Biofuels from Switchgrass: Greener Energy Pastures

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The grass stretched as far as the eye could see, and hundreds more miles beyond that. An ocean of grass—deep enough to swallow a horse and rider—swaying and singing in the steady wind of the Great Plains. § The American prairie—tens of millions of acres— once looked like this. But that was centuries ago, before the coming of the white man, the railroad, and the steel plow. Today, corn and beans hold sway, and the remnants of America's tallgrass prairie are confined mostly to parks and preserves. § Now, though, in research plots and laboratories in the Plains states and even in the Deep South the seeds of change are germinating. The tall, native grasses of the prairie, so vital to our land's ecological past, may prove equally vital to its economic future. Such grasses once fed millions of bison. Soon, grown as energy crops, they may help fuel millions of cars and trucks, spin power turbines, and supply chemicals to American industries.

Test plots of switchgrass at Auburn University have produced up to 15 tons of dry biomass per acre, and five- year yields average 11.5 tons—enough to make 1,150 gallons of ethanol per acre each year.

The U.S. Department of Energy (DOE) believes that biofuels—made from crops of native grasses, such as fast- growing *switchgrass*—could reduce the nation's dependence on foreign oil, curb emissions of the "greenhouse gas" carbon dioxide, and strengthen America's farm economy. The Biofuels Feedstock Development Program (BFDP) at DOE's Oak Ridge National Laboratory (ORNL), has assembled a team of scientists ranging from economists and energy analysts to plant physiologists and geneticists to lay the groundwork for this new source of renewable energy. Included are researchers at universities, other national laboratories, and agricultural research stations around the nation. Their goal, according to ORNL physiologist Sandy McLaughlin, who leads the switchgrass research effort, is nothing short of building the foundation for a biofuels industry that will make and market ethanol and other biofuels from switchgrass and at prices competitive with fossil fuels such as gasoline and diesel.

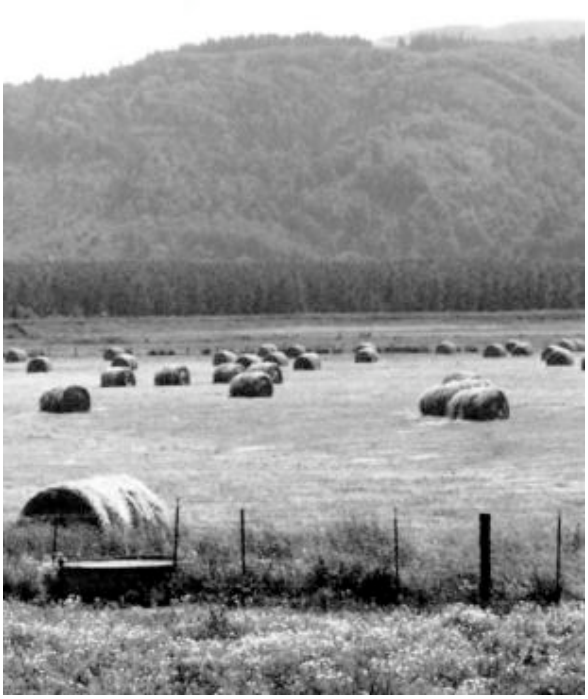
Not the grass in your backyard

First, a distinction: switchgrass and your suburban lawn grasses—bluegrass and zoysia grass— are about as similar as a shopping-mall ficus and an old-growth redwood. Switchgrass is big and it's tough—after a good growing season, it can stand 10 feet high, with stems as thick and strong as hardwood pencils.

But what makes switchgrass bad for barefoot lawns makes it ideal for energy crops: It grows fast, capturing lots of solar energy and turning it into lots of chemical energy— cellulose—that can be liquified, gasified, or burned directly. It also reaches deep into the soil for water, and uses the water it finds very efficiently.

And because it spent millions of years evolving to thrive in climates and growing conditions spanning much of the nation, switchgrass is remarkably adaptable.

Now, to make switchgrass even more promising, researchers across the country are working to boost switchgrass hardiness and yields, adapt varieties to a wide range of growing conditions, and reduce the need for nitrogen and other chemical fertilizers. By "fingerprinting" the DNA and physiological characteristics of numerous varieties, the researchers are steadily identifying and breeding varieties of switchgrass that show great promise for the future.



Switchgrass can be cut and baled with standard farming equipment.

Yield of dreams

In the hard, shallow soil of southern Alabama, Dave Bransby is turning cotton fields into swatches of grassland. Some Alabama farmers joke that there's no soil in Alabama to farm—two centuries of King Cotton and steady erosion haven't left much behind. Yet Bransby, a forage scientist at Auburn University, has found a crop that thrives there: Among the 19 research sites in the Eastern and Central United States raising switchgrass for the BFDP studies, Bransby's site holds the one-year record at 15 tons per acre. Those are dry tons weighed after all the moisture's been baked out. Convert that into ethanol, an

alcohol that can fuel vehicles, and it equals about 1,500 gallons per acre. Bransby's 6-year average, 11.5 tons a year, translates into about 11,500 gallons of ethanol per acre. An added bonus is the electricity that can be produced from the leftover portions of the crop that won't convert to ethanol.

Many farmers are already experienced at raising switchgrass for forage or to protect soil from erosion. Besides showing great promise for energy production, switchgrass also restores vital organic nutrients to farmed-out soils.

Many farmers already grow switchgrass, either as forage for livestock or as a ground cover, to control erosion. Cultivating switchgrass as an energy crop instead would require only minor changes in how it's managed and when it's harvested. Switchgrass can be cut and baled with conventional mowers and balers. And it's a hardy, adaptable perennial, so once it's established in a field, it can be harvested as a cash crop, either annually or semiannually, for 10 years or more before replanting is needed. And because it has multiple uses—as an ethanol feedstock, as forage, as ground cover—a farmer who plants switchgrass can be confident knowing that a switchgrass crop will be put to good use.

Farmers working in production mode might not match Bransby's carefully tended research plots, but if the future brings rises in oil prices—or if environmental taxes are eventually imposed on fossil fuels—energy from switchgrass could prove economically competitive with petroleum and coal, making biomass crops attractive to American farmers. And with recent advances in the technology of gasification, switchgrass could yield a variety of useful fuels—synthetic gasoline and diesel fuel, methanol, methane gas, even hydrogen—as well as chemical by-products useful for making fertilizers, solvents, and plastics.

Strong environmental roots

Annual cultivation of many agricultural crops depletes the soil's organic matter, steadily reducing fertility. But switchgrass adds organic matter—the plants extend nearly as far below ground as above. And with its network of stems and roots, switchgrass holds onto soil even in winter to prevent erosion.

Besides helping slow runoff and anchor soil, switchgrass can also filter runoff from fields planted with traditional row crops. *Buffer strips* of switchgrass, planted along streambanks and around wetlands, could remove soil particles, pesticides, and fertilizer residues from surface water before it reaches groundwater or streams—and could also provide energy.

And because switchgrass removes carbon dioxide (CO_2) from the air as it grows, it has the potential to slow the buildup of this greenhouse gas in Earth's atmosphere. Unlike fossil fuels, which simply release more and more of the CO_2 that's been in geologic storage for millions of years, energy crops of switchgrass "recycle" CO_2 over and over again, with each year's cycle of growth and use.

The road ahead

One reason BFDP researchers are confident that switchgrass can become an important feedstock for ethanol production is the groundwork that's already been laid by corn growers. U.S. ethanol production

from corn currently totals nearly 2 billion gallons a year. Some of this ethanol is blended with gasoline to make gasohol; some is further refined to make gasoline octane boosters; and some is burned, either in pure ("neat") form or mixed with a small percentage of gasoline, in fleets of research and demonstration vehicles.

Looking down the road, McLaughlin believes switchgrass offers important advantages as an energy crop. "Producing ethanol from corn requires almost as much energy to produce as it yields," he explains, "while ethanol from switchgrass can produce about five times more energy than you put in. When you factor in the energy required to make tractors, transport farm equipment, plant and harvest, and so on, the net energy output of switchgrass is about 20 times better than corn's." Switchgrass also does a far better job of protecting soil, virtually eliminating erosion. And it removes considerably more CO_2 from the air, packing it away in soils and roots.

Switchgrass offers excellent habitat for a wide variety of birds and small mammals.

Back to the future

At the turn of the last century, America's transportation system was fueled by biomass: 30 million horses and mules, give or take a few million, pulled buggies, hauled wagons, dragged plows. According to Ken Vogel, a U.S. Department of Agriculture forage geneticist helping develop and test switchgrass for the BFDP, replacing animal power with machine power freed up 80 million acres of U.S. land—land that had been used to grow grass and other feed for these millions of animals. Now, at the dawn of the next century, the wheel could begin to turn full circle. On millions of acres of farm land not needed for food crops, fast-growing energy crops of switchgrass—harvested and converted efficiently to clean-burning, affordable ethanol, methanol, or diesel—could once again supply vast amounts of horsepower.

In short, biomass could bring back a 21st-century version of the prairie. And along with the prairie, it could bring a new crop to America's farms, a boost to U.S. energy independence, and brighter prospects for a clean, sustainable future. According to BFDP and its research partners across the country, that's a future worth cultivating.

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