Forests for Maine's Future

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FOREST BIOPRODUCTS
RESEARCH INITIATIVE

Discovering
a Sustainable Bio-Economy

THE UNIVERSITY OF MAINE

Scientists study potential for fuel, other 'bio-products' from forests

More than 20 UMaine researchers engaged in largest research project in state's history

Maine Tree Foundation

Small Woodland Owners Association of Maine

Maine Forest Service

University of Maine

By Andrew Kekacs

"The time will come, in two or three decades, when we will look at the days of only sawing boards and making paper as the Dark Ages," says Robert G. Wagner, professor of forestry at the University of Maine. "The chemical versatility of wood is so great, we will cringe at the idea we were once wasting it."

Wagner is one of more than 20 scientists who are involved in the Forest Bio-products Research Initiative, the largest public research project in Maine's history. The project brings together some of the brightest people in the state to answer two core questions: Can we do more than make forest products with the vast quantity of wood harvested in Maine each year? If so, what would the impact be on the state's economy and environment?

"This project leverages Maine's traditional strengths in forestry and forest products," says Stephen Shaler, professor of wood science at the University of Maine, and scientific director of the research initiative. "We understand the existing forest-products industry, and we understand forests. It was strength on strength."

In a world where oil prices are at record levels, production has reached its peak and supply is threatened by developments beyond our control, wood has become the focus of intense scrutiny. This seemingly simple material, used for thousands of years to make fires and build shelters, might one day provide plant-based fuels, chemicals, plastics and a host of other products.

In the process, it could transform Maine's manufacturing base, with pulp and paper mills becoming centers for the production of a wide range of "bio-products." Scientists believe the mills could make the new, high-value products without increasing the amount of wood they buy, and without reducing the amount of paper they produce. That could substantially improve the financial picture for Maine's paper industry, which is under increasing pressure from foreign

Prof. Robert Wagner

What is bio-mass?

In the broadest sense, "biomass" is the name given to any plant- or animal-based material, from corn to switchgrass, trees to animal waste. At the University of Maine, scientists are studying hemicellulose, which makes up about 20 percent of trees and other woody material but is not needed for making high-quality wood pulp for paper.

Hemicellulose could also be extracted from tree branches and tops that now remain in the forest after a harvest; poor-quality trees; and other woody material that has little or no economic value.

competition.

Reducing the amount of oil used to run engines and make chemicals would also help to reduce the threat of global warming. Carbon now captured in prehistoric oil reserves becomes carbon dioxide -- a key "greenhouse" gas -- when petroleum-based fuel is burned. Well-managed, fast-growing forests "breathe in" carbon dioxide from the atmosphere and lock it up in wood. That means wood-derived fuels could potentially be "carbon-neutral" over the long term, and not add to global warming.

"Wood is the most environmentally sound material on the planet," says Wagner. "Anything you can make out of oil, you can make out of wood."

Is this for real?

It sounds too good to be true. But scientists at UMaine, led by Adriaan R.P. van Heiningen, a professor of chemical engineering, have already proven the idea will work. The innovation will get a real-world test during the next two years, as Red Shield Environmental begins to produce ethanol (a fuel commonly mixed with gasoline) in addition to wood pulp (the raw material for paper) at the once-closed

Fuel from the forest

Scientists at UMaine have already demonstrated the production of ethanol from wood chips. Ethanol -- whether made from corn, sugar cane, trees or other sources of bio-mass -- is commonly used to replace up to 10 percent of the gasoline in motor fuel and can also help to reduce pollution from vehicle emissions.

In addition, researchers are studying whether wood chips and other bio-mass can also be used to produce bio-diesel fuel, which is worth even more than ethanol.

Federal recognition

The U.S. government has been focused on encouraging ethanol production from corn (and to a lesser degree from sugar cane and grass). Maine Sen. Susan Collins successfully introduced an amendment to the 2007 federal energy bill that added $275 million over five years for competitive funding of projects studying ethanol

Georgia-Pacific mill in Old Town. About 40 percent of the 450 workers who were laid off when the plant closed in March 2006 have already returned to work.

The Forest Bio-products Research Initiative was launched 18 months ago, with a $6.9 million grant from the National Science Federation and a $3.45 million matching contribution from the state. Proof that the effort is gaining national attention came just last month, when the U.S. Department of Energy contributed another $2.9 million toward the work.

The money is funding a one-of-a-kind effort that brings together chemists, engineers, foresters, business professors and many others, not only to fine-tune Heiningen's breakthrough, but also to study whether it can be used to improve the health of the forest and the condition of the economy. Maine has never undertaken such a wide-ranging effort to investigate a new technology.

How does the process work? Right now, about half of every log delivered to Maine's pulp mills is not used to make pulp. Wood chips used to create most high-quality pulp (the first step in making paper) are processed with chemicals, heat and pressure to remove two components -- lignin and hemicellulose. The components are recovered at the end of the pulping process, dried and burned to create energy that powers the mill.

Professor Hemant Pendse, managing director of FBRI and chairman of the department of chemical and biological engineering at UMaine, says lignin (which makes up about 30 percent of the weight of the wood chips) provides a large amount of energy when burned. Hemicellulose is not as valuable as a fuel, but using van Heiningen's process, it can be recovered and used as a raw material for a host of other products now made with oil.

Maine is not the only state investigating new products from wood. Researchers at a number of other universities are studying how to

production from wood and other alternative sources. UMaine scientists helped to write the amendment.

Prof. Hemant Pendse

Other partners

In addition to enlisting about 20 scientists in the University of Maine System in the research effort, FBRI has involved a host of students and staff and is reaching out to the state's teachers. The research initiative partnered with Maine TREE Foundation to conduct a series of workshops that introduce high-school and middle-school teachers to the emerging technology.

make ethanol from wood chips, but the fibers that remain are not suitable for making pulp. If those processes were used in Maine, they would reduce the amount of pulp available to make paper. Van Heiningen, however, discovered how to remove hemicellulose in a separate process that occurs before the wood chips are turned into pulp. By removing about half of the hemicellulose found in the chips (or about 10 percent of the weight of the raw logs), van Heiningen can capture a valuable raw material for making ethanol and other bio-products -- without reducing the quantity or quality of wood pulp that is ultimately produced. It's nothing but a gain for the mill.

While soaring gasoline prices and uncertain supplies have cast a national spotlight on ethanol production, hemicellulose can also be used to make products that are even higher in value. In a paper presented last year at the World Renewable Energy Congress in Florence, Italy, van Heiningen described his vision of an "Integrated Forest Bio-Refinery," which could produce wood pulp and a variety of other products. In 2006, the price of wood pulp was about $500 per ton. Hemicellulose was worth about $50 per ton as a fuel, but $420 if converted into ethanol. Some of the other products that could be made in a bio-refinery were worth up to $3,000 per ton.

Show me the money

"Not only are there some practical applications in labs," says Sherry F. Huber, executive director of Maine TREE Foundation. "We hope students will see the potential for future careers in bio-products research."

The vision

"Woody biomass from our forests will be used to create new bio-products: transportation fuels, wood-based chemicals, consumer products and electrical energy to reduce our reliance on fossil fuels. Innovative uses for sustainably harvested wood have great potential to reinvigorate forest management strategies, help landowners conserve forest lands, and transform industrial facilities into bio-refineries that manufacture many valuable wood products at one location.

FBRI is the University of Maine's commitment that Maine will become a regional, national and world leader in

At first glance, 10 percent of the weight of the raw logs used by paper mills might seem like a small amount. But consider that about 6 million cords of wood are harvested in Maine each year. Of that, about 4 million cords go into pulp. Assuming each cord weighs about 5,000 pounds, there are 20 billion pounds of raw logs cut for pulp each year. Using van Heiningen's process, paper mills could capture about 2 billion pounds of hemicellulose without increasing their purchases of wood at all.

That's 1 million tons of new products that range in value from $420 to $3,000 per ton -- or a potential increase to the state's economy of $420 million to $3 billion each year.

In fact, there is even more raw material available. Wood waste from some of the 2 million cords that are cut for lumber and other building products each year also is sent to pulp mills. In addition, there is as much as 12 billion pounds of other wood that is potentially available each year in Maine, according to Kenneth M. Laustsen of the Maine Forest Service. That includes branches and treetops that are left in the forest after a harvest, dead and poor-quality trees, and other woody material.

The use of this material, however, would raise some important questions about forest health and sustainability. Researchers at UMaine are also considering those questions:

How would removing additional woody material affect forest health? On one hand, a market for such "bio-mass" could give landowners an incentive to be more active managers of their forests, which could improve overall health and productivity. On the other hand, removing such material could reduce the amount of nutrients available in the soil or reduce wildlife habitat.

How would the public view bio-mass harvests? What do Maine people want from the forest, and how would a new bio-products industry fit

the transformation of forest resources to a valuable bio-economy."

UMaine presentation to the American Association for the Advancement of Science

with their desires?

What concerns would environmental groups have about such harvests?

How would landowners respond to the new market opportunity?

Do we have enough logging capacity to remove the extra woody material? Can it be done efficiently? What harvesting technology is needed to do the job?

What would be the net impact of bio-mass harvesting on global warming?

The Forest Bio-products Research Initiative seeks to answer those questions and many others as it considers the potential for new products from one of Maine's oldest resources, it's trees.

"I know we have the know-how," says Pendse. "We have a good focus and a good team, and we have assessed the technological risks. I just see this as moving forward."