Array of sensors watching forest breathe

A sophisticated array of electronic sensors in the H.J. Andrews Experimental Forest is giving ecologists at Oregon State University a view of the forest ecosystem they've never had before: They are literally watching the forest breathe, the plants interact with and feed the soil microbes and rivers of air pour up and down slopes in ways never before understood.

Forest science professor Barbara Bond, right, works with faculty research assistant Nicole Czarnomski in H.J. Andrews Forest near Blue River.

The studies relate to a concept that explorers such as Columbus and Magellan demonstrated 500 years ago – the Earth is not flat. Neither are forests in mountainous terrain, but many existing concepts and models of forest processes have been based on the way these systems function on fairly flat land.

Now, with years of work at one of the nation's premier outdoor ecological laboratories in the central Oregon Cascade Range, a new understanding is emerging of how the forest watersheds and "airsheds" interact, creating complex micro-climates and hydrological cycles in the steep, hilly terrain.

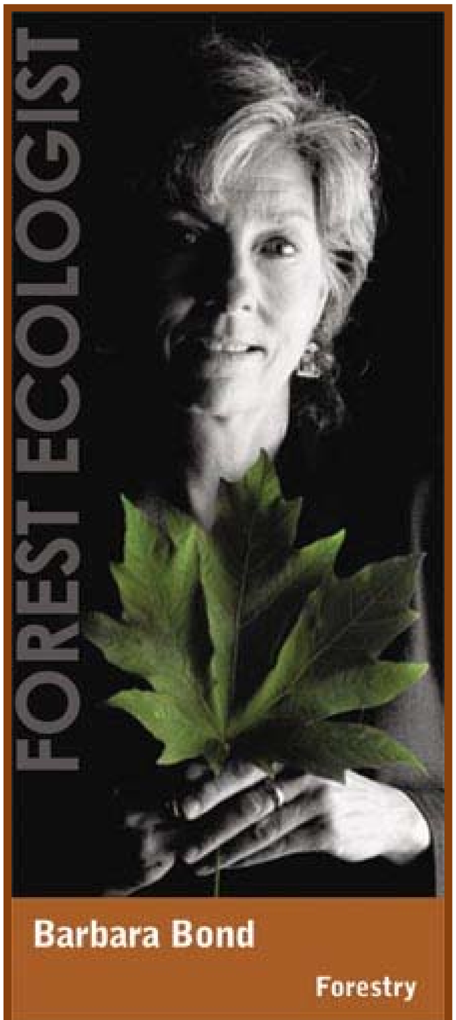
The studies should be further amplified in coming years with a new $1.1-million grant from the National Science Foundation that will help place a new generation of battery-free, interactive sensors over a much larger area to further enhance the data stream coming from the forest into OSU laboratories.

"Topography has an enormous impact on forest ecology. It creates all kinds of different interactions compared to flat land," said Barbara Bond, a professor of forest tree physiology in the OSU Department of Forest Science. "You get different temperature gradients, micro-climate, humidity, air and water movement, carbon dioxide concentrations and sometimes protective buffers."

But historically, Bond said, flat terrain has been an easier, less costly environment in which to do experiments, and much of the science about forest processes is based on data from such areas. Most research has also been done by people from individual disciplines, looking at tiny pieces of the puzzle.

"What we need to do now is look at where we really grow most of our trees, which is in mountainous terrain," Bond said. "And we need to bring together the ecosystem scientists, the atmospheric experts, the engineers and soil scientists, and try to put all the pieces back together to really understand how the whole system works."

The current research at the H.J. Andrews Forest is doing that, Bond said, and already yielding surprising results. Among the findings:



Barbara Bond, a professor of forest tree physiology in the Department of Forest Science, is the second of 12 people to be featured in OSU This Week through the end of fall term. Bond is also shown in the new OSU TV commercial.

- The night drainage of cold air down slopes is fast, deep and well developed, like a river of air careening down the landscape;
- These large air flows carry with them respired carbon dioxide from plants and trees, which provides a signal based on carbon isotopes that is related to plant stress, and could be used to monitor plant stress over large areas;
- Fluxes of carbon move back and forth between trees and soils on a constant basis, as the soil provides water and nutrients to the plants, and the plants in turn feed the soil microbes.

"What we've learned about the interactive relationship between plants and microbes has been one of the most fascinating results," Bond said. "This is a two-way street, with water and nutrients going up, and sugars coming down from the leaves into the soil to feed the microbes there. The plants are like the farmers of the below-ground microbial community."

This process is also fast. During daylight there's a flush of new carbon moving from the atmosphere into the tree that appears to work its way into the soil within literally a few hours. And measurement and monitoring of this process, researchers believe, may ultimately provide a picture of tree stress – such as during periods of drought or climate change.

"We believe that a comprehensive understanding of a forest airshed will give us a range of information about the health and physiological status of the forest, much like a doctor can tell a lot about your health from a blood sample," Bond said. "Related to the issue of climate change, we may be able to see trees under stress much earlier, well before they begin to show visible symptoms or problems."

In the field work on this project, scientists take gas samples from soil depths at different times of day, including the middle of the night. Study plots are also located adjacent to other sites where such issues as tree growth, stream flow and stream chemistry are being analyzed, to ultimately provide a very comprehensive view of forest ecology.

The studies may also raise questions about other important topics related to climate change, such as carbon sequestration. Growth of forests has often been viewed as a mechanism to remove or "sequester" carbon from the atmosphere and help offset the increases provided by human activity, including the use of fossil fuels.

"However, results from this and other studies are suggesting that a lot of carbon does not go to plant or tree growth at all, but rather is just being pumped through the roots into the soil, where a lot of it is quickly respired back into the atmosphere," Bond said. "This means that carbon sequestration may not be tightly linked to the photosynthetic rate of plants. It may not be that simple."

Elizabeth Sulzman, an assistant professor of soil science at OSU working on this project, said there's a remarkable variation in soil activity in forests that must be considered before researchers will fully understand the big picture.

"Soil can be so different from one spot to another, just a foot or two away," Sulzman said. "It has a lot to do with distance from plant roots and the sugars or exudates they provide. The link between soil, plant and atmosphere still has a lot of questions we have to answer."