USDA FOREST SERVICE NORTHERN RESEARCH STATION

Research *Review*

VOL 1 | SUMMER 2007

Global Climate Change: What Could Happen to Our Northern Forests?

Environmental scientists are being called on to provide information about possible outcomes of global climate change for the public and policymakers. Some initial outcomes are clear to see, such as the melting of polar icecaps and mountain glaciers. Others are visible only to the experienced eye, and the far-reaching results may not be immediately apparent. Scientists at the U.S. Forest Service's Northern Research Station (NRS) have been studying possible effects of climate change on our forests.

OUR FORESTS ARE IMPORTANT IN MANY WAYS

Forests are major ecosystem types in the northeastern and midwestern United States, and trees are their foundation species. From the conifer-dominated forests across northern New England and the upper Midwest, to the various mixed hardwood forests of the Appalachian Mountain Range, forests cover about 42 percent of the landmass served by the Northern Research Station.

These forests are important for many reasons: they are the ecological foundation of our part of the world and its inhabitants at all levels, with a rich biodiversity of animals, plants, fungi, and microbes. For the 123 million human residents of the 20-state NRS region, we could not live without the ecosystem services such as clean water and air that our forests provide. In addition, many rural residents in the NRS region depend on forests for income from (1) tourists who come to view fall colors, take photographs, ski, and hike; (2) recreationists who fish from forest lakes and rivers, hunt, or harvest mushrooms and other non-timber forest products; and (3) forest industries, large and small, such as logging, furniture making, millwork, flooring, and papermaking.

continued on page two

Birds and mammals can migrate to better environments, but trees simply cannot pick up their roots and walk. ■

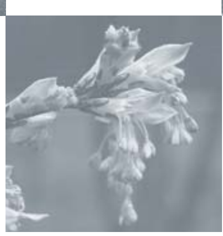
continued from page one

HOW WOULD CLIMATE CHANGE AFFECT OUR FORESTS?

Climate changes could mean large, wide-ranging changes in forest composition, productivity, and sustainability. Climate heating probably will involve warmer winter low temperatures and hotter summer highs, changes in the timing of spring warming and fall cooling, and changes in precipitation patterns, timing, and amounts. As these changes happen, although forests per se probably will not be wiped out, many of the trees will be living under less-than-optimal conditions. What could happen to trees stressed by such conditions?

- They may become more vulnerable to pest insects and diseases.
- They may not thrive and thus be out-competed by other invasive non-native species that overwhelm the forest floor and choke out seedlings or strangle them with vines.
- They may not produce as many seeds (beechnuts, hickory nuts, and acorns) and fruit (wild cherries) that many animals depend on for food.
- They may change their distribution patterns and species combinations.

In addition, fires may become more frequent and/or more intense and precipitation may come in intense, heavy storms instead of gentle rain or snow, all causing serious disturbances such as tree death (low-intensity fires generally only affect the undergrowth), flooding, and erosion. Birds and larger mammals can migrate, but trees simply cannot pick up their roots and walk—like the trees of the Entwood in *The Lord of the Rings*! When environmental conditions deteriorate, they can move only by sending out their seeds (or maybe shoots or root fragments that can sprout), a few of which might find a better-suited growing site. Thus, forest migrations will come about slowly and may be blocked by barriers such as large water bodies and developed land. Developing and maintaining healthy forests in their new habitats may come to depend heavily on human intervention and management.



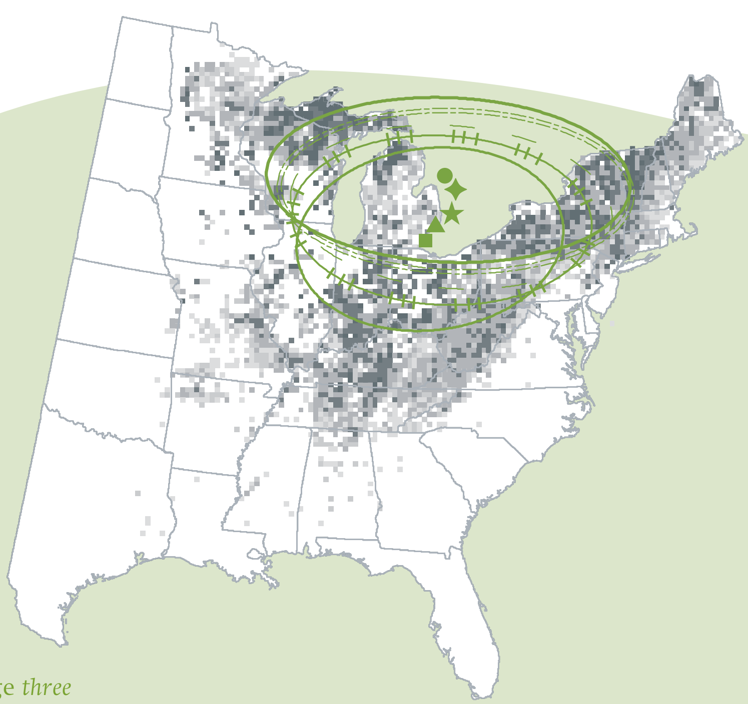
NORTHERN RESEARCH STATION SCIENTISTS ARE MODELING POSSIBLE FOREST RESPONSES

Scientists at the Northern Research Station are well positioned to study the effects of climate change on North American forests. A team of ecologists at the NRS's Delaware, Ohio, laboratory—Dr. Louis Iverson and Anantha Prasad—began modeling and mapping tree species from the eastern United States for their potential response to several scenarios of climate change around 1996. Their first climate change atlas examined 80 tree species. Then they joined with Stephen Matthews and Raymond O'Connor (now deceased) to produced a change atlas for 150 bird species. Now, along with Matthew Peters, they have expanded their tree analysis to 134 species (the new tree atlas is now available on the web and an updated bird atlas will soon follow). For the new atlases, each species was modeled individually to show current and potential future distributions according to two emissions scenarios (A1fi-high emissions on current trajectory and B1-reasonable energy conservation energy implemented) and three climate models: the Parallel Climate Model (PCM), the Hadley CM3 model (Hadley), and the Geophysical Fluid Dynamics Laboratory (GFDL) model. In addition, they modeled both emission scenarios under an average future climate from all three models.

The three scenarios they used are the latest generation of numerical models that couple atmospheric, ocean, sea-ice, and land-surface components to represent historical climate variability and estimate projected long-term increases in global temperatures due to human-induced emissions. Tree data were obtained from more than 100,000 plots (from the Forest Service's Forest Inventory and Analysis (FIA) Programs) for the eastern United States. The plots represent data for nearly 3 million trees.

Because changes in distribution will occur independently among species, the various species will probably combine to form new communities under climate change. The modelers found that of the 134 species, the average of all three models with low emissions would result in 61 species gaining and 53 species losing at least 10 percent of their suitable habitat under climate change. Under high emissions, those numbers rise to 67 gaining and 58 losing habitat. Most of the species' new best habitats would move generally northeastward, up to 800 km in the hottest scenario with the highest emissions trajectory. The models suggest a retreat of the spruce-fir forest type into Canada and a northward advance of southern oak and pine species. Of the species showing habitat loss of at least 10 percent, some will drop in area by more than half. Many of these, at least in the high-emissions scenarios, could be substantially reduced in suitable habitat; some will have most of their habitats retreat into Canada and higher altitudes. These include balsam fir; red and black spruces; black, red, mountain, and sugar maples; quaking and bigtooth aspens; and paper and yellow birches—a list containing many of the species currently providing much of the Northeast's commercial and tourism value.

Is this so far fetched or just over-worrying? Well, in a recent study of boreal forests of Siberia, Canada, and Alaska, many modeled predictions of forest change are occurring now: northern and upslope migration of certain species, dieback of other species, and increased outbreaks of insects and fire. Changes consistent with global warming are already under-way across the Northeast. Since 1970, the region has been warming at a rate of nearly 0.5 °F per decade. Average winter temperatures have risen even faster, at a rate of 1.3 °F per decade from 1970 to 2000. This warming has been correlated with many noticeable changes across the Northeast, including more frequent extreme-heat days, a longer growing season, earlier leaf and bloom dates for plants, shifts in the mating cycles of frogs to earlier in the year, earlier migration of Atlantic salmon, earlier breakup of winter ice on lakes and rivers, less snow and more rain, rising sea surface temperatures and sea level, and reduced snowpack and increased snow density.



Sugar Maple ***Acer saccharum***

MC=Mean Center
DD=Directional Deviation Ellipse
One standard deviation ellipse for actual and four climate scenarios.

■ Actual MC
✦ GCM3 High MC
★ GCM3 Low MC
● Had High MC
▲ PCM Low MC

Actual DD
GCM3 High DD
GCM3 Low DD
Had High DD
PCM Low DD

FIA Importance Value
1
2-3
4-10
11-20
21-92

0 250 500 750 Miles

IN CLOSING

We realize that the owner of a New England sugarbush (sort of a sugar maple orchard) won't have to worry about rising sea levels changing the family business. However, that sugarbush might not survive down the generations and the family business will have transformed from maple syrup to maple furniture to housing developments for people migrating from flooded coastal areas!

The problem of global climate change will ultimately become larger than its effects on one species or one local ecosystem or even landscape. Finding out what global climate change could do to the Earth and thus to human culture becomes extremely urgent. At this point, we do not know just how much and what kind of change there will be, how far the thermometer will go up, and what those increased temperatures will do. Because humanity still has the opportunity to mitigate global climate change by slowing or halting the causes of the atmospheric change, it is important for us to know what possible changes in the biosphere could occur, so that we can act to reduce these deleterious outcomes. Good information is vital for good decisions and the *NRS Global Climate Change Tree and Bird Atlases* provide vital information for predicting what might happen to our forests. ■

"With the highest emissions trajectory, most tree species' new best habitats would move generally northeastward, up to 800 km in the hottest scenario. Some species will drop in area by more than half. These include many species currently emblematic of New England and the North Country that provide great environmental, commercial, and tourism value—balsam fir; red and black spruces; black, red, mountain, and sugar maples; quaking and bigtooth aspens; and paper and yellow birches."

Louis Iverson, Research Landscape Ecologist
Northern Research Station, Delaware, Ohio

Biographies

Dr. Louis R. Iverson *(left)* received his BS (1976) and PhD (1981) degrees from the University of North Dakota, then studied as a Fulbright-Hayes Scholar at the University of York, England. He worked for the Illinois Natural History Survey and the University of Illinois and began his Forest Service career in 1993 as a research landscape ecologist. **Matthew Peters** *(center left)*, a GIS technician at the NRS, was graduated from Ohio University with a BS in GIS analysis and began working for the Forest Service in May 2006. He is involved in most of Louis Iverson's recent research, creating many of the maps in the new tree atlas website. **Anantha Prasad** *(center right)*, who joined the Forest Service in 1993 as an ecologist/GIS specialist, received his BS in electrical engineering from Bangalore University in India and MS in environmental resource analysis from Miami University in Oxford, Ohio. He worked on a USAID project estimating carbon emissions at Oak Ridge National Laboratory in Tennessee and on the Tropical Forest Resource Assessment Project for the Food and Agricultural Organization in Rome. Prasad and Louis have received awards for the tree climate change atlas (2000) and for technology transfer (2003) from the NRS. **Stephen Matthews** *(right)*, an ornithologist, received his BS from Frostburg State University, Maryland (1997) and his MS from the University of Maine, Orono (2003). He is currently a PhD candidate at Ohio State University, focusing his research on avian migration and continuing his research on modeling tree species distribution patterns. ■

Contact Dr. Iverson and his colleagues at 359 Main Road, Delaware, OH 43015; 740-368-0097; liverson@fs.fed.us

More About the Climate Models

In this study, we rely on three global climate models—(a) the National Center for Atmospheric Research's Parallel Climate Model (PCM); (b) the United Kingdom Meteorological Office's Hadley Centre Climate Model, version 3 (HadCM3), and (c) the U.S. National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamics Laboratory (GFDL) CM2.1. They represent different levels of climate sensitivity, which is defined as the temperature change resulting from a doubling of atmospheric carbon dioxide concentrations relative to pre-industrial times. It determines the extent to which temperatures will rise under a given increase in atmospheric concentrations of greenhouse gases. Because many of the processes at work in the earth-atmosphere system and their feedbacks are not yet fully understood, these are represented somewhat differently in different global climate models. GFDL and HadCM3 have medium to medium-high climate sensitivities, whereas PCM has low climate sensitivity. The ranges in projected temperature change and other climate variables presented in this report arise from the different climate sensitivity of these models. ■

References and Resources

New tree atlas: www.nrs.fs.fed.us/atlas
Old tree atlas: www.fs.fed.us/ne/delaware/atlas
Intergovernmental Panel on Climate Change: www.ipcc.ch/

Iverson LR, Prasad AM, Hale BJ, Sutherland EK. 1999. An atlas of current and potential future distributions of common trees of the eastern United States. GTR-NE-265. Newtown Square, PA: USDA Forest Service, Northeastern Research Station. 245 pp. ■

Matthews S, O'Connor R, Iverson LR, Prasad AM. 2004. Atlas of climate change effects in 150 bird species of the eastern United States. GTR-NE-318. Newtown Square, PA: USDA Forest Service, Northeastern Research Station. 340 pp. ■

Climate Changes in the U.S. Northeast: A Report of the Northeast Climate Impacts Assessment. www.climatechoices.org/assets/documents/climatechoices/NECIA_climate_report_final.pdf ■

National Arbor Day Foundation's new climate zone map. www.arborday.org/media/mapchanges.cfm ■

Hayhoe K and others. 2006. Past and future changes in climate and hydrological indicators in the U.S. Northeast. Climate Dynamics 28:381B407. ■

Parmesan C. 2006. Ecological and evolutionary responses to recent climate change. Annual Review of Ecology, Evolution, and Systematics 37:637-639. http://cns.utexas.edu/communications/File/AnnRev_ccimpacts2006.pdf ■

Soja AJ and others. 2006. Climate-induced boreal forest change: Predictions versus current observations. Global and Planetary Change 56. www.ScienceDirect.com ■

Contact the Northern Research Station: www.nrs.fs.fed.us

Michael T. Rains,
Station Director
11 Campus Boulevard #200
Newtown Square, PA 19073

610-557-4017
mrains@fs.fed.us

Rebecca G. Nisley,
Newsletter Editor

203-230-4338
rnisley@fs.fed.us

For additional copies or to be put on the mailing list, e-mail ne_pubs@fs.fed.us or call 740-368-0123; you can request printed or electronic copies.

NRS Research Review is published quarterly by the Communications and Science Delivery Group of the Northern Research Station (NRS), USDA Forest Service. As part of the nation's largest forestry research organization, NRS serves 20 states in the Northeast and Midwest and beyond, providing the latest research on current problems and issues affecting forests and the people who depend on them.

Our research themes are (1) Managing Forests with Disturbance, (2) Urban Natural Resources Stewardship, (3) Sustaining Forests, (4) Providing Clean Air and Water, and (5) Natural Resources Inventory and Monitoring.

There are 157 NRS scientists working at 20 field offices, 22 experimental forests, and universities located across 20 states, from Maine to Maryland, Missouri to Minnesota. ■

Photographs: Bill Cook, Michigan State University; Paul Wray, Iowa State University, Bugwood.org; Dr. Louis Iverson, Delaware, OH, and Sugar Maple Research Project, Burlington, VT, Northern Research Station.

Northern
RESEARCH STATION
USDA Forest Service

11 Campus Boulevard, Suite 200
Newtown Square, PA 19073