United States
Department of
Agriculture

Economic
Research
Service

Agricultural
Economic
Report
Number 667

May 1993

Ethanol and Agriculture

Effect of Increased Production on Crop and Livestock Sectors

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Expanded ethanol production could increase U.S. farm income by as much as $1 billion (1.4 percent) by 2000. Because corn is the primary feedstock for ethanol, growers in the Corn Belt would benefit most from improved ethanol technology and heightened demand. Coproducts from the conversion process (corn gluten meal, corn gluten feed, and others) compete with soybean meal, so soybean growers in the South may see revenues decline. The U.S. balance of trade would improve with increased ethanol production as oil import needs decline.

Ethanol production is expected to rise to 1.2 billion gallons per year by 1995 and remain at that level. Ethanol's environmental benefits could lead to increased demand. This analysis looks at consequences for agriculture of two possible demand alternatives: producing 2 billion gallons of ethanol per year by 1995 (a 0.8-billion gallon increase over expected production) and 5 billion gallons by 2000 (a 3.8-billion gallon increase).

Ethanol is an attractive supplement to gasoline for many reasons. Increased ethanol use reduces levels of carbon monoxide and carbon dioxide emissions, and improves energy security by reducing reliance on oil imports, thereby improving the U.S. balance-of-payments account. Increased ethanol production also benefits agriculture. Wider use of ethanol would provide new uses for domestic farm resources, increase grain production, support grain prices, reduce deficiency payments, and increase total farm income. Boosting ethanol production to 5 billion gallons per year would lead to significant increases in farm income, particularly for grain farmers.

Corn. Most ethanol is processed from corn, but research aims at economical production of ethanol from biomass crops (energy crops such as energy sorghum and switchgrass). In the near term, major increases in ethanol output would likely come from expanded corn production. Increased ethanol production will increase corn demand, leading to more production of and income from corn and other feedgrains. Increased competition for cropland will boost corn and other feedgrain prices if ethanol production is more than doubled. Feedgrain prices will change little if corn production expands on cropland not currently in production. Land idled in 1992 feedgrain acreage reduction programs, for example, could be employed to roughly double ethanol production without significant effects on feedgrain prices.

Soybeans. Increasing ethanol production increases the supply of ethanol coproducts--corn gluten feed, corn gluten meal, distillers' dried grains, and corn oil--which compete with soybeans in animal feed and vegetable oil markets. The increased competition exerts downward pressure on soybean meal and oil prices. At the same time, corn competes with other feedgrains and soybeans for land. Expanding ethanol production could lead to reduced soybean production, which would offset some of the price-dampening effects of increased coproduct production.

Livestock. Farmers feeding livestock will incur higher feed costs due to higher grain prices if ethanol production more than doubles. Increased supplies of coproduct feeds would offset some feedgrain use. Total feed costs would depend on how much prices of grain and coproducts change. A smaller increase (less than double) in ethanol production could mean lower feed costs, if feedgrain prices were unchanged and protein feed (such as soybean meal and ethanol coproducts) prices fell. Feedgrain costs account for about one-quarter of livestock production costs, so changes in feed markets can lead to changes in income from livestock production.

Regional Effects. Farmers' individual income prospects depend on their mix of crop and livestock enterprises. In the Corn Belt, Lake States, and Northern Plains, farmers often combine soybean or livestock production with the production of corn or some other grain. Farmers would probably experience a net gain from increased crop production, and farm income is likely to increase. In the South, farmers seldom combine soybeans with corn or other grains, and possess few alternatives as profitable as soybeans. If soybean demand fell, soybean farmers there would probably see a decline in crop revenues.

Energy Crops. Farmers may shift to energy crops if technological advances make conversion to ethanol from energy crops more economical than from corn. Energy crops have shown most promise when produced on prime farmland. Increased ethanol production from energy crops grown on such land would compete with conventional crops. Energy crops may be produced on marginal lands with fewer productive alternatives, which could benefit producers in Southern States whose land is less able to compete with grains produced in the Corn Belt and Lake States.

Increased Ethanol Production and Agriculture

This analysis examines effects of increased ethanol production on key indicators of the farm sector, such as acreage planted, commodity prices, crop, livestock, and processed commodity supply-use, farm income, and government program costs. It assesses the implications of ethanol production targets of 2 billion gallons by 1995 and 5 billion gallons by the year 2000. A mathematical programming model of the U.S. agricultural sector (USMP) is used to carry out the scenario analysis (see box, "About USMP"). Ethanol production is currently about 0.9 billion gallons per year (based on 1991 market conditions). As a result of the Clean Air Act of 1990, it is expected to rise to 1.2 billion gallons per year by 1995 and remain at that level through the year 2000.

To provide a benchmark from which to measure potential impacts of alternative conditions, USMP is first calibrated to agricultural conditions (USDA projections of supply, use, prices, acreage, livestock product demand, and other indicators) for the 1995 and 2000 base years. Alternative scenarios are analyzed for each year. The first scenario assumes that U.S. ethanol production in 1995 is 2 billion gallons. The corn acreage reduction program (ARP) rate is assumed to be reduced to free up enough land to produce the additional corn used for ethanol production. Wet-milling is assumed to account for 60-70 percent of ethanol production and dry-milling the remaining 30-40 percent (see box, "Wet- and Dry-Milling").

The second scenario assumes that ethanol production in the year 2000 is 5 billion gallons instead of the expected 1.2 billion gallons. Corn, sorghum, barley, and wheat ARP rates are assumed to be reduced to zero. Cellulosic conversion technology is assumed to be fully adopted by the industry and wet-milling is assumed to increase its share of ethanol production to 90 percent.

Crop Effects

Increasing ethanol production to projected levels leads to both increased production of corn and diversion of corn from other uses. The diversion of corn from other uses is buffered by the increase in supply of ethanol coproducts, which can substitute for corn in many instances. The increase in demand for corn stimulates demand for other feedgrains, while the increase in supply of ethanol coproducts depresses the demand for soybeans.

Scenario 1: Ethanol Production of 2 Billion Gallons in 1995

Increasing ethanol production from the expected 1.2 billion gallons to 2 billion gallons in 1995 requires an additional 0.3 billion bushels of corn, 3.5 percent of projected corn production. Of this amount, 95 percent comes from increased corn production; the remainder comes from reduced domestic feed and export use. Corn production rises 3.4 percent, but the corn price rises only 0.5 percent (table 1). Effects on corn prices and other crops are modest due to the extra 2.4 million acres made available by relaxing the corn ARP.

Other feedgrains (sorghum, barley, and oats), wheat, and soybeans all face increased competition from ethanol coproducts (corn gluten meal, corn gluten feed, and distillers' dried grains) in livestock feed markets. Increased corn planting slightly intensifies competition for acreage among these crops. The combined input and output market effects reduce other feedgrain production by 0.2 percent. Other feedgrain prices rise 0.3 percent, on average. Wheat production falls 0.6 percent and prices gain 0.3 percent, as feed use of wheat falls slightly. Soybeans are affected more, due to the comparable protein content of ethanol coproducts and soybean meal and to more direct competition for land between soybeans and corn. Soybean output and price fall 0.9 and 1.1 percent. A lower soybean price leads to slightly higher exports.

Acreage planted to the eight major field crops (corn, sorghum, barley, oats, wheat, cotton, rice, and soybeans) increases 1.5 million acres (table 2). Increased corn acreage offsets soybean acreage declines in regions where corn is an economic alternative. Southeastern regions, which are less competitive in corn, move some acreage into cotton, which sees production gain 0.5 percent (50,000 acres) and price fall 2.8 percent (table 1).

Corn acreage rises 2.6 million acres nationwide, while soybean acreage falls 0.5 million acres. Most of the adjustment occurs in the Corn Belt, where corn acreage gains 1.3 million acres and soybean acreage declines 0.3 million acres. The Lake States and Northern Plains gain 0.4 and 0.5 million acres of corn (table 2).

Scenario 2: Ethanol Production of 5 Billion Gallons in 2000

Increasing ethanol production from 1.2 to 5 billion gallons in 2000 amplifies the crop sector effects shown in the 1995 scenario. This scenario assumes

About USMP

The USMP regional model is a comparative static, market equilibrium model that represents U.S. crop and livestock production for the 10 farm production regions. USMP specifies production of 10 crops: corn, sorghum, oats, barley, wheat, rice, cotton, soybeans, hay, and silage. Some 16 primary livestock production activities are included, the principal being dairy, swine, and beef cattle. Several dozen processed and retail products are included in the model structure, the principal being dairy products, pork, fed and nonfed beef, soy meal and oil, livestock feeds, and corn milling products. In addition, the model incorporates domestic use, imports, exports, and inventory/stock product markets. USMP also includes government commodity acreage reduction, price, and income support programs. Production, consumption (demand), trade, and price levels for crop and livestock commodities and most processed or retail products are endogenously determined within the model structure.

Wet- and Dry-Milling

Ethanol affects agriculture not only by boosting corn demand, but also by yielding coproducts that can be used as livestock feed. Processors use one of two processes to turn corn into ethanol: wet-milling or dry-milling. The wet-milling process is similar to the process used to make high-fructose corn syrup. Corn is ground up, turned into starch, and then fermented, producing ethanol and several important coproducts: corn gluten meal, corn gluten feed, and corn oil. The dry-milling process is similar to the process used to make beverage alcohol. Corn is ground and fermented, producing ethanol and a single coproduct, distillers' dried grains. Corn gluten meal, corn gluten feed, and distillers' dried grains are used as livestock feeds. Dry-milling is the simpler process of the two, but wet-milling produces higher valued coproducts, giving it a cost advantage.

Technological advances may alter the economic relationships between ethanol and agriculture (Hohmann and Rendleman, 1993). Cellulosic conversion of corn hulls can improve ethanol yields by 15 percent (fig. 1), reducing corn requirements by the same amount. Adoption of cellulosic conversion would also reduce yields of corn gluten feed and distillers' dried grains by 47 percent (fig. 1), while increasing their protein content 60 percent (fig. 2). The increase in protein content allows corn gluten feed and distillers' dried grains to compete with soybean meal on a protein basis.

Figure 1

Quantity of ethanol and selected coproducts produced per bushel of corn, under current technology and with cellulosic conversion technology

Ethanol yields increase, but ethanol coproduct yields decrease.

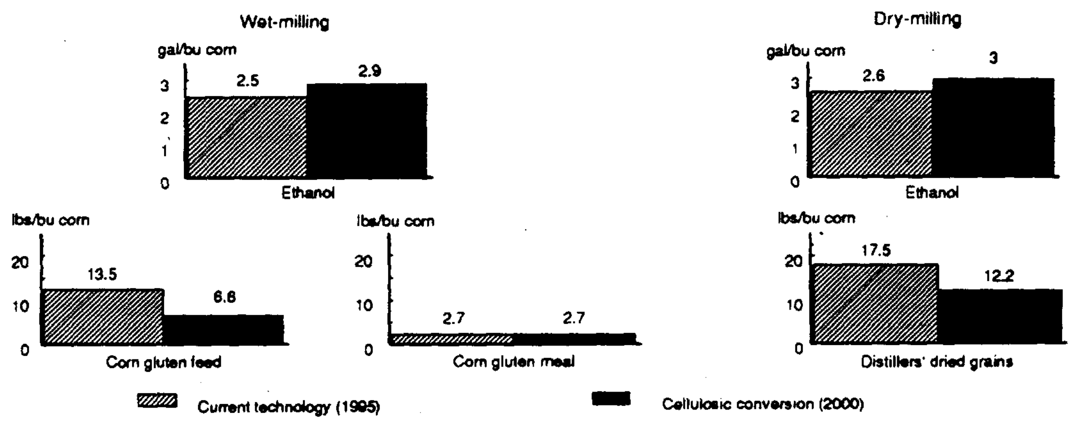

Figure 2

Protein content of ethanol coproducts (with current and cellulosic conversion technology), in comparison with corn and soybean meal

Cellulosic technology will increase corn gluten feed and distillers' dried grains protein content to nearly that of soybean meal.

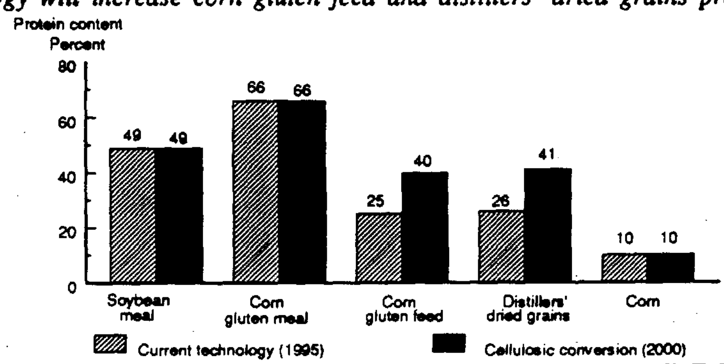

Table 1--Change in price, production, domestic use, and exports of crops due to increased ethanol production in 1995 and 2000

Corn production and corn price rise and other crops adjust to increased milling of corn into ethanol.

Crop	Price	Production	Total domestic use[1]	Exports
		Percent change		
1995 (Base: 1.2 billion gallons; Scenario: 2 billion gallons)				
Corn	0.5	3.4	4.4	-0.2
Other feedgrains[2]	0.3	-0.2	-0.1	-0.6
Wheat	0.3	-0.6	-1.3	-0.2
Rice	-	-	-	-
Soybeans	-1.1	-0.9	-1.4	0.3
Cotton	-2.8	0.5	0.4	0.7
2000 (Base: 1.2 billion gallons; Scenario: 5 billion gallons)				
Corn	7.6	11.8	16.7	-3.1
Other feedgrains[2]	5.5	6.0	9.5	-3.7
Wheat[3]	-2.0	0.8	0.2	1.3
Rice	0.1	-	-	-
Soybeans	-4.8	-5.5	-8.7	1.2
Cotton	-0.2	-	-	0.1

Note: - indicates a change of less than 0.05 percent.
[1] Includes food, seed, livestock feed, and industrial uses.
[2] Sorghum, barley, and oats.
[3] Wheat effects in this scenario result from eliminating its ARP rate, not from expanded ethanol production.

Table 2--Changes in area planted to crops due to increased ethanol production, by region, 1995 and 2000

Acreage planted increases and impacts are concentrated in the Corn Belt, Lake States, and Northern Plains.

Crop	Northeast	Lake States	Corn Belt	Northern Plains	Appalachia	Southeast	Delta States	Southern Plains	Mountain	Pacific	U.S. total
						Change, million acres					
1995 (Base: 1.2 billion gallons; Scenario: 2 billion gallons)											
Corn	0.1	0.4	1.3	0.5	0.1	0.1	-	-	-	-	2.6
Other feedgrains[1]	-	-	-	-	-	-	-	-	-	-	-0.1
Wheat	-	-	-	-0.2	-	-	-	-0.2	-0.1	-	-0.5
Rice	-	-	-	-	-	-	-	-	-	-	-
Soybeans	-	-	-0.3	-	-	-	-0.1	-	-	-	-0.5
Cotton	-	-	-	-	-	-	-	-	-	-	-
Total	0.1	0.4	1.0	0.2	0.1	-	-	-0.2	-0.1	-	1.5
2000 (Base: 1.2 billion gallons; Scenario: 5 billion gallons)											
Corn	0.3	1.5	4.6	1.7	0.6	0.2	0.1	0.1	0.1	0.1	9.3
Other feedgrains[1]	-	0.1	-0.1	0.7	-	-	0.1	0.6	0.3	0.1	1.9
Wheat	-	-	-	0.3	-	-	-	-	0.2	-	0.6
Rice	-	-	-	-	-	-	-	-	-	-	-
Soybeans	-0.1	-0.3	-1.8	-0.3	-0.2	-0.1	-0.3	-	-	-	-3.2
Cotton	-	-	0.1	-	-	-	-	-0.1	-	-	-
Total	0.3	1.3	2.7	2.4	0.4	0.2	-0.1	0.7	0.6	0.2	8.6

Note: Region values may not sum to totals due to rounding. - indicates a crop not present in a region or a change of less than 0.05 million acres.
[1] Sorghum, barley, and oats.

enhanced ethanol production technology, but still requires 1.3 billion additional bushels of corn for ethanol production, 1 billion bushels more than scenario 1. About 86 percent of the added corn comes from increased production and the remainder comes from reduced domestic feed and export use. Corn output rises 11.8 percent, and the corn price increases 7.6 percent (table 1).

Extra land is made available by eliminating the corn, sorghum, barley, and wheat ARP requirements, which are otherwise projected to exist in 2000. This relaxation frees up 6.2 million acres, moderating price increases for corn and other feedgrains to about half of what they would otherwise be. Feedgrain prices are projected to remain under target price levels.

Increased corn prices prompt increased demand for alternate livestock feeds, boosting production of other feedgrains (sorghum, barley, and oats) 6.0 percent and raising their prices an average 5.5 percent. Wheat production rises 0.8 percent, and the wheat price falls 2.0 percent, mainly from elimination of the wheat ARP in this scenario. Feed use of wheat is constrained by the relatively low price of other feedgrains.

More ethanol coproducts are produced in 2000 than in the 1995 scenario, exerting downward pressure on soybeans' price (down 4.8 percent) and production (down 5.5 percent). The assumed change in milling technology makes ethanol coproducts higher in protein and more competitive with soybean meal.

Acreage planted for the eight major field crops increases 8.6 million acres (table 2). Increases in corn acreage (9.3 million acres) more than offset soybean acreage declines (3.2 million acres). Again, most of the adjustment occurs in the Corn Belt. Acreage planted increases in all regions except the Delta. The Delta States' 0.3-million-acre decline in soybeans is offset by 0.2 million additional acres of corn and other feedgrains and an additional 0.1 million acres of hay production (not reported in table 2).

Changes in Ethanol Coproduct Uses

Revenue from sales of ethanol coproducts is important to the economics of ethanol production and to U.S. agriculture. The most plentiful ethanol coproduct is corn gluten feed. About 95 percent of the corn gluten feed produced in the United States is exported (see box, "European Community"), and the rest is fed to domestic livestock. Increased ethanol production yields a greater supply of corn gluten feed, and the responsiveness of the corn gluten feed export market largely determines the corn gluten feed price. This analysis assumes exports of corn gluten feed will rise 3.5 percent for each 1-percent decline in its price (Peeters, 1990).

The share of ethanol coproducts fed to domestic livestock should increase as their prices fall relative to other livestock feeds. It is not known, however, what coproduct-to-feedgrain price ratios would cause U.S. livestock producers to favor corn gluten feed. Economic models of livestock feed formulation indicate that at current prices, corn gluten feed use by domestic livestock producers should be much greater than current use. The only time domestic livestock producers used a significant portion of corn gluten feed was when its price was about 30 percent less than its current level. This analysis assumes the price of corn gluten feed would have to fall 30 percent for its use in the U.S. livestock industry to rise significantly.

Scenario 1: Ethanol Production of 2 Billion Gallons in 1995

Additional coproduct supply due to ethanol expansion (to 2 billion gallons) causes the price of corn gluten meal to fall 6.7 percent, and the price of corn gluten feed to fall 5.3 percent. The price of distillers' dried grains, down 0.3 percent, is virtually unchanged (table 3).

The reduced prices of corn gluten meal and distillers' dried grains (relative to other livestock feeds) cause a slight increase in their use by domestic livestock producers and a slight reduction in the amount of corn, other grains, and soybean meal fed to domestic livestock. Reduced soybean meal demand causes its price to fall. Export markets absorb the entire increased supply of corn gluten feed because its price, though reduced, does not decline the 30 percent assumed necessary to stimulate its use by U.S. livestock producers.

Scenario 2: Ethanol Production of 5 Billion Gallons in 2000

Producing 5 billion gallons of ethanol in the year 2000 yields an even greater supply of corn coproducts than under scenario 1. Again, coproduct prices decline: corn gluten meal 7 percent, corn gluten feed 12.3 percent, and distillers' dried grains 4 percent (table 3).

The decline in coproduct prices relative to other livestock feed prices favors the domestic use of corn gluten meal (up 81 percent) and distillers' dried grains (up 1.8 million tons from a very small initial level) over corn (down 1.5 percent) and soybean meal (down 11.6 percent). Again, the additional corn gluten feed is absorbed entirely in the export market. Corn gluten feed's price, while declining, does not decline the 30 percent needed for it to be fed in the domestic market.

Cellulosic conversion technology (in the 2000 scenario) doubles the protein content of corn gluten feed and distillers' dried grains, increasing their value as livestock feeds. As a result, corn gluten feed and distillers' dried grain prices remain higher than the 1995 base levels (table 4).

European Community

The European Community (EC) is the major market for corn gluten feed. The United States exports to the EC about 95 percent of its corn gluten feed production. The size of the EC market is determined by its agricultural policy, which supports corn internally and restricts imports. Corn gluten feed in 1992 was priced competitively with corn and other grains in the EC. The Uruguay Round of the General Agreement on Tariffs and Trade (GATT) and proposed changes to the EC's Common Agricultural Policy could lead to changes in corn gluten feed exports to the EC.

The changes to the EC's Common Agricultural Policy, adopted in May 1992 to be phased in over 3 years, include: reductions in supported prices (35 percent for grains, 15 percent for beef, 5 percent for butter); set-asides for grains, oilseeds, and protein crops; and a deficiency payment scheme to compensate producers for price reductions and set-asides.

These EC changes, combined with the GATT trend toward reduced internal support, indicate that corn gluten feed and other nongrain feed alternatives may lose their comparative price advantage to grains. Lower grain prices in the EC will place downward pressure on corn gluten feed prices. If EC grain prices fall relative to corn gluten feed prices, then U.S. exports of corn gluten feed to the EC will decline.

The uncertain size of the EC market for corn gluten feed may cause U.S. producers to pursue domestic uses or other markets such as Eastern Europe and the former Soviet Union. If all corn gluten feed produced (7.6 billion pounds) in the 1995 scenario had to be marketed in the United States, then demand for corn, wheat, and other grains would fall, as would their prices. U.S. livestock producers would benefit from reduced feed costs, exports would increase, but grain producers' incomes would fall by more than the increase in livestock producers' incomes, causing net farm income to decline.

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The reduced prices of corn gluten meal and distillers' dried grains (relative to other livestock feeds) cause a slight increase in their use by domestic livestock producers and a slight reduction

Table 3--Change in price, domestic feed use, and exports of soybean meal, corn, other grains, and ethanol coproducts due to increased ethanol production in 1995 and 2000

Lower prices of ethanol coproducts increase their export and use as domestic livestock feeds.

Product	1995 Base: 1.2 billion gallons Scenario 1: 2 billion gallons			2000 Base: 1.2 billion gallons Scenario 2: 5 billion gallons		
	Price	Domestic feed use	Exports	Price	Domestic feed use	Exports
	Percent change					
Soybean meal	-1.0	-1.3	0.3	-4.4	-11.6	1.2
Corn gluten meal	-6.7	45.6	1.8	-7.0	80.8	3.1
Corn gluten feed	-5.3	0	18.4	-12.3	0	43.2
Distillers' dried grains	-0.3	94.1	0.1	-4.0	2,025.1[2]	1.3
Corn	0.5	-0.2	-0.2	7.6	-1.5	-3.1
Wheat	0.3	-17.2	-0.2	-2.0	0.9	1.3
Other feedgrains[1]	0.3	-0.2	-0.6	5.5	14.7	-3.7

[1] Sorghum, barley, and oats.
[2] Increase of 1.8 million tons from a small initial level.

Table 4--1995 base level and 2000-scenario level ethanol coproduct prices

Cellulosic conversion would boost the protein content of coproducts, increasing their value as livestock feeds.

Product	1995 Base: 1.2 billion gallons	2000 Scenario 2: 5 billion gallons
	Dollars per hundredweight	
Corn gluten meal	11.06	10.01
Corn gluten feed	5.65	9.21
Distillers' dried grains	5.01	7.77

Livestock and Dairy Effects

Scenario 1: Ethanol Production of 2 Billion Gallons in 1995

Livestock and milk prices and livestock production are virtually unaffected (table 5) when ethanol production is increased to 2 billion gallons in 1995. The decrease in feed costs causes the supply of feeder cattle to increase slightly, resulting in a small (0.1 percent) reduction in feeder cattle price.

Scenario 2: Ethanol Production of 5 Billion Gallons in 2000

Producing 5 billion gallons of ethanol in 2000 causes slightly more significant increases in livestock and milk prices and greater reductions in livestock and milk production than in scenario 1. Due to a 7.6-percent increase in corn price, milk prices rise 0.2 percent, hog slaughter prices rise 0.5 percent, and fed beef prices rise 0.3 percent (table 5). The increased demand for corn and associated increase in costs of feeding result in reduced demand for feeder cattle and a decline in feeder cattle prices.

Livestock supply and price responses may seem small given the 7.6-percent increase in corn price. The small supply and price changes appear reasonable, however, because total livestock production costs rise much less than grain prices. The most recent cost-of-production budgets released by the Economic Research Service show that feedgrains accounted for 15.8 percent and protein supplements for 3.9 percent of the variable cash costs of producing fed beef in 1990. The average feedlot experiences only a 1-percent increase in variable cash costs when feed prices increase by the magnitude in the 2000 scenario. Similar changes in variable cost can be cited for dairy and pork.

When costs of production increase faster than farmer revenues, the livestock industry restructures because higher cost producers are squeezed by shrinking margins. Regions with more efficient producers gain more of national production at the expense of less efficient regions. However, the small changes in cash expenses for livestock farmers brought about by the increased price of corn and other feedgrains in the ethanol scenarios do not suggest any restructuring of producers.

Table 5--Change in livestock prices and supply due to increased ethanol production in 1995 and 2000

The supply of livestock is virtually unaffected and livestock product prices increase slightly in response to higher feed costs.

	1995 Base: 1.2 billion gallons Scenario: 2 billion gallons		2000 Base: 1.2 billion gallons Scenario: 5 billion gallons	
Product	Price	Supply	Price	Supply
	Percent change			
Milk	-	-	0.2	-0.1
Hog slaughter	-	-	0.5	-0.2
Feeder cattle	-0.1	-	-0.2	-0.1
Cattle slaughter	-	-	0.3	-0.1

Note: - indicates a change of less than 0.05 percent.

Income and Expense Effects

Increased production of corn-derived ethanol is projected to raise crop producer incomes. Results for livestock producers depend on what happens to feedgrain prices. A moderate increase in ethanol production can reduce livestock production costs by increasing supplies of lower cost high-protein feed (the 1995 scenario). A further increase in ethanol output raises feedgrain prices sufficiently to reduce incomes for livestock producers (the 2000 scenario). Slack resources in the agricultural sector (such as land withheld from production by acreage reduction programs) determine the extent by which ethanol production can increase without substantial feed price increases.

The 1995 and 2000 scenarios result in changes that are small relative to cash receipts from field crop and livestock marketings, which totaled $170 billion in 1990. Farm income and expense are difficult to predict. Expense and receipt estimates that each vary by 1 percent can affect the agricultural sector's net cash income estimate by 6 percent, or $3 billion. A 10-cent increase in corn price translates to a billion-dollar change in crop revenue.

Scenario 1: Ethanol Production of 2 Billion Gallons in 1995

Net income (value of production plus deficiency and conservation reserve payments less variable costs) from production of 10 major crops (corn, sorghum, barley, oats, wheat, cotton, soybeans, rice, hay, and silage) rises $153 million (table 6). Revenue rises $407 million from increased feedgrain prices and output. A $7-million decline in deficiency payments and a $246-million rise in variable costs offset more than half of the gain in revenue.

Most of the increased value of production occurs in the Corn Belt ($301 million), Northern Plains ($111 million), and Lake States ($94 million), the regions growing the most corn. The declines in deficiency payments (due to the higher corn price) are also concentrated in these regions. Crop net income rises $102 million in the Corn Belt, $39 million in the Northern Plains, and $37 million in the Lake States after changes in costs of production are taken into account. Crop net income changes less than $15 million in each of the remaining regions.

Table 6--Changes in agricultural income from increased ethanol production
Increasing ethanol production boosts farm income; large increases favor crop producers.

Item	1995 Base: 1.2 billion gallons Scenario: 2 billion gallons	2000 Base: 1.2 billion gallons Scenario: 5 billion gallons
	Change, million dollars	
Major crops:		
Value of production	407	3,603
Deficiency payments	-7	-873
Variable costs	246	1,128
Net income[1]	153	1,602
Major livestock:		
Value of production	-22	85
Variable costs	-42	640
Net income	19	-555
Total livestock and crops:		
Revenue	377	2,815
Variable costs	205	1,768
Net income	172	1,048

Note: Item values may not sum to totals due to rounding.
[1] Differs from net farm income by vaule of inventory change, imputed rents, onfarm use, and other factors.

A $19-million (0.1 percent) gain in livestock net income occurs with this ethanol scenario. High-protein feed costs decline, leading to a $42-million decline in livestock variable production costs. Prices and output adjust to yield a $22-million decline in value of production. The small gain in livestock net income is spread evenly across production regions.

Overall, farm net income rises by $172 million (0.3 percent) if ethanol output is increased to 2 billion gallons. Regional changes are essentially those reported for crop net income.

Scenario 2: Ethanol Production of 5 Billion Gallons in 2000

Crop net income rises $1.6 billion in the 2000 scenario. Value of production gains $3.6 billion from output and price increases while deficiency payments decline $0.9 billion due to higher crop prices. The increase in corn production boosts variable production costs by $1.1 billion.

Crop net incomes rise noticeably more in 2000 than in the 1995 scenario, due to ethanol's increased demand for corn and the resulting 6- to 8-percent feedgrain price increase. Income gains are again greatest in regions growing the most corn: $531 million in the Corn Belt, $367 million in the Northern Plains, and $192 million in the Lake States.

The 2000 scenario leads to a $555-million (1.5 percent) decline in livestock net income. The grain price increases induce a $640-million rise in livestock variable costs. This expense is partially offset by price and production changes, which raise livestock production value $85 million. These changes are spread evenly across production regions.

Net income for the crop and livestock products examined rises $1.05 billion. The rise in feedgrain income exceeds declines in deficiency payments, declines in soybean revenues, and declines in livestock income by over a billion dollars.

Income effects of increased ethanol production depend both on the size of the increase and the conversion technology. With a modest increase in ethanol production--to 2 billion gallons, for example--current ethanol technology would be preferred by livestock producers while cellulosic conversion would be preferred by crop producers. Current ethanol technology produces more coproducts than would cellulosic conversion. These coproducts compete with protein feeds such as soybean meal in livestock feed markets, restraining prices. At some greater increase in ethanol production--less than 5 billion gallons--the effect of technology on livestock feed costs reverses. The increased use of corn for milling drives up the costs of energy feeds (like corn and sorghum) such that cellulosic conversion, which uses less corn, would lead to lower feed costs than with conventional milling technology.

U.S. Balance-of-Payments Effects

Scenario 1: Ethanol Production of 2 Billion Gallons in 1995

Increasing ethanol production to 2 billion gallons improves the U.S. balance-of-payments account by an estimated $1 billion (table 7). Reduced oil imports account for the bulk of the improvement (see box, "Petroleum Industry"). The additional 0.8 billion gallons of ethanol is assumed to replace about 41 million barrels (mmbbl) of imported oil (valued at $24/bbl, U.S. Dept. Energy, *Annual Energy Outlook*, January 1992), reducing the total cost of imported oil by nearly $1 billion.

Processing corn into ethanol increases domestic use of corn, raising its price. Relaxation of the acreage reduction program moderates the price effect somewhat, but exports decline in response to the higher corn price. The net effect on corn export earnings is positive: the 0.5-percent rise in corn price offsets the 0.2-percent decline in corn export volume, leaving a $13-million increase in the value of corn exports.

Secondary effects on other crops result in a $78-million deterioration in the trade account, primarily due to a 1.1-percent decline in soybean prices. The trade account worsens for processed agricultural products (soybean meal, retail cuts of meat, dairy products, and others) as higher ethanol production yields more coproduct feeds (corn gluten feed, corn gluten meal, and distillers' dried grains). The coproducts compete with soybean meal and depress its price and the value of exports by 1 percent. The value of coproduct exports rises by an estimated $100 million due to higher export volume.

Scenario 2: Ethanol Production of 5 Billion Gallons in 2000

Increasing ethanol production to 5 billion gallons in 2000 leads to a $7.6-billion improvement in the U.S. balance-of-payments account (table 7). The additional ethanol could replace 198 mmbbl of imported oil, valued at $7.3 billion (the U.S. Department of Energy projects the cost of oil at $37/bbl in 2000). Increased corn demand leads to higher corn prices, so the net value of corn exported increases $239 million (4.3 percent).

Table 7--Change in U.S. balance-of-payments account from increased ethanol productions by subsector

Additional ethanol production can substitute for imported oil and improve the balance of payments account.

Subsector	Net change from base[1] 1995	2000
	Million dollars	
Crude oil	993	7,309
Corn	13	239
Other crops	- 78	- 222
Livestock (live animals)	1	3
Processed agricultural products	- 9	- 48
Corn (ethanol) coproducts	100	364
Total	1,020	7,642

[1] A positive number indicates an improvement in U.S. balance-of-payments.

Petroleum Industry

Large increases in ethanol use could cause a decrease in the quantity of oil refined and thereby affect the supply and price of other products derived from oil. The U.S. Department of Energy, Energy Information Administration (EIA), reported that in 1990, 45.6 percent of crude oil was converted to finished motor gasoline, 20.9 percent to distillate fuel oil, 9.4 percent to kerosene-type jet fuel, 6.8 percent to residual fuel oil, and the remaining 17.3 percent to other petroleum products. The declines in production (under our ethanol scenarios) are less than 1 percent of projected 1995 consumption and 2-3 percent of projected 2000 consumption in the United States (EIA, 1992). Any petroleum product effects from these scenarios would likely be minor.

The net export value of other crops declines approximately 1.7 percent or $222 million. Net export earnings from processed agricultural commodities also decline. Increased production of coproduct feeds places downward pressure on livestock feed costs. Exports of soybean meal rise, but the 4.4-percent price decline more than offsets the modest 1.2-percent growth in export volume.

Producing Ethanol from Energy Crops and the Effect on Agriculture Beyond 2010

The Department of Energy has projected that energy crops (energy sorghum, switchgrass, and others) will become the main feedstock for ethanol after the year 2010 (see box, "Energy Crops"). For this to occur, energy crops must be produced cheaply enough to permit ethanol to compete with gasoline and they must generate returns great enough to outcompete other crops for land. These two requirements may conflict with one another: lower energy crop prices will lead to less expensive ethanol, but reduce returns to energy crops such that competition with other crops for land is compromised.

Higher Energy Crop Yields Are Needed

Current energy crop yields are too low for energy crop-derived ethanol to compete successfully in fuel markets. For example, given energy sorghum's current average yield of 5.6 dry tons per acre on prime farmland, its growers require a price of $52 per dry ton to profit. But, ethanol producers can afford to pay only $34 per dry ton for energy sorghum if they are to compete with gasoline. (Break-even prices are derived from ethanol and energy crop production costs provided by Bioenergy International and Turhollow--see References.)

Improved variety selection and plant breeding show promise in sharply raising yields and reducing the costs of producing energy crops. The Department of Energy projects that energy sorghum yields on prime farmland can be increased to 11.9 dry tons per acre by 2010. With this yield, growers need a price of only $31 per dry ton to profit, slightly below the $34 that ethanol producers can afford to pay (fig. 3).

The same amount of land is required, with current energy crop yields, to produce 1 gallon of ethanol from energy crops as from corn. (One acre of energy sorghum produces approximately 342 gallons of ethanol, while 1 acre of corn in the Corn Belt produces approximately 333 gallons of ethanol. We assume that 1 dry ton of energy sorghum converts to 61 gallons of ethanol.) If energy crop yields nearly double, as projected, then the land required to produce a gallon of ethanol from energy crops will be cut in half. (At a yield of 11.9 dry tons per acre, 1 acre of energy sorghum converts to approximately 725 gallons of ethanol.)

Energy Crop Competition with Other Crops

Current energy crop returns are too low for energy crops to compete successfully with corn and soybeans. At the *projected* future yield of 11.9 dry tons per acre and with ethanol producers paying $34 per dry ton, energy sorghum could successfully compete with corn priced at or below $2.60 per bushel, with program corn (receiving deficiency payments) at or below $1.20 per bushel, and with soybeans at or below $6.60 per bushel (fig. 4).

Energy Crops

Energy crops are those grown for producing alternative fuels such as ethanol. While almost any crop can be used as a feedstock for the production of ethanol, ethanol cellulosic conversion technology favors crops with high cellulose content such as trees and grasses.

The differences between grain sorghum and energy sorghum highlight the differences between energy crops and other crops. Typically used as a livestock feed in the United States, grain sorghum varieties are short-stemmed and have most of their energy concentrated in the seed stem. Energy sorghum varieties are long-stemmed and bushy, and have most of their energy concentrated in the leaves.

The Department of Energy (1992) has identified hybrid poplar, sycamore, black locust, and eucalyptus as the tree species, and reed canary grass, tropical grass (napier or energy cane), tall fescue, switchgrass, and energy sorghum as the crop species with the greatest potential for use as feedstock in the production of ethanol. Of the crop species, reed canary grass and tall fescue are well suited for the Northern Plains; tropical grass for the coastal areas of the Delta and the Southeast; switchgrass for the Pacific, Northern and Southern Plains, and the Southeast; and energy sorghum for the Northern and Southern Plains, Pacific, and the Corn Belt.

Energy sorghum is currently the most economical crop. Many experts favor switchgrass because it is high-yielding, resists drought, reduces soil erosion, grows throughout the United States, and uses the same harvesting equipment used to harvest hay.

This successful competition, though, presumes that corn and soybean prices are unaffected by energy crop production. Substantial energy sorghum production on prime farmland would displace crops currently grown on that land. Reduced corn or soybean acreage would reduce their supply, causing their price to increase. With a higher price, returns to corn and soybean production would rise, raising the return required to keep land in energy crops. Land competition would raise energy crop prices, and in turn, the cost of producing ethanol. This relationship between increased production of energy crops and the cost of producing ethanol may limit the potential of ethanol from energy crops.

Producing energy crops on land not currently in production would avoid the problem of competition with corn and other crops. Land not currently in production is marginal for the most part. Yields on marginal lands are substantially less and costs per unit of output are higher (the increased yield projections for energy sorghum assume use of prime farmland). No evidence suggests that production of energy crops on marginal land will be profitable.

Some land not currently in production is idled under the Conservation Reserve Program (CRP) and will become available for production as contracts expire over the 1995-2005 period. Some of this land has potential for biomass production, but CRP land is not likely to provide a major base for biomass. CRP acreage is dispersed across the Nation. A biomass-processing facility requires a nearby concentration of feedstock to minimize transportation costs. Some CRP land has been devoted to permanent cover and is not likely to return to production. Some CRP land is marginal and probably not economical for energy crop production. Some CRP land is prime farmland, but may be highly erodible, inviting such energy crops as hybrid poplar or switchgrass, which may provide better protection from soil erosion than traditional crops. Energy sorghum, the crop with the greatest biomass potential, likely provides erosion protection similar to traditional crops.

Effects of Energy Crop-Based Ethanol Production on Agriculture

Shifting from corn to energy crops does not negate issues associated with an increase in corn-based ethanol production, such as volatile feedstock prices and higher feedstock costs. If energy crops must compete with other major crops for land, as seems likely, then energy crop prices will be affected by changes in agricultural conditions and are likely to be just as volatile as the price of corn.

If energy crop yields increase as projected by the Department of Energy, then energy crop ethanol production of 2-5 billion gallons would have little effect on agriculture. But if energy crop yields do not reach their promised levels, then energy crop ethanol production would have much the same effect on agriculture as described for corn-derived ethanol. Animal feeds are not produced as energy crop coproducts, so the increase in corn price would be slightly stronger while the decline in soybean price would be slightly less.

Uncertainties in biomass-derived ethanol include future yields of energy crops (especially those on marginal lands), the technology for converting biomass into ethanol, and changing energy prices. The more the price of gasoline rises, the more can be paid for ethanol feedstocks. Finally, energy crops face competition for land from other field crops. If farm prices for field crops go up, energy crops would be less competitive, and vice versa.

Figure 3

Ethanol cost as determined by energy sorghum price

Costs of producing ethanol and price of ethanol to its users (blended price) rise with the (delivered) price of energy sorghum. The price of gasoline to blenders (62 cents per gallon) equals the highest price blenders are willing to pay for ethanol. The market price of ethanol ($1.16) includes the 54-cent-per-gallon subsidy.

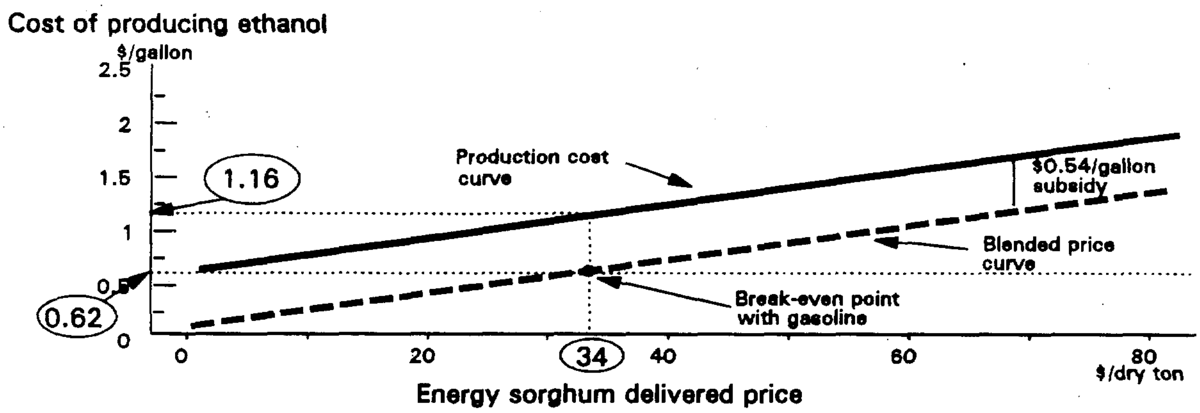
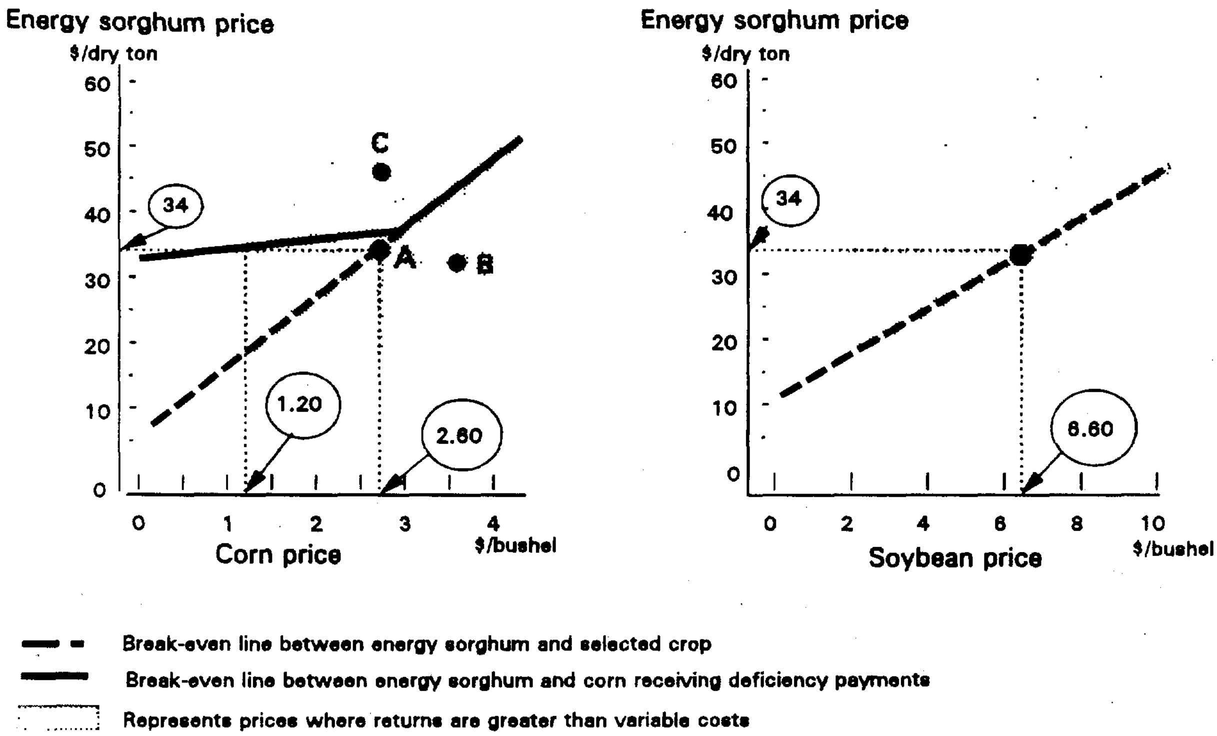


Figure 4

Break-even prices for energy sorghum vs. corn and soybeans in the Corn Belt[1]

For any point on the break-even line, energy sorghum is as profitable as the other crop. $34 is the price for energy sorghum that allows sorghum-derived ethanol to compete with gasoline and corn-derived ethanol. At point A, net cash returns to energy sorghum equal net cash returns to corn. At point B or any other point to the right of the break-even line, returns to energy sorghum are less than returns to the other crop. At point C or any other point to the left of the break-even line, returns to energy sorghum are greater than returns to the other crop.



[1] Based on a projected yield of 11.9 dry tons per acre for energy sorghum and 1989 yields and costs of production for corn and soybeans in the Corn Belt.

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Acknowledgments

The authors thank Jim Hrubovcak and Betsey Kuhn for their helpful comments. Special thanks to Larry Salathe and others for careful reviews of the report, and to Dale Simms for editorial assistance.

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