The Crystal Ball of Biofuel

Divining *alternative options* to a *petroleum-powered* world

By Michael Tennesen

ROB JACKSON AND I TAKE THE ROAD OUT OF AUSTIN, TEXAS on a sweltering afternoon in late spring. We cruise along the highway, passing fields of corn, sorghum, and cotton. For Jackson, who heads the Center for Global Change at Duke University's Nicholas School in Durham, North Carolina, the futures of agriculture and the Earth are entwined.

He points out that some of the land around us, in arroyos and on steep slopes, isn't fit for cultivation because of shallow soils, poor drainage, erosion potential, or other reasons. The Conservation Reserve Program pays U.S. farmers to convert this land back to grass-covered and wooded areas, which provide habitat for wildlife, protect against erosion, and store carbon. Approximately 34 million acres across the United States are enrolled in this program.

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REUTERS/MARK BUNCH (2)

At Greenfield Ethanol Plant in Chatham, Ontario, a process operator shows a handful of corn (left, top), and another worker pours ethanol into a bottle (bottom). In the search for renewable energy, turning corn into ethanol is something of a Holy Grail, but frontline scientists worry about the environmental consequences.

But as high corn prices entice farmers to pull out of the program when their contracts expire, many will begin to re-plow these areas. In doing so, they will release much of the carbon that is stored in the grasses, forbs, and trees as CO_2 into the atmosphere.

Jackson contends that planting corn on these lands to produce biofuel is counterproductive. "If you take a fifteen-year-old plot in the Conservation Reserve Program and convert it to corn to make ethanol, it takes more than forty years of ethanol production before you've saved as much carbon as you lost when you plowed the land in the first place."

To meet the U.S. renewable standard for biofuel energy with ethanol—which requires replacing 30 percent of our petroleum consumption with biofuels by 2030—we would have to expand corn production to currently uncultivated lands. Jackson and his associates have discovered, however, that the carbon benefits accrued by replacing petroleum with biofuels do not account for the carbon that is lost when these lands are cultivated. Their research suggests that preserving restored land makes more sense in terms of preventing global warming than growing corn for ethanol on it.

Following glowing reports, scientists are questioning the carbon balance sheet for other biofuels as well. Examples of ineffectual tradeoffs are palm oil plantations that clear lowland forest in Southeast Asia and soybean or sugarcane farms that destroy woodland savannas or rainforests in Brazil.

The biggest threat is to tropical rainforests. "If Brazil cuts down rainforest to grow a soybean fuel crop, then that's bad news for global warming," says Jackson.

Gervasio Piñeiro, a University of Buenos Aires agronomist, agrees. He says, "It takes a hundred to two hundred years of biofuel use to make up for the loss of tropical forest to biofuel production." Rainforests are critical for wildlife, including the orangutans that remain on the island of Borneo. The red ape's habitat has shrunk due to the palm oil industry, which propels deforestation in Indonesia and throughout Southeast Asia.

"The problem is, if you need to farm new land, then that land isn't storing carbon," says Tim Searchinger, a research scholar and lecturer at Princeton. Searchinger is more pessimistic about the current biofuels than are Jackson and others. Says Jackson, "Biofuel can be a good idea. It harvests the sun's energy in plant growth, and every gallon produced reduces our dependence on petroleum. But it has to be done right."

On a muggy tropical morning last summer, I pull up to a gas station just off the Amazon River with Newton Falcao, an agricultural engineer with the Manaus-based National Institute for Research in the Amazon. He fills up his Ford van with 85-percent ethanol. I ask Falcao why American cars sold to Brazil can run on ethanol, yet U.S. automakers won't sell these cars in their own country. Falcao smiles and says, "The government won't let them sell cars in Brazil unless they can run on ethanol."

A century ago, Henry Ford ran his first car on alcohol, and Rudolf Diesel fired up his first diesel engine with peanut oil. They soon discovered that petroleum, when slightly refined, had more power per gallon than plant-based fuels. Petroleum was cheaper then, too. During the 1970s, Brazil imported 75 percent of its oil. Then the OPEC oil embargo hit, and Brazilians had to wait in lines for up to two hours to buy gas. General Ernesto Geisel, the country's dictator at the time, decided . . . No more.

Sugarcane drives Brazil's ethanol production these days. Unlike corn, which has to be broken down into sugars with a costly enzyme process before it can be fermented, sugarcane is already 20 percent sugar, and the cane begins fermenting almost as quickly as it's cut. Plus sugarcane is one of the fastest growing crops on the planet. It yields twice as much ethanol per acre as does corn.

According to Bill Parton, senior research scientist at Colorado State University in Fort Collins, sugarcane can produce enough energy to run the plants that process it, with surplus energy to spare to feed electricity into the grid. "That beats anything we can produce in the U.S.," he adds.

Sugarcane requires a warmer climate than exists in most parts of the U.S., hence our reliance on corn. But switching corn use away from food to supply energy boosts the demand for corn and for more cornfields. It also drives up the price of corn, which can have far-reaching effects, such as encouraging farmers in South America, Asia, and Africa to cut down forests to compete in the market for corn or other biofuel stocks. Increased food and energy production will also raise demands for water, putting more pressure on undeveloped lands. And this problem is not going away. "We could have three billion more people on the planet by 2050, and we're going to have to feed them," says Jackson.

Just growing, transporting, and distilling corn uses a lot of carbon. Thus, according to Jackson, burning ethanol means only a 10 percent to 20 percent reduction in greenhouse gases released to the atmosphere, compared with petroleum-based gasoline and diesel.

In Mato Grosso do Sul state in southern Brazil, a worker cuts sugarcane for sugar and ethanol production (below). Brazil is rapidly expanding its sugarcane output to meet growing domestic and world demand for ethanol.

REUTERS/JAMIL BITTAR

STEVE PARSONS/AP; REUTERS/LUKE MACGREGOR (RIGHT)

Sir Richard Branson, president of Virgin Atlantic, drinks what he says is biofuel from a coconut (above) prior to the world's first commercial biofuel flight from London (left) to Amsterdam.

What Jackson and Piñeiro see as a better alternative is cellulose-based ethanol production from grasslands. To produce ethanol from corn, only the kernels of the corn are harvested. The stalks and other plant materials are left on the ground. Dupont is working on a more complex process that would create ethanol from cellulose, the main component of plant stems and leaves. This would utilize material that would otherwise be wasted.

Jackson thinks widespread production of cellulose-based ethanol could be in place within a couple of decades and might work particularly well with grasses. Relying on grasslands to produce this ethanol may actually increase the amount of carbon stored in the soil, if the grasslands are replanted on abandoned agricultural lands.

The fast-growing poplar offers another potential source of biofuel. According to Parton, the wood could be burned to drive plant processing, and perhaps contribute electricity back to the grid. "It's a bit like sugarcane in this respect," says Parton.

At the American Geophysical annual conference held in San Francisco last December, which Parton attended with 15,000 other scientists, one of the hot topics was *Miscanthus*. *Miscanthus giganteus* is a perennial grass native to Africa and Asia. It can grow up to 13 feet tall in less than a year and can thrive in many parts of the U.S. You can plant it in March, and by August you will have thick stands. Parton says that microbes associated with *Miscanthus* absorb nitrogen from the atmosphere to benefit the plant, while the plant provides carbon-based sugars for the microbes. Plus *Miscanthus* transports nitrogen from the biomass above ground to the root system, preserving in the soil these nutrients that would otherwise be lost during processing. The grass can be used for biofuels or, like poplar and sugarcane, for burning, thus enabling it to produce the energy needed to run its own refinery processes.

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The airline industry is pushing research into still more interesting biofuels. In February 2008, Virgin Atlantic ran a test flight from London to Amsterdam on a fuel mixed with coconut oil and babassu oil, from the seeds of a Brazilian palm. Continental is planning to test a mixture of algae and oil from the seeds of the jatropha—a weed that resembles a fruit tree. Jatropha can grow almost anywhere though questions remain about whether this plant might become invasive if grown in non-native environments. It doesn't need much water or fertilizer, and it is not edible.

If inedible sources are your fancy, algae could tickle you green. A 75-gallon tank of goo was the star of last summer's Farnborough International Air Show in England. Continental and Virgin are giving algal fuel sources a serious look. Parton says Colorado State University has invested a massive amount of research into its use, particularly because it requires the least amount of land for growing.

Sapphire, a San Diego, California company, already has made a type of gasoline from algae that meets fuel quality standards, is compatible with gasoline-manufacturing infrastructure, and achieves a 91 octane rating. The company says that its fuel will be available to the public in three to five years. Solazyme, another biofuel startup in southern San Francisco, is trying to make biodiesel from algae. Harrison Dillon, president, doesn't worry about competition. "The demand for fuels is so huge, if you can make it at the right price, you can sell as much as you can produce."

"POWERED BY VEGGIE OIL!" proclaims the sticker on the side of a bus that students at Virginia's Emory & Henry College plan to drive more than 1,500 miles during this year's spring break to Texas's Big Bend National Park.

On a rainy day in Torrance, California, Chris Pine pulls up to a trailer which is parked near several oil refineries. Inside the trailer are two large tanks filled with recycled vegetable oil, reclaimed from restaurants. Pine switches on an electric pump attached to a hose and fills up his 2005 Volkswagen diesel Bug. Pine, a founding member of the Biodiesel Coop of Los Angeles (with actress Daryl Hannah), thinks that ethanol is not the only answer to our fuel problem. "Diesel engines create combustion from high compression rather than electric spark and can run on cruder oil," explains Pine. Diesel engines are a little noisier but have fewer moving parts and last longer. They also get better gas mileage. Pine's car gets 30 miles per gallon around town and 40 miles per gallon on the road without a hybrid engine. For another advantage, he points to his bumper sticker. It proclaims, "Requires No War."

Today, diesel engines power big trucks and ships, but diesel fell out of favor as an automobile fuel because of its sulfur emissions. Running on biodiesel, however, creates no sulfur emissions. Biodiesel has allowed school boards in Torrance, California and Las Vegas, Nevada to hang on to aging, but perfectly good, school bus fleets that operate with diesel motors.

Jackson agrees with Pine that future fuel needs are not likely to come from a single source like petroleum. "It's possible that some new technology such as fusion could answer our energy needs the way oil did. Unfortunately, that isn't likely anytime soon. We need a much more diverse portfolio in our energy future—and fast."

Michael Tennesen drives a Honda Civic hybrid that gets 42 miles per gallon. But he looks forward to the day when plant-based biofuels will provide even better mileage.

AP PHOTO/BRISTOL HERALD COURIER/DAVID CRIGGER (2)

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