Food vs. Fuel

The question has been posed in print, debated on the radio and argued about by talking heads on television talk shows: should agricultural crops be used to make biofuels if diverting them from the food supply is causing the price of food to spike? Should the quantity of ethanol produced in the United States, mandated by the most recent Energy Bill, be lowered or waived? And if we're not making ethanol or other biofuels, how will the country ever be less dependent on imported petroleum?

"The fear that the fuel versus food debate causes creates the risk that people will perceive they have to choose between *only* food and *only* fuel," said MAES scientist Chris Peterson, who holds the Nowlin Chair for Consumer Responsive Agriculture and directs the MSU Product Center for Agriculture and Natural Resources. "There is definitely room for both, and we definitely have long-term needs for both."

Analyses by Peterson, MAES agricultural economist Dave Schweikhardt and Bill Knudson, product marketing economist for the Product Center, conclude that biofuels have contributed to the increase in food prices, but exactly how much of the increase can be attributed to biofuels is unclear. *(See related story on what influences the cost of food on page 11.)*

"Several credible sources say that the maximum impact of biofuels would be one-third of the rise in food prices," Peterson said. "But I've seen studies saying the impact ranges from 3 percent of the increase — from the U.S. Department of Agriculture — to 78 percent of the increase — from the United Nations."

Knudson cited a study by Iowa State University scientists that determined that consumers paid 1.1 percent more for food in 2007 as a result of more corn grain ethanol production.

"So that's about 25 percent of the increase," Knudson said.

"Biofuels being responsible for about 15 to 30 percent of the increase in food seems accurate to me," Peterson added.

Does society really have to choose between food and fuel?

MAES scientists are studying all the angles of making fuel from trees and other non-food crops to offer information to policymakers and the public and forge partnerships with state agencies and other universities to help Michigan carve out its niche in the emerging bioeconomy.

From Forests to Fuels

Forests cover more than half of Michigan's land, and the 19.3 million acres of trees is a 5 percent increase since 1980, according to statistics from the Michigan Department of Natural Resources. With 18.6 million acres of timberland (forestland classified as timberland must meet minimum timber production standards), Michigan is behind only Georgia, Oregon, Alabama and North Carolina in timberland acreage.

Trees and other plants are a huge potential source of energy — each year, the biomass in the Earth's plants captures about eight times the total amount of energy used by people from oil, coal, natural gas, wind, water, etc. But about 90 percent of this energy in fibrous plant biomass isn't readily available because it's locked up in cellulose and hemicellulose, the complex sugars that make tree trunks, grasses, plant stems and stalks, and leaves rigid. Unlike the simple sugars in the grains of plants, such as corn kernels, cellulose and hemicellulose don't dissolve in water. This is good for keeping plants healthy and helping them thrive, but it's a problem for making biofuels. Before the complex sugars can be converted into ethanol or other biofuels, they have to be broken down into simple sugars, such as glucose, by enzymes.

Doing that cost effectively has been the main issue slowing cellulosic biofuel production. Because the process is difficult to do efficiently, it can significantly raise production costs. This is why cellulosic biofuels aren't available commercially. Yet.

"In Michigan, our research and development emphasis is on making renewable fuels from cellulose — trees, stems and stalks that aren't food products," said Steve Pueppke, MAES director and director of the MSU Office of Biobased Technologies. "If the cellulose comes from crops that we're already growing, we can increase fuel production from crop residues without further effects on food prices. Cellulosic biofuels also would allow the state to tap forestland — land that isn't in the food system — to make fuel."

"Right now, the cheapest ethanol on the market is made from Brazilian sugar cane, which isn't cellulosic ethanol," added Ray Miller, who oversees forestry research at MAES properties in the Upper Peninsula, serves as director of the U.P. Tree Improvement Center in Escanaba and was named MAES forest biomass development coordinator in September in recognition of the growing importance of cellulose as a raw material for bioproducts. "We really don't know how much cellulosic ethanol will cost when it comes on the market, but there is a suspicion that it will cost more than ethanol made from corn grain. With that said, we also know that the cellulosic ethanol industry will get more efficient, which will bring the price down. And we also may find that there are other fuels such as dimethyl ether or biogas that may be better biofuel choices than ethanol. Ethanol may be a transition fuel. There's a lot of research work to be done."

MAES scientists and other researchers at Michigan State have made Michigan a leader in cellulosic biofuel research. Michigan State, along with Michigan Technological University, is providing research support to the Massachusetts-based Mascoma Corporation as the company works to build the nation's first cellulosic ethanol plant in Chippewa County in the Upper Peninsula.

"We can produce ethanol and other transportation fuels from cellulosic materials," said Bruce Dale, MAES chemical engineer, who has more than 30 years' experience in studying pretreatments to make cellulose easier to break down. Dale also serves as associate director of the MSU Office of Biobased Technologies. "There are some studies that say we should be able to produce cellulosic ethanol for about $1 per gallon. We're not there yet, but I believe we should be able to get cellulosic biofuels to the pump for about $2 per gallon. One of the most important things that we as scientists can do is to help everyone understand the difference between making biofuels from grain and making biofuels from cellulose.

"Support for making ethanol from corn grain has attracted some negative attention because food prices have gone up," Dale continued. "But what's been overlooked is how much energy is needed to make food and, therefore, how much of the increase in food prices has been driven by energy prices. Because the raw material for cellulosic ethanol is considered waste in many cases — the branches, stalks and stems of harvested crops — it's cheaper than the raw material for corn grain ethanol. Once the technology and supply chain for cellulosic ethanol is mature, I think cellulosic ethanol will cost about $2 per gallon to produce."

Dale has developed a pretreatment process, ammonia fiber expansion (AFEX), to pretreat cellulosic biomass with ammonia. MSU has

received several patents on the process. The AFEX process makes the breakdown of cellulose and hemicellulose more efficient. Using enzymes alone, about 15 percent of cellulose and hemicellulose is broken down into simple sugars; when AFEX is used before adding the enzymes, more than 90 percent of the cellulose and hemicellulose is broken down into fermentable sugars. After treatment, the plant material comes out looking a bit like popcorn — slightly puffed up and dry.

The AFEX pretreatment process also increases the value of some cellulosic materials as feed for dairy and beef cows. This may provide some welcome relief to producers who have been squeezed by rising corn prices. Dale is working with MAES animal scientist Michael Allen to evaluate the feed potential of several pretreated cellulosic materials.

Cellulosic materials that have been treated with the AFEX process are also easier and less expensive than raw, untreated materials to turn into pellets. Combined with regional biomass processing centers, pretreatment and pelletizing could solve a major logistical issue in the cellulosic biofuels industry. Therefore, another facet of Dale's research is studying the potential for regional biomass processing centers.

"Because cellulosic materials are bulky, it's expensive to ship them very far," Dale explained. "Getting enough of these materials together in one place is a challenge that the regional biomass processing centers would address. If we densify the cellulosic materials into pellets, it's likely that traditional corn grain handling equipment will work to load and unload the materials."

Dale envisions biomass processing centers located approximately every 10 to 20 miles in areas producing cellulosic biofuel raw materials. Processing centers would create jobs in rural areas and increase the value of the raw materials. Dale; MAES agricultural, food and resource economics scientist Satish Joshi; and doctoral student Joe Carolan are using a grant from General Motors to better define the economics, job creation and logistical issues surrounding the regional biomass processing centers.

Besides the processed biomass that will go to biorefineries, Dale

Briefing Congress on the Sustainability of Cellulosic Biofuels

Michigan State University is known internationally for its work on sustainability, especially research on the ecology of agricultural systems done at the Long-Term Ecological Research (LTER) site at the Kellogg Biological Station in Hickory Corners.

The national LTER network, funded by the National Science Foundation, is made up of 26 sites for study of ecology and environmental biology to provide a better understanding the ecology of both natural and managed systems. The MSU site, established in 1988, is the only site in the network to focus on agriculture. Research at the MSU LTER site looks at how biodiversity — plants, animals and microbes in agricultural landscapes — contributes to farm productivity, environmental performance and profitability. The site attracts researchers from all over the world and is available to any scientist with a legitimate research interest.

Two MAES scientists who conduct research at the MSU LTER and are members of the Great Lakes Bioenergy Research Center took part in an Ecological Society of America-hosted U.S. House and Senate briefing on the sustainability of cellulosic biofuels in June.

Phil Robertson, MAES crop and soil scientist and director of the MSU LTER program, and Doug Landis, MAES entomology researcher, discussed the ecological and economic considerations surrounding the use of cellulosic biomass to produce biofuels. Madhu Khanna, agricultural economist at the University of Illinois, also participated.

Landis spoke about the value, both environmental and monetary, of maintaining high levels of biodiversity in agricultural systems. Growing cellulosic crops can help maintain high biodiversity levels because farmers can grow a greater variety of crops and more complex mixtures of plant species than if they were growing only food crops. A mixture of native grass and tree crops can keep wildlife habitat intact and support vital ecosystem services, including those that help other crops in the landscape.

"Our research is focused on identifying the impact of various biofuel crops on the biodiversity of agricultural landscapes," Landis explained. "Carefully selected cellulosic crops could enhance agricultural landscape diversity, pest suppression, pollination and wildlife while reducing greenhouse gases. We have a historic opportunity to use science to guide policy in ways that would allow cellulosic biofuel crops to be a win-win for agriculture and the environment."

Robertson spoke about the economic, environmental and social elements of biofuel sustainability. Cellulosic crops can be grown on land that is not suitable for food crops, so they would help to reduce the perceived competition for land that underlies the food versus fuel discussion. Cellulosic biofuel systems can help mitigate carbon dioxide emissions as well as clean water and air, but achieving the benefits requires proper balancing of environmental aspects and economic incentives.

All three scientists cautioned that cellulosic biofuel environmental benefits are not guaranteed — they depend on the crops chosen, the management practices used and the geographic location of the crops.

***Far left:* "One of the most important things that we as scientists can do is to help everyone understand the difference between making biofuels from grain and making biofuels from cellulose," says MAES scientist Bruce Dale.**

***Near left:* Poplar (left) and willow trees growing in a test plantation on the MSU campus are potential raw materials for cellulosic biofuels.**

sees the processing centers eventually creating byproducts — bybioproducts — possibly nitrogen fertilizer, proteins for animal feed, enzymes for the biorefining industry, and minerals and other nutraceutical products that can be used by other industries.

"The biomass supply chain is very important to creating a stable cellulosic biofuel industry and a stable bioeconomy for Michigan," Pueppke said. "This is an area that hasn't received a lot of attention, so we're pleased to partner with GM on the project."

Biofuel Crop Building Blocks

As more research focuses on ethanol, biodiesel and other renewable fuels, most experts predict that scientists will develop varieties of crops designed specifically to be converted into biofuels. In Dale's opinion, this also will help defuse the food vs. fuel controversy because food crops will stay in the food system.

"The ultimate success of biofuels will be determined largely by the ability to manipulate plants at the genetic, seed and field levels," Dale said. "MSU is the premier place for this work to be done. We have one of the top three plant science programs in the world. MSU is the foremost university worldwide in the field of plant metabolism and biochemistry. MSU researchers such as Christoph Benning, John Ohlrogge, Dean Della Penna, Yair Shachar-Hill and Ken Keegstra are manipulating non-food plants — woody plants and grasses — so the conversion process from biomass to biofuel is more efficient. This research is going to fundamentally change biofuel production."

In part, it was expertise in plant science that helped MSU, in partnership with the University of Wisconsin-Madison, receive funding for the Great Lakes Bioenergy Research Center (GLBRC) from the U.S. Department of Energy (DOE) in 2007. The GLBRC, one of three DOE bioenergy research centers, conducts basic research aimed at solving some of the most complex problems in converting natural materials to energy. MSU's $50 million portion of the grant is the largest federal grant exclusively for research endeavors in university history.

Benning, MAES biochemistry and molecular biology researcher and member of the GLBRC, announced the identification of a new protein necessary for chloroplast development in a paper in the August 2008 issue of the journal The Plant Cell. The discovery could lead to plant varieties tailored for biofuel production. Other members of the research team are Changcheng Xu, research assistant professor of biochemistry and molecular biology; Jillian Fan, research technician; and Adam Cornish, a biochemistry undergraduate student at the time of the research who is now a graduate student.

Chloroplasts are specialized compartments in plant cells that convert sunlight, carbon dioxide and water into sugars and oxygen ("fuel" for the plant) during photosynthesis. The newly discovered protein, trigalactosyldiacylglycerol 4 (TGD4), offers insight into how the process works.

"Nobody knew how this mechanism worked before we described this protein," Benning explained. "This protein directly affects photosynthesis and how plants create biomass and oils."

Benning's research shows how TGD4 is essential for the plant to make chloroplasts. Plants that don't have the protein die before they can develop beyond the embryonic stage.

Most plants that are used to produce oils that are converted into biofuels or biochemicals — corn, soybeans and canola, for example — accumulate the oil in their seeds, which is almost always the part of the plant used for food or feed. Understanding how TGD4 works may allow scientists to create plants that accumulate high levels of oil in other parts of that plant that are normally considered waste, such as the leaves.

"We've found that if the TGD4 protein is malfunctioning, the plant then accumulates oil in its leaves," Benning said. "More research is needed so we can completely understand the mechanism of operation. But if the plant is storing oil in its leaves, there could be more oil per plant, which could make production of biofuels more efficient."

C. Robin Buell, MAES plant biology researcher, is using a joint grant from the DOE and the U.S. Department of Agriculture to create an easily accessible, Web-based database of genomic information on crops that can be used to make cellulosic ethanol.

"Ultimately, this will allow us to create better biofuel crops," Buell said. "Right now, about half of the biofuel crops don't have genomic databases, and the ones that do are in many places and are annotated differently, so it's difficult to compare and use the information."

Buell and Kevin Childs, a postdoctoral researcher in her lab, are using the grant to centralize the genomic databases, create uniform

Far left: **As forest biomass development coordinator, MAES scientist Ray Miller will oversee many of the forest-based biofuel relationships between MSU and other entities.**

Left: **MSU forestry researchers are studying the best way to grow and harvest varieties of willow trees for biofuels.**

annotations (notes or descriptions of the genomes), provide data-mining and search tools, and provide a Web site for scientists from around the world to access the databases. They also will regularly update the information. Genomic databases contain information on the molecular biology and genetics of a particular species.

"Our biofuel genomic database portal will include information on any crop that can be used to produce cellulosic ethanol, including all the grasses — such as corn, rice, maize and wheat — and other biofuel species such as poplar, willow and pine," Buell explained. "This will save researchers a lot of effort, so we expect it to be a valuable resource for scientists at MSU and around the world."

A Gut Reaction to Biofuels

As the state's land-grant university, Michigan State has a long tradition of providing practical, science-based answers to some of society's most pressing problems. Bioeconomy issues are no exception as MSU biofuel research moves from the lab to the private sector through licensing and commercialization agreements.

A recent example is MSU technology that uses enzymes from a microbe in a cow's stomach to create plants that can be more efficiently turned into biofuel. These enzymes, which allow a cow to digest grasses and other plant fibers, can be used to turn fiber from other plants into simple sugars. Mariam Sticklen, MSU professor of crop and soil sciences, discovered a way to insert a gene from a bacterium in a cow's stomach into a corn plant so the plant then makes the enzymes in its leaves. This makes the fiber in corn leaves and stalks easier to convert into simple sugars, which can then be turned into biofuels or other valuable chemicals.

"This technology is a step ahead for science, for technology and for producing fuel in our own country," Sticklen said.

Edenspace Systems Corp., a plant biotechnology company that develops new crops for biofuels and environmental cleanup, licensed the technology and expects to use it to release biofuel corn varieties directly to growers as well as sublicense the technology to other companies that want to add the gene to their corn varieties. The company also will investigate using the technology in other biofuel crops such as sorghum, switchgrass and sugar cane.

"We're excited to start commercializing this technology," said Bruce Ferguson, president of Edenspace. "We've been helping to fund Dr. Sticklen's research for the past four years. This is a very productive extension of that work."

Sticklen's corn variety for biofuel production, Spartan Corn III, contains all three enzymes necessary to convert the cellulose in plant fiber into sugars that can be made into biofuel. Spartan Corn III builds on Sticklen's earlier research on biofuel corn varieties. The first version, released in 2007, cuts cellulose into large pieces with an enzyme from a microbe that lives in hot spring water. Spartan Corn II, with a gene from a naturally occurring fungus, takes the large cellulose pieces created by the first enzyme and breaks them into sugar pairs. Spartan Corn III, with the cow stomach microbes, produces an enzyme that separates pairs of sugar molecules into simple sugars, which can be readily converted into ethanol or other biofuels or chemicals.

Because of the regulations surrounding the release of transgenic crops, Ferguson estimated that the new biofuel varieties would be available commercially in 2011 at the earliest.

Building the Business of Biofuel

Besides research, creating a renewable fuel industry in Michigan requires coalition and network building to disseminate information, assist entrepreneurs and ensure that all interested groups have a voice in the process. So Michigan State researchers are reaching out across the state and around the world to develop bioeconomy partnerships.

Adding "forest biomass development coordinator" to his duties means that MAES forestry researcher Miller will coordinate many of the forest-based biofuel relationships between MSU and other entities, including Michigan Technological University, the Michigan Economic Development Corp. and the Swedish Forest Agency.

"I'm now the university's point person for forest biomass production," Miller said. "Besides working with faculty members in the Forestry Department who are already studying cellulosic biomass, I'll be learning more about what's going on outside forestry so I can connect faculty members from across departments."

Experts agree: environmental standards needed for biofuels

Phil Robertson

The United States lacks the standards to ensure that producing biofuels from cellulose won't cause environmental harm, says a distinguished group of international scientists. But because the industry is so young, policymakers have an exceptional opportunity to develop incentive programs to ensure the industry doesn't harm the environment.

"Environmental standards are needed now, before the industry moves out of its research and development phase," said Phil Robertson, MAES crop and soil sciences researcher and lead author of the paper "Sustainable Biofuels Redux" published in the Oct. 3 issue of the journal Science. "With production standards and incentive programs, cellulosic biofuel cropping systems could provide significant environmental benefits."

Currently, all the commercial ethanol produced in the United States is made from grain, primarily corn. Robertson said that science has shown that almost all intensive grain-based cropping systems, as currently managed, cause environmental harm. As director of the MSU Long-Term Ecological Research program at the Kellogg Biological Station, part of Robertson's research focuses on management practices that can reduce these negative effects.

"We can soften the environmental impacts by using strategies such as no-till farming to minimize erosion and planting cover crops to sequester carbon and reduce nitrogen and phosphorus run-off," he said. "But few farmers use all of the best available practices because there are limited incentives — and many disincentives — for them to do so. As the technology to make biofuels from cellulose is refined and commercialized, we believe it's crucial that the industry and legislators adopt policies that reward environmentally sustainable production practices for cellulosic biofuels. It's equally important for grain-based systems."

This is one of the first times such a large and diverse group of internationally recognized scientists have spoken with one voice on the issue. The 23 authors are some of the world's top ecologists, agronomists, conservation biologists and economists. The paper is the result of discussions that took place at a spring workshop on the environmental sustainability of biofuels sponsored by the Ecological Society of America.

"This was truly a collaborative effort," Robertson said. "There are strong and divergent scientific opinions on the sustainability of biofuel cropping systems. That this group, with its diverse backgrounds and professional experiences, can come to consensus is remarkable. Decision-makers should take notice."

In addition to Robertson, other authors are: Virginia H. Dale, Oak Ridge National Laboratory; Otto C. Doering, Purdue University; Steven P. Hamburg, Brown University; Jerry M. Melillo, Woods Hole Marine Biological Laboratory; Michele M. Wander, University of Illinois; William J. Parton, Colorado State University; Paul R. Adler, U.S. Department of Agriculture Agricultural Research Service; Jacob Barney, University of California-Davis; Richard M. Cruse, Iowa State University; Clifford S. Duke, Ecological Society of America; Philip M. Fearnside, National Institute for Research in the Amazon; Ronald F. Follett, U.S. Department of Agriculture Agricultural Research Service; Holly K. Gibbs, University of Wisconsin-Madison; Jose Goldemberg, University of São Paulo; David J. Mladenoff, University of Wisconsin-Madison; Dennis Ojima, The H. John Heinz Center for Science, Economics, and the Environment; Michael W. Palmer, Oklahoma State University; Andrew Sharpley, University of Arkansas; Linda Wallace, University of Oklahoma; Kathleen C. Weathers, Cary Institute of Ecosystem Studies; John A. Wiens, PRBO Conservation Science; and Wallace W. Wilhelm, U.S. Department of Agriculture Agricultural Research Service.

MSU's biofuels partnership with Michigan Tech was hailed by Gov. Jennifer Granholm when it was announced last year.

"Finding alternative sources of energy and fuel is going to be critical for our nation and can mean thousands of jobs for Michigan citizens," she said. "Our state has the assets to be a leader in this sector, and we are looking to our universities to provide the knowledge to get us there. I'm delighted Michigan State and Michigan Tech are going to be working together on research to refine fuel from forest products."

By combining their biofuel expertise, the universities are creating new collaborative research, outreach and economic development programs centered on fuels and energy made from forest biomass. The programs are overseen by an eight-member Renewable Fuels Working Group made up of four scientists from each university.

Members of the Renewable Fuels Working Group are, from Michigan State: Miller; Kyung-Hwan Han, MAES forestry researcher; Daniel Keathley, Forestry Department chairperson; and Chris Saffron, MAES forestry and biosystems and agricultural engineering scientist. From Michigan Tech: Margaret Gale, School of Forest Resources and Environmental Science dean; Jeffrey Naber, associate professor of mechanical engineering-engineering mechanics; David Shonnard, professor of chemical engineering; and Barry Solomon, professor of social sciences. Miller and Shonnard are co-chairpersons of the group.

Miller and Shonnard also were part of the contingent that traveled to Sweden with Granholm and members of the Michigan Economic Development Corp. last August. During the visit, Chemrec AB, a Swedish company, and the NewPage Corp., which operates a paper mill in Escanaba, signed a memorandum of understanding to explore developing a plant to produce fuels from woody biomass at the Escanaba paper mill. Miller maintains liaison with both Chemrec and NewPage to provide advice and research support.

With his colleagues on the Renewable Fuels Working Group, Miller hosted a biofuels summit in Escanaba in February attended by 50 representatives of businesses from all aspects of the forest-based bioeconomy and state and local government agencies.

The goal of the summit was to identify key questions the universities should address in three priority areas: feedstock production, feedstock supply chains, and feedstock conversion systems and integration. The summit also furthered the MSU-Sweden relationship by featuring presentations from four Swedish bioenergy researchers, who explained Sweden's transition to renewable fuels. Sweden has 69 million acres of forestland and an enormous forest products industry, so wood is the raw material of choice for Sweden's bioeconomy. Miller and other researchers believe that Michigan can use Sweden as a model when developing the state's forest-based bioeconomy.

In April, the working group released a list of five critical research and outreach needs:

- Complete a comprehensive, detailed inventory of forest-associated woody biomass feedstocks in Michigan.
- Establish sustainability guidelines for the management and use of forest-associated woody biomass based on sound scientific results.
- Aggressively expand technology and information transfer to forest landowners, bioeconomy industries and the general public in an accurate, unbiased and user-friendly way.
- Develop a supply chain model to be used to understand the effects of technological innovation on economic, biological and ecological factors throughout the system.
- Continue technological innovation in woody feedstock production, harvesting, transportation and conversion within the context of the supply chain model.

The working group is forming steering committees for each identified critical area. Work on some of the projects, such as the woody biomass feedstock inventory, has started.

Miller also maintains liaison with the Boston-based Mascoma Corporation, the company that plans to build the country's first cellulosic ethanol plant in the U.P.

Many areas in the state where forest product industries have declined may be perfect locations for cellulosic biofuel companies, Miller suggested.

"There are places in the state where the markets for forestry products have fallen away; the mills have shut down, and the infrastructure that was in place is starting to fall apart — the truckers and the loggers are gone," he said. "Southwestern Michigan is a good example of that. There would be no competition for small trees harvested there."

In places such as the U.P., where the forest industry remains strong, a company using trees to make fuel would be in competition with existing paper mills and other forest product businesses. Miller pointed out that the state grows more wood than it uses, so meeting the potential increased demand is certainly possible.

"But the infrastructure to harvest and handle trees for cellulosic biofuel production won't be put in place until there's a market," Miller said. "Policymakers need to look at what will entice biorefineries to locate here, as well as what will entice landowners to cultivate the types of trees needed for biofuel production. Policy could have a huge effect on the future of Michigan's bioeconomy — even more than technology. That's why we're working so hard to provide sound, science-based information to everyone involved.

"There isn't one thing that's going to make us energy-independent," Miller continued. "It's not as simple as substituting one fuel for another. Replacing all the gasoline the country uses with ethanol won't help us in the long run. If we turned every kernel of corn into ethanol, it would offset only about 12 percent of our gasoline use. We have to use less and be more thoughtful about how we use it. People are worried about using forests for energy, but we're not talking about turning forests into farms. By working together, we can do this intelligently in a way that benefits both the economy and the environment."

::: Jamie DePolo