Forest Research in Response to Climate Change:
A Strategic Plan for the Northern Research Station

January 10, 2007

Michael T. Rains, Director
Northern Research Station
11 Campus Blvd
Newtown Square, PA 19073
610-557-4017
http://www.nrs.fs.fed.us/

Northern
RESEARCH STATION
USDA Forest Service

Forest Research in Response to Climate Change:
A Strategic Plan for the Northern Research Station

TABLE OF CONTENTS

Vision and Overview 3

Organization of Climate Change and Related Research 4

Forest Responses to Atmospheric and Climatic Change 8

Forest Carbon Management 12

Forest-Based Bioenergy 15

Appendix: Organization Action Items 18

Forest Research in Response to Climate Change: A Strategic Plan for the Northern Research Station

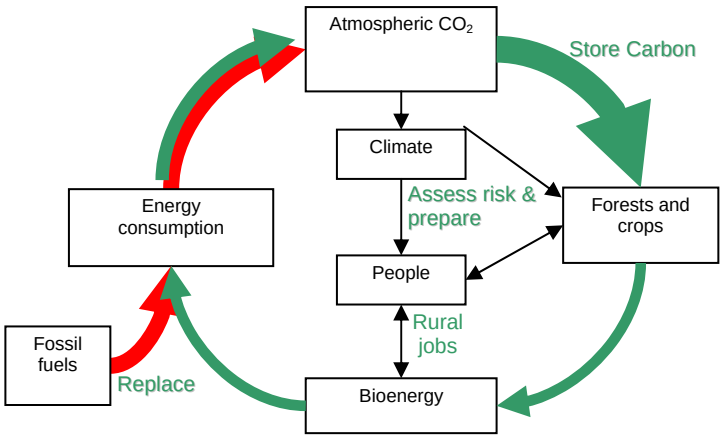
Vision: Our nation's forest resources are managed to enhance ecosystem services such as carbon storage and bioenergy for a sustainable society with global climate change.

Mission: By connecting climate change research and societal values, we foster innovative management solutions to sustain forests, forest-based values and quality of life.

What we do:

- Assess sensitivity of forest ecosystems, markets, and forest-based communities to climate change.
- Determine how to adapt forest management to climate change-related needs (e.g., carbon storage and the production of wood for biomass energy) while preserving ecosystem services.
- Monitor and map forest resources and maintain databases useful for climate impact assessment and greenhouse gas mitigation (e.g., forest carbon storage, and biomass energy feedstocks).
- Provide knowledge, improve awareness, educate, and inform policy on climate change-based threats to forests and on forest-based solutions to these threats.

Connections among climate, carbon, and energy



Humans produce greenhouse gasses which have changed our atmosphere. Both atmospheric change in greenhouse gas concentration and possible climate change can threaten our ecosystems and degrade human health. We are adapting forest management to respond to likely changes, to reduce the flow of carbon dioxide into the atmosphere, and to replace a portion of fossil energy with bioenergy which provides national energy security and also reduces the accumulation of greenhouse gasses.

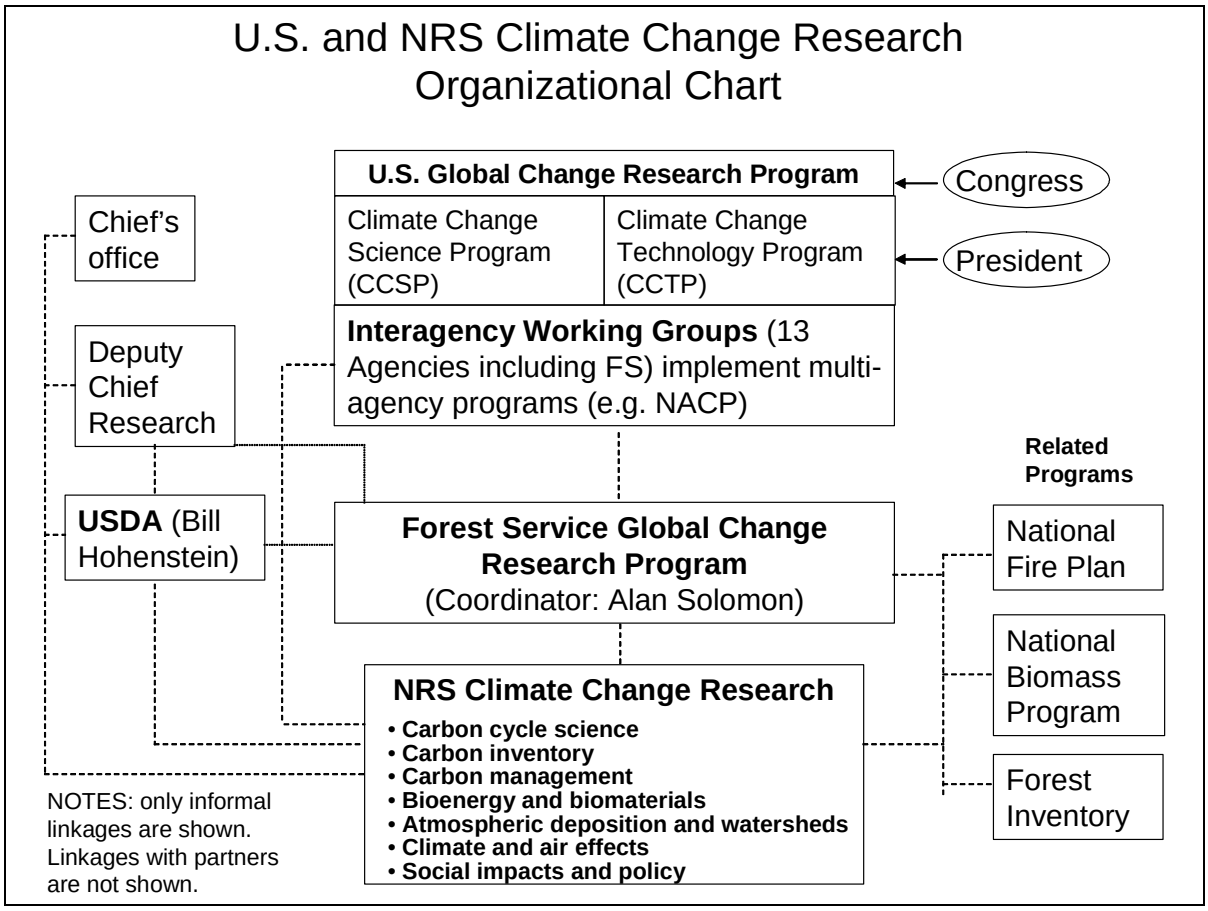
Current Opportunities:

- Anticipate how and where forests will change in response to climate, and develop best management practices to adapt to future conditions.
- Meet national demands for greenhouse gas inventory and carbon management of forestlands and grasslands.
- Support the emerging bioenergy and bioproducts opportunities with precision feedstock availability data, market analyses, and sustainable feedstock production systems.

Organization of Climate Change and Related Research at NRS

Program Organization and Links to National Programs

Climate change research at the NRS is conducted within the broad structure of an interagency Global Change Research Program authorized by Congress and the President (see figure below). Leadership of the NRS Climate Change Research Program is shared among the Project Leaders and Program Manager.



Several closely related national programs are also shown in Figure 1. National programs that have significant relevance to climate change research include the Fire Plan, the Biomass Program, and Forest Inventory and Analysis. The National Fire Plan is linked through common interest in climate variability, quantification of fuel loads (i.e. carbon mass), and large-scale ecosystem models. The national Biomass Program addresses the nation's energy needs and utilization of forest products, both of which may also be considered in carbon accounting and reporting. The nation's Forest Inventory and Analysis provides the basic data about forest resource condition at scales from county to continent, and is the basis for estimating changes in forest carbon stocks.

Program Components , Contacts, and Budget

Climate change research at the Northern Research Station (NRS) involves many different elements of the existing organization.

1. The Northern Global Change Research Program (NGCP) was formed in 1991 to coordinate and manage climate change research. From inception, the NGCP was a joint program of the Northeastern and North Central Research Stations.
2. The Northeastern Ecosystem Research Cooperative (NERC) was formed in 2001 to study the health of terrestrial and aquatic ecosystems in the northeastern U.S. and eastern Canada, and sponsors research on air pollution and climate change effects.
3. The Northern Institute of Applied Carbon Science (NIACS) was formed in 2003 to provide ecological, economic, and social information that can be used to manage forests for the sequestration of atmospheric carbon.
4. Twenty of the 34 NRS Research Work Units currently participate in the NGCP. These units perform most of the basic and applied research that underlies the Climate Change Research Program of the NRS.

To help organize and communicate this complex of climate change and related research, we have organized the program into seven components shown in Table 1.

Table 1. Northern Research Station Climate Change and Related Research – Program Components and Primary Contact.

Contact	Program Component

R. Birdsey, [1]NGCP Program Manager	▪ Carbon cycle science
	  ◦ North American Carbon Program
	  ◦ Forest/atmosphere/river carbon exchange
	  ◦ Effects of climate and natural disturbance
	▪ Atmospheric deposition and watersheds
	▪ Climate and air effects
	▪ Greenhouse gas registries
	▪ Social impacts and policy

A. Friend, NIACS Director	▪ Carbon cycle science
	  ◦ Below-ground processes
	  ◦ Effects of forest management
	  ◦ Life cycle analysis of wood production/energy use
	▪ Carbon Management
	▪ Bioenergy and biomaterials

L. Heath Project leader, Carbon Research Work Unit	▪ Carbon inventory

Most of the funding for climate change research is considered "crosscut", meaning that the funds are appropriated to formally defined institutional units (i.e., a Research Work Unit), but the funds also support climate change research that is integrated across organizational units. The climate change research budget for FY 2006 has been tabulated by program element and research unit (Table 2). The budget required to fully fund climate change research at NRS, by program element, is shown in Table 3.

Table 2. NRS Climate Change and Related Research Budget, FY 2006 ($1000).

	TOTAL	Carbon cycle science	Carbon inventory	Carbon management	Bioenergy and biomaterials	Atmospheric deposition and watersheds	Climate and air quality effects	Social impacts and policy
NE-4103 Schaberg	325					200	125	
NE-4104 Heath	689	100	464	125				
NE-4153 Yaussy	226						226	
NE-4301 Adams	100					100		
NE-4352 Eagar	1100	100				700	200	100
NE-4352 Eagar (NERC)	370					165		205
NE-4454 Twery	150			75				75
NE-4455 Birdsey	1404	636		204		200	260	104
NE-4455 Hom	200	100					100	
NE-4458 Long	100					100		
NE-4505 Smith	225					225		
NE-4952 Nowak	250		100	100			50	
NE-4152 Stout	50			50				
NE-4155 Brissette	100	100						
NC-4101 Palik	50	25		25				
NC-4152 Nelson	1124	376			265		483	
NC-4154 Thompson	237			237				
NC-4159 Friend	725	425					300	
NC-4159 Friend (NIACS)	218			218				
NC-4351 Kolka	316	200				116		
NC-4401 Heilman	170						170	
NC-4455 Birdsey	210	80					130	
NC-4803 Jakes	75			75				
NC-4902 Westphal	35			35				
TOTAL	8449	2142	564	1144	265	1806	2044	484

Definitions:

Carbon cycle science	Basic research -- FACE, flux, experiments, models
Carbon inventory	Estimation and reporting of carbon stocks and stock changes
Carbon management	Forest management practices; greenhouse gas policies; accounting rules and guidelines
Bioenergy and biomaterials	Biological and economic opportunities to produce and use wood for bioenergy and biomaterials
Atmospheric deposition and watershe	Effects of air pollution (N and acid deposition) on ecosystem and watershed processes, structure and function
Climate and air quality effects	Effects of climate change and air pollution on ecosystems at multiple scales
Social impacts and policy	Assessment of climate change and air pollution effects and potential responses

Table 3. NRS Climate Change and Related Research Budget Summary and Needs for Full Funding.

Program Element	*FY 2006*	*Additional needs (+)*
Carbon cycle science	2,142	600
Carbon inventory	564	400
Carbon management	1,144	400
Bioenergy and biomaterials	265	1,100
Atmospheric deposition and watershe	1,806	0
Climate and air quality effects	2,044	1,000
Social impacts and policy	484	300
TOTAL	8,449	3,800

Links to NRS Science Theme and National Strategic Program Areas (SPAs)

Climate change and related research at the NRS is related to the station themes and the national research strategy as shown in the table below.

NRS Climate-Related Research Element	NRS Science Themes	National SPAs
▪ Carbon cycle science ▪ Carbon inventory ▪ Carbon management ▪ Bioenergy and biomaterials	▪ Clean air and water ▪ Urban natural resource stewardship ▪ Sustaining forests	▪ Resource management and use ▪ Inventory, monitoring & analysis ▪ Strategic opportunities
▪ Atmospheric deposition and watersheds ▪ Climate and air effects ▪ Social impacts and policy	▪ Clean air and water ▪ Urban natural resource stewardship ▪ Managing with disturbance	▪ Water and air

Forest Responses to Atmospheric and Climatic Change: Sustaining Forest Resources by Anticipating Forest Responses and Adapting Forest Management

Issue: Forest landscapes are changing because of climate and environmental change. These changes affect people and the forest ecosystems they depend on for clean air and water, forest products, biological diversity, and recreation. How can we best manage our forest resources to provide this array of ecosystem goods and services under increasing environmental stress and a changing climate?

Goal: We work to understand the impacts of environmental change on forests and people who depend on forests. We provide research products that assist landowners, policy makers, and land managers in developing, evaluating and implementing strategies for adapting to, mitigating, or capitalizing on changes in forest health, productivity, and diversity because of environmental change.

Background: The Northern Research Station has a long history of research on the effects of air pollution and climate change on forests and watersheds in the Northeastern and North Central United States. We have documented climate trends, increasing atmospheric carbon dioxide, ozone exposure, high levels of acid and nitrogen deposition, and land use pressures, all simultaneously affecting northern forests. We observe that in the past, northern forests have shown remarkable resiliency and adaptability to high levels of environmental stress. We build on this research background to develop and evaluate management and policy options for adapting to global change. We need long-term management strategies that optimize the role of northern temperate forests in sequestering carbon while maintaining production of goods and services under increasing threats. The land we care for is changing in many ways, in part due to climate change and climate variability: the average annual temperature in the North has increased, growing seasons are getting longer, species are shifting their ranges and disturbance regimes are likely changing as well. To develop effective strategies to adapt to these long-term changes, we need to better understand and anticipate the interacting effects of a changing climate and other factors on forest productivity, water availability, and nutrient cycling. As these effects accumulate, we begin a new century with high uncertainty about future forest resource sustainability.

Key Points: Effects on Ecosystems and Implications for People

- *Healthy forests provide clean water to millions of people.* Climate change and air pollution are serious threats to the future ability of the North's extensive forest area to protect watersheds and river basins by regulating the flow of water and absorbing chemical pollution.
- *Climate variability can affect disturbance occurrences.* Global climate forcing factors (e.g. El Nino – Southern Oscillation, Pacific Decadal Oscillation) can affect the occurrence of regional weather and climate disturbances (e.g. thaw-freeze events, extreme cold events) that may increase risk of forest dieback.
- *The ability of forests to sequester carbon is dependent on the availability of water and nutrients.* Changing climate and air quality affects precipitation amounts and the availability of nutrients on which forest growth depends.

- *We need better understanding of feedbacks to the atmosphere under climate change.* Although forest and wetland systems tend to sequester carbon, we need to better understand how management options affects sequestration dynamics and greenhouse emissions.
- *Northern forests are subject to multiple environmental stresses.* We are beginning to understand how the interacting effects of climate change, elevated CO_2, increasing ozone exposure, high levels of acid deposition, land use changes, and invasive pests change the growth and distribution of northern forests.
- *Climate change affects tree species distributions and severity of forest pest outbreaks.* Individual species react differently to changing climate, and many tree species may not be able to migrate as fast as their habitat is changing. As forest ecosystems and associated organisms respond to changing conditions, intensity of pest outbreaks and species composition of forests is likely to change dramatically.
- *Climate variability can increase fire risk.* Historically, fire has been a common disturbance in Northern forests. Although most fires are now suppressed, future fire frequency, size, intensity, and distribution may increase. Recent increases in large fires in the Northeast may be due to climate change as more heat and drier conditions combine with more fuel.
- *In the North, people live in a surrounding forest landscape.* Development and land use change cause fragmentation and loss of forest benefits. Our scientists are mapping the wildland urban interface (WUI) and projecting future land use, population and housing density.
- *Urban conditions such as the heat island effect may affect human health.* Our research shows that urban forests reduce the heat island effect and human health risk by cooling and cleaning the air, as well as increasing aesthetics, well being, and property values.
- *Effective policies depend on understanding people's perceptions of climate change.* People have different views of how climate and environmental change affects them, forests, and the services that forests provide. Our challenge is to provide information that facilitates the transition to new types of ecological communities and services.
- *We work with a large, diverse community to develop an effective approach to adaptation.* We work with Congress, the State Department, the Department of Energy, NASA, NOAA, USGS, other federal and state agencies, the National Science Foundation, the National Council on Air and Stream Improvement (NCASI), regional planning commissions, researchers at universities, and NGOs such as The Nature Conservancy.

Current Products and Capability

- Long-term experimental research such as the Aspen FACE ecosystem experiment at Rhinelander, Wisconsin show how ozone interacts with elevated CO_2, to cause changes in productivity, carbon sequestration, and insect outbreaks for northern hardwood forests.
- We produce assessments of hazards, risk and opportunities of forest management under climate change by integrating available information about forest responses to changes in climate, soil, hydrology, and air quality. These assessments can be done at various scales: regions, watersheds, states, or counties.
- We produce maps summarizing observed climate changes and disturbances such as insects and disease outbreaks, ozone exposure, and acid deposition.
- We develop projections of climate variability, fire weather, air pollution transport, and their effects on vegetation distribution and other important ecosystem properties at the

regional scale such as bird species abundance or water yield for river basins. These projections can help identify effective response strategies.

- We have mapped potential changes in suitable habitat for most of the tree and bird species in the region.
- We identify areas and species that are sensitive to individual or multiple stresses using ecosystem models. We produce maps at different scales that predict human land-use patterns.
- We support an intensive forest-monitoring network providing continuous information about the exchange of water, energy, and carbon between forests and the atmosphere.
- We support the world's largest ecosystem-scale experiment (in Rhinelander, WI) addressing atmospheric impacts on forests.
- We maintain excellent landscape and regional-scale climate, disturbance, and ecosystem models.
- We support state-of-the-art computational environments for running climate, weather, and ecosystem models.

What We Need to Do

- Enhance our Experimental Forest monitoring network to provide an early warning of climate change effects, and augment experimental research by developing best forest management practices and decision support systems to sustain healthy, resilient ecosystems that can continue to deliver the values, goods, and services under future climate change and climate variability.
- Based on our extensive existing capability, we have the capacity to bring together climate scenarios, regional weather modeling, landscape disturbance, and forest succession /species shift models to develop risk maps at multiple scales of significant changes in vegetation, fire and fuel regimes, and water quality and quantity.
- Expansion of our ecosystem science work to include the perspectives brought by social scientists will integrate our rapidly evolving biological knowledge with better understanding of people's perceptions of climate change, to develop effective adaptation policies and management practices.

Link to Station Research Themes

The nature of global change research is multidisciplinary and crosscutting, thereby linked to all the NRS research themes: Providing Clean Water and Air, Managing with Disturbance, Sustaining Forests, and Urban Natural Resources Stewardship

Funding history and needs ($1000):

Program Element	FY 2006	Additional Needs
Atmospheric deposition and watersheds	$1,806	0
Climate and air quality effects	2,044	+1,000
Social impacts and policy	484	+300
Total	$4,344	+1,300

Additional funding is needed because:

- We cannot develop and implement effective adaptation policies and management practices without a stronger base of social science knowledge.
- The highly integrated research required to link across disciplines to provide assessment products is not currently part of the mission of Research Work Units, so basic research would be sacrificed without additional, compensating resources.
- We lack funding to sustain our research with towers that monitor carbon, energy, and water exchange between northern forests and the atmosphere.
- We lack sufficient computing infrastructure, data management systems, and specialists in technology transfer.

Forest Carbon Management: Cleaning the Air by Reducing Harmful Greenhouse Gasses

Issue: Significant opportunities exist for forest carbon management to help reduce net greenhouse gas emissions, to increase the income stream of private landowners, and to enhance the ecosystem services derived from forests by society. Our nation's forests are a strategic asset for greenhouse gas emissions reduction, carbon sequestration, and rural economic health. Our research can provide the science, technology and applications options so that effective action can be taken and effective policy can be made at the Federal and State level.

Goal: To reduce atmospheric CO_2 concentration by increasing the amount of carbon stored in U.S. forest ecosystems and forest products, and to assist Northern States, landowners and forest industry to integrate carbon management into their forest management and production goals.

Background: Increased carbon sequestration in forests and forest products is an important element of a comprehensive strategy to reduce net emissions of greenhouse gases. U.S. forests and forest products currently remove 200 million tons of carbon from the atmosphere each year, offsetting 10% of U.S. emissions from fossil fuels. There are a variety of opportunities to develop and apply forest management technology to maintain and enhance the role of forests and forest products as carbon sinks, to provide additional income to forest landowners from sale of carbon credits, and to reduce greenhouse gas emissions. The keys to increased carbon sequestration and reduced greenhouse gas emissions are enhanced productivity, sustainable resource management systems based on understanding and manipulating biological processes, and developing effective deployment strategies and implementation technologies. Evolving markets may eventually increase the value of carbon sequestration in the U.S. Forestry activities to improve carbon management support other goals of forest landowners such as producing wood products or restoring ecosystems.

Key Points:

- The Forest Service is a participant along with other agencies in the U.S. Climate Change Science Program. The NRS has a key strategic role in the North American Carbon Program, and in providing national estimates of carbon in forests and wood products.
- The USDA Forest Service leads in developing information and tools for successful carbon management in our nation's forests, grasslands and other terrestrial ecosystems.
- Forest landowners and forest industry are participating in markets and registries such as the Chicago Climate Exchange and the national 1605(b) Voluntary Greenhouse Gas Registry.
- Seven northeastern states recently established the first cap and trade program for greenhouse gases in the U.S. Midwest states also have greenhouse gas initiatives.
- Forest management, wood products, and woody biomass energy provide opportunities to offset fossil fuel emissions and provide alternative energy sources.
- Carbon sequestration in forests and wood products can be enhanced while maintaining or improving other forest benefits.
- There is a confusing array of programs and policies emerging, and a lack of strategic assessments and specific technologies for managing carbon in forests and wood products.

Current Products:

- We provide basic science and technical support for development of state, regional, national, and international greenhouse gas action plans.
- We quantify carbon stocks and fluxes in forests and wood products of the U.S., Canada, and other countries. We develop methods and estimates for the forest sector of the U.S. greenhouse gas inventories compiled by USDA, EPA, and many states.
- We conduct or support efforts to develop and expand the use of forests for bioenergy and biomaterials.
- We identify forest carbon management opportunities and develop tools that facilitate carbon management in northern forests, including information on best management practices for forest carbon sequestration.
- We develop forest carbon accounting tools and information for forest landowners and managers responding to national and regional greenhouse gas registries.
- We conduct research on the role of forests in the global carbon cycle, and how carbon stocks change in response to management and disturbance.

What We Need:

- We need to develop and maintain science-based decision-support tools to assist landowners and businesses, in urban and rural areas, with making decisions about good forest carbon management, and with participating in carbon markets and incentive programs. A specific application mandated in the Federal Register is to complete the Carbon OnLine Estimation (COLE) model, a portal and web tool designed to provide "one-stop-shopping" for forest carbon inventories, reporting, and management (URGENTLY NEEDED BY DECEMBER 2006).
- Capability to provide expert scientific support, customized analyses, and demonstration projects, to support carbon policy and management decisions by international, federal, state, and private interests.
- Additional support for understanding the socioeconomic aspects of carbon management: reducing barriers to technology deployment; economies of scale and transaction costs; and optimal design of policies such as carbon trading systems and the role of incentives for carbon sequestration and abatement.
- We will extend and expand experimental work by developing forest management strategies, systems, and best practices and decision support systems to sustain and enhance productive, healthy, resilient ecosystems to deliver the values, goods, and services that people want.
- We need to improve our ability to monitor and verify the changes in carbon storage that result from forest management activities and wood product substitution.
- We need to demonstrate the technological potential for reducing greenhouse gas emissions at selected Forest Service facilities.

Link to Station Research Themes:
Assessing and managing forest carbon is linked to all four of the NRS themes: Providing Clean Water and Air, Managing with Disturbance, Sustaining Forests, and Urban Natural Resources Stewardship.

Funding history and needs ($1000):

Program Element	FY 2006	Additional Needs
Carbon cycle science	2,142	+600
Carbon inventory	564	+400
Carbon management	1,144	+400
Total	3,850	+1,400

Additional funding is needed because:

- In recent years, demand for annual information has grown so strong that we have lost capability to develop and maintain estimation methods and tools that make use of current technology developments in remote sensing and GIS.
- There is an increasing need for science applications products, such as tools to help landowners evaluate carbon credits in their forest management and processing strategies, and we lack personnel to effectively develop these products while continuing to make progress in the underlying science of understanding responses of forest carbon to management and disturbance.
- We lack funding to sustain our experimental research and long-term observational studies using forest canopy towers that monitor carbon, energy, and water exchange between northern forests and the atmosphere.
- Limited available funding has been taken up by the need for improved biological understanding of forest carbon, leaving little available for understanding socioeconomic aspects of carbon management.

Forest-Based Bioenergy: A Sustainable Practice that Enhances Energy Security and Global Environmental Quality

Issue: The United States is heavily dependent on fossil fuels, and an increasingly large proportion of our energy needs are being met by imported petroleum and natural gas. This reliance on fossil fuels and imports reduces U.S. energy, economic, and environmental security. Increased bioenergy production from forest biomass provides a sustainable renewable energy source, improves local economies, and contributes to U.S. energy security. Bioenergy can help ameliorate atmospheric change and global warming, in that carbon dioxide emissions are absorbed by the growing forest that produced the biomass and by all the forests that follow.

Goal: Forest-derived biomass transformed into bioenergy can help relieve our dependence on fossil fuels. We believe that the biobased revolution will continue to present new business opportunities for farmers and others. *Our goal is to reduce the uncertainties that surround U.S. biomass production.* Less uncertainty will promote capital investment in a bioenergy industry. A thriving bioenergy industry will benefit rural communities who provide the feedstocks. We also seek a bioenergy future where economic goods and environmental services upon which forest-based industries and communities depend remain valued and maintained.

Background: The United States Department of Agriculture (USDA), Forest Service, Northern Research Station (NRS) has contributed to our national understanding of bioenergy and energy crop development since 1973 in partnership with the U.S. Department of Energy (DOE), particularly the research program in Rhinelander, Wisconsin, but also partnering with many other institutions. Our knowledge of the bioenergy issue is substantial.

The bioenergy research program is not organizationally part of the climate change research program for the Forest Service, USDA, DOE, or the nation, and is a critically important program in its own right. However, the environmentally positive linkage between bioenergy and carbon sequestration gives bioenergy another attribute and relates it to the climate change research program.

Key Stakeholders, Partners: National Forest System, universities, new and existing forest-based industries, the ethanol industry, other federal agencies, state governments, forest landowners, farmers, timber producers, environmental NGOs.

Key points:

- Bioenergy is a potential user of biomass resulting from HFI activities.
- Using wood for energy rather than fossil fuel lowers greenhouse gas emissions because biomass energy is closed loop, not resulting in net CO_2 accumulation.
- Bioenergy enhances national security by lessening the demand for oil imports.
- Using wood for energy is an environmentally sustainable and economically viable enterprise given current and expected oil prices.

- The United States has committed to a massive increase in ethanol addition to motor fuel; to satisfy this demand, tree as well as crop residues will need to be used in the production of cellulose ethanol production.

Current Products:

- We have developed guidelines for establishing and cultivating hybrid poplar plantations in the North Central United States.
- We have quantified biomass production rates for hybrid poplars grown on short rotations.
- We have conducted preliminary economic and energy production analyses for hybrid poplars.
- We have new improved hybrid poplar trees in testing within our ongoing breeding program.
- We have estimates of harvest residuals at a relatively coarse scale.

What we need to do:

- *Measure the existing forest-based biomass supply and develop new sources:* Much timber is harvested each year, but parts of those trees remain underutilized. We can determine the amount and distribution of this harvest "residual" using our Forest Inventory and Analysis expertise. Geneticists and silviculturists can develop management systems and new trees that grow quickly as energy crops and for other uses.
- *Understand the economics of biomass production:* Our economists can determine the costs of harvesting, transporting, and preparing biomass and how these costs depend on the surrounding landscape, which are important parts of bioenergy investment decisions. Further, we can evaluate the benefits and costs of government policies for increasing forest-based biomass supply such as large-scale forestation of agricultural land.
- *Quantify the environmental implications of a bioenergy economy:* Our ecologists can determine whether biomass harvests from the forest or the farmer's field improve or compromise ecosystem sustainability and can help design sustainable systems. We can demonstrate the economic and environmental benefits and costs of bioenergy to the community by converting one of our research facilities to bioenergy.
- *Lend reason to future debate:* Our social scientists have the ability gauge the perspectives of communities and society to changing forest management and land uses and help communicate scientific principles and socioeconomic outcomes of forest-based biofuels.
- *Learn how bioenergy fits the landscape:* Our landscape ecologists can map places where agriculture, forests, and energy crops can jointly contribute to new and existing biomass refineries. We can better understand how cities can provide "waste" biomass from the urban landscape. We can learn how biomass and bioenergy can revitalize rural economies and the relationship between rural and urban America.

Link to Station Research Themes:

Bioenergy strategies can reduce greenhouse gas emissions thereby "Providing Clean Air and Water". Forests provide a bioenergy feedstock, thus a central concern is "Sustaining Forests". One bioenergy feedstock is urban waste; we need to consider "Urban Natural Resource Stewardship" in our planning. Further, bioenergy can foster "Managing with Disturbance" by providing markets for "disturbed" timber.

Funding history and needs ($1000):

Program Element	FY 2006	Additional Needs
Bioenergy and biomaterials	265	+1,100

Additional funding is needed to:

- Build a small-scale demonstration bioenergy plant at the Rhinelander Forestry Sciences Laboratory to supply most of the energy for this facility. This will become a model for other facilities within the Forest Service and similar institutions.
- Determine the amount and distribution of forest harvest residual in the northern U.S. at a resolution useable for commercial application.
- Develop technology to utilize abundantly available wood biomass in overstocked and/or unhealthy forests.
- Fully fund the development of new trees that are disease resistant and grow quickly as energy.
- Crops and fiber sources and of new management systems for producing bioenergy feedstock.
- Elucidate the economics of bioenergy production.
- Understand the environmental implications of a forest-based bioenergy economy and design bioenergy production systems that are sustainable.
- Determine the socio-political ramifications of bioenergy production systems.

Appendix: Organizational Action Items

We have identified some actions that can be taken to help achieve additional efficiency and reduce duplication for climate change research at the NRS:

1. The NRS leadership team (Executives and Project Leaders) needs to develop clear and consistent expectations about climate change research, and follow through with implementing and monitoring any recommended changes.
2. Discussions have begun to coordinate research on carbon inventory and the Carbon OnLine Estimation (COLE) model with the FIA Program, USDA, EPA, and other interested parties. We recommend that a small team be formed to begin these discussions, led by Linda Heath, and including others as appropriate (Birdsey, May, Schmidt, others?). Because of the interagency linkages, this discussion should culminate in one or more Memoranda of Understanding.
3. To present a coordinated climate change research program to those outside of NRS, especially the customers we are trying to serve, a web page that provides "one stop shopping" for climate, carbon, and bioenergy information should be developed. We recommend that NIACS (Friend) take the lead on developing this web site, with support from Birdsey, Heath, and Iverson (and others?).
4. There are opportunities to review elements of the research infrastructure to achieve more efficiency in use and allocation of resources, and to better serve the public. Examples include centralized data archiving and broader use of NRS research facilities (e.g. experimental forests or GIS labs). We recommend that a small team be formed to identify several high priority opportunities, with members including Hom, Heilman, Nelson, others?).
5. We have begun a review of the carbon cycle research organization to identify overlaps and gaps in coverage. This activity, primarily involving Birdsey, Heath, and Friend, should continue.
6. In the areas of science applications and technology transfer, there is a need to consider how the activities of Scientists, Project Leaders, Managers, and NIACS are integrated with the NRS Science Application Program and the NRS Communications Staff. This discussion should involve Birdsey, Friend, Heath, Stout, Dietzman, and others.