## **US Forest Carbon Budget:**

The potential for forests to sequester large quantities of CO<sub>2</sub> from the atmosphere has become a key issue in international negotiations to reduce greenhouse gas emissions. Our scientists estimate how much CO<sub>2</sub> is taken up and released by U.S. forests, evaluate how this may change in the future as a consequence of forest management and natural disturbances, and evaluate policy options for increasing the role of forests as carbon sinks. This information helps negotiators from the U.S. State Department develop a policy for overall U.S. emissions reductions that minimizes the negative impacts on society. Forest growth, particularly in the Northeast, currently offsets 15-25% of U.S. emissions of  $CO_2$  from fossil fuels.



Tree carbon per hectare by U.S. county (Heath et al.)

#### The Aspen FACE Experiment:

he Aspen FACE experiment consists of twelve 30m rings in which the concentrations of carbon dioxide and opospheric ozone can be controlled. The design provides the ability to assess the effects of these gases lone and in combination on many ecosystem attributes, including growth, leaf development, root haracteristics, and soil carbon.

)ur scientists have developed an automated, temperature and CO $_2$  controlled, multiple cuvette photosynt system to measure daily carbon sums for leaves and stems within a treatment ring. The continuous hotosynthesis and respiration measurements under ambient conditions, will contribute to the suite of ysiological parameters that are being measured at the Rhinelander FACE site. The Aspen FACE periment is funded DOE, NSF, NCASI, the Northern Global Change Program, Michigan Technological niversity, and the USFS North Central Research Station.

#### **Country Level Carbon Budgets:** China:

#### New estimates of carbon storage and sequestration in China's forests

We developed an age-based methodology to estimate carbon storage and sequestration rates in China forests between 1973 and 1993 based on plot level forest inventory data, national-level inventory statistics, and data from ecological site studies to estimate biomass in different tree components. Our results indicated that carbon storage in China forest trees was 4.34 Pg C in the early 1990s, an increase of 13% since the early 1970s. The forest carbon sequestration rate from the late 1980s to early 1990s was 0.068 Pe C/yr and approximately four to five times higher than that in the 1970s and

#### Russia:

## Carbon Storage in Forests and Peatlands of Russia

This report is the result of the joint Russian-American research project 23-817, Carbon Budget in Boreal Forests, sponsored by the V.N. Sukachev Institute of Forest, Siberian Branch of the Russian Academy of Sciences, and the USDA Forest Service's Global Change Research Program. This research was initiated to evaluate contemporary carbon storage in the forests of Russia and other countries of the Earth's boreal belt, and to assess past and future dynamics of carbon. The initial research results in this report include detailed statistical estimates of carbon storage in the forests and peatlands of Russia. More extensive results were published by the editors in a 1994 monograph entitled "Carbon in Ecosystems of Forests and Peatlands of Russia" (in Russian).



The total area of forests in China increased 3.5% from 1973 to 1993 due to intensive national plantings



## Potential Impacts of Climate Change on Northern Forests:

The products presented in this atlas were a result of a modeling effort that involved the use of USDA Forest Service's Forest Inventory Data, numerous environmental variables gleaned from various sources and 2xCO2 equilibrium climate variables provided by five Global Circulation Models (GCMs) -, i.e., GISS, GFDL, Hadley, UKMO and CCC. The information includes distribution maps and tables for different climate change scenarios, life-history and disturbance attributes, ecological attributes, forest type maps and sorted list of species importance values by state/county for different climate change scenarios, and more for 80 species in the eastern half of the United States (east of the 100th meridian)

Current and Future distribution of sugar maple

Iverson, L. R., A. M. Prasad, B. J. Hale, and E. K. Sutherland. 1999. An atlas of current and potential future distributions of common trees of the eastern United States. General Technical Report NE-265. Northeastern Research Station, USDA Forest Service. 245 pp. http://www.fs.fed.us/ne/delaware/atlas/index.html



U.S. forests currently sequester carbon at a rate that is 15% of U.S emission. (Heath 2001, reported in EPA GHG Inventory)

#### USDA Forest Service USDA Delaware River Basin: Collaborative Environmental Monitoring and Research Initiative (CEMRI) NASA Application: Large Scale Validation of Carbon Stocks and Fluxes from Remote Sensing The Northern Global Change Research Program

Richard Birdsey, John Hom, & Kevin McCullough 11 Campus Boulevard, Suite 200, Newtown Square, Pa 19073

# **Program Summary:**

The Northern Global Change Research Program studies the effects of air pollution and climate change on forests of the Northeastern and North Central United States. Research findings are used by policy makers and land managers to evaluate ways to mitigate or adapt to current and expected changes in forest health and productivity. A key focus of our program is to estimate how much  $CO_2$  is taken up and released by U.S. forests, evaluate how this may change in the future as a consequence of forest management and natural disturbances, and evaluate policy options for increasing the role of forests as carbon sinks.



FACE Site Rhinelander, Wisconsin



## **Northern Network of Ameriflux Sites:**

Studies on carbon flux and carbon dioxide concentration in disturbed and managed forested sites

Tower research can estimate long-term carbon dioxide fluxes of forests and their interaction with the climate. The Northern Global Change Program helps support a network of 9 AmeriFlux eddy correlation towers for carbon sequestration research under disturbance and forest management treatments. Active towers are in Northern Wisconsin ( Jiquan Chen, U. of Toledo: 5 towers for harvesting, chronosequence, post fire), Howland Forest (Dave Hollinger, FS: 3 towers for nitrogen deposition and selective harvesting), and the Baltimore Urban LTER (John Hom, FS/Sue Grimmond, IU: land use change).





Landscape Level Carbon Exchange in Disturbed Mosaics- Jiquan Chen, U. of Toledo

Northern Wisconsin, there are 5 towers to study landscape level carbon exchange in a forest mosaic with harvesting, age structure, and disturbance



Currently, there are 72 AmeriFlux towers in North America in 5 Countries.

Worldwide, there are 202 Fluxnet sites

CO<sub>2</sub> and H<sub>2</sub>O uptake measured by the eddy correlation is the dominant method for measuring inter-annual carbon dynamics in forested systems

## Regional climate and fire danger modeling for the Pine **Barrens of New Jersey:**

This research will develop a more responsive fire danger rating system specific to the New Jersey pine barrens by focusing on the interaction between climate, fire and vegetation. The 1.1 million acres of the pine barrens represent 22% of the land area of New Jersey. It is characterized by highly volatile fuels, historically having a fire return cycle of 25 years, with large 100,000+ acre fires common prior to fire suppression practices. The existing fire danger rating system does not meet the needs of the wildfire managers in this part of the U.S. This may be due to several possible factors; the unique characteristics of the vegetation, low water holding capacity of the soil, and high humidity levels from the maritime influence.

dies on Carbon Flux in the John Hom, USFS and Sue Grimmo Indiana U.

Studies on carbon dioxide concentration, CO<sub>2</sub> flux, and the effects of land use change on the urban forests are being conducted in the Baltimore Urban LTER



growing season •<sup>15</sup>N plots to examine fate of N •Tree growth (FIA) •N fluxes (throughfall, volatilization, leaching, litterfall) •NEE by eddy covariance Soil temperature, moisture, espiration, N content •Footprint modeling, NEE simulation

Shelterwood Harvest •~30% of basal area removed **Ouantify wood removal by species** •NEE by eddy covariance Slash production/decay, litterfall Tree growth (FIA) Soil temperature, moisture, espiration – •Fate of wood products budget simulation



"It can rain in the morning and I can light it on fire in the afternoon." - David Harrison, former NJ state fire supervisor



Communities vulnerable forest fire in Southern N.J.

The US Forest Service (USFS), US Geological Survey (USGS), and the National Park Service (NPS), has developed a monitoring strategy that will link forestry information, vegetation, soil, hydrological monitoring, and air quality across the landscape of the Delaware River Basin. The project links existing intensive ecological research and monitoring stations, regional surveys, fixed-site monitoring networks and remote sensing programs, in order to track complex environmental issues at a range of spatial and temporal scales. This framework is being tested as a strategy between monitoring and research programs for understanding complex environmental issues and more effectively tracking environmental health.



#### ssue Based Studies

- Forest Biomass and Production:
- River Basin.
- extent of calcium depletion in the

# National and Regional Ecosystem Modeling:

Predicting the impacts of increasing atmospheric nitrogen deposition on forest production, water yield and nitrogen leaching losses in the Chesapeake Basin:

Northeastern forests absorb and retain large quantities of airborne chemicals and keep them from polluting lakes, streams, and estuaries. This research will model and analyze the effects of atmospherically deposited nitrogen on the Chesapeake Bay watershed basin using spatially explicit process models with high specificity for forested watershed processes in the Northeast. It will address the Chesapeake Bay Program research priority for predicting the retention of atmospheric nitrogen deposition on forested watersheds on a site specific and on a regional basis. It utilizes model enhanced, high resolution, wet N deposition and precipitation data to forests based on NADP/NTN data.



## Summary:

Northern forests have shown remarkable resiliency and adaptability despite high levels of environmental stress. Climate trends, ozone exposure, high levels of acid and nitrogen deposition, non-native invasive pests, and land use pressures, all simultaneously affect northern forests. Yet northern forests appear healthy as a whole despite evidence of local problems. However, evidence from long-term research suggests that decades of stress may have altered soil characteristics sufficiently to affect forest health and productivity. Therefore an increased level of monitoring, targeted to areas suspected to be sensitive to environmental change, has begun. Endangered forests in the Northern U.S. include red spruce forests, which are damaged by acid deposition and winter injury and are vulnerable to additional climatic stress. Aging hardwood forests of the Mid-Atlantic region is vulnerable to decline disease as a consequence of years of heavy air pollution. Aspen/birch forests in the Lake States are highly sensitive to ozone, which is expected to increase in the region at the same time as climate warming, with potentially harmful consequences.

#### **Cooperators:**

Research is conducted in cooperation with many other Forest Service Work Units, and with the following Institutions: University of Colorado Department of Energy Indiana University

- •Johns Hopkins University, Maryland
- •University of Maine
- •Michigan Tech University
- •University of Minnesota, Minneapolis •University of Minnesota-Duluth. Natural Resources Research Institute
- •University of New Hampshire
- •Penn State University
- Rutgers
- •Syracuse University of New York
- University of Vermont •University of Wisconsin

Augmenting and verifying FIA-based estimates of carbon stocks and fluxes.

Forest Fragmentation and associated ecosystem changes in the Delaware

Causes, consequences, and regiona forests of the Appalachian Plateau



An example of the type of sampling work being done in the DRB.

Protocols for Identification and Monitoring of Forest Vulnerable to nonnative invasive pests

Downstream water-quality effects of multiple land uses

Large scale validation of carbon stocks and fluxes from remote sensing



FIA Plots will be used for modeling based on intensive site data

PnET- CN runs showing N leaching under 1 X N scenario and 2XN scenarios Forests under 1 X N has 86% retention of N, and only 76% under 2 X N.

- •NASA NCASI
- •New Jersey Department of Forestry
- •The U.S. Geological Survey
- •USDA Natural Resources Conservation Service •The Ecosystems Center, Marine Biological Laboratory, Massachusetts
- Institute of Ecosystem Studies, New York
- •Terrestrial Ecosystems Research Center
- •Woods Hole Research Center
- •Institute of Applied Ecology, Chinese Academy of Science China
- •St. Petersburg Ecological Center, Russia

#### Staff:

The following staff manages, provides support, and conducts research for the Northern Global Change **Research Program:** 

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