, overdense conditions of many hundreds of trees per acre to a fraction of that level (typically 25 to 60 trees per acre, depending on age and site conditions). A "thinning from below," or "low" thinning, can accomplish both fuel reduction and growth-and-yield objectives by removing the smaller trees in the stand. These types of thinnings are ideal for biomass and small-wood markets because they use materials that might be consumed by wildfires (and produce GHG emissions) and generate energy with biomass (rather than fossil fuels). 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 (Western Governors' Association 2006).

Fire is an essential ecological process in most forest landscapes, often serving as the primary recycling mechanism. Used appropriately, prescribed fire can be an effective hazardous fuel reduction strategy and an ecologically sound process. However, as noted by the US Forest Service and The Nature Conservancy, "short of rekindling primordial fires, the best way now to reduce the density of our forest stands that currently support many more trees per acre than in historical times is through mechanical thinning" (Kaufmann et al. 2005, 10). Even when mechanical methods of removal are employed, a follow-up prescribed fire is usually recommended to complete the consumption of fine fuels and residual slash.

Prescribed fire has numerous ecological benefits, including restoring native plant communities, stimulating the opening of serotinous cones, providing bare soil for seedling establishment, and reducing invasive species and competition for water and nutrients. However, significant reduction in soil carbon retention and potential carbon capture (regrowth) can occur when wildfires or prescribed burns occur in dry soil conditions. In most cases, removing some of the fuels through mechanical means prior to prescribed fire can meet the ecological objectives while also reducing emissions. Other benefits of combining mechanical and prescribed fire treatments include reducing the threat of escaped fire, allowing for better protection of desired habitat components (such as snags and downed logs), and ensuring a more precise vegetative structure and treatment result. IPCC summarized the challenges and opportunities for carbon management:

> Where fuel removal is carried out, wildfire ignitions are less likely to result—and when they happen, they will often burn at lowered severities, with reduced fuel consumption, heat production, and GHG emissions. Because fire management is an integral part of forest management, it must be viewed in connection with other management practices, including harvest and wood utilization, to evaluate its full carbon flux effect. (Sampson and Scholes 2000, 271)

Mechanical fuel reduction treatments can provide an opportunity to produce valued-added forest products (engineered lumber, pulp and paper, furniture), bioenergy, and other bio-based products. These forest products (discussed in more detail in Chapters 3 and 4) are byproducts of effective fuel treatment strategies to protect communities from wildfires, yet also provide stable, living wage jobs in rural communities.

Preventing GHG Emissions through Avoided Land-Use Change

Land-use change from forests to nonforest uses releases forest-stored GHGs into the atmosphere. Globally, forestland conversions released an estimated 136 billion tonnes of carbon, or 33 percent of the total emissions between 1850 and 1998—more emissions than any other anthropogenic activity besides energy production (Watson et al. 2000). Currently, tropical deforestation releases an estimated 2.6 billion tonnes of carbon annually (Malhi and Grace 2000).

Recent land-use change trends in the United States differ from the global trends (Figure 6-1). In the United States, agricultural land is decreasing, and forestland and developed land are increasing. Developed and urban lands expanded from 73 million acres to 108 million acres from 1982 through 2003, while nonfederal forestlands grew slightly, from 402 million acres to 406 million acres (NRCS 2007). Although the afforestation of agricultural lands offset the losses from development of forestlands, future afforestation opportunities will likely decrease.

US Forests as GHG Sinks

Land uses offset approximately 14 percent of US GHG emissions in 2005 (US EPA 2007b). Forests sequestered the vast majority of those emissions (Table 6-1).

More carbon is stored in forests than in agricultural or developed land. Each year in the United States, forestlands sequester an additional 190 million tonnes of carbon in vegetation and soils (84 percent of all carbon sequestered by land use), whereas developed land sequesters only 12 percent (US EPA 2007b). Harvested biomass from forests also provides other offsets to GHG emissions when used for energy (see Chapter 4). Activities on developed lands consume more fossil fuels and produce more associated emissions than activities on forestland. Future increases in forest-based carbon sequestration (based on forest growth) depend on the availability of forestland. Loss of forestland to other uses also limits the potential positive net sequestration effects of technological advances in tree growth and silvicultural practices.

Forest conversion and land development liberate carbon from soil stocks. For example, soil cultivation releases 20 to 30 percent of the carbon stored in soils. Malhi and Grace (2000) estimate that nearly 3 billion tonnes of carbon is sequestered in the US Northeast's 117 million acres, 62 percent of which is forestland; if all those forests were developed, 400 million to 600 million tonnes of sequestered carbon would be released into the atmosphere from the soil

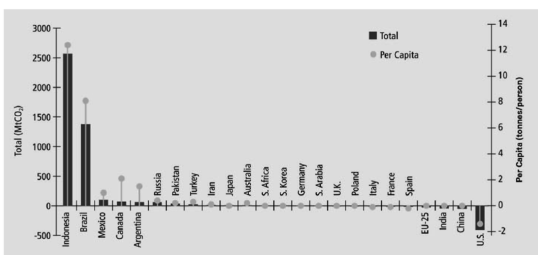


Figure 6-1. CO_2 from land-use change, total and per capita, 2000 (Source: Baumert et al. 2005, 15).

Table 6-1. Net GHG emissions from land uses ($MtCO_2$ eq.).

Land-use category	1990	1995	2000	2001	2002	2003	2004	2005
Forestland	(598.5)	(717.5)	(638.7)	(645.7)	(688.1)	(687.0)	(697.3)	(698.7)
Cropland	(28.1)	(37.4)	(36.5)	(38)	(37.8)	(38.3)	(39.4)	(39.4)
Grassland	0.1	16.4	16.3	16.2	16.2	16.2	16.1	16.1
Settlements (urban trees)	(57.5)	(67.8)	(78.2)	(80.2)	(82.3)	(84.4)	(86.4)	(88.5)
Other (land-filled yard trimmings, food scraps)	(22.8)	(13.3)	(10.5)	(10.6)	(10.8)	(9.3)	(8.7)	(8.8)

Parentheses indicate net sequestration of GHGs (i.e., carbon sinks).
Source: US EPA 2007b.

alone (Sampson and Kamp 2007). Additional emissions would occur from the loss of the forest biomass, since a third of a tree's biomass is located in its root system (Malhi and Grace 2000). The net loss of these carbon stocks would depend on the carbon emissions and sequestration characteristics of the new land use.

Conversion of forestland to cropland is a case in point. Though not associated with forest biomass, nitrous oxide, which has a global warming potential (GWP) of 296, is produced naturally and emitted from soils by microbial processes. The application of nitrogen-based fertilizer to agricultural lands increases the concentration of nitrous oxide in the soil. Since 2000, the release of nitrous oxide from agricultural soil management has averaged 255 million tonnes of carbon equivalent. Within the same period, forest soils released nitrous oxide averaging 300,000 tonnes of carbon equivalent (US EPA 2006). Conversion of forestlands to agricultural lands, which is likely if energy policies favor corn-based ethanol over cellulose-based ethanol, would increase the release of nitrous oxide.

Forest soils can be a sink for methane, which has a GWP of 23. Worldwide, soils sequester 20 million to 60 million tonnes of atmospheric methane per year, equivalent to 400 million to 1,300 million tonnes of carbon (Reay et al. 2001). Soil microbes capture atmospheric methane in a process known as methane oxidation. Research has shown that forest soils are more effective than other land uses in storing methane, particularly in the well-aerated soils of temperate forests, and that the conversion of forest to other uses reduces methane oxidation. Experiments suggest that increased nitrogen inhibits the ability of the soil bacteria to oxidize methane. Methane oxidization also diminishes with increased soil moisture, such as in wetlands and peatlands, which tend to be methane sources (Bradford et al. 2001; Reay et al. 2001).

Forest vegetation also plays a vital role in affecting surface temperatures through its surface albedo. Forests tend to have a lower albedo than other land uses and thus reflect less shortwave radiation into the atmosphere. Although this effect can increase temperatures at the surface, particularly in tropical regions, atmospheric temperatures are reduced by the absorption of shortwave radiation. Converting forestland to other uses increases surface albedo and reflection of shortwave radiation. This produces a net cooling of surface temperatures in some regions but also results in increased radiation in the atmosphere, similar to the effect of heat trapping from GHGs (Betts 2001).

Threats to Retaining Forestland

Increases in Land Value. Land values associated with low-density development in much of the United States have increased substantially in the past two decades while the value of land for timber production has remained stable or declined. For example, forestland in the US Southeast has been appraised for forest use at $415 per acre and for urban use at $36,216 (Alig and Plantinga 2004). Similarly, there is a significant disparity in the Pacific Northwest between the values of land for timber production ($1,000 per acre) and low-density residential development ($20,000 per acre) (Partridge and MacGregor 2007). The forestland conversion rate to urban and developed uses exceeded 1 million acres per year between 1992 and 1997, and another 23 million acres of forestland nationwide is expected to be lost by 2050 (Alig et al. 2003). This conversion would cause significant net releases of GHGs currently stored in these forests, as well as preclude future forest-based sequestration opportunities.

Landowners generally convert forestland to residential and commercial uses to capture increasing land values; however, damaging agents can also trigger conversion. When forests in the wildland-urban interface are damaged by wildfire, insects, or other disturbances, the decision to sell land for development rather than invest for long-term reforestation can be attractive to landowners. Since climate change may increase the prevalence of these disturbances, forestland conversion may increase in the future.

Land values associated with agricultural crop production can reverse the recent cropland-to-forestland trend. For example, a 1999 study of Alabama Conservation Reserve Program participation found that 89 percent of acreage enrolled in tree planting was likely to remain in forests and the remainder would return to agricultural use (Onianwa and Wheelock 1999). Recent increases in agricultural crop production, especially corn and soybeans, and the development of new energy crops, such as switchgrass, may increase reversion rates to cropland. Although agricultural land is generally viewed as more environmentally desirable than developed land use, cultivation releases organic carbon into the atmosphere. Soils contain up to 60 percent of the carbon stored in temperate forests (Lal 2005). When tillage occurs on recently converted forestland, 24 to 43 percent of the soil organic carbon is emitted. In the Southeast, first-year soil-based carbon losses of 9 tonnes per acre are common but have been measured as high as 15 tonnes per acre. Soil-based carbon losses decrease in subsequent years (Franzluebbers 2005).

Effects of Taxation. Property taxes and other tax policies may increase the cost of maintaining forestland and contribute to decisions that lead to forestland loss. The annual property tax on forestland is frequently the largest annual management expense in a forestry investment and results in poor financial returns followed by shifts away from forest investments (Gayer et al. 1987). Landowners are sometimes forced to sell their lands to pay the federal estate tax imposed after inheritance of forestland. For example, one study determined that 16 percent of Mississippi forestland owners who owed estate taxes sold land and/or timber to comply with the requirements (Cushing et al. 1998).

Changes in Ownership. Ownership structure affects forestland retention. Nearly two-thirds of the 620 million acres of forestland in the United States is privately owned, with 4 of every 10 forested acres being owned by "family" forest owners. In 2004, the average age of family forest owners was 60 years (Butler and Leatherberry 2004). Inheritance patterns and laws will likely increase the number of owners controlling smaller and smaller tracts. There is little evidence that the new generation of landowners will pursue commercial forest management as a primary objective. Furthermore, the logistics of implementing forest management practices become more difficult as forest tract size decreases. Even where reforestation vendors and timber harvesting companies have the ability to operate on small tracts, the high costs of these operations are often prohibitive and further encourage the abandonment of forestland management (Cubbage et al. 1989). Nevertheless, some future owners of small tracts may pursue forest management to support other goals, such as wildlife habitat improvement. Encouragement and assistance to help these small landowners pursue forestry on their lands can help maintain sequestration and storage of carbon and other GHGs.

The structure of corporate forestland ownership is also changing. Most vertically integrated forest products companies within the United States have sold large portions of their forestland holdings within the past 15 years. Within the South alone, more than 18.4 million acres of industrial forestland was sold between 1996 and 2005 (Clutter et al. 2005). The majority of this industrial forestland has been sold to timber investment management organizations (TIMOs) and real estate investment trusts (REITs), which usually pursue forest uses under a 10- to 15-year planning horizon. The financial objectives of some financial organizations could increase pressures for land-use change to development (Clutter et al. 2005).

Tools for Forest Retention

Forestland retention can occur in various ways—through public ownership of forests, higher values of forest products grown in private forests, land-use planning and related regulations on private forestlands, monetary incentives to capture the values of ecological services, and conservation easements, whether alone or as a part of other value programs.

Public Forest Ownership. Publicly owned forestland in the National Forest System and other federal and state ownerships is the least likely to be converted to other uses. Existing public forests sequester an estimated 40 million tonnes of carbon each year (Smith and Heath 2004). Efforts by states to purchase private forests continue in some areas, such as Washington State. However, concerns have been raised about the loss of the economic development values of forest production areas, diminished private ownership tax base values, and the need for government funding in other areas. This means efforts to prevent GHG releases from forestland conversion must focus primarily on retaining privately owned forestlands.

Income from Forest Products. The objectives of the private individuals and organizations that own forests range from timber production to recreational uses. Financial returns associated with forestland ownership are important to the forest industry and to TIMOs and REITs (Clutter et al. 2005). A National Woodland Owners survey indicates that approximately 30 percent of US family forestlands are owned by those who consider timber production very important or important. This number increases to 41 percent in the South, where the majority of forestland is privately owned (Butler and Leatherberry 2004). Maintaining or increasing the income potential from forest products provides incentives for forestland retention by these owners. Recent globalization and wood product substitution trends have reduced the income potential from traditional US forest-grown products (Haynes et al. 2007). However, recent advancements in developing new products, such as cellulosic ethanol and engineered wood products, may add value to working forests. Bioenergy-related products can be produced from portions of trees that have been traditionally considered nonmerchantable, as well as from the merchantable portions of trees. Sustainable utilization of working forests for a combination of wood products, including bioenergy, can improve forest landowners' returns on their land, bolster continued interest in forest management, thwart conversion to other uses, and prevent potential carbon emissions.

Land-Use Policy and Planning. Land-use planning and associated regulations have been used on large and small scales to restrict development and prevent the conversion of forestlands. Oregon's land-use planning program uses a regulatory approach to retain forest and agricultural lands. Cathcart et al. (2007) estimated that Oregon's program will prevent the conversion of 204,688 acres of forestland between 2004 and 2024. However, land-use regulation can restrict forest landowners' management options and may increase forestland conversion (Mortimer et al. 2006; Prisley et al. 2006).

Local governments have developed transfer of development right (TDR) systems to protect forestland and farmland near the wildland-urban interface (Daniels and Lapping 2005). TDRs are usually implemented through land-use planning and allow higher-than-usual-density development in certain areas in exchange for the developer's purchasing development rights from owners of nearby forests and farms (Daniels 1991).

Value of Ecological Services. Forests provide an array of ecological services, such as purifying air and water, protecting soil, and providing habitat for wildlife. These services have long been recognized and have been both regulated and subsidized by federal, state, and local governments. However, only recently have projects been developed to capture the real value of these services for private landowners. For example, an Environmental Protection Agency program allows commercial and residential developers who destroy wetlands to pay forestland owners to create and maintain wetland forests and forest riparian areas (US EPA 1990).

As Chapter 8 details, some markets for forest carbon offset projects provide landowners the ability to "capture" the ecological value that their lands provide by sequestering GHGs. These markets may provide the additional income that encourage private landowners to retain forests.

Conservation Easements. Conservation easements prevent the future development of private lands by imposing limitations on land uses and development rights (Sauer 2002). Land under conservation easements in the United States more than doubled, from 2.6 million acres to 6.2 million acres between 2000 and 2005 (Alvarez 2007). Conservation easements provide landowners tax benefits and allow landowners and easement holders to tailor development restrictions to meet the needs of each situation. The easements are typically established in perpetuity and are not easily changed after initiated. Working-forest conservation easements and the accompanying management plans generally allow for the management of forests for a variety of uses (timber, recreation, wildlife habitat) while preventing commercial and residential uses (Mortimer et al. 2007). Other conservation easements are designed to allow the ecosystem to change naturally over time with little or no vegetation management. Although conservation easements are voluntary legal mechanisms, they may be required as a condition of participation in other conservation programs, such as the trading of development rights and environmental mitigation programs.

chapter 7

Reducing Atmospheric GHGs through Sequestration

Previous chapters have evaluated the roles of forests and forest products in *preventing* GHG emissions through wood substitution, biomass substitution, modification of wildfire behavior, and avoided land-use change. This chapter considers the role of forests and forest products in *reducing* GHG emissions. Among all possible options for reducing or mitigating GHG emissions, forests are unique in that they contribute to both goals while simultaneously providing essential environmental and social benefits, including clean water, wildlife habitat, recreation, forest products, and other values and uses.

Forest Carbon Pools

As the most efficient natural land-based carbon sink, forests play an important role in global carbon cycling. The world's forests cover 4,100 million hectares (Mha) and contain 80 percent of all above-ground carbon (Dixon et al. 1994). The greatest threat to forests is land-use change and deforestation in the tropics, which contribute about 18 percent of global greenhouse gas emissions (Stern et al. 2006). Consequently, forests are critical to stabilizing carbon dioxide and oxygen in Earth's atmosphere.

Globally, forest vegetation and soils contain about 1,146,000 million tonnes (Mt) of carbon, with approximately 37 percent of this carbon in low-latitude forests, 14 percent in mid latitudes, and 49 percent at high latitudes (Dixon et al. 1994). The greatest changes in forest sequestration and storage over time have been due to changes in land use and land cover, particularly from forest to agriculture (Caspersen et al. 2000; Bolstad and Vose 2005). More recently, changes are due to conversion from forest to urban development, dams, highways, and other infrastructure.

Forestland in the United States covers 302.3 Mha (33 percent) of the land base. These forests contain 71,000 MtC, with about 35 percent in living biomass, 51 percent in the soil, and 13 percent in dead material including the forest floor (Heath, Smith et al. 2003). The average rate of sequestration from 1953 to 1997, not including wood products, is estimated at 155 MtC/yr (Heath, Smith et al. 2003). A similar estimate from direct measures in 28 eastern forests during the late 1980s to early 1990s indicated a net uptake of 170 MtC/yr above ground (Holland et al. 1999).

Productive, nonreserved forestland (timberland) in the United States constitutes 204 Mha and is commonly considered the forest base potentially available for management. The average rate of carbon uptake on timberland is approximately 0.53 tC/ha/yr, with a potential uptake capacity (estimated by IPCC 2000) of 108.1 tC/ha (Kimble et al. 2003).

Because the area of US forests is so vast, even small increases in carbon sequestration and storage per hectare add up to substantial quantities. Private forestland holds 63 percent of total forest carbon, indicating the importance of private lands in policies or incentives aimed at sequestering carbon. In western forests, most carbon per unit area is in the hemlock–Sitka spruce type, which has 353.6 tC/ha; chaparral has 105.6 tC/ha. In eastern forests, aspen-birch has 309 tC/ha, and loblolly-shortleaf pine carries 163 tC/ha (Heath, Smith et al. 2003).

Urban forests are increasingly being recognized as important carbon sinks; they cover about 28 Mha, with tree cover averaging 27 percent (Birdsey and Lewis 2003; Kimble et al. 2003). This tree cover qualifies them as "forestland," which is often defined as cover exceeding 10 percent. Nowak and Crane (2002) estimate that urban trees, which cover 3.5 percent of the US land base, store 700 MtC with an annual sequestration rate of 22.8 MtC/yr. The potential for expanding the cover and extent of urban forests for both direct and indirect benefits on mitigating climate change makes them increasingly important and potentially cost-effective in sequestering and storing carbon (McHale et al. 2007).

Typically, forest soils contain a high proportion of carbon, and management practices are consequently very important in their potential effects on carbon storage. Within forest biomes as a whole, 68 percent of the carbon is in the soil, but the proportion is 50 percent in tropical forests, 63 percent in temperate forests, and 84 percent in boreal forests (Kimble et al. 2003). In southern Appalachia, Bolstad and Vose (2005) estimated the average allocation of carbon in above-ground biomass at 37 percent, mineral soil 44 percent, coarse roots 10 percent, surface litter 8 percent, and fine roots 1 percent; percentages varied depending upon the forest system. The potential net carbon sequestration in forest soils is 48.9 to 185.8 MtC/yr, with an average of 105.9 MtC/yr (Heath, Kimble et al. 2003). Immediately after harvesting, carbon in soils increases, then declines below initial values for about a decade, and ultimately increases (Heath and Smith 2000). Given the high proportion of carbon in forest soils, management of forest ecosystems should limit exposure and potential for increased soil temperature, which increases rates of decomposition, soil respiration, and erosion (Birdsey et al. 2006).

Forest CO_2 Uptake and Sequestration. In the process of photosynthesis, trees take up CO_2 from the air and, in the presence of light, water, and nutrients, manufacture carbohydrates that are used for metabolism and growth of both above- and below-ground organs. Concurrently with taking up CO_2, trees utilize some carbohydrates in metabolism and give off CO_2 in respiration. Consequently, in evaluating the capacity of trees and forests to sequester and store carbon, the important metric is net carbon uptake and storage.

Because the chemical reactions of respiration are temperature driven, increases in air temperature critically affect net uptake and storage of carbon. Studies on Douglas-fir and pine trees in Washington and California have shown that net CO_2 uptake is markedly lower in midday under conditions of summer stress, when temperatures are high and water content in both air and soil is low (Helms 1965). With climate change–induced higher temperatures, environmental stress is likely to increase. This will lower the capacity of plants to have positive net gains in carbon uptake, which could contribute to changes in forest type boundaries. The trend is offset to some extent by a general rise in worldwide forest productivity due to CO_2 fertilization and nitrogen deposition—both, ironically, products of anthropogenic atmospheric pollution. For example, conifer plantations in northern Britain are reportedly growing 20 to 40 percent faster than in the 1930s because of increased nitrogen deposition, atmospheric CO_2, and temperature (Cannell et al. 1998).

Net rates of CO_2 uptake by broad-leaf trees are commonly greater than those of conifers, but because hardwoods are generally deciduous while conifers are commonly evergreen, the overall capacity for carbon sequestration can be similar. Mixed-species, mixed-age stands tend to have higher capacity for carbon uptake and storage because of their higher leaf area.

The capacity of stands to sequester carbon is a function of the productivity of the site and the potential size of the various pools, including soil, litter, down woody material, standing dead wood, live stems, branches, and foliage. In part, this is related to the capacity of stands to grow leaf area: the more leaves, the greater the stand capacity for photosynthesis and biomass production, but also the greater loss of CO_2 in respiration. Other stand dynamics that can influence sequestration capacity include age class distribution and shade tolerance. In the long run, stands of shade-tolerant species growing on high-quality sites typically have more leaf area, grow more wood, and sequester more carbon than stands of shade-intolerant species. On similar sites, stands of intolerant species initially have higher rates of wood production and carbon sequestration,

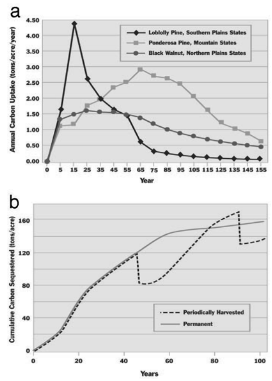


Figure 7-1. (a) Carbon sequestration rates. (b) Carbon accumulation rates for loblolly pine (Source: Richards et al. 1993).

which culminate earlier but do not grow as much wood, overall, as shade-tolerant species.

The rate of CO_2 uptake by trees and stands is primarily a function of species, site quality, temperature, and availability of water and nutrients. Young trees and young stands have higher rates of carbon sequestration but lower levels of total amount stored; older trees and older stands have lower rates of net uptake because, as trees age, mortality and respiration are higher. However, older stands have higher carbon storage, providing carbon is not lost to insect depredations or wildfire.

Figure 7-1 illustrates two important principles. First, young trees, and fully stocked stands of young trees, have high rates of net carbon uptake that culminate earlier for rapidly growing shade-intolerant pines than for less rapidly growing, more shade-tolerant trees, which are initially slower growing but culminate growth later and sequester more carbon overall (Figure 7-1a). Thus management practices using very short rotations of trees such as poplars and eucalypts are appropriate for intensive biomass production. Second is a general relationship involving long rotations starting from bare ground: the total amount of carbon accumulated in a given stand increases over time and reaches a plateau, after which net carbon accumulation remains relatively constant as net CO_2 uptake tends to zero because of increases in stand respiration, mortality, and decay (Figure 7-1b). Indeed, the first State of the Carbon Cycle Report acknowledges that carbon absorption by vegetation, primarily in the form of forest growth, is expected to decline over time because maturing forests grow more slowly, take up less carbon dioxide from the atmosphere, and might become carbon neutral (King et al. 2007). The report suggests that older forests could become a net carbon source because of emissions from wildfires. Figure 7-1b also shows the effect of two thinnings on carbon accumulation. In particular, after thinning, between stand ages 45 and 90 years for loblolly pine, the rate of carbon accumulation reverts to the level for stand ages 20 to 45 years. These general relationships are similar to those governing the familiar relationships between periodic and mean annual wood increment.

Carbon Release from Forests. Forests also release carbon and can become net sources of carbon to the atmosphere, particularly after a disturbance or in newly regenerated stands when soils are exposed during harvesting and site preparation. After disturbance, heterotrophic soil respiration is greatest in young forests and declines as forests age. Pregitzer and Euskirchen (2004) reported that mean temperate net ecosystem productivity in forests aged 0–10, 11–30, 31–70, 71–120, and 121–200 years was −1.9, 4.5, 2.4, 1.9, and 1.7 MgC/ha/yr, respectively. As forests become older, the amount of carbon released through respiration and decay can exceed that taken up in photosynthesis, and the total accumulated carbon levels off. This situation becomes more likely as stands grow overly dense and lose vigor, and it will become more probable in areas where climate change causes higher temperatures. However, as maturing forests become less productive, they may continue to accumulate carbon in coarse woody debris, the forest floor, and the soil.

Wildfires are the greatest cause of carbon release. In 2006, 96,385 wildfires burned 3,997,467 ha in the United States. Although 83 percent were human-caused, aggressive fire suppression policies over past decades and other factors have resulted in greatly increased fire hazard conditions that tend to make wildfires catastrophic and stand-replacing. From 1997 to 2006, 24,122,967 ha burned (National Interagency Fire Center 2007). The amount of carbon released by wildfires is difficult to estimate because of the great variability in fire intensity and fuel loads. It is estimated that every dry ton of forest biomass burned releases roughly 1.3 to 1.5 tonnes of CO_2, 0.05 to 0.18 tonnes of carbon monoxide, and 0.003 to 0.01 tonnes of methane (Sampson 2004). Average emissions might be 29 tonnes of CO_2 equivalent per hectare (Sampson 2004). Therefore, the amount of greenhouse gases emitted in 2006 through wildfires could be 128 $MtCO_2$.

Climate change–induced increases in wildfire occurrence and intensity will increase the tendency for forests to become a source rather than a sink for carbon (Dale et al. 2001; Nitschke and Innes 2006; Westerling et al. 2006). Changes in the fire regime could even overshadow the direct effects of climate change on species distribution and migration (Dale et al. 2001; Nitschke and Innes 2006). Limiting the extent of wildfires through forest management would therefore contribute greatly to mitigating climate change. For example, Lippke et al. (2006) estimated that, primarily as a result of reduced forest fire emissions and increased long-lived forest production, 56 percent more carbon could be stored over a 50-year period in a managed than in an unmanaged forest in eastern Washington.

Historically, insects and disease have caused mortality on approximately 1.6 Mha/yr in the United States (Birdsey and Lewis 2003). Recent years have seen a number of large outbreaks of pine beetles and other insects that appear to be directly related to a warming climate. In 2006, the mountain pine beetle epidemic in British Columbia destroyed 9.2 Mha of lodgepole pine forests, for a cumulative effect of 14 Mha (Carrol et al. 2004; BC Ministry of Forests and Range 2007). In 2003, 1.5 Mha of pinyon pine forests in eight states of the Southwest was affected, with mortality reaching 90 percent. Tree mortality caused by insects and disease in recent years thus equals or exceeds that caused by wildfires.

Other important forest disturbances include hurricanes, ice storms, droughts, and floods. In 2005, Hurricane Katrina affected 2 Mha of forest in Mississippi, Louisiana, and Alabama, killing or severely damaging approximately 320 million large trees and releasing, over time, approximately 105 million tonnes of carbon dioxide to the atmosphere—roughly the net annual sink in US forest trees (Chambers et al. 2007). Harvesting occurs on approximately 4 Mha/yr, with 62 percent being partial harvests. Interestingly, the area harvested annually in 1907 was 3.8 Mha (Birdsey and Lewis 2003).

In general, forests may be either carbon sinks or sources, depending on their age and health. Unmanaged, older forests can become net carbon sources, especially if probable losses due to wildfires are included (Oneil et al. 2007). Because of the variable conditions of US forests, particularly overstocking on federal lands, forest management has substantial opportunities to both enhance sequestration and reduce carbon emissions, particularly by reducing carbon lost because of wildfires, insect and diseases, and avoided conversion of forests to other land uses.

Enhancing Storage and Reducing Emissions

Forests of all ages and types have remarkable capacity to sequester and store carbon. Enhancement of this capacity depends on ensuring full stocking, maintaining health, and reducing losses due to tree mortality, wildfires, insect, and disease. Addressing each of these issues requires management that controls stand density by prudent tree removal; this provides society with renewable products, including lumber, engineered composites, paper, and energy, even as the stand continues to sequester carbon. Above all, enhancing the role of forests in reducing GHGs requires keeping forests as forests, avoiding conversion to other land uses, increasing the forestland base through afforestation, restoring degraded lands, and increasing tree density on understocked areas.

The Western Forestry Leadership Coalition (2007) suggests that two active forest management approaches should be considered to enable forests to provide ecological, social, and economic benefits to society in the face of the environmental stress associated with climate change. The first approach is adaptation, which involves positioning forests to become more healthy, resistant, and resilient. The second is mitigation, in which forests and forest products are used to sequester carbon, provide renewable energy through biomass, and avoid carbon losses due to fire, mortality, and conversion. On any given area of forestland, adaptation and mitigation objectives at the same time could be either complementary or incompatible. A complementary situation would occur where activities to maintain healthy, resilient forests also reduced the risk of uncharacteristically severe wildfire, CO_2 emissions, and damage to watersheds, and where the byproducts of such activities are used to offset fossil fuel burning. Incompatible competition could occur, for example, on some parts of national forests, where the objectives of sequestering high levels of carbon may conflict with adaptation needs that require reducing carbon stocks.

Adaptation. As described in Chapter 2, climate change will likely create stress on forest systems, changing competitive relationships among species and altering the tendencies for species to be more or less successful in a given locality. In general, species are expected to move northward in latitude and upward in elevation, although there will likely be opportunistic expansions and contractions of species and communities as habitat suitability changes. Scientists suggest that existing biological communities will change as individual species move in response to changing climatic conditions and chance events. Thus, existing communities are likely to disassemble, species by species, and then reassemble, perhaps into communities or "novel ecosystems" that have no analog today (Hobbs et al. 2006). This makes predicting future plant associations exceedingly difficult.

An important question is whether management can help forest systems adapt to new environmental conditions. Can management protect, enhance, modify, or adapt to changing ecosystem values? Because past experience may no longer be a valid basis for management planning (Perschel et al. 2007; Millar et al. 2007), the first task is anticipating what kinds of changes can be used as a basis for informed decisionmaking. In particular, Breshears et al. (2005) ask, can we identify what triggers ecosystem change and how well can we judge the extent of change? It is perhaps especially important to identify the potential response of overstory, or "keystone," species—those that will rapidly alter ecosystem type if they lose vigor or die (Breshears et al. 2005). By the end of the century, the climate of 55 percent of western US landscapes may be incompatible with today's vegetation (Rehfeldt et al. 2006). Therefore, predicting the composition and distribution of future plant communities from contemporary climate profiles in large, heterogeneous physiographic regions may be impossibly complex (Rehfeldt et al. 2006).

Already, past protracted droughts and water stress have triggered large-scale dieoffs and landscape changes. In the Southwest, massive outbreaks of bark beetle infestations have occurred in ponderosa pine and pinyon pine. Not only are these accompanied by possible shifts in forest ecotones, but there are other ramifications as well, including potential runoff and erosion, effects on associated wildlife, changed competitive relations of understory species, and altered dynamics of carbon sequestration and storage. Similarly, changed climate, particularly warmer winters, appears to be responsible for triggering the current epidemic outbreaks of mountain pine beetle in the lodgepole forests of British Columbia and Colorado.

Consideration of how management might address changed climate–ecosystem relations focuses attention on modeling. However, land managers should use model results and generalizations regarding climate change with great caution. Model projections at global and regional scales may indicate climate trends with confidence, but it is much more difficult to assess trends at the local scales important to land managers. This is particularly important in topographically complex mountainous areas, where high-quality, daily meteorological data at fine spatial scales are needed (Daly et al. 2007). It is even more difficult to assess trends in biotic responses to anticipated climate change and, with confidence, judge the likelihood of shifts in species and communities of forest biota at spatial scales consistent with local management and ownerships. Management is further complicated by the need to understand interactions among landscape fragmentation and population mobility and dynamics (Halpin 1997). Responding may incur greater risk than doing nothing (Spittlehouse and Stewart 2003).

Nevertheless, models can provide very useful guides. An example is the work of Rehfeldt et al. (2006), who modeled 35 expressions of temperature, precipitation, and their interactions in the context of plant-climate relations for the western United States. They showed that global warming should increase the abundance of montane forests and grasslands at the expense of subalpine, alpine, tundra, and arid woodlands. Important factors were the ratio of summer to annual precipitation and the summer-winter temperature differential, together with complex interactions. Rehfeldt et al. suggest that although future vegetation may retain the general characteristics of deserts, grasslands, and forests, it is commonly likely to support quite different plant associations. As climate changes, plant fitness may deteriorate, which activates evolutionary processes. Modeling efforts are becoming increasingly sophisticated, and rapid advances are being made in predictive capacity. To better guide understanding and response to change, increased capability is needed in analysis at the landscape rather than the regional level (Rehfeldt et al. 2006). A good example is the effective use of models for the Greater Yellowstone Ecosystem, where temperature and temperature-related variables have been used to describe the distribution of whitebark pine in relation to tree line (Schrag et al. 2007). Insights into the adaptation of plants to changing conditions can also be obtained by reexamining the relative performance of species and varieties planted in seed orchards and progeny test sites, and consulting studies of range-wide comparisons.

So, how might management adapt to possible climate changes? A prudent approach is that the greater the uncertainty and risk, the greater the flexibility in setting both short-term and longer-term goals and decisions (Perschel et al. 2007; Millar et al. 2007). No single solution is likely to fit all future challenges, and it is best to mix strategies (Millar et al. 2007). Three adaptive strategies based on understanding ecological processes rather than structure and function are currently being discussed (Perschel et al. 2007; Millar et al. 2007): increasing resistance, increasing resilience, and assisting migration.

Increase resistance. Resistance is the capacity of an ecosystem to avoid or withstand disturbance, such as anticipated increased insect and disease epidemics and wildfires. Management actions would aim at forestalling damage and protecting valued resources, such as water, endangered species, wildland-urban interface areas, and special forest stands. Treatments to be considered include thinning of overstocked stands, prescribed burning, removal of invasive species, and restoration of native species. Since it may not be feasible to conduct treatments at the landscape scale because of fragmented ownerships and jurisdictions, implementation of this strategy could include identifying which populations are most at risk and which areas in the landscape are more likely to be buffered against the effects of changes in climate (and thus act as refugia).

The likely benefit of this approach is that it is proactive (planned and implemented before a disturbance event) and has a high probability of being successful. A potential drawback is that the scale of the disturbance could be sufficiently large to overcome the capacity of the forest to resist its effects, with negative consequences for the forested ecosystem.

Increase resilience. Resilience is the capacity of an ecosystem to regain functioning and development after disturbance. Management actions would aim at retaining desired species even if sites become less optimal. Possible treatments include 1) promoting diversity in species and age classes when replanting or conducting other treatments after a disturbance event; 2) broadening genetic variability of seedlings when reforesting after harvesting, fires, or other disturbances; 3) supporting existing forest communities while allowing transitions to new forest types; 4) identifying and enhancing possible refugia prior to disturbance; and 5) enhancing landscape connectivity so that ecological movement can take place unimpeded across the landscape, including prevention of further forest fragmentation and restoration of ecosystem processes, such as watershed function and hydrologic processes.

Likely benefits are that management can identify and plan actions in advance of a disturbance and then implement postdisturbance treatments. Planning postdisturbance actions focuses attention on which system components are most likely to be altered when changes might come about. Potential drawbacks are that actions may be taken to restore or enhance ecosystems based on past climate and experience, whereas climate change may be driving the area toward new assemblages of species. Managers should identify the appropriate vegetation communities needed for restoration forestry in conditions of change.

Assist migration. What might be needed to enable an ecosystem to adapt to changed conditions? Management actions would seek to facilitate the transition of an ecosystem from current to new conditions. Consideration would be given to introducing different, better-adapted species, expanding genetic diversity, encouraging species mixtures, and providing refugia. This approach is highly controversial—it involves taking action based on modeling and other projections for which outcomes or expectations are highly uncertain—and is in a youthful stage of development (McLachlan et al. 2007).

However, modeling at the global, regional, and landscape levels can be combined with current species climate distribution maps to suggest where tree species populations may migrate over the next century in response to various climate change scenarios. Models can possibly be used in a decision support context informing management on how to consider the potential risks and benefits of assisting migration.

Assisted mitigation might be considered in several circumstances: 1) where, after a fire or insect or disease outbreak, planting of the original species is predicted to fail; 2) on the edge of an ecotone where new species are known to be migrating into the area in a manner that validates the climate change models for the region; 3) for rare, threatened, or endangered species that are endemic to a small area and not expected to be successful in migrating without assistance; 4) new species could be added to the mix of trees being planted if these are not expected to have negative ecological consequences; and 5) where refugia have been identified as places to plant and "store" endangered species.

Assisting migration would require the development of policies and guidelines addressing the precise conditions under which species should be moved into new areas and lay out protocols for the detailed monitoring required (McLachlan et al. 2007). Because of its controversial nature and the risk of unanticipated consequences—for example, the planted species might become an invasive in its new range, or climate change might not occur in the expected manner—this level of experimentation within forested ecosystems may not win public or scientific support.

Changes in climate already appear to be occurring. It seems prudent, therefore, that adaptive approaches to management be considered. The considerable risk and uncertainty notwithstanding, the diverse values of forest ecosystems are too high to simply do nothing. The hallmarks of future forest management should be flexibility in both short-term and long-term planning, increased use of modeling, increased monitoring to detect the occurrence and direction of change, and adaptive management.

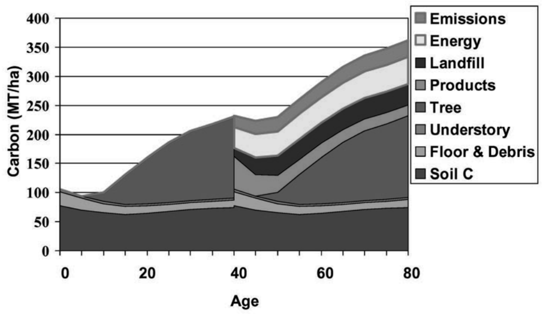
Mitigation. Whether, in the long run, managed forests can positively affect the global carbon balance compared with leaving forests unmanaged depends on several assumptions, such as the level of forest productivity, likelihood of tree mortality, uses of wood products, and extent of product substitution. Heath and Birdsey (1993), for example, projected that a no-harvest scenario sequestered more carbon. Schlamadinger and Marland (1996) commented that reduced CO_2 emissions to the atmosphere could be attained through four mechanisms: storage of carbon in the biosphere, storage of carbon in forest products, use of biofuels to replace fossil fuel use, and the use of wood products that displace other products requiring more fossil fuel for production. These authors found, over the long run, that the amount of carbon stored in the biosphere and in forest products reached a steady state, and continuing mitigation of carbon emissions depended on the extent to which fossil fuel was displaced by bioenergy and wood products. They concluded that the net carbon balance at the end of 100 years was very similar, whether trees were harvested and used for energy and traditional forest products, or the area was reforested and forest protection strategies implemented. Marland and Schlamadinger (1999) concluded that storing carbon on site in the forest and harvesting forests for a sustained flow of forest products are not necessarily conflicting options: mitigating net emissions of carbon depends on site-specific factors, such as forest productivity and the efficiency with which harvested material is used.

The issues are complex and defy easy generalizations. For some forest conditions, it is possible that early harvesting and use of wood products, while economically viable, could result in a lower rate of carbon accumulation compared with letting the forest grow to an older age before harvesting. Alternatively, focus on managing for carbon accumulation could lead to earlier harvest for some forest growth conditions. The degree to which forest management would change carbon sequestration and storage would also be influenced by whether wood use is long- or short-lived, whether the substitution offset is high or low, and whether there is high or low energy conversion efficiency.

In several cases, managed forests have been shown to sequester more carbon and have fewer emissions than unmanaged forests (Birdsey et al. 2000; Krankina and Harmon 2006; Lippke 2007; Hoover and Stout 2007). There are five prime reasons for this: 1) managed forests consist of younger trees that have higher rates of net carbon uptake; 2) managed forests are a source of wood products that continue to store carbon (in use or in landfills) for varying periods, depending on the product; 3) the use of wood products substitutes for use of alternative materials, such as steel, brick, concrete, aluminum, and plastic, all of which are based on nonrenewable resources that require much more energy in manufacture; 4) managed forests have lower greenhouse gas emissions resulting from wildfires, insect depredations, and land conversion; and 5) offset markets are more attractive for managed forests (Skog and Nicholson 1998; Lippke 2007; Krankina and Harmon 2006; OFRI 2006). Unmanaged forests can store more carbon over their lifespan above and below ground per unit area, but as they become mature, carbon accumulation reaches a steady state. Also, given fire return intervals that range from 10 to more than 100 years, there is high probability that in time, unmanaged, dense forests face a higher risk of stand-replacing fires or insect infestations than managed forests.

The modeling of stand dynamics enables a comparison of managed and unmanaged stands in terms of carbon sequestration and storage. For simplicity, researchers developed Figures 7-2, 7-3, and 7-4 for even-aged stands commencing with bare ground, but comparable diagrams could be prepared illustrating the growth of uneven-aged stands. Figure 7-2 shows the accumulation of carbon over two 40-year rotations of southern loblolly pine and illustrates the distribution of harvested carbon into diverse products and the decline in forest carbon stocks during the reforestation phase (Birdsey and Lewis 2002). Figure 7-3 illustrates the results of modeling the accumulation and distribution of carbon over four clearcutting rotations in western Washington (Oneil et al. 2007). Here, carbon in the forest has a stable trend line, and the carbon in product pools—net of energy used in harvesting, processing, and construction—steadily increases over time. The area in gray shows the substantial carbon savings associated with substitution of renewable and carbon-neutral wood products for alternative, fossil fuel–intensive building products (Oneil et al. 2007).

The top diagram of Figure 7-4 illustrates the results of modeling the growth on national forests in eastern Washington and shows the forest carbon pools assuming no management, fire disturbance, or insect or disease damage (Oneil et al. 2007). The bottom diagram is a preliminary analysis incorporating the occurrence of wildfires, which because of climate change were estimated to burn 1.7 percent of the area every decade. This approximation does not include regeneration delays and success rates, but the



NOTE: Energy and emissions are releases of C to the atmosphere

Figure 7-2. Accumulation of carbon over two 40-year rotations of loblolly pine (Source: Birdsey and Lewis 2002).

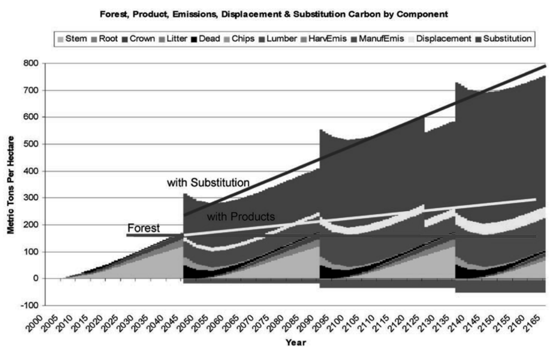


Figure 7-3. Carbon accounting over four rotations of even-aged management in Douglas-fir in western Washington (Source: Oneil et al. 2007).

model outcome suggests that unmanaged national forests in Eastern Washington would likely become a carbon source rather than a carbon sink (Oneil et al. 2007).

Silvicultural Treatments That Affect Carbon. Traditional silvicultural treatments focused on wood, water, wildlife, and aesthetic values are fully amenable to being applied to enhancing carbon sequestration and reducing emissions from forest management (Helms 1996). When considering the application of alternative kinds and levels of stand or landscape treatments in the context of multiple goals and values, managers should consider it likely that attempts to enhance the output of one value will diminish the outputs of others.

Choice of management regime. One of the primary silvicultural choices foresters face is the management regime. Currently, management regimes are chosen in consideration of the economic, site, and silvical characteristics of forest stands, along with other factors. The choice of an even- or uneven-aged management regime for a forest is likely to have little effect on above-ground carbon storage over long periods of time (multiple rotations). These two broad regimes do, however, have variable carbon uptake characteristics over short time horizons, such as a rotation. By providing continuous canopy cover, uneven-aged management is likely to provide continuous carbon uptake, depending on the periodicity and intensity of partial harvest entries. In comparison, the carbon uptake under even-aged management is strongly influenced by rotation length and the length of regeneration periods when the stand has little canopy cover. Management for carbon uptake does underscore the importance of choosing the appropriate regime for each stand. Adaptive approaches to matching the appropriate silviculture with each site as a mosaic across the forest enhance overall forest productivity and carbon uptake.

Choice of species. Initially, fast-growing, shade-intolerant species have higher rates of carbon sequestration at a younger age than more shade-tolerant, slow-growing species. However, over time, shade-tolerant species are likely to have higher stand densities and leaf area and therefore higher accumulation of carbon stocks. Mixed-species and mixed-age stands are likely to accumulate more carbon than single-species stands. Genetic selection, tree improvement, and biotechnology can enhance the rate of carbon uptake and storage by providing trees with higher net carbon uptake capacity. These trees are likely to have special application in growing short-rotation tree crops for bioenergy or cellulosic ethanol.

Slash disposal. Tops, needles, and branches that are residues from harvesting can be evaluated for the extent to which various treatments affect the carbon balance. Allowing this material to decay and return nutrients to the soil is a carbon-neutral process that takes several years, during which time the slash may increase the risk of wildfire. Burning the slash, although also a carbon-neutral process, immediately releases carbon, volatilized nitrogen, other greenhouse gases, and particulates into the atmosphere. Incorporating wood residues into the soil rather than burning it or leaving it to decay can increase or prolong carbon storage in the soil (Birdsey et al. 2006). Alternatively, depending on costs, this material could be used for bioenergy or the production of cellulosic ethanol. Removal of slash, however, may not be appropriate for sites with low productivity.

Site preparation. Site preparation is intended to give the desired vegetation greater access to limited resources, such as soil or water. In the context of carbon sequestration, a major consideration is limiting loss of

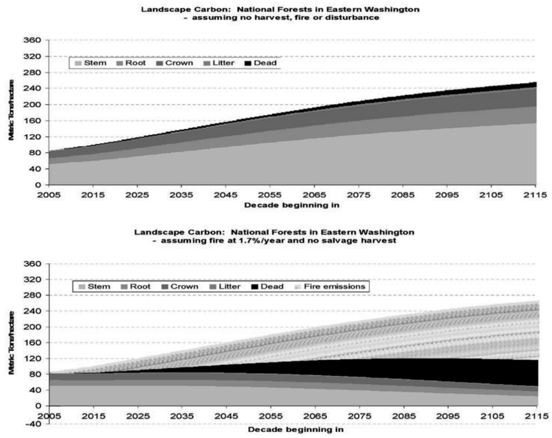


Figure 7-4. Carbon sequestration potential on national forests in eastern Washington. No disturbance compared with fire and no salvage harvest (Source: Oneil et al. 2007).

soil carbon that follows exposure during such treatments, which may increase oxidation of soil carbon, temperature (which increases respiration of soil organisms), disturbance, and in particular soil erosion. Site preparation that incorporates wood residues into the soil can increase or prolong carbon storage in the soil (Birdsey et al. 2006).

Regeneration. Whether by natural seeding, direct seeding, planting, or some mixture of treatments, regeneration should be done promptly to minimize the time soil is exposed and the canopy is open. Prompt tree regeneration also reduces the risk that the site becomes occupied by brush, which has lower leaf area and less CO_2-sequestering capacity than trees. Early brush control has been shown to have important leverage in improving wood-growing capacity and storing carbon in both the forest and stored products (CFR 2007).

Fertilizer. Sometimes applied in planted forests and in short-rotation plantations, fertilizers increase rates of growth and leaf area production and therefore the rate of carbon uptake and sequestration. In carbon accounting, however, the source of materials used as fertilizers and the source and cost of energy used in manufacture, transportation, and application must be factored in.

Thinning and partial harvesting. Thinning and partial harvesting are techniques used in even- and uneven-aged management, respectively, to control stocking levels and stand density. The operations may be either precommercial (i.e., the thinned material is not merchantable) or commercial and are designed to improve the growth of preferred trees. The basic concept is to allocate growth and leaf area among either a greater number of small-diameter trees or a fewer number of large-diameter trees. Both treatments make openings in the canopy, and in the context of carbon storage, it is preferable to conduct light, frequent thinnings rather than heavy, infrequent thinnings. The latter create larger openings in the canopy that require a longer time to regain leaf area and capacity for carbon storage.

Rotation length. Rotation length in even-aged management influences carbon accumulation because longer rotations and larger trees increase on-site storage. (In uneven-aged management, decisions on the maximum-sized tree follow the same logic.) Longer rotations in even-aged management favor carbon accumulation because less time is taken up in reforestation and rebuilding the canopy. However, longer rotations can incur larger management costs as the value growth rates of timber fall below the expected cost of money, and delay in harvesting reduces value from other uses, including carbon storage in wood products and substitution of wood for fossil-intensive products. Longer rotations and management cycles may also involve thinnings or partial cuts to maintain forest health.

Expansion of forestland (afforestation). One of the most widely recognized forestry practices for the mitigation of climate change is the afforestation of nonforested areas to increase sequestration and storage. Because forest is the most efficient land use for carbon uptake and storage, landowners with plantable acres and degraded areas that can be restored to a productive condition have a significant opportunity to sequester carbon. Whether the land was degraded by unsustainable practices or natural events, such opportunities may provide economic incentives to turn these areas back into productive forests.

Managing for Carbon. Forest management is often categorized as even- versus uneven-aged approaches. Either approach may still be appropriate at the stand level; however, at the landscape level, both approaches can be used in mosaics depending on ownership objectives and stand conditions. Incorporating carbon sequestration into the suite of management objectives focuses attention on developing and maintaining high levels of leaf area because the more leaves, the more potential for photosynthesis and carbon dioxide uptake. More leaf area also increases the potential for higher respiration rates, and consequently attention must be given to net carbon uptake under the particular growing conditions.

If the goal is to immediately sequester the most carbon in the near term, shade-intolerant species with high initial growth rates, grown at the highest stocking density the site will support and harvested at the culmination of mean annual increment, will sequester the most carbon in the shortest amount of time. This short rotation, even-aged forest management regime, repeated in perpetuity with succeeding rotations of shade-intolerant trees, is often said to sequester the most carbon. However, to determine the net amount of carbon sequestered, one must factor in 1) losses of soil and detritus carbon during disturbance for harvesting, site preparation, and other management activities; and 2) the carbon emissions associated with these harvesting and management activities.

If the goal is to sequester the maximum amount of carbon over a longer time frame, the best approach is to grow shade-tolerant species at the maximum stand density the site will support and implement a similar even-aged management regime, harvesting and replanting the whole stand at the culmination of mean annual increment. Shade-tolerant species can be grown at a higher stand density than shade-intolerant species but have lower initial growth rates that culminate later; however, the overall amount of carbon sequestered per unit of forest area will be greater. Moreover, harvesting and site preparation activities will be less frequent and thus the associated carbon emissions will be lower.

For continuous and overall maximum sequestration, mixtures of shade-intolerant and shade-tolerant species would utilize all the photosynthetic niches in the forest canopy and forest understory while maintaining overall growth rates at a thrifty level. Uneven-aged management would use a combination of individual tree selection, crown, and understory thinning, group selection, irregular shelterwood, and other intermediate cuttings to maintain a kaleidoscope of different age classes of thrifty intolerant and tolerant trees. Again, emissions would have to be calculated for the frequent management entries, as would the combined mean annual increment for all the different species and age classes of trees, which must be discounted to an annual basis.

The important carbon sequestration metric for all three of the above approaches is the area under the mean annual increment curve, which will reveal the total amount of carbon sequestered during the management cycle. This metric can then be discounted over the time period of the management cycle to calculate the average annual carbon sequestration rate for any management scenario. Below-ground carbon sequestration in root fiber, soil, macro- and microorganisms, down woody material, and other pools must also be calculated.

If the landowner's goal is to enhance the capacity of the forest to sequester and store carbon and to reduce its likelihood of becoming a source of carbon and other GHGs in the long run, the forest should be managed. This is because, in the long run, 1) management enables the maintenance of forest health, which reduces the likelihood and severity of emissions from wildfires and insect or disease mortality; and 2) it provides products that have both short- and long-term storage capacity and can substitute for fossil fuel–based materials and sources for energy, building, and other uses. Much of the technical knowledge needed to enhance sequestration and storage is available or can be adapted from traditional practices. Knowledge gaps include the effects of management on carbon pools and the extent to which enhancing carbon reduces the outputs of other forest values and uses. There is thus a need for increased monitoring and adaptive approaches to management.

Under current economic conditions, however, carbon sequestration is not likely to be a primary management objective for most forest owners (Birdsey et al. 2006). As with any type of management, goals, costs, incentives, regulations, policy, and values will drive decisions. Carbon sequestration through forest management may, however, provide forest owners who meet requisite protocols with an additional income stream from the sale of offset credits. If realized, this additional economic return could change the economic viability of some management practices, alter the intensity with which forests are managed, and influence other management decisions. The degree to which carbon sequestration opportunities influence forest management will depend heavily on such factors as the value of carbon financial instruments, the costs of program or market participation, regulatory requirements for emission controls, market-wide recognition of offset credits from forestry projects, and opportunity costs.

Debate continues regarding the relative benefits of young, managed forests compared with older, unmanaged forests in terms of efficacy of forest carbon sequestration. But all forests, under varying levels of management or no management, can provide carbon sequestration benefits, depending on their particular condition or situation. It is important to take into account the different objectives for managing forests of varying age and the associated benefits that can accrue from older, mixed age and mixed-species forests. Indeed, there are sites of low productivity where production of timber may be so slow or uncertain that managing for forest health and fire protection could be a superior carbon sequestration strategy.

Carbon Storage in Wood Products

Harvesting reduces carbon storage in the forest both by removing organic matter and by increasing heterotrophic soil respiration (Pregitzer and Euskirchen 2004). However, much of this is offset by the carbon that is stored in forest products for varying lengths of time. The carbon in those forest products, for example, may not be released for decades. Along with the benefits of consistently high sequestration levels, it is this aspect of sustainably managed forest carbon projects that provides the maximum benefits for climate change mitigation when compared with unmanaged forests, which can suddenly release huge amounts of carbon if they burn. Forest management that includes harvesting provides increased climate change mitigation benefits over time because wood-decay CO_2 emissions from wood products is delayed (Ruddell et al. 2007). Accounting for this carbon pool is critical to accurately representing forest carbon uptake and storage on a project level. A forestry project that fails to consider it may significantly overestimate emissions from the project over time (US DOE 2007).

Until recently, carbon stored in harvested wood products (HWPs) had received little recognition in international GHG mitigation programs. In fact, the 1996 United Nations Framework Convention on Climate Change guidelines for carbon accounting for countries participating under the Kyoto Protocol considered the inputs (additions) and outputs (emissions) at the national level for the HWP carbon pool to be equal (IPCC 2006). This position was revisited in 2006 in the revised IPCC guidelines, in which HWP accounting rules for Kyoto-compliant countries were presented in greater detail (IPCC 2006). The new rules facilitated a more thorough recognition of this important carbon pool, offering participating countries the option to account for carbon accumulation in this area.

In their early stages, many US climate change mitigation programs considered the harvesting of wood an immediate release of carbon. The carbon storage potential of HWPs has since become more widely acknowledged. To date, storage of HWP carbon has been recognized by some but not all domestic climate mitigation programs and registries. Although their accounting methods vary, the US Department of Energy 1605b guidelines, the Chicago Climate Exchange, the California Climate Action Registry, and the Georgia Carbon Sequestration Registry are examples of programs that now recognize this important carbon pool, though the California registry does not consider it a tradable pool at this time.

The HWP pool consists of two parts:

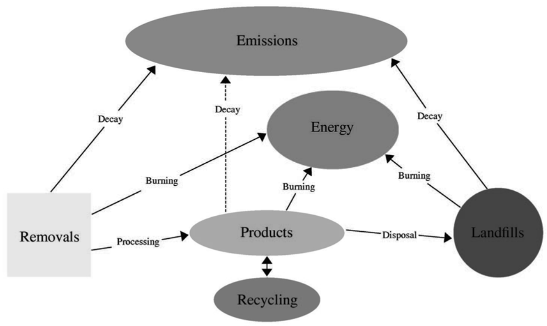


Figure 7-5. Harvested wood products pool (Source: Heath et al. 1996).

Table 7-1. Half-life for products by end use.

End use or product	Half-life (years)
New residential construction	
Single-family homes	100
Multifamily homes	70
Mobile homes	12
Residential upkeep and improvement	30
New nonresidential construction	
All except railroads	67
Railroad ties	12
Railcar repair	12
Manufacturing	
Household furniture	30
Commercial furniture	30
Other products	12
Shipping	
Wooden containers	6
Pallets	6
Dunnage	6
Other uses for lumber and panels	12
Solid wood exports	12
Paper	2.6

(Source: US DOE 2006).

wood in use, and wood discarded in landfills or recycled (US DOE 2006). Their interrelationships are illustrated in Figure 7-5. The delay in the release of carbon from HWPs depends on the manner in which the harvested wood is used. For example, carbon may be stored for decades in sawn lumber used in housing construction, but wood harvested for the production of paper may store carbon for only one to five years. Accounting approaches of the current US carbon programs vary somewhat, but most consider six basic categories of harvested wood in use: waste wood, wood used to produce energy, solid wood (lumber), composite wood products, paper products, and nonstructural panels. Each wood category has its own specific rate of decay or release to the atmosphere. One example of depreciation or half-life values for various end uses of wood products is provided in Table 7-1, which illustrates the variable decay rates specified in the US Department of Energy 1605b rules.

The accounting methods for HWPs in use fall into two main techniques. The first approach is to track, over time, the decay of materials stored in wood products and account for the specific emissions in the year in which they occur. Under this method, each harvest year is depreciated individually over a project's lifespan in accordance with the proportion of wood product types generated from the harvests. In addition to the contributions made annually to the HWP pool through harvests, annual emissions for the pool are also calculated. These calculations produce the annual net contribution to or emissions from the HWP pool. If there is a positive difference between a specific year and the previous year's HWP levels, a positive sequestration result is realized. If the result is negative, then the HWP pool has experienced net emissions and that amount would be deducted from total reported sequestration for that year. The benefits of this approach are largely in maximizing positive results over shorter project lifespans and in more project-specific accounting. There are also potential drawbacks to this approach. Over longer time frames, emissions from the HWP pool could exceed total additions, resulting in carbon deficits. Also, this accounting system is somewhat complex.

The second HWP accounting method uses established depreciation tables to calculate the quantity of carbon remaining in harvested wood (also by product class) after 100 years. Based on standard decay equations, this 100-year rule allows project owners to annually retain the net carbon credits represented by the carbon estimate for their harvested wood products. The approach is much simpler and does not create net negative flows of carbon over the project lifespan. Drawbacks include fewer project-specific calculations and potentially very conservative estimates of carbon storage in the HWP pool.

If the wood product is transferred to a landfill, the time frame for the ultimate release of its carbon into the atmosphere may be even longer. To illustrate, carbon may be stored in a paper product five years after harvest, then in a landfill for 10 years, and decomposed as emissions after yet another decade or two. In accounting for carbon storage in landfills, the current US registries are even more variable. Although accounting rules for this aspect of carbon storage currently exist, this part of the pool is less uniformly recognized by domestic carbon programs than carbon stored in wood products in use. One reason involves concerns over ownership of the carbon stored in landfills, and thus who can claim credit for the carbon sequestered.

The climate change benefits of wood products are twofold: the true value lies in the combination of long-term carbon storage with substitution for other materials with higher emissions. Although some carbon accounting systems are beginning to recognize the importance of the carbon stored in wood products, fewer incorporate the system boundaries that recognize the importance of the way wood is used. Because wood can substitute for other, more fossil fuel–intensive products, the reductions in carbon emissions to the atmosphere are comparatively larger than even the benefit of the carbon stored in wood products. Research both in the United States and internationally (Borjesson and Gustavsson 1999; Buchanan and Levine 1999; Lippke et al. 2004; Lippke and Edmonds 2006; Perez-Garcia et al. 2005; Sathre 2007; Valsta et al. 2008) has suggested that this effect—the displacement of fossil fuel sources—could make wood products the most important carbon pool of all.

Markets for Forest Carbon Offset Projects

Historically, command-and-control regulation has been the approach to regulating emissions and discharges of pollution into the environment in the United States. The Clean Air Act of 1970 and the Clean Water Amendments of 1972 effectively equalized pollution levels across all polluters. While effective in achieving absolute reductions in pollution, these acts prescribe technology-based and performance-based standards to pollution abatement in ways that stifle innovation and discourage the development of better, lower-cost technologies (Stavins 2001). Since it is not possible for regulatory oversight agencies to know the pollution abatement cost function of each polluter, uniform standards force some firms to incur a larger cost burden per unit of production for controlling pollution.

Market-based instruments encourage the desired behavior through market signals rather than through explicit directives for pollution levels or control methods (Stavins 2001). Two such climate change policy instruments include emissions trading and carbon taxes. When well designed and implemented, these instruments create incentives that alter the producer's pollution control strategy in ways that benefit the producer while meeting pollution reduction policy goals. Compared with command-and-control approaches, market-based climate change policy instruments accomplish a cost-effective allocation of pollution control burden by equalizing the marginal costs (the incremental amount spent to reduce pollution) across all entities even though the regulator does not know their individual pollution abatement cost functions. Market-based climate change policy instruments provide economic incentives that promote innovation in the development of pollution abatement technologies because it is in the polluter's best interest to do so (Stavins 2001).

Market-Based Policy Instruments

Emissions Trading versus Carbon Taxes. In practice, the selection of a market-based climate change policy instrument is a political decision. This decision is based on the extent to which the instrument 1) is economically effective; 2) is cost-efficient; 3) provides social equity and fairness within and across generations; and 4) is flexible enough to adapt to changing social, political, and environmental conditions (Hanley et al. 1997).

Tradable permits are utilized within regulated emissions trading programs, also known as cap-and-trade programs. Rules for cap-and-trade programs can be highly variable. In general terms, under an emissions trading program, the allowable level of pollution (cap) within a sector is determined through a political process that allocates or auctions emission allowances among the polluting entities. In theory, the polluters will choose the least-cost means to comply with the cap. Those that keep emission levels below the cap can sell their surplus emission allowances. Those that emit more than the cap must either buy surplus emission allowances from others or, if permitted, offset their excess pollution (over the cap) by purchasing emission reduction credits from offset providers. Although emissions trading is a cost-effective policy instrument, it can also create uncertainty in the total cost of compliance for the polluter. Emissions trading programs are, however, very flexible instruments and can easily adjust to changes in the cost of emitting pollutants.

Carbon taxes are charges or penalties levied on the amount of carbon dioxide that a firm generates. Under this policy instrument, the polluter will reduce emissions to the point where its marginal abatement pollution costs are equal to the carbon tax, and thus different firms control emissions at different levels. Those with high marginal abatement costs (high-cost polluters) will reduce pollution less than those with low marginal abatement costs (low-cost polluters). One drawback of carbon taxes is that the environmental outcome—the total reduction in emissions—cannot be guaranteed because the regulator cannot know the marginal pollution abatement costs for each firm. Determining the appropriate tax rate therefore becomes a major challenge for policymakers. In theory, to achieve an economically efficient level of pollution, the tax will be applied on each unit of production at a rate that equals the social costs of pollution (Perman et al. 1996).

Emission Allowances versus Emission Reduction Credits. The design of any emissions trading program includes two primary transactions: emission allowances and emission reduction credits. Emission allowances (also called allowance-based carbon transactions) are created by a regulatory cap-and-trade body and are initially allocated or auctioned to the user. Emission allowance transactions are based on the entity's direct emissions. Entities must reconcile their emissions account at the end of each compliance period through direct and verified measurements to ensure compliance with their allocated or auctioned emission allowances.

Emission reduction credits (also called project-based carbon transactions) are issued to projects that can credibly demonstrate reductions in GHG emissions compared with what would have happened without the project. Forestry is one category of projects that can provide carbon dioxide emission reduction credits (capturing landfill methane, conservation tillage practices, and alternative energy are others), and several project types are eligible (Sampson et al. 2007).

• *Afforestation:* planting trees on land that has been in a nonforest land use for a number of years (the Kyoto Protocol requires 50 years; other registries and programs require 10 or 20 years).

• *Reforestation:* planting trees on land that had previously been forested but has lost forest cover and is not recovering naturally. Severely burned forests may qualify under this definition if they show no recovery after a time period.

• *Forest management:* managing a forest to protect and/or enhance carbon stocks. The entire forest estate under management should be included to prevent the possibility that the owner will report only on areas of growing forest and avoid including the areas where the forest may be in a declining condition.

• *Harvested wood products:* providing credit for harvested wood is usually connected to forest management that includes periodic harvests.

• *Forest conservation or protection:* preventing a land-use change that would destroy or degrade an existing forest, such as conversion to agricultural or development uses. This type of offset project is also known as avoided deforestation.

Emission reduction credits should be issued only after their reductions have been verified; they can then be used to offset direct carbon dioxide emissions above a firm's allocated or auctioned emission allowances. The purchase or sale of contracts for emission reduction credits typically carries higher transaction costs and risk than emission allowances. Once emission reduction credits are issued and used to offset direct emissions, they provide the same mitigation benefit in reducing or preventing GHG emissions as emission allowances (Ruddell et al. 2006).

Programs and Markets for Forest Carbon

Project-based emission reduction credits, such as those developed through forest carbon offset projects, are used to reduce rather than prevent GHG emissions. To operate efficiently and provide the market signals required for polluters to implement the lowest-cost pollution strategy, an emissions trading program must have active trading in credits. In the absence of federal regulation in the United States, registries, voluntary emissions trading programs, and voluntary carbon offset markets have developed to satisfy demand primarily created by direct emitters wanting to reduce their GHG emissions. Mandatory emissions trading programs have become well established through the Kyoto Protocol.

The Kyoto Protocol, an international treaty of the United Nations Framework Convention on Climate Change (UNFCCC), set GHG emissions limitations on its signatory countries and established mechanisms for reducing overall GHGs by at least 5 percent below 1990 levels by the end of 2012. The protocol, which took effect in February 2005, has been ratified by all industrialized countries except the United States. Until it ratifies Kyoto or passes federal laws governing carbon emissions, the United States will remain a voluntary market for trading emission allowances and reduction credits.

Another policy option is a renewable energy credit. One type of renewable energy credit is associated with the substitution of wood-based building materials for nonrenewable building materials, such as steel, plastic, concrete, and aluminum. Research by Lippke et al. (2004), Winistorfer et al. (2005), and Perez-Garcia et al. (2005) demonstrates, through life-cycle carbon dioxide modeling, that wood-based building materials have significantly lower carbon dioxide emissions per unit of production compared with nonrenewable building materials. If these credits are recognized in US energy legislation, markets may emerge that recognize the role that this substitution plays in preventing GHG emissions.

The second type of renewable energy credit involves the substitution of wood-based biofuels, such as wood waste, for fossil fuels to generate electric power for direct emitters. Evolving carbon markets (such as the Chicago Climate Exchange) provide credits to firms with direct emissions that substitute wood-based biofuels for fossil fuels. Forest biomass is one fuel type that is being recognized as eligible for such credits under developing US Senate bills in the 110th Congress (Point Carbon News 2007).

Mandatory (Regulated) Emissions Trading Programs

Kyoto Protocol. Anthropogenic changes in Earth's climate have been the focus of climate change policy since the signing of the UNFCCC at the 1992 "Earth Summit" in Rio. To date, this convention has been ratified by 191 countries, including the United States (UNFCCC 2007c). The objective of the convention was to stabilize greenhouse gas emissions "at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC 2007b, Art. 2).

A global carbon market has emerged as a result of the Kyoto Protocol of the UNFCCC. Article 3 of the protocol introduced concepts of GHG emissions by sources and GHG removals by sinks, but it limited the role of forestry to afforestation, reforestation, and reducing emissions during deforestation activities conducted since 1990. In November 2001, the Marrakesh Accord provided definitions for these forestry activities and considered forest management (UNFCCC 2002). To date, only afforestation and reforestation methodologies have been approved for creating emission reduction credits for Kyoto compliance purposes. Reducing emissions from deforestation and degradation in developing countries, as part of the sustainable management of forests, was acknowledged during a December 2007 meeting in Bali, where the 13th Conference of the Parties established processes to demonstrate how such reductions could be considered climate mitigation measures and be included in the second compliance period of the Kyoto Protocol, beginning in 2013.

To combat climate change, the Kyoto Protocol uses a market-based approach—emissions trading and tradable emission reduction credits for offset projects (UNFCCC 2007b)—involving two mechanisms, the Clean Development Mechanism (CDM) and Joint Implementation (JI). Both were designed to lower the overall costs of participating countries in meeting their domestic emission reduction targets while helping developing countries and countries in transition achieve their sustainable development goals (IETA 2007).

The CDM allows Annex 1 (industrialized) countries with mandated Kyoto Protocol GHG reduction targets to invest in emission reduction projects in developing ("host") countries. In theory, these projects reduce global GHGs at a lower cost than would be possible in the Annex 1 country itself. For an afforestation or reforestation project, once a project is registered (approved), implemented, and certified, the CDM executive board issues certified emission reduction (CER) credits based on the verified difference between the baseline and the actual emission reductions that can be

Table 8-1 Traded volumes and values of carbon credits.

Year	EU Emissions Trading Scheme		Chicago Climate Exchange (CCX)		Over-the-counter (OTC) markets	
	Volume ($MtCO_2$ eq.)	Value (US$ millions)	Volume ($MtCO_2$ eq.)	Value (US$ millions)	Volume ($MtCO_2$ eq.)	Value (US$ millions)
2004	—	—	2.25	2.6	—	—
2005	322	8,220	1.47	2.8	—	—
2006	1,101	24,353	10.34	38.2	14.3	58.5
2007	1,600	43,879	22.90	68.7	42.1	258.4

$MtCO_2$ eq. = Million tonnes (metric tons) of carbon dioxide equivalent.
Sources: for European Union, Capoor and Ambrosi 2007; for CCX, J. O'Hara, Chicago Climate Exchange, pers. comm., November 9, 2007; for OTC, K. Hamilton et al. 2008.

used toward compliance targets (UNFCCC 2007a).

JI is designed to help Annex 1 countries meet their mandated Kyoto Protocol GHG reduction targets through investments in emission reduction projects in another Annex 1 country. Verified emission reductions generate emission reduction unit (ERU) credits that can be used toward compliance targets.

The Kyoto Protocol covers only afforestation and reforestation projects, and forestry CDM projects represent only 1 percent of the 2006 volume of traded emission reduction credits (Capoor and Ambrosi 2007). As of October 2007, of the approximately 810 registered CDM projects, only 12 afforestation projects had been approved, and only one had been certified through the CDM Executive Board.

European Union Emissions Trading Scheme. An event that dramatically increased global carbon dioxide trading volume was the emergence of Phase I of the European Union Emissions Trading Scheme (EU ETS), which went into effect in January 2005. The EU ETS, the largest multinational, multisector GHG trading scheme in the world, was created to assist the 25 EU countries in meeting Kyoto Protocol–mandated emission reduction targets (European Commission 2005). Forestry activities are not eligible for either CERs or ERUs, however, effectively eliminating all international investment in forest carbon offset projects through the CDM or JI mechanisms. Table 8-1 compares traded volumes and values in the EU ETS and two other carbon markets, discussed below.

Regional Greenhouse Gas Initiative. The Regional Greenhouse Gas Initiative (RGGI), a 10-state program in the US Northeast for reducing GHG emissions, will be the nation's first cap-and-trade carbon program when it goes into effect in 2009. Its goal is to reduce CO_2 emissions 10 percent by 2019. Emission reduction targets are limited to large power plants—those with energy production capacity greater than 25 megawatts—that burn fossil fuels to generate more than half of their electricity. The RGGI rules allow for the use of emission reduction credits from offset projects based on market prices for those credits. The lower the price of CO_2, the fewer the emission reduction credits that can be applied against a plant's emission reduction targets. Sequestration of CO_2 from forestry projects is limited to participating in afforestation projects. However, RGGI has contracted with the Maine Forest Service to learn how other forest carbon offset project types might be included. To date, no forest offset projects have been registered with the RGGI program.

California Climate Action Registry. In 2001, California Senate Bills SB1771 and SB527 created the California Climate Action Registry (CCAR), the nation's first statewide GHG inventory registry. Like other registries, CCAR develops rules for the issuance, qualification, quantification, verification, and registration of emission allowances and emission reduction credits for forest carbon offset projects. The Global Warming Solutions Act of 2006 (AB32) mandates that the state reduce its GHG emissions to 1990 levels by 2012 across all sectors of the economy and assigns responsibility to the California Air Resources Board to implement the cap, which will likely require emissions trading. Credits for afforestation, managed forests, and forest conservation (avoided deforestation) are allowed, and offset project rules are defined by CCAR's Forest Sector Protocol (CCAR 2007). To date, credits from one forest carbon offset project have been registered and sold.

Voluntary Markets for Forest Carbon. Voluntary carbon markets are developing globally to address the increased demand to reduce GHG emissions where not otherwise required by Kyoto, RGGI, CCAR, or other regulations. The global voluntary carbon market includes over-the-counter transactions and emissions trading transactions through the Chicago Climate Exchange (K. Hamilton et al. 2007).

Chicago Climate Exchange. The Chicago Climate Exchange (CCX) is the world's first and North America's only legally binding rules-based GHG emission allowance trading system. CCX is also the only global system for emissions trading of all six greenhouse gases. Members make a voluntary but legally binding commitment to meet annual reduction targets of 6 percent below baseline emissions by 2010. Members that reduce below the targets have surplus allowances to sell or bank. Those that emit above the annual targets comply by purchasing emission reduction credit contracts, called carbon financial instruments. Table 8-1 provides traded volumes and values on CCX.

Emission allowances are issued in accordance with a member's emissions baseline and the CCX emission reduction schedule. Integrated commercial forest entities that own mills and comply with a sustainable forest management standard with third-party verification have the option of claiming their forest operations as carbon stable or using an approved forest growth-and-yield model to account for the annual net change in forest carbon stocks as a part of an entity-wide accounting of GHG emission allowances.

Nonmembers can also use the CCX trading platform. The forest carbon offset projects that are eligible to be registered and traded by approved aggregators or offset providers on CCX include afforestation, reforestation, sustainably managed forests, and forest conservation (avoided deforestation). The CCX forest carbon offset rules also allow for the counting of long-lived harvested wood products in use. Annual verification of net changes in carbon stocks by an approved verification body is required before emission reduction credits can be registered and traded.

Over-the-counter markets. Society's heightened awareness of global warming has led many organizations and individuals to look for ways to mitigate their own greenhouse gas emissions. Terms such as "carbon footprint" and "carbon neutral" have entered the vernacular. Many environmentally conscious organizations and individuals have sought to mitigate their personal contributions by participating in the above registries and markets, and also through other voluntary direct sales, frequently referred to as over-the-counter (OTC) transactions. OTC transactions provide a wide range of global opportunities. Large organizations can invest directly in specific mitigation projects that meet their environmental, cost, and/or GHG mitigation objectives. Individuals can mitigate on a smaller, more retail scale.

Suppliers of carbon offset projects within the OTC have generally been classified as offset project providers, developers, aggregators, wholesalers, and offset credit retailers (K. Hamilton et al. 2007; Clean Air–Cool Planet 2006). OTC suppliers are a highly fragmented group of for-profit and not-for-profit conservation and private sector organizations that allow polluters to offset their direct emissions, and retailers can sell credits to consumers who want to offset the GHG emissions of their personal activities, such as travel. Suppliers include well-known organizations such as the Climate Fund, Conservation Fund, Pacific Forest Trust, New Forests, Terrapass, and The Nature Conservancy. Credits issued in OTC markets are referred to as voluntary (or verified) emission reduction (VER) credits to distinguish them from CER credits issued under a certified UNFCCC CDM project. Private corporations are the single largest buyers of emission reduction credits in OTC markets.

Currently, there are no uniform standards under which voluntary offset projects are developed and sold. The various standards that do exist typically define approved baseline methodologies and test for additionality, permanence, and leakage (discussed below). Offset projects for the OTC market apply a variety of design elements defined by either the supplier or the buyer of the credits, but this is changing. The lack of standards for OTC market transactions has led to several standards development efforts:

- Voluntary Carbon Standard, a global benchmark standard for project-based voluntary emission reductions;
- Gold Standard, a voluntary standard designed to improve the quality of CDM and JI and voluntary offset projects;
- Green-e, a voluntary certification program that sets consumer protection and environmental integrity standards for GHG reductions sold in the voluntary market; and
- Harnessing Farms and Forests, a technical guide on the implementation of offset projects developed by scientists at Duke University, Environmental Defense, and elsewhere.

These standards define rules that can be adopted by suppliers or prescribed by buyers to create transparency, primarily in the quality of clean technology project development. However, the standards may not be wholly appropriate for sequestration offset projects like forestry. Table 8-1 provides traded volumes and values on the OTC market.

CCX and OTC CO_2 demand curves and prices. Since the OTC market is voluntary and not driven by compliance requirements, demand for OTC offset project VERs and the prices paid for CO_2 are not publicly available. Two primary differences distinguish these voluntary forest carbon markets.

One is their CO_2 demand curves. Offset credits in CCX are registered as a fungible commodity—that is, they are not distinguishable from other carbon offset project credits, such as conservation tillage, alternative energy, or landfill methane projects. On the CCX trading platform, "a ton is a ton." Because demand is derived from compliance with CCX emission reduction commitments, the quality of an offset project is determined by the CCX rules, which provide consistency across the varying forest project types. In contrast, within OTC transactions, offset credits are not a fungible commodity; the rules behind them are important purchasing criteria that distinguish offset projects and enable buyers to discriminate among them.

The other difference is the way the price of CO_2 is determined. In the OTC market, project design and benefits are important criteria that determine the value of credits from forest carbon offset projects. For example, forest projects typically include design elements that provide for social and conservation cobenefits, such as improved water quality and promoting biodiversity goals. For suppliers selling credits into OTC markets, buyers discriminate among projects based on these environmental, social, or economic benefits. The demand for and the price of CO_2 are driven by the quality characteristics of the project's design and the social and conservation benefits it produces. Therefore, "a ton is *not* a ton" on OTC markets, as it is with the fungible CO_2 commodity traded on CCX.

Those two primary differences are reflected in the current prices paid for OTC and CCX forest carbon offset credits. In a recent survey of more than 70 suppliers to the voluntary carbon market, K. Hamilton et al. (2007) found that social values, additionality, environmental quality, and certification were more influential purchasing criteria than price, advertising, or convenience. Because buyers of carbon credits may be interested in an array of conservation and economic values provided by forest projects, registries and providers that offer offset credits of high quality are frequently able to generate higher prices.

Economic Factors of Forest Carbon Offset Projects

Perhaps the most significant decision that influences economic factors in the voluntary carbon market is the choice of market a forest project owner participates in—CCX or OTC. Compared with emissions reductions from clean technology, forest carbon offset projects have unique characteristics that mean higher transaction costs. Each of the multiple registries and programs in the United States has its own rules for participating—the setting of carbon baselines, the eligibility of managed forest versus afforestation and reforestation, monitoring methods, verification rules, the pools of carbon that can be registered (i.e., above ground, below ground, harvested wood products)—all of which can raise transaction costs for organizations that manage forestlands in multiple regions of the nation (Ruddell et al. 2006).

For many forest owners, participation in new environmental markets will require new investments. Most registries and programs require an initial investment and ongoing participation costs throughout a project's life. Common examples of startup costs include conducting a forest inventory to program specifications, securing third-party certification to a recognized sustainable forest management standard (such as the Forest Stewardship Council, standards endorsed by the Program for the Endorsement of Forest Certification, the Sustainable

Forestry Initiative, and the American Forest Foundations Standards of Sustainability), and developing new accounting mechanisms to track the annual net change in carbon stocks. Participation involves registration and trading fees, aggregation or broker fees, costs of verification, monitoring and remeasurement costs, annual reporting expenses, and possible costs of additional insurance policies.

One influential factor for forest owners is the opportunity cost associated with forest carbon offset projects. Opportunity costs can be difficult to quantify because they differ from one project or program to another.

A potentially significant opportunity cost that needs to be considered by project owners involves permanence. Many of the current registries and programs require that forest projects remain as forests for a certain length of time to ensure the permanence of any credits sold. Two mechanisms typically used to accomplish permanence are deed restrictions on land use and long-term or permanent conservation easements. Both can increase the opportunity cost of investing in or maintaining ownership of forests for climate change mitigation.

This issue is problematic for sustainably managed forests because investors, policymakers, and buyers of carbon offset projects may not fully understand how opportunity costs apply in forestry. Forest carbon offset projects must absorb the opportunity costs associated with keeping the forest intact, forgoing potential profits from development or conversion to other land uses. In the case of permanent conservation easements, the opportunity cost of forgoing land development (forever) may be enormous—a reality not currently reflected in compensation mechanisms (Ruddell et al. 2006).

Accounting for Forest Offset Projects

The standards discussed above are attempts to provide consistent rules under which all offset projects can participate (Ruddell et al. 2007; Sampson et al. 2007). Since a major purchasing criterion for offset buyers is project quality, standards create value for buyers and suppliers, as well as financial institutions and investors, but the current standards were developed primarily with clean technology projects in mind, not sequestration projects like forestry.

Through mandatory markets driven by the Kyoto Protocol, forest project participation has been restricted to afforestation. To date, only 12 afforestation projects have been approved under Kyoto, and one has been certified through UNFCCC's CDM executive board. The main reason for the paucity of sequestration projects is that they present unique accounting issues. Cathcart and Delany (2006) and Ingerson (2007) describe and discuss carbon accounting issues in detail; here, we briefly discuss additionality, baseline setting, permanence, and leakage as they apply to forestry.

Additionality and Baseline Setting. Since benefits to the environment are the goal of any emission reduction credits program, the net amount of carbon sequestered must be additional to what would have occurred without the offset project. For forest projects, additionality can be difficult to demonstrate. A carbon baseline must be established against which the net change in carbon stocks is measured so that emission reduction credits can be quantified, verified, and registered. Typically, baseline carbon values are determined through standard forestry biometric methods that include direct and statistically designed and modeled measurement techniques.

Two types of baselines used in US registries and programs are the business-as-usual (BAU) and base-year approaches. The BAU scenario is based on the proposition that emission reductions that would (or might) have happened in any event should not be allowed to offset industrial emissions. This scenario works well for clean technology but not for land-based sequestration practices, where natural ecosystem dynamics and unpredictable future human actions make any projection highly uncertain.

Changing forest management objectives, markets for alternative land uses, timber prices, and ecosystem service prices (e.g., the price of sequestered carbon) all contribute to a high level of inherent uncertainty when defining a baseline under the BAU scenario. No credible methods currently exist to separate the effects of management action on a forest from those of environmental conditions over time. Given the current trend of converting sustainably managed forestland and high-value forest ecosystems to other uses, such as housing, it is clear that BAU cannot be applied to forestry unless it is redefined. Unlike the baseline emissions of a direct emitter of CO_2 (a coal-fired power plant, for example), which are precisely measured and operationally controlled, forest BAU baselines cannot be defined with certainty, and under the current rules, if the BAU baseline cannot be precisely defined, the project cannot be quantified, verified, or registered.

In the base-year approach to establishing a baseline, an inventory is taken at the beginning of the project period, and a second inventory is conducted some years later, using the same inventory design. The net change in carbon stocks (of all allowable carbon pools within the forest offset project) represents the carbon sequestration in the forest for that period of time. In a sustainably managed forest, this net change in carbon stocks will include all forest management actions, such as harvesting, tree planting, and fertilizing. It will also reflect the effects on carbon stocks of natural events like weather, wildfire, and insects and disease. This carbon accounting systems thus accounts for (and verifies) the total net change (positive or negative) in carbon stocks associated with both natural events and human management.

Permanence. When forest carbon credits are used to permanently offset industrial emissions, the forest project must demonstrate permanence. Ensuring that a forest project is permanent can be difficult if not impossible, however, since some of the carbon sequestered might be released through natural events, such as wildfires and hurricanes, or through management activities, such as harvesting. Some registries and programs require that any released carbon be included in the net change calculations so that credits previously issued can be paid back; no additional credits can then be issued until the net change in carbon stocks is again positive.

The mechanisms typically used to accomplish permanence—deed restrictions on land use and long-term or permanent conservation easements—can provide protection against land-use change but have no force against catastrophic disturbances that may destroy the forest carbon stocks. If conservation easements mandate prescriptive forest management practices based on current technology or requirements like mandatory reforestation, they may create future barriers for meeting additionality requirements.

An alternative approach is to enter into short-term contracts with project owners to sequester and maintain forest carbon stocks. These contracts protect the buyer or market of carbon credits from loss during the contract period. If the forest carbon stocks are lost, the buyer or market must be reimbursed. At the end of the contract, the ultimate buyer (the polluter) is still liable for those emissions and must either cover the obligations by repurchasing forest credits that are still valid or find other sources of offsets.

Leakage. Leakage is the indirect or secondary effect that a project might have outside the boundaries of the project itself. Large projects, for example, may shift activities in unintended ways, as when an afforestation project in one location displaces an afforestation project in another area. Or a project may alter the supply and demand forces of forest product markets and consequently the total area of forestland. Several kinds of leakage are possible.

• *Internal leakage:* when the project causes activities to shift within a forest operation. For example, the carbon sequestration created in one portion of the ownership prompts the owner to carry out carbon-emitting activities elsewhere.

• *External leakage:* when one forest owner's action causes other owners to change their behavior. For example, where the rules for developing forest carbon projects require sustainable forest management certification, one forest owner's actions may increase the area of certified forestry in the region. Or a forest project that halts land clearing for agriculture in one place causes farmers needing land to move and clear another forest. Or project rules require a large forest owner not to harvest, reducing supplies of lumber and prompting producers elsewhere to respond by harvesting more timber.

Whether positive or negative, leakage can be very difficult if not impossible to measure for forest offset projects. Past efforts to quantify leakage have been generally theoretical and remain hard to apply to a specific situation. There are currently very few empirical data that reliably establish leakage for all forest carbon offset project types. Murray et al. (2004) suggested establishing leakage (discount) rates that would require a leakage factor to be applied at the regional level for specific activities; all projects within that region should then factor that discount into their calculations. However, the decision to adopt this or any other methodology will be a political decision, since the validity of leakage discounts will be based on the assumptions made in the analyses for a specific forestry activity.

Although most leakage discussions consider how a project might cause other owners to increase emissions or reduce sequestration, some efforts seek to prevent the internal leakage that could occur if an owner counted carbon on rapidly growing areas while not inventorying areas that were in decline for any reason. Registries and programs tend to cover this through two approaches. The first is to require forest-wide reporting, such that all forestlands in the ownership are included in any reporting. The second is to require that the project demonstrate that it is certified as meeting the requirements of an internationally recognized sustainable forest management standard. Certification of forest carbon offset project lands provides three distinctive advantages: 1) buyers are assured that the quality of the carbon credits is high; 2) in well-functioning forest product markets, where sustainable forest management is practiced across the entire forest ownership, leakage will not be an issue; and 3) certification standards may provide the foundation for carbon accounting systems.

Current accounting systems may not adequately cover all aspects of leakage at the project level and for product use. Many greenhouse gas mitigation programs have yet to fully acknowledge leakage across all forest carbon pools.

Equivalence. Since forest carbon offset projects compete against clean technology projects in voluntary markets, forestry credits must be equivalent as climate mitigation measures. Forest carbon stock changes are typically derived from statistical sampling (direct measurement), reference tables, or models, however, and therefore the measurements will be less accurate than those for clean technology projects, whose emissions are measured with a high level of precision, using meters. Most forest project proponents have encouraged project developers to make carbon stock measurements, calculations, and projections intentionally conservative by using discounting methods. Because significant discounting can be a disincentive for offset project development, particularly at low CO_2 prices, the main challenge is establishing a policy that balances discounts and other related transaction costs with statistical precision and measurement accuracy. One idea is to discount the growth portion of forest credits to provide conservative estimates for CO_2 and thereby strengthen the additionality and permanence of a project. Insurance instruments or reserve pools can also be effectively used to accomplish similar results.

Policymakers' Task. The Kyoto Protocol and subsequent Conference of the Parties meetings have identified forest project accounting issues that are handled differently by the US registries and programs and thus affect eligibility and transaction costs for potential participants. The current definitions for forest carbon accounting principles were developed several years before forest carbon offsets were recognized by UNFCCC as a way for direct emitters of CO_2 to meet emission reduction targets. As a result, these definitions do not fully reflect the important role of sustainably managed forests as carbon sinks for climate change mitigation. The forestry community needs to rethink the accounting principles. The goal should be to ensure that offset rules are appropriate for all offset project types, including managed forests, and promote additional and long-term forest carbon sequestration benefits.

Opportunities and Challenges for Society, Landowners, and Foresters

Seven conclusions are apparent from the analyses presented in this report:

1. The world's forests are critically important in carbon cycling and balancing the atmosphere's carbon dioxide and oxygen stocks.
2. Forests can be net sinks or net sources of carbon, depending on age, health, and occurrence of wildfires and how they are managed.
3. Forest management and use of wood products add substantially to the capacity of forests to mitigate the effects of climate change.
4. Greenhouse gas emissions can be reduced through the substitution of biomass for fossil fuels to produce heat, electricity, and transportation fuels.
5. Avoiding forest conversion prevents the release of GHG emissions, and adding to the forestland base through afforestation and urban forests sequesters carbon.
6. Existing knowledge of forest ecology and sustainable forest management is adequate to enable forest landowners to enhance carbon sequestration if there are incentives to do so and if carbon and carbon management have value that exceeds costs.
7. How global voluntary and mandatory markets develop will play a significant role in establishing the price of carbon dioxide and thus creating the incentives to ensure that forests play a significant role in climate change mitigation.

Given those facts, society's current reluctance to embrace forest conservation and management as part of the climate change solution seems surprising. Time is of the essence. Forest management can mitigate climate change effects and, in so doing, buy time to resolve the broader question of reducing the nation's dependence on imported fossil fuels.

Opportunities, incentives, and recommendations for including carbon storage as part of the forestry solution vary markedly depending on ownership and market and nonmarket considerations. It is essential that natural resource professionals provide leadership in recognizing these opportunities and in encouraging the development of incentives that enhance forest conservation and management.

Ownership Considerations

US forests are owned by a diverse array of federal, state, industrial, nonindustrial corporate, nonindustrial family, and tribal entities. The forests themselves differ markedly in species, composition, stocking, and productivity. Each ownership manages its forests, either intensively or extensively, under different policies and regulations, and each has different goals, objectives, and incentives that determine how the land is managed. Specific opportunities to incorporate carbon storage as part of management will be highly dependent upon the particular forest and forest owner. Overarching policies, programs, and incentives to enhance carbon sequestration must recognize this diverse ownership pattern and encourage partnerships and collaboration. This will require substantial effort in technology transfer, education, and information outreach.

Private forest owners and public land managers should investigate developing opportunities for incorporating carbon storage and addressing the challenges of climate change into management objectives for their respective forest ownership type, whether the opportunities are market or nonmarket based.

Market Considerations

Private forest owners and managers must monitor the developing forest carbon sequestration markets and become familiar with the concepts of carbon pools, carbon baselines, additionality, permanence, and leakage. As the markets for forestry offsets develop, the standards associated with these concepts will become better established. Specific forest tracts within specific ownerships and operating with set objectives will have varying degrees of opportunity to market carbon offsets, based on how these standards develop. For example, a forest managed on a sawtimber rotation primarily to produce wood building products might have little opportunity to market carbon credits unless wood-frame structures are accepted as a pool for carbon storage.

It is impossible to accurately predict how a future carbon market will develop and how that market will affect forest owners. At recent traded values of CO_2 equivalents, income from carbon offset projects would not be high enough to preempt forest management practices employed to produce traditional forest products. However, this potential income would likely provide incentive to alter management practices to produce some level of traditional value combined with increased carbon sequestration. Market compensation for all ecological services, including GHG reductions, may help balance landowner income streams, thereby reducing the pressure to convert forests to other uses.

Emerging biopower and biofuels markets will likely enhance values for small-diameter materials and increase competition for traditional forest products. Although this increased revenue should benefit forest landowners, the traditional forest products industry may lose suppliers or see lower profit margins because of the new markets. Likewise, carbon trading and emission reduction credits associated with biomass power production could also benefit industries and forest owners investing in the new bioenergy industry.

Nonmarket Considerations

Management of forests is complex. It includes consideration of diverse components—soil, vegetation, wildlife habitat, water, recreation, aesthetics—as well as diverse products and values. Management involves determining what balance of revenues and outputs is desired and what costs and inputs are needed to sustain those outputs. Nonmarket forest resources, such as species diversity, clean water, enhanced fish and wildlife habitat, fire-resilient ecosystems, and scenic values, are also likely to be affected by carbon management strategies. Typically, efforts to increase the output of one forest product or value will likely decrease the outputs of others.

Carbon sequestration and storage are likely enhanced by increasing the rate of leaf area production and maintaining canopy cover. This could be accompanied by, for example, a decrease in wildlife diversity or water yields. Commercial timber production is commonly driven by value growth rate rather than volume growth rate, and thus stocking levels for timber production may be lower than if the goal were to maximize biomass production. Conversely, opportunities for pulpwood production and biomass energy will encourage higher stocking levels. If wood products are accepted as carbon pools, the mix of products from the forest may change. Possibilities for carbon management must also include consideration of spatial and temporal issues—whether one is managing stands, forests, or landscapes, and what time frames are involved. Justification for increased carbon storage will be influenced by such factors as carbon prices, policy incentives, and regulations.

The Profession

The profession of forestry is a broad field covering biological, physical, quantitative, managerial, and social components. The values, needs, and uses of forests are similarly broad. Carbon storage is a new "ecosystem service" that is being added to the management opportunities that traditionally included wood, water, wildlife, and recreation. Forest managers are already beginning to consider carbon sequestration and storage and the fate of carbon following disturbance and management treatments. In addition, foresters must consider the threats that climate change poses for forests and develop strategies to mitigate potential increases in pests, drought, severe weather events, and wildfires.

America's foresters must become informed and actively consider opportunities and effects associated with climate change so that forests and forest management can continue to both serve and enhance the welfare of society. The profession must be proactive in communicating to society the importance of growing and managing the nation's forests both for the sustainable supply of diverse values and uses and for their capacity to contribute to mitigation of the adverse effects of global climate change.

There is now agreement among many that the world is facing global climate change. It is beyond argument that forests play a decisive role in stabilizing the Earth's climate and that prudent management will enhance that role. For example, the Intergovernmental Panel on Climate Change (Nabuurs et al. 2007, 543), the preeminent international body charged with periodically assessing technical knowledge or climate change, has stated, "Forestry can make a very significant contribution to a low-cost mitigation portfolio that provides synergies with adaptation and sustainable development. However this opportunity is being lost in the current institutional context and lack of political will and has resulted in only a small portion of this potential being realized at present (high agreement, much evidence)."

The challenge is clear, the situation is urgent, and opportunities for the future are great. History has repeatedly demonstrated that the health and welfare of human society are fundamentally dependent on the health and welfare of a nation's forests. Society at large, the US Congress, state legislators, and policy analysts at international, federal, and state levels must not only appreciate this fact but also recognize that the sustainable management of forests can, to a substantial degree, mitigate the dire effects of atmospheric pollution and global climate change. The time to act is now.

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Subject Index

LETTERS

Correction

This letter corrects and clarifies a number of issues that have been brought to our attention since the publication of the SAF Climate Change Task Force's report, "Forest Management Solutions for Mitigating Climate Change in the United States," in the April/May 2008 issue (Vol. 106, No. 3) of the *Journal of Forestry*.

1. Page 120, middle column, fourth full paragraph. The paragraph should be amended to read:

"***Sequestration in Forests.*** The capacity of stands to sequester carbon is a function of the productivity of the site and the potential size of the various pools—soil, litter, down woody material, standing dead wood, live stems, branches, and foliage. Net rates of CO_2 uptake by broad-leaf trees are commonly greater than those of conifers, but because hardwoods are generally deciduous while conifers are commonly evergreen, the overall capacity for carbon sequestration can be similar. Forests of all ages and types have remarkable capacity to sequester and store carbon. There may be potential to sequester or store additional carbon in complex stand structures with mixed species compositions or several age classes."

This clarifies a statement in this paragraph of the original report regarding mixed-species, mixed-age stands.

2. Page 126, caption to Figure 1–2. The caption should be amended to read:

"Figure 1-2. Carbon cycle, c. 2004. White* numbers indicate how much carbon is stored in various pools, in billions of tonnes (i.e., gigatonnes, Gt). Purple numbers indicate how much carbon moves between pools each year. The diagram does not include the approximately 70 Gt of carbonate rock and kerogen (oil shale) in sediments (Source: http://earthobservatory.nasa.gov/Library/CarbonCycle/carbon_cycle4.html)."

This corrects the reference (*) to "black numbers" in the first sentence of the caption.

3. Page 126, left column, first full paragraph. The paragraph should be amended to read:

"Trees and other vegetation store 610 Gt* (610 gigatonnes or 610 billion metric tonnnes) of carbon (Figure 1-2) (1 tonne = 1 metric ton = 1,000 kilograms = 2,205 pounds). In the process of photosynthesis, trees and other plants take CO_2 from the air and in the presence of light, water, and nutrients manufacture carbohydrates that are used for metabolism and growth of both above-ground and below-ground organs, such as stems, leaves, and roots. Concurrently with taking in CO_2, trees utilize some carbohydrates and oxygen in metabolism and give off CO_2 in respiration. Vegetation removes a net of 500 million tonnes** of carbon dioxide (Mt CO_2) (i.e., net primary production) from the atmosphere each year. When vegetation dies, carbon is released to the atmosphere. This can occur quickly (in a fire), slowly (as fallen trees, leaves, and other detritus decompose), or extremely slowly (when carbon is sequestered in forest products). In addition to being sequestered in vegetation, carbon is also sequestered in forest soils. Soil carbon accumulates as dead vegetation is added to the surface or as roots "inject" it into the soil. Soil carbon is slowly released to the atmosphere as the vegetation decomposes (Gorte 2007)."

This corrects the reference (*) to "610,000 tonnes" in the first sentence of the paragraph, and corrects the reference (**) to "500 million Mt CO_2" in the third sentence of the paragraph.

4. Page 127, right column, third full paragraph. The paragraph should be amended to read:

"In 2005, US GHG emissions were 7,260.4* (7,260.4 teragrams, Tg) Mt CO_2 equivalents (US EPA 2007b). From 1990 to 2005, US emissions rose 16.3 percent as the US gross national domestic product increased by 55 percent (Figure 1-4) (US EPA 2007b). However, because of the sheer size of US emissions, even this relatively small percentage increase in emissions (compared with other countries) contributed considerably to total GHG emissions. For example, USGHG emissions increases from 1990 to 2002 "added roughly the same amount of CO_2 to the atmosphere (863 Mt CO_2) as the combined 64% emissions growth from India, Mexico, and Indonesia (832 Mt CO_2)" (Baumert et al. 2005, 13)."

This corrects the reference (*) to "7,260.4 million" in the first sentence of this paragraph.

5. Page 133, right column, third full paragraph (which continues on to page 134). The paragraph should be amended to read:

"Figure 3-5 illustrates the integrated effect of all carbon pools present in a forest as it matures, along with the carbon removed by product pools based on the life-cycle assessment. It shows a modest increase of carbon in the combined forest and product pools over time (yellow* line), unlike the steady state that exists in a forest (green line; i.e., when wood products are not removed). More importantly, as wood products are substituted for fossil fuel–intensive building materials like concrete and steel framing (black** line), emissions are avoided. The combined pools of carbon stored in the forest, forest products (net of processing, including the bioenergy from bark, or hog fuel, from mill waste), and avoided fossil fuel–intensive substitutes increase over time—with important consequences for carbon policy (USFS 2005)."

This corrects the reference (*) to "lower red line" in the second sentence of this paragraph, and corrects the reference (**) to "upper red line" in the third sentence of this paragraph.

6. Page 140, right column, third full paragraph. The paragraph should be amended to read:

"One forest management option for increasing the production of woody biomass is short-rotation energy crops using rapid-growing species such as alder, cottonwood, hybrid poplar, sweetgum, sycamore, willow, and pine. Perlack et al. (2005) did not count short-rotation tree energy crop production potential or account for possible production increases achievable through genetics or more intensive silvicultural practices. A yield figure of 8 dry tons per acre would add approximately 10 million dry tons annually to the estimated 368 million* dry tons of US woody biomass production."

This corrects the reference (*) to "368 billion" figure in the last sentence of this paragraph.

7. Page 146, left column, third full paragraph. The paragraph should be amended to read:

"Forest vegetation also plays a complex but vital role in affecting surface temperatures. Forests tend to have a lower albedo than other land uses and thus absorb more shortwave radiation. Afforestation can therefore increase temperatures at the surface, particularly in boreal regions where there is potentially large contrast between forests and snow-covered open land (Betts 2000). Deforestation can result in increased surface albedo and, therefore, deforested areas in northern mid-latitude agricultural regions might be 1–2°C cooler in winter and spring (Betts 2001). However, deforestation in the tropics might warm the region due to changes in soil moisture, evapotranspiration and clouds (Bonan 2008)."

This paragraph corrects and clarifies the relationship between forests and the albedo effect stated in this paragraph in the original article.

8. Page 149, left column, second full paragraph. The paragraph should be amended to read:

"Net rates of CO_2 uptake by broad-leaf trees are commonly greater than those of conifers, but because hardwoods are generally deciduous while conifers are commonly evergreen, the overall capacity for carbon sequestration can be similar. There may be potential to sequester or store additional carbon in complex stand structures with mixed species compositions or several age classes due to complimentary resource use or facilitative improvement in nutrition (Kelty 2006)."

This clarifies a statement in this paragraph of the original report regarding mixed-species, mixed-age stands.

9. Page 152, right column, first full paragraph. The paragraph should be amended to read:

"The modeling of stand dynamics enables a comparison of managed and unmanaged stands in terms of carbon sequestration and storage. For simplicity, researchers developed Figures 7-2, 7-3, and 7-4 for even-aged stands commencing with bare ground, but comparable diagrams could be prepared illustrating the growth of uneven-aged stands. Figure 7-2 shows the accumulation of carbon over two 40-year rotations of southern loblolly pine and illustrates the distribution of harvested carbon into diverse products and the decline in forest carbon stocks during the reforestation phase (Birdsey and Lewis 2002). Figure 7-3 illustrates the results of modeling the accumulation and distribution of carbon over four clearcutting rotations in western Washington (Oneil et al. 2007). Here, carbon in the forest has a stable trend line, and the carbon in product pools—net of energy used in harvesting, processing, and construction—steadily increases over time. The area in blue* shows the substantial carbon savings associated with substitution of renewable and carbon-neutral wood products for alternative, fossil fuel–intensive building products (Oneil et al. 2007)."

This corrects the reference (*) to "gray" in the last sentence of this paragraph.

10. Page 165, middle column. The column should be amended to add the following reference (which is referred to in the seventh correction/clarification above): "Bonan, G.B. 2008. Forests and climate change: Forcings, feedbacks, and climate benefits of forests. *Science* 320:1444–1449."

11. Page 167, right column. The column should be amended to add the following reference (which is referred to in the eighth correction/clarification above):

"Kelty, M.J. 2006. The role of species mixtures in plantation forestry. *For. Ecol. Manag.* 233:195–204."

We would like to thank the *JOF* readers who brought the need for these corrections and clarifications to our attention.

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