Issue Analysis

Biofuels, Food, or Wildlife?

The Massive Land Costs of U.S. Ethanol

by Dennis Avery

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Executive Summary

The high price of fossil fuels, environmental concerns, and geopolitical instability in some major oil-producing nations have spurred intense interest in the United States in alternative fuels, especially from renewable energy sources.

While popular with environmental activists, wind and solar power, because of their costs and unreliability, are not expected to grow significantly, even with massive subsidies.

Nuclear power is still viewed with suspicion, even though other countries, including France, supply a majority of their energy needs from nuclear plants.

Crop-based fuel production, especially corn ethanol, has been the main focus of interest, with government subsidies and mandates stimulating demand. Cellulosic ethanol produced from crop wastes has been heralded as the alternative fuel of the future, but it is yet to be produced outside experimental production facilities. More recently, Brazil's example of producing ethanol from sugar cane has been presented as a model for the United States to follow.

There are significant trade-offs, however, involved in the massive expansion of the production of corn and other crops for fuel. Chief among these would be a shift of major amounts of the world's food supply to fuel use when significant elements of the human population remains ill-fed.

Even without ethanol, the world is facing a clash between food and forests. Food and feed demands on farmlands will more than double by 2050. Unfortunately, the American public does not yet understand the massive land requirements of U.S. corn ethanol nor the unique conditions that have allowed sugar cane ethanol to make a modest energy contribution in Brazil.

The United States might well have to clear an additional 50 million acres of forest—or more—to produce economically significant amounts of liquid transport fuels. Despite the legend of past U.S farm surpluses, the only large reservoir of underused cropland in America is about 30 million acres of land—too dry for corn—enrolled in the Conservation Reserve. Ethanol mandates may force the local loss of many wildlife species, and perhaps trigger some species extinctions. Soil erosion will increase radically as large quantities of low-quality land are put into fuel crops on steep slopes and in drought-prone regions.

The market is already responding to the high price of oil, as investors flock to alternative fuels, including investments in cellulosic ethanol research and development. Those developments are healthy, if markets are allowed to discover the winners and losers in future alternative energy sources without government intervention through subsidies and fuel mandates, and with a clear assessment of the trade-offs that may be involved.

Introduction

The United States is caught in a severe energy dilemma.

The world is going through the strongest surge in energy prices since the oil crises of the 1970s. U.S. crude oil prices have soared from their post-1950 average of $21 per barrel to more than $70 per barrel. Natural gas prices tripled between late 2001 and late 2005.

Widespread concern about global warming has raised serous questions about whether America should dig more of its abundant coal or permit more offshore oil drilling, since burning more of these fossil fuels would increase atmospheric carbon dioxide (CO_2). Currently, much of America's own oil and natural gas deposits—both offshore and on federally owned lands—are off-limits to development due to fears of oil spills. Such incidents are unlikely with modern production methods, but the political will to overcome environmental pressure groups' objections has been sapped by fears about global warming.

Nuclear power is worrisome to the public, due to the Three Mile Island accident, the Soviet meltdown at Chernobyl, and activist claims that nuclear wastes cannot be stored safely.

Meanwhile, economic growth is surging in the largest emerging economies—at nearly 10 percent annually among China's 1.3 billion people and at around 7 percent per year for India's 1.1 billion—driving strong and permanent increases in global energy demands. The Chinese auto market, for example, has been growing at 10 to 15 percent per year, with car sales topping 3 million in 2005. Indian auto demand is following the same trend.[1]

Renewable energy sources, especially the solar panels and wind farms favored by eco-activist groups, have been severely hampered by their high initial costs and the erratic nature of wind and sunshine. Even after decades of heavy public subsidies, wind power in 2005 provided only 0.4 percent of total U.S. power generation, while grid-connected solar provided only 0.1 percent. The Energy Information Agency expects these technologies to grow slowly over the next 30 years.[2]

The cost of energy from renewable sources has even increased for other reasons. The University of Manitoba's Vaclav Smil notes that the price of PV silicone has more than doubled, while the costs of steel, aluminum, and plastics used in wind turbines have been rising.

It was this energy dilemma that pushed California into its rolling blackouts in 2000. The Golden State had not built any new power plants in more than a decade because no energy source was considered environmentally appropriate, even though California's energy needs were rising.

Now the dilemma has worsened. America has discovered—in the wake of the September 11, 2001 terrorist attacks—that major oil suppliers in the Middle East have been using their oil earnings to undermine the West. They have funded terrorists and extremist Islamist schools, and begun programs to develop weapons of mass destruction. The U.S. faces a long-term "war" launched by Islamists against both moderate Muslims and the affluent energy-importing countries.

Other major U.S. oil suppliers, such as Nigeria, suffer from severe corruption and security problems that can disrupt supply, while tensions with Venezuelan strongman Hugo Chavez create uncertainty about the stability of the supply.

These factors have produced an unlikely national energy consensus: That the United States should radically expand its production of energy from crop biomass; specifically, America must produce lots of auto fuel from corn.

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Unfortunately, the land requirements of corn ethanol are massive and its costs high. Worse, a major American commitment to biofuels would likely raise food costs and hunger risks for the world's poor. It would also drive a massive clearing of U.S. forests, accompanied by a major displacement of our wildlife species to grow the biofuel corn.

Can Corn Carry the Country?

In 2004, 30 state governors, including those of most states between the Appalachians and the Rockies, urged President Bush to expand the federal government's support for fuel ethanol. They called their plan "a logical roadmap for reducing consumer fuel prices, increasing energy security, stimulating rural economies and generating jobs."[3]

The Energy Policy Act of 2005 now mandates consumption of at least 4 billion gallons of renewable fuels in 2006, with the mandate rising to 7.5 billion gallons (5.5 percent of current U.S. gasoline consumption) by 2012. Ethanol is expected to provide the vast majority of the renewable fuels. This effectively mandates a near-doubling of ethanol production by 2012, and raises industry hopes for an even larger expansion of ethanol after that.

President Bush, speaking to the Renewable Fuels Association in 2006, highlighted his Advanced Energy Initiative:

> "Ethanol has the largest potential for immediate growth…Without much cost, your automobile can be converted to use 85 percent ethanol, a product made from corn grown right here in America... The use of ethanol is good for the agricultural sector...Ethanol is good for the environment...and ethanol is good for drivers. Ethanol is home-grown. Ethanol will replace gasoline consumption...The ethanol industry is on the move, and America is better off for it." [4]

The general public associates corn ethanol with both cleaner air and energy independence. As a result, ethanol is virtually the only energy source that has broad, bipartisan public support for expansion.

Is this an ideal way to diminish America's "addiction" to imported oil? Or is it an expensive dead end that will leave the country's fuel prices higher, its taxpayers poorer, and its forests diminished? Will American farmers lose their long-term profits from exporting feed and meat to Asia

for an ethanol boom to be followed by a bust?

America is the world's largest corn producer. It has profitably marketed record crops of corn in recent years as demand for feed corn has expanded with rising incomes for more people overseas. To date, corn has been more valuable—both to farmers and to the nation—in its traditional uses than as the feedstock for ethanol.

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Ethanol supporters say:

"We have the capacity to make nearly 4.5 billion gallons of ethanol, but that is a long way from helping us deal with our gas problems…We need to be moving on a much faster track." – Sen. Hillary Clinton (D-N.Y.)[5]

"I'm absolutely convinced that without putting any more land under agriculture and without changing food production, we can introduce enough ethanol in the U.S. to replace the majority of our petroleum use in cars and light trucks." – Vinod Khosla, co-founder of Sun Microsystems[6]

"Hoosier farmers will produce enough corn on average to meet our goal of producing 1 billion gallons of biofuels *and* doubling Indiana's pork production." – Indiana Lieutenant Governor Becky Stillman[7]

Ethanol opponents say:

"In the early 1980s, ethanol subsidies were used to prop up America's struggling corn farmers. Unfortunately, the 'trickle down' effect of agricultural subsidies is clearly evident. Beef and dairy farmers, for example, have to pay a higher price for feed corn, which is then passed on in the form of higher prices for meat and milk. The average consumer ends up paying the cost of ethanol subsidies in the grocery store...The Congressional Research Service, the Congressional Budget Office and the Department of Energy all acknowledge that the environmental benefits of ethanol use, at least in terms of smog reduction, are yet unproven...ethanol is an inefficient, expensive fuel." – Sen. John McCain (R-Ariz.)[8]

"Abusing our precious croplands to grow corn for an energy-inefficient process that yields low-grade automobile fuels amounts to unsustainable subsidized food burning." – David Pimentel, Cornell University entomologist[9]

"To run our cars and buses and lorries on biodeisel, in other words, would require 25.9 million hectares [of cropland]. There are 5.7 million in the UK. Even the EU's more modest target of 20 percent by 2020 would consume almost all our cropland." – George Monbiot, columnist, *The Guardian*[10]

"Ethanol is the largest scam in our nation's history—and if Congress ratchets the subsidy up any more, this twisted policy...has the potential of undermining our food security." – Nicholas E. Hollis, President, Agribusiness Council[11]

Biofuels' Massive Land Requirements

The first intractable reality about corn ethanol is that it takes enormous amounts of land to produce in any significant amount. U.S. gasoline consumption was 134 billion gallons in 2003.[12] It would take more than 546 million acres of U.S. farmland to replace all of our current gasoline use with corn ethanol.

Ethanol yields 35 percent less energy per gallon than gasoline.

In 2002 a panel of top U.S. energy experts, writing in the journal *Science*, noted that current global power use is 12 trillion watt-hours per year, with 85 percent of it coming from fossil fuels. The panel concluded that replacing those fossil fuels with biomass energy would require planting as much additional land as is already planted on the entire planet.[13]

America's corn fields produce the equivalent of a meager 244 gallons of gasoline per acre per year. The U.S. Department of Agriculture (USDA) says that each bushel of corn is now producing about 2.7 gallons of the fuel, and U.S. corn crops have averaged 138 bushels per acre over the past decade, for an average per-acre yield of about 375 gallons of ethanol.[14] Moreover, gasoline contains 116,030 BTUs/gallon, compared to ethanol's 76,330 BTUs/gallon—in other words, ethanol yields 35 percent less energy per gallon than gasoline.[15]

Total U.S. crop plantings have recently been about 440 million acres—and that land has produced all our food and fiber, plus a multi-billion-dollar annual profit from farm exports. Ethanol byproducts—distillers, dried grains, and corn oil—offer only one-third of the feed energy that was in the corn when it entered the ethanol plants.[16]

As the final nail in the policy coffin, corn ethanol delivers barely more energy than it takes to make it. The USDA's Dr. Hosein Shapouri estimates the net energy gain in corn ethanol at a tiny 25 percent. Corn needs lots of nitrogen fertilizer, made with natural gas, and lots of fossil-derived pesticide protection. Then it needs fuel to heat the ethanol fermentation process.[17] (Shapouri has more recently estimated a modestly higher net energy gain for corn, but that estimate relies on a higher credit for co-products that is not explained or justified.[18])

Given the high fossil fuel inputs of the corn and processing, the United States needs to produce more than 5 gallons of ethanol to replace the fossil energy in one gallon of gasoline. The mandated 7.5 billion gallons of corn ethanol production in 2012 would thus reduce American fossil energy imports by only 56,000–75,000 barrels per day, or less than 0.5 percent.

Some activists, including Cornell Professor Emeritus David Pimentel, argue that corn ethanol is produced at an actual net energy *loss*. For an analogous example, take the case of soybeans. An acre of U.S. soybeans is worth only 52 gallons of biodiesel per year. Each soybean acre produces only 40 bushels of soybeans, or one-third the grain yield of corn.[19] Each bushel of soybeans produces 1.4 gallons of biodiesel, with 93 percent of diesel's energy.[20]

Projected world power requirements in 2052 will rise to a total of 22 to 42 trillion watt-hours, say the earlier cited *Science* authors. Producing this

from crops could require as much as 80 percent of the Earth's total land area—especially if they are grown without such fossil-energy products as nitrogen fertilizer and pesticides. Supposedly, we'd be energy-cropping the Gobi Desert, the Amazon River basin, and northern Siberia.

Only in Brazil is there a major, identifiable opportunity to expand cropland without massive risk of soil erosion and major forest loss. Yet massive forest clearing is hardly an effective anti-greenhouse strategy, whether the forests lost are in Brazil or in Washington State. And even Brazil's large tracts of underused acid savannah land would be overwhelmed by any major global effort to substitute biofuels for petroleum.

Food Demands on World Farmland to Redouble by 2050

The second intractable reality of biofuels is that the world's food and feed demand is set to more than double by 2050. That means that good cropland will become very scarce around the world. Human society is already farming about 37 percent of the global land area, and already using almost all of the good-quality land.[21] Additional farmland will have to come at the expense of forest and wild species, and is likely to incur heavy penalties in terms of soil erosion, drought risks, and endangered wild species.

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The world's human population—now 6.3 billion—will peak at between 8 and 9 billion around 2040, based on the United Nations Population Division's Medium Variant.[22] That still means a 25 to 40 percent increase in people eating meals.

In addition, most of the 8 to 9 billion people in 2050 will probably be able to afford high-quality diets. The World Bank expects global GDP will nearly triple, in constant dollars, by 2050.[23] Billions of additional people will be able to afford meat, milk, and varied fresh fruits and vegetables. These foods take more farming resources than diets based on corn, beans, rice, or cabbage.

The Hudson Institute projects world meat demand to increase by 135 percent by 2050, as per capita incomes rise by 180 percent, driving a per capita meat consumption increase of 68 percent.[24] These high-quality protein calories will demand massive increases in feed crops—primarily the corn and oilseeds that are also the key biofuel feedstocks for non-tropical countries.

There will even be a pet factor in the cropland equation. Dog and cat populations are rising rapidly virtually everywhere that incomes are rising. If China has as many pet cats and dogs per capita in the future as Americans do today, that will mean raising food for an additional 500 million non-vegetarian animals, in just one country. Many people who can afford pets dote on them almost as intensely as parents dote on their children. No politician dares to stand between pet owners and their pets' favorite foods.

Thus, the real conflict over cropland in the 21st century will set people's desire for biofuels against their altruistic desire that all the children on the planet be well-nourished—and their own desires for hamburgers, fresh raspberries, and filling Fluffy's food dish. These will all add pressure to clear more of the world's forests for cropland.

The Ethics of Burning Food as Auto Fuel

The world's cropland resources seem totally inadequate to the vast size of the energy challenge. We would effectively be burning food as auto fuel in a world that is not fully well fed now, and whose food demand will more than double in the next 40 years.

Land too poor to farm has contained virtually all of the world's wildlife species from time immemorial. The world's best cropland never had many wild species.

The traditional human priorities on use of good cropland start with food. Famine, after all, is a human society's ultimate failure. Tightening the world's food supply by diverting major quantities of its grain stocks into fuels will drive up the prices of all food. This will inevitably hit hardest at the poorest people in the world's food-shortage regions. This would not be ethical even if there were no other sources of energy.

The second priority on land use has gone to producing high-quality protein, for much the same reasons that producing adequate food is the top priority. Children grow taller and stronger, and learn more quickly, if they have high-quality animal protein, and its key micronutrients such as iron and zinc. Children who eat livestock products do not go blind due to Vitamin A deficiency. (The world has never had large numbers of voluntary vegans who eat no livestock products. Even the vast majority of the world's vegetarians consume large quantities of milk, dairy products, and eggs, all of which require nearly as many farming resources per calorie as meat.)

Fuel has ranked a poor third in terms of cropland use. Biofuels are unlikely to keep a high priority as it becomes clear that they compete with good farmland's other important uses: combating hunger, saving forests for wildlife, and providing high-quality protein for kids.

The Ethics of Displacing Wild Species for Auto Fuel

"Until he extends the circle of his compassion to all living things, man will not himself find peace." – Albert Schweitzer[25]

Land too poor to farm has contained virtually all of the world's wildlife species from time immemorial. The world's best cropland never had many wild species. The best-quality land has typically had large numbers of only a few wild species, such as the bison and prairie dogs of the American Great Plains and the kangaroos of the Australian grasslands.

In sharp contrast, a national park in the Peruvian Amazon contains more than 1,300 plant species, 332 bird species, 131 species of amphibians and reptiles, 70 different species of non-flying mammals, plus thousands of species of bats, flying squirrels, and insects! [26] A few square miles of tropical forests may contain more above-ground species than all of North America. Expanding fuel crops onto poorer-quality land is likely

to exact a high price in terms of wild species displaced or lost. This will be especially true in the tropical forests of places like India and Indonesia, where livestock product demand is rising rapidly. As Michael Huston, ecologist at the Oak Ridge National Laboratory and author of *Biological Diversity,* told a Hudson Institute farm policy conference in 1995:

> "Fortunately for both humans and nature, the world's best soils support the most productive agriculture, but relatively low biodiversity. The world's poorer soils are terrible for crop production, but harbor our largest reservoir of wild plant species and their genes. There is no inherent conflict between sustainable farming and biodiversity and conservation, at least on a global basis...Nothing is more important for world biodiversity preservation than for American agricultural policymakers to understand their environmental imperative—to use America's unique soil resources and agricultural potential as fully as sustainably possible to feed the hungry populations of the world, particularly those on the poor soils of tropical countries." [27]

Already, environmental pressure groups are raising red flags about the land costs of fuel from crops. At a recent conference in Europe, three environmental organizations—Birdlife International, European Environmental Bureau, and Transport & Environment— warned the European Commission that Europe had little land to be wasted on biofuels. The EU has announced a goal of replacing 5.75 percent of its fossil fuels with biofuels, but the environmental groups warned this could "consume" 14 to 27 percent of the region's farmland.[28]

> "Europe must act now or biofuels could spell disaster for biodiversity worldwide…Already we are seeing European wildlife affected by biofuel production. The little bustard in France and the red kite in Germany are both examples of species being put in danger by the unmanaged conversion of land into biofuels production. The problems get even more serious when we consider the prospect of imports that are produced at the expense of the rainforest."

These groups specifically warn of imported palm oil produced on land cleared of species-rich tropical forest. They even want Europe to keep its current farmland set-aside measures, which date from the period of Europe's "farm surpluses." They argue that the set-aside land has become too crucial to the species of "the farmed landscape" to be sacrificed for tiny percentages of Europe's transport fuel requirements.

The European Environment Agency, in its report *How Much Bioenergy Can Europe Produce Without Harming the Environment?,* argues that large-scale production of biomass fuel from agriculture would put

additional pressure on farmland, starve soils, and use up scarce water.[29]

High-yield farming has so far preserved about 16 million square miles of global forests despite intense population and development pressures. It would be ironic in the extreme if our past success at growing corn for food should lead us into a massive bout of forest-clearing for high-cost auto fuel.

Land Constraints on U.S. Corn and Soybeans

America's total corn crop in 2005 was about 280 million metric tons, second only to the record 2004 crop of 300 million tons. In both those years, the U.S. produced about half of the world's corn crop, and an even higher percentage of its corn exports. However, a recent University of Minnesota study says that if *all* the current output of U.S. corn and soybeans were put into biofuels, it would replace only 12 percent of our gasoline demand and 6 percent of our diesel needs.[30]

Replacing 10 percent of U.S. gasoline with corn ethanol would require planting more than 55 million more acres of corn, on top of the 80 million acres of corn U.S. farmers are already planting. Where would we plant the additional corn? The only underused cropland in the U.S. is roughly 30 million acres of land enrolled in the Conservation Reserve—which is mostly too arid to grow corn.

Efforts to force-feed the U.S. corn ethanol industry are likely to trigger lots of forest clearing, but U.S forestland is of substantially poorer quality than its corn land. Our corn is grown on our best land, while our forests grow on our worst. Forest land is steeper, dryer, poorly drained, or somehow lacking—and therefore low-yielding. If the land quality of the cleared forests is only half as high as the quality of the current corn land, the additional land required to displace 10 percent of our gasoline with corn ethanol could total 110 million acres.

Privately owned forest on the farms of the nine major Corn Belt states totals only 80 million acres. Most of that is in the northern reaches of Minnesota, Wisconsin, and Michigan, which are too far north for corn to mature successfully. [31]

Planting the additional corn land without energy-intensive nitrogen fertilizers would require doubling the land requirements yet again—to a staggering 220 million acres. Much of that land would be used to "grow nitrogen" as cattle forage or green manure crops.

Some additional corn can be expected from the long-term trend of rising yields. U.S. corn production averaged 115 bushels per acre during 1986–1995 and 138 during 1996–2004.[32] Unfortunately, the very high oil prices that have triggered the oil-ethanol crisis have increased farmers' costs for diesel fuel, fertilizer, and irrigation pumps. These costs are now suppressing high-yield corn production. Barring some unknown breakthrough in genetic engineering for corn, we can expect a slowing of the uptrend in corn yields.

Meanwhile, the amount of corn going into ethanol has risen from less

than 500,000 bushels in 1995 to nearly 2 million bushels projected for 2006—that's 20 percent of the 2006 U.S. corn crop. Robert Wisner of Iowa State University warns that ethanol's percentage of U.S. corn is likely to double again by 2012. Each additional bushel of corn bid into the ethanol plants will drive up the price of corn—and that of food. The price of feed corn for U.S. livestock could rise by 60 to 70 percent over the next two years, warns Wisner. [33]

Biofuels from Sugar, at What Cost?

The U.S. can and does grow sugar, from both cane and beets, but only small amounts and only under heavy subsidy. Nearly half of the sugar cane is grown just upstream from the Florida Everglades, where environmentalists have long asserted that it poses an intolerable threat to the Everglades' vast and vulnerable ecosystem.[34] Sugar cane is also still grown in Hawaii, despite the ultra-high and rising land and labor costs there. The other half of the U.S. sugar cane crop is grown in Louisiana and Texas, where land pressures are lower, but not low enough to match cane costs in Brazil and other tropical countries.

U.S. sugar prices are roughly twice the world market level. American jobs in candy making have been driven offshore, and our soft drinks are sweetened with corn fructose instead of sugar, all because of America's already-high sugar support.

The U.S. also has about 1.5 million acres of sugar beet, mostly grown in the Northwest and upper Midwest, including Michigan, Minnesota, North Dakota, and Idaho. Sugar beets are a far higher-cost source of sugar than sugar cane, due primarily to lack of tropical sunshine. No country grows sugar beets except to conserve foreign exchange—often at high cost—and placate its own farmers. Environmentally, beet sugar takes lots of irrigation water, fertilizer, and pesticides.

American sugar beets are typically grown on some of the finest cropland in the country, land that could produce high yields of various food and feed crops, including potatoes and corn. But sugar is grown, at nearly three times the cost of Brazilian cane sugar, only because of U.S. sugar price supports and tariffs.

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The world has no shortage of tropical land that can produce low-cost ethanol from sugar cane. Brazil alone says it could produce more than 500 million acres of it. Other countries, including Australia, the Dominican Republic, Guatemala and the Philippines, could also supply more sugar cane ethanol to the U.S. market if it were freed from its current 54-cent-per-gallon import tariff. These represent a broad array of non-Mideast energy sources.

U.S. corn growers should be exporting higher-value grain and meat, while U.S. sugar beet growers should produce more high-value irrigated crops. Foregoing American sugar cane would be a scant loss to the island of Hawaii, and a major environmental gain for Florida.

The Cost of U.S. vs Brazilian Ethanol

Corn land that might cost $2,500 an acre in the United States might be available in Brazil's Cerrados Plateau for $100 per acre. The hourly cost of a Brazilian manufacturing worker was $3.03 in 2005, compared with $23.17 for a U.S. worker.[35]

U.S. corn's feedstock cost per gallon of ethanol was three times that of sugar cane's in 2004, according to F.O. Licht, the world's leading sugar analysts. They estimated U.S. feedstock costs at about 24 cents per liter, compared with Brazilian sugar at only about 8 cents per liter.[36] Licht noted that this may enable Brazil to produce ethanol for as little as 50 cents per gallon, which made ethanol competitive when crude oil rose above $26 per barrel.[37] For U.S. ethanol, the processing subsidy alone imposes costs equal to $32 per barrel oil.

Rising costs for diesel and nitrogen fertilizer have since sharply increased corn's disadvantage. Sugar cane needs only 57 lbs of nitrogen per acre, while corn needs 130 lbs per acre. Much of the corn crop is plowed annually, a fuel-intensive operation, while sugar cane can be re-grown from its cut stalks for several years.

The ethanol push has recently begun to bid up the price of corn. The Chicago futures markets were bidding $3 for a bushel in the summer of 2006, compared with only $2 per bushel for Illinois farmers marketing their 2006 grain.[38] The market clearly recognized what many had been predicting for years, that ethanol was tightening the grain market.

The federal ethanol mandate also drives up gasoline prices at the pump for another intractable reason: Ethanol cannot be shipped from its Midwest production facilities to other regions by pipeline, because the hygroscopic fuel absorbs too much water when thus transported, and would then damage vehicle engines. It must be trucked. To reach California, the ethanol trucking costs alone represent 14 to 17 cents per gallon.[39] Brazilian ethanol, by contrast, could be landed cheaply from tanker vessels at California ports.

The lack of paved roads and railroads that hampers corn and soybean crops grown on Brazil's far western frontier does not hamper its ethanol. The sugar industry has already built its infrastructure under the heavy subsidies that the Brazilian government provided for fuel alcohol in the 1970s and 80s.

The U.S. Department of Agriculture in early 2006 published a cost comparison of ethanol in Brazil, Europe and the U.S., *The Economic Feasibility of Ethanol Production from Sugar in the U.S.* It showed:[40]

Ethanol Cost per Gallon (U.S.$)

	Brazil Cane	U.S. corn wet mill	U.S. corn dry mill	U.S. sugar cane	U.S. sugar beets	EU sugar beets
Feedstock	0.30	0.40	0.53	1.48	1.58	0.97
Processing	0.51	0.63	0.52	0.92	0.77	1.92
Total Cost	0.81	1.03	1.05	2.40	2.35	2.89

The USDA estimates claim that U.S. sugar costs are more competitive with Brazil's than does Licht. However, the table makes it clear that U.S. sugar is already three times as costly an ethanol source as Brazilian sugar cane, and more than twice as expensive as U.S. corn, because America's sugar subsidies are even higher than its corn subsidies. The inescapable conclusion is that Brazilian sugar cane is—and will remain for the foreseeable future—a far more efficient source of auto fuel than U.S. corn or soybeans.

The sugar subsidy was originally justified for national security, after sugar rationing during World War I. With today's big corn sweetener industry, that justification is long gone. Today, there are strong ethical and environmental reasons not to allow the already generously subsidized and protected U.S. sugar industry to get any part of any ethanol subsidies. Instead, U.S. sugar tariffs and import quotas should be eliminated, so that Brazilian and Philippine ethanol could be imported to help tamp down high gasoline prices.

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Nevertheless, U.S. sugar growers and their organizations are talking about ethanol as a new rationale for sugar subsidies continuing and expanding! One company is already planning Florida's first ethanol plant, near Tampa. The plant will begin operations by processing ethanol from Midwest corn imported by water. However, U.S. EnviroFuels President Bradley Krohn says he hopes to eventually make his fuel from sugar cane and other high-sugar crops better suited to Florida's climate.[41]

How Did Brazil Achieve Biofuel Success?

Brazil is the world's largest sugar producer and exporter. The country produces some 300 million tons of sugar cane per year on nearly 15 million acres of land. Roughly half of this is turned into ethanol—with the exact amount depending on oil prices. About 100,000 tons of sugar is exported—again, depending on world sugar prices.

Brazil's land abundance, and its savings on scarce foreign exchange make cane sugar ethanol a reasonable source for 12 to 15 percent of its net energy needs. Brazil values ethanol both for its contribution to energy independence and as an alternative market or "balance wheel" for its massive sugar industry in years when world sugar prices are low. More than one million workers are employed in the sugar industry, although at low wages.

After the oil shocks of the 1970s and early 1980s, Brazil was spending a huge proportion of its foreign exchange on imported oil. At the same time, the prices for its huge sugar crops had plummeted. The country's military government then decided that "national pride" demanded more energy independence. Government subsidies were offered to support the shift of the cane sugar from sweetener to fuel alcohol, and to the production of cars that could burn alcohol without corroding their engines or fuel systems.

The Licht paper credits Brazil with getting about 600 gallons of ethanol per acre from its sugar, while the U. S. gets about 345 gallons of ethanol

per acre from its corn.[42] That's nearly a two-to-one advantage.

Brazil also powers its ethanol processing by burning the crushed stalks and leaves of the sugar cane itself. That means that its processing energy requires no additional input costs. Corn must be heated and fermented to produce ethanol, and the heat must come from a fossil fuel, such as coal or natural gas. That offsets most of the energy produced by the corn ethanol. A Brazilian study found that cane sugar ultimately produces 3.67 units of energy for each energy unit invested, while corn yields only 1.1 units.[43]

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If the U.S. wants to divorce its energy sources from the unstable Middle East, it would make more sense to suspend the 54-cent-per-gallon import tariff on ethanol and buy its ethanol from Brazil. The ethanol import strategy is further supported by the fact that Brazil is the only country in the world with lots of good, underused cropland. Brazilian Agriculture Minister Luiz Fernando Furlan claims that the country could cost-effectively grow sugar cane on 225 million acres of land. [44] Only its southern regions are too cool for the cane.

Brazil also has very large amounts of land available for its non-sugar crops. Brazilian researchers have recently discovered how to successfully and sustainably farm huge tracts of the vast acid-soil savannah on its central-western Cerrados Plateau. This land has historically been covered mostly with stunted brush and termites. Brazil's Cerrados ranks just about at the bottom of the world's biodiversity assets.

Brazil has perhaps 100 million acres of additional Cerrados land to clear for crops. (The Cerrados is *not* in the Amazon River basin, nor is it tropical forest. Confusion has sometimes arisen because much of it is in a Brazilian state named Amazonas.)

In addition, Brazil has more than 400 million acres of pastures that have no agronomic constraints for crop growing. The rest of the world's pastures are too dry, too rocky, too steep, or too wet for crops. [45]

The Glimmering Promise of Ethanol from Wastes

In an old fairy tale, a dwarf named Rumpelstiltskin spun straw into gold. Can bioengineering make this fairy tale come true in the next 25 years?

The ethanol dream is to find ways of efficiently getting auto fuel from the world's high-cellulose biomass—corn stalks, wheat straw, crushed sugar cane stalks, and massive amounts of wood chips from forest trees and underbrush. The cellulose and lignin in these biowastes are the most abundant materials on Earth. But we currently lack the technology to turn any of them cost-effectively into liquid fuel.

The problem is that two-thirds of their dry mass is made up of cellulose and hemicellulose, which lock their simple sugars into tough, long-chain polysaccharides. Most of the other third of dry mass is lignin, a chemical-resistant substance that binds cellulose fibers together.

The current proposals are to make the long-chain sugars available for fermentation by pre-treating them with dilute acid, steam explosion,

ammonia fiber explosion, organic solvents and/or bioengineered bacteria. The leftover lignin is supposed to be separated and burned to provide the heat for the fermentation process.

Vinod Khosla, a co-founder of Sun Microsystems, is now betting that he can supply ethanol cheaply from the crushed stalks and leaves of Louisiana sugar cane. He has a full-scale commercial plant under construction, hoping that bioengineered E. coli can ferment the xylose—or "wood sugar"—that has previously defied fermentation. [46]

President Bush is betting even more heavily on cellulosic ethanol, having set a goal of making it competitive within six years, and requesting $150 million for it in the 2007 federal budget.

The Wall Street Journal reports that both Genencor and Novozymes Biotech have cut the fermentation enzyme cost for a gallon of ethanol from $5 to less than 30 cents. But that still hasn't put cost-effective ethanol from cellulose within our grasp. [47]

Nathanael Greene, who authored the report *Growing Energy* for the Natural Resources Defense Council (NRDC), says we could obtain enough energy to replace 100 billion gallons of gasoline per year from 114 million acres of switchgrass by 2050. All it will take, says NRDC, is another $2 billion in federal research funding over the next 10 years. Maybe.

Reade Dechton of the Energy Futures Coalition, a bipartisan political group, says, "In the enzyme camp we have only scratched the surface of the potential of biotechnology to contribute to this area. We are at the very beginning of dramatic cost improvements."[48] Energy Futures wants to convert America's current cotton and sugar subsidies to ethanol subsidies. That would replace a bad idea with a still-unworkable idea. Is that progress?

The reality is that we do not yet have the high-yield switchgrass varieties, the cost-effective pre-treatments, or the high-yield enzymes to convert simple sugars from the cellulosic feed stocks. We are still analyzing the guts of Costa Rican termites to find out how nature breaks down cellulose.

Optimists say we are likely to have such enzymes within five to 10 years. That argues for researching the enzymes, but it does not argue for building the ethanol plants before we know what biowastes we can turn into cellulosic ethanol, or where the biowastes are likely to be found.

Nor is it clear that federal research dollars are needed to reach the cellulosic dream. Oil at over $70 a barrel has put stars in the eyes of everyone from venture capitalists like Khosla to the agribusiness giant Archer Daniels Midland, and from genetic researchers like the Joint Genome Institute to financiers like Goldman Sachs. *The Wall Street Journal* says that with the high oil prices in the summer of 2006, some of the existing corn ethanol plants generated 35 percent profits per year!

Private investors have already marshaled many millions of dollars to fund ethanol research and technology. Farm groups have come forth with their own dollars. The biotech industry is broadly searching for the cellulosic keys. These organizations move more quickly and directly than

do government programs, have fewer strings on their activities—and ultimately have a much higher degree of success.

The United States could gather more than a billion tons of biomass per year, and might displace as much as 30 percent of its petroleum use with biomass energy, according to a report by the U.S. Departments of Energy and Agriculture.[49] The report is titled *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-ton Annual Supply*—which seems to indicate that the bureaucrats were tasked with ginning up a heroic number, an impression that seems borne out by the report's overly bold assumptions:

- **We will have cost-effective cellulosic ethanol, making ethanol from wood chips and corn stalks with genetically engineered enzymes.** We cannot yet make cellulosic ethanol cost-effectively, as earlier noted, and do not know when we might be able to do so.

- **There will be public approval for harvesting far more wood and wood wastes from nearly 700 million acres of our forests than we do today.** The report envisions logging 500 million acres of current timberland more heavily. It also envisions cutting brush and under-story biomass on 168 million acres of "other" forests too poor to qualify for logging now. The biomass project would amount to an industrial transformation of the nation's forest regions. Both sets of forests would need logging roads and infrastructure to support the biomass production. They would need a sizable number of local fuel distilleries to turn the biomass into liquid fuel, because the cost of hauling the biomass any long distance would be prohibitive.[50] Gathering the under-story biomass would reduce forest fire risks, but it would still be a very expensive and disruptive project.

- **We can have a 50 percent increase in crop yields.** This we also do not have.

- **We can gather all crop biomass not needed for no-till cropping, and all urban biomass refuse—almost regardless of collection costs.** This report only assesses whether we have the *technical ability*—as in power rakes, forklifts and trucks—to pick up biomass scattered widely around the countryside, not whether it would make sense—in either economic or national security terms—to gather it.

- **We will make ethanol from manure.** Manure is extremely heavy because of its high water content. Reducing the water content takes lots of heat—that is, energy. More importantly, the manure is almost certainly most valuable as organic fertilizer. It would make no sense to turn the nation's manure into high-cost ethanol, only to force the import of more natural gas for nitrogen fertilizer. Both the U.S. Department of Agriculture and the Environmental Protection Agency have long agreed that the U.S. has less than one-third of the organic nitrogen to maintain soil fertility levels.[51]

The University of Manitoba's Vaclav Smil, a prominent agriculturist, notes that, "the [biofuels] prospect does not change radically by using crop residues to produce cellulosic ethanol: Only a part of these residues could be removed from fields in order to maintain key ecosystemic services of recycling organic matter and nitrogen, retaining moisture and preventing soil erosion."

Essentially, Smil is highlighting the soil-erosion, soil carbon, and moisture-retention benefits of crop residues staying on the crop fields. Crop residues are especially important for the highly praised system of low-till farming, which uses herbicides to control weeds instead of plowing and mechanical cultivation. Low-till reduces soil erosion by 50 to 95 percent, and often doubles the soil moisture available to the crop plants. However, it requires that billions of tons of crop residue be left on the soil surface (with no-till) or tilled into the top two or three inches of soil (in low-till) to work effectively. If farming sustainability requires that half the crop residue be left on the soil surface, the cost of collecting the other half could more than double.

Smil concludes that "proposals of massive biomass energy schemes are among the most regrettable examples of wishful thinking and ignorance of ecosystemic realities and necessities." [52]

Land producing corn for ethanol is producing no food grain, and far less feed for livestock or poultry.

What the Corn Growers Say

The National Corn Growers Association (NCGA), on its website, says of the potential conflict between food and fuel: "The production of ethanol does not translate into less grain available for food, since farmers do not grow more or less corn based on ethanol production."[53] This is a terribly misleading statement. Land producing corn for ethanol is producing no food grain, and far less feed for livestock or poultry. And if the ethanol distilleries offer high prices for corn, the farmers will grow more of it.

NCGA has produced a paper, *How Much Ethanol Can Come from Corn?*, that is also misleading. Its most egregious errors include:

- **Corn yields will rise rapidly.** Corn yields may rise, but the recent trend line would take nearly 35 years to raise U.S. corn yields by 50 percent! Even that assumes unknown strategies from biotechnology can maintain the recent upward trend despite rising costs for irrigation, fertilizer, and pesticides.
- **More acres will be shifted to corn.** More acres will be shifted to corn under the mandates of the U.S. Energy Act of 2005. However, NCGA does not point out that any additional corn land must come from other crops, or be taken from forestland.
- **The demand for corn is flat except for ethanol.** The demand for feedstuffs is not flat. World corn use rose from 511 million tons in 1992 to 623 million tons in 2002. Most of the increase went for livestock and poultry feed to meet rapidly rising overseas demand for more meat and milk, and the World's Bank's high projections of unprecedented economic growth indicate an even stronger growth in

demand over the coming decades. Farm trade barriers have limited U.S. corn exports to many land-short countries, including China and India. The Doha Trade Round has attempted to liberalize farm trade. In opposition, NCGA, emboldened by ethanol subsidies, has lent its political support to keeping U.S. corn and sugar subsidies instead of supporting farm trade reform.

•**The livestock will eat more ethanol by-products.** Distilled dried grains (DDGS) from ethanol plants will indeed supply an increasing portion of the feed market, but DDGS has only one-third the feed value of corn.

Cargill, one of the world's largest ethanol processors, says biofuels conflict with feeding people. Archer Daniels Midland, an even bigger ethanol processor, says they do not.[54]

America wasted tens of billions of dollars and years of frustration trying to create "synfuels" and a shale oil industry through federal mandates. The result was a set of expensive and useless facilities and a series of half-built towns near the oil shale deposits of the Rocky Mountains.

Markets vs. Mandates

Remember that the United States has been down the federal energy mandate road before, and the experience was neither successful nor pleasant.

In the early 1970s, the U.S. had oil import quotas, which were designed to maintain a vigorous domestic oil industry. Critics charged that the oil import limits amounted to a "burn our own oil first" policy. As oil and gas became more difficult to find in the lower 48 states, the pressure for more imports mounted, and the quotas were lifted. By the late 1970s, the OPEC oil-exporters' cartel was formed. Over the next decade, the cartel and Middle East conflicts had raised oil prices from $6 to more than $70 a barrel—a price far higher in real terms than the 2006 oil price surge has reached.

America responded with price controls on "old oil"—that is, oil found before 1974—that were designed to encourage more domestic oil exploration. Instead, the controls fostered the withdrawal of "old oil" from the market, a price spike in "new oil"—and gasoline rationing. Americans sat in long lines at gas stations while artificially restricted supplies led to shortages.

America also wasted tens of billions of dollars and years of frustration trying to create "synfuels" and a shale oil industry through federal mandates. The result was a set of expensive and useless facilities and a series of half-built towns near the oil shale deposits of the Rocky Mountains.

Some critics say that the U.S. nuclear power industry expanded too rapidly during this period, based on power plant designs that were essentially designed for nuclear submarines rather than land-based safety. They suggest that nuclear power got a black eye as a result, and point to the standardized nuclear power plants that have been quietly supplying about 75 percent of France's electricity for decades.[55]

Nor is there any likelihood of the federal government providing a silver bullet that can quickly and cheaply provide low-cost energy security. Energy systems are now so big and so capital-intensive that they cannot shift very rapidly.

Protecting the Future for U.S. Farmers

American corn farmers' recent profits are documented by their rising farmland values. Corn Belt cropland rose by a robust 7.8 percent annually between 2001 and 2005, with only modest demand from ethanol plants.[56]

However, U.S. farmers have been demanding for decades the opportunity to export their food and feed to meet the rapidly-growing demand for grain and livestock products in densely populated Asian countries. Asian cities' populations are expanding; the demand for meat, milk and other high-quality foods is soaring; and most Asian countries lack the land and water to cost-effectively produce their own dietary upgrades. A doubling of U.S. farm exports from their recent level of about $60 billion per year seems possible.

Yet American farm exports have been blocked by the farm subsidies of the European Union (EU)—and to a lesser extent by the farm subsidies of the U.S. itself. Rich-country farm subsidies foster resentment and import tariffs in potential overseas markets. The EU has permitted virtually no competitive farm imports, and has depressed world prices by dumping huge quantities of subsidized farm surpluses. America's big direct payments to its farmers have insulated them from the impacts of overproduction and low export prices, especially in such commodities as cotton.

With the "renewable fuels initiative," American farmers will simply not have enough land to supply much of the growing Asian demand for meat and feed.

Globally, the average tariff on nonfarm products has dropped from about 40 percent to 4 percent since 1948, under the World Trade Organization (WTO) and its predecessor General Agreement on Tariffs and Trade. However, the U.S. Trade Representative's office still estimates the average tariff on farm products at 65 percent. Moreover, huge chunks of farm market demand are simply barred to imports in such countries as China and India.

With the "renewable fuels initiative," American farmers will simply not have enough land to supply much of the growing Asian demand for meat and feed. Thus, U.S. corn farmers will be supplying the less valuable part of the corn market, the ethanol distilleries. Farmers will become even more dependent on the federal treasury—which will lead them to lobby for increased federal payments in future years.

Congress is ill-equipped to resist any new farm subsidies that the urban public will accept. At least half of the Senate is elected in Midwest states where the tiny "farm vote" is a swing factor. Neither party is willing to risk losing either chamber of Congress or the White House to a few unhappy farmers who can be bought off with a few more billions of somebody else's tax dollars.

Now U.S. sugar producers are jumping onto the ethanol bandwagon with the corn farmers. The prospect is for large and permanently escalating U.S. ethanol subsidies that will contribute very little to U.S. energy independence.

American farmers have not only the world's largest tracts of good cropland, but also the world's best network of farm-to-market roads, rail connections, and processing facilities, along with an unmatchable set of rivers linking its farms and overseas markets.

Brazil today has the land and labor to export more food and feed, but it lacks the sophisticated roads, rails, and processing facilities to cost-effectively get its crops to markets. Brazilian farmers in the Cerrados are trying to compete by hauling truckloads of soybeans 400 miles more through clouds of dust and seas of hub-deep mud.

As American agriculture shifts toward subsidized ethanol, however, the profitable expansion of corn and soybean exports to Asia will be supplied by Brazilian farmers. America's ethanol subsidies will underwrite Brazilian farmers' road improvements and hand them the export markets of the farming future.

America's ethanol mandates will leave U.S. corn growers with only the subsidized market for corn ethanol. When, and if, cellulosic ethanol succeeds, it will destroy the corn farmers' investments in ethanol. Corn-producing regions, such as Illinois, would lose out to switchgrass from Kansas or wood chips from Mississippi and Idaho. Switchgrass is too bulky to be hauled from the Great Plains to Corn Belt ethanol plants. Wood chips are too bulky to be cost-effectively hauled from the fast-growing pine forests of Mississippi to Illinois.

American farmers have become enthralled with federal subsidies—again. They have lost all eagerness for the farm trade liberalization that would offer them the strongest income gains over the next 50 years, as food and feed demand expand along with overseas population and income growth.

The stage is set for a classic boom-bust cycle in Corn Belt ethanol. Some 40 percent of the current ethanol capacity may be farmer-owned, and current high oil prices may well stimulate rapid further farmer investments in ethanol processing expansion. A farmer-owned corn ethanol plant producing a modest-but-efficient 40 million gallons per year might well cost $60 million to build.[57]

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Encouraged by the prospect of ethanol subsidies, the powerful American Farm Bureau Federation has even prepared to block any Doha Round farm trade liberalization in the U.S. Senate. That would prevent its own members' profitable export expansion for the long-term future in order to protect cotton, rice, and sugar subsidies today.

The Doha Round may yet be revived, but the prospects of farm trade liberalization—once the fondest dream of American agriculture and the U.S. trade balance—are poor.

The Welfare of the American Public

The American people need a way out of their energy dilemma. Unfortunately, corn-based ethanol is not a viable way out. Meeting even 10 percent of our auto fuel needs with ethanol would require at least half of our current average annual corn crop. In the Corn Belt's inevitable drought years, the ethanol plants would either have to shut down or threaten American food security. The ethanol mandate for 2012 of 7.5 billion gallons would have required 75 percent of the drought-reduced

corn crop in 1995, when the crop only yielded 7.4 billion bushels.[58]

The real cost of U.S. ethanol must include the government subsidies to corn farmers, which USDA has recently estimated at more than $5 billion per year for about 12 billion bushels of corn annually.[59] That is more than 40 cents per bushel, paid not just by consumers of corn but by *all* American taxpayers. In addition, refiners enjoy a federal excise tax forgiveness of 51 cents per gallon. Finally, the U.S. offers ethanol tariff protection from low-cost (Brazilian) imports of 2.5 percent—plus 54 cents per gallon. The refiner subsidy alone is equal to oil at $32 a barrel. Clearly, Congress was not trying to protect the public from high ethanol prices.

Other Fuel Sources

Making ethanol has always been more expensive than producing its equivalent transport energy in the form of gasoline. This is true even in Brazil, where ethanol is lower in cost than in any other country.

Nothing in either the fossil fuel markets or agriculture indicates that the underlying comparative advantage of fossil fuels has evaporated. Deep-ocean drilling and the Canadian tar sands have both just received massive new investment flows because of the $70 dollar spike in oil prices.

Alberta's tar sands have oil reserves estimated at 280 to 300 billion barrels, recoverable with current technology. This is more than the estimated Saudi Arabian reserves of 240 billion barrels. The total reserves for Alberta, including oil not recoverable using current technology, are estimated at 1,700 to 2,500 billion barrels. These reserves lie just north of Montana, in friendly, stable Canada. The first new steam injection unit is being installed, which is projected to produce oil at $10 to $13 a barrel, and steam injection units will be massively arrayed throughout Alberta if oil prices stay high.

For those concerned about greenhouse emissions, the French have long been getting most of their electricity from safe, standardized nuclear plants with no safety problems. The world's reserves of uranium are limited, but fuel reprocessing would extend them for a very long time—while radically reducing the need for spent-fuel storage. Beyond uranium, the much more abundant element thorium can also be used for nuclear fuel, at moderately higher costs. It's no wonder, then, that there is a perceptible worldwide shift in public opinion in favor of nuclear power.

- **France** has built 59 standardized nuclear plants which have a low risk of safety problems.

- **Finland** is building Europe's first new nuclear plant in many years.

- **China and India** are building and planning dozens of nuclear plants.

- **Sweden's Liberal Party** is demanding a re-vote on phasing out its nuclear plants, saying that today's alternatives are not wind and solar but coal and natural gas.

The environmental movement has unintentionally done its best to push the world into a policy corner where nuclear power remains the safest way to power our modern civilization.

It is neither moral nor constructive to shift major amounts of the world's food supply to fuel production when significant elements of the world's people remain ill-fed.

Conclusions

It is neither moral nor constructive to shift major amounts of the world's food supply to fuel production when significant elements of the world's people remain ill-fed. It is neither moral nor constructive to needlessly destroy broad tracts of wildlands for fuel crops when alternative energy sources, such as nuclear power, are not being used. And it is a dreadful breach of human ethics to adopt a policy that creates both of these harms at the same time.

Corn ethanol will cost the nation billions of dollars without replacing much imported gasoline. Due to corn ethanol's low yield per acre, its low net gain in energy per gallon, and its 35 percent energy discount compared with gasoline, the U.S. would have to produce more than 5 gallons of corn ethanol to displace one gallon of imported gasoline. If oil prices moderate as they have in the past to the cost of the marginal barrel—presumably somewhere below $30 per barrel—the U.S. might end up paying close to $100 for each displaced gallon of imported gasoline. To that must be added the higher prices American consumers will pay for steaks, milk, cheese, and pet food.

The land cost of corn ethanol is enormous. Even without ethanol, the world is facing a clash between food and forests. Food and feed demands on the farmlands will more than double by 2050.

Global food prices will rise as the U.S. shifts its grain from food and feed to fuel, hurting the world's poor. This will be especially painful in bad-weather years. In years of Corn Belt drought, the U.S. might have to shut down ethanol plants to prevent unreasonable increases in U.S. food costs, especially for meat and milk.

The U.S. might need to clear an additional 50 million acres of forest, or more, to produce economically-significant amounts of liquid transport biofuels. Despite the legend of past U.S farm surpluses, the only large reservoir of underused cropland in America is about 30 million acres of land—too dry for corn—enrolled in the Conservation Reserve. Ethanol mandates may force the local loss of many wildlife species, and perhaps trigger some species extinctions. Soil erosion will increase radically as large quantities of low-quality land are put into fuel crops on steep slopes and in drought-prone regions.

The forests lost to corn ethanol could be in America. More likely, massive amounts of U.S. grain will be diverted from food exports to ethanol. The forests will then be cleared in such exotic, species-rich places as Indonesia and southern India, where farm imports will be barred, heavily tariffed, or rendered costly due to the limited supply from the U.S. and other developed countries. Losses in forestland, wherever they occur, will reduce the amount of CO_2 exchanged into oxygen by trees.

The dream of ethanol supporters is to produce auto fuel from wastes.

However, we cannot yet turn wood chips, cornstalks, or switchgrass into ethanol. Nor do the higher-yielding energy crops envisioned by President Bush yet exist. In the meantime, our corn ethanol will be worth only 45 gallons of displaced gasoline imports per acre.

Neither the President nor the Congress know when breakthroughs in cellulosic ethanol might be achieved, or whether federal subsidies will hasten them. Recent oil prices above $70 per barrel have already created massive incentives for the private sector to pursue cellulosic ethanol, with better prospects for success than companies would have with federal subsidies.

The only source of large and cost-effective ethanol supplies in the world is Brazil, which has a unique combination of tropical climate and hundreds of millions of acres of underused farmland. Brazil could supply large quantities of sugar cane-based ethanol at far lower economic and ecological costs than American farmers. Its net energy gain from ethanol is more than 3.6 energy units gained for each unit of energy invested; the net energy gain of U.S. corn ethanol is no more than 1.25. Brazilian ethanol is being kept out of the U.S., however, by a tariff of 2.5 percent plus 54 cents per gallon.

Ironically, the U.S. ethanol program has made farm trade liberalization less likely, at the same time that the European Union is shifting away from its historic policy of farm protectionism, thanks in part to its 15 new member countries. The ethanol subsidies have rekindled U.S. farmers' hopes of having their profits guaranteed by the government rather than by expanded food and feed exports.

Due primarily to high tariffs and other subsidies, U.S. sugar producers have already priced themselves out of the ethanol market. U.S. sugar is three times as costly an ethanol feedstock as Brazilian sugar, and twice as costly as U.S corn. It would be a miscarriage of environmental and economic justice for American sugar producers to share in ethanol subsidies, but they're likely to try—witness their relentless defense of the economically absurd and environmentally destructive U.S. sugar program.

The market is already responding to the high price of oil, as investors flock to alternative fuels, including investments in cellulosic ethanol research and development. Those developments are healthy, if markets are allowed to discover the winners and losers in future alternative energy sources, without government intervention through subsidies and fuel mandates.

In the meantime, only tropical sugar cane producers should strive to produce ethanol for transport fuel. Oil-importing countries can best encourage transport ethanol production by reducing or eliminating their ethanol tariffs and trade barriers. This will allow markets to stimulate production of the maximum amount of cost-effective ethanol, strongly encourage ethanol research and development worldwide, and help promote a secure future in both food and energy for the world.

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