

# HOW MUCH ETHANOL CAN COME FROM CORN?



The U.S. ethanol industry is expanding at a dramatic rate. The industry is expected to produce approximately 5 billion gallons of ethanol in 2006, nearly three times the amount produced in 2001. Nearly 2 billion bushels of corn will likely be used for ethanol production in calendar year 2006. Rapid growth is expected to continue well into the future. The considerable increase in corn use for ethanol has caused many traditional corn customers to question how feed, food, and export markets will be affected by increased ethanol production. Among the most frequently asked questions are:

- Will there be enough corn to satisfy feed, food, and export demand, as well as growing demand for ethanol?
- How much corn can go to ethanol without significantly disrupting other markets?

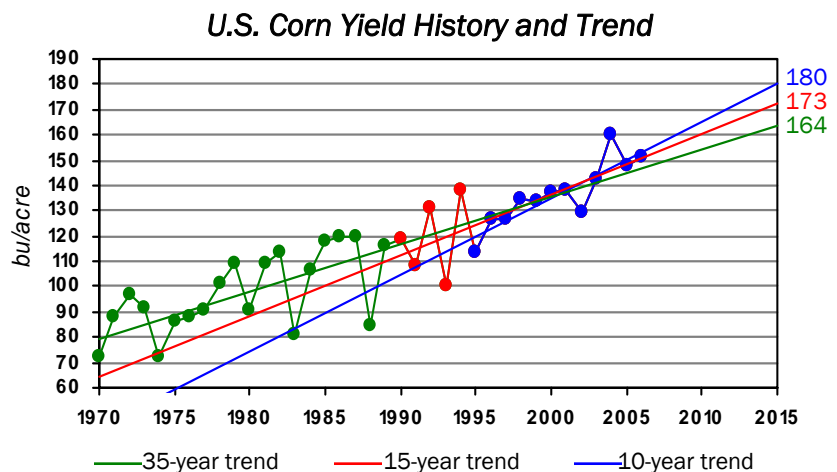
In addressing these questions, the following factors must be considered:

## 1. INCREASING CORN YIELDS

The corn yield curve is increasing at an accelerated rate because of advances in biotechnology and improved cropping practices. Increased yields allow growers to harvest considerably more corn without significantly increasing acreage. Growers set a new yield record in 2004 with 160.4 bushels per acre. Despite drought conditions in many parts of the Corn Belt in 2006, the average yield per acre is projected to be 151.2 bushels, the second-highest average yield on record.

Based on a 15-year trend line (1990-2005), average yields are projected to hit 173 bu./acre by 2015. However, if yield continues to increase at the rate of the last 10 years (1995-2005), average yields could reach 180 bu./acre by 2015. To illustrate the impact of incremental yield growth, consider that an increase of just two bushels per acre from one year to the next results in an additional 150 million bushels of corn. That additional corn could be used to produce 420 million gallons of ethanol.

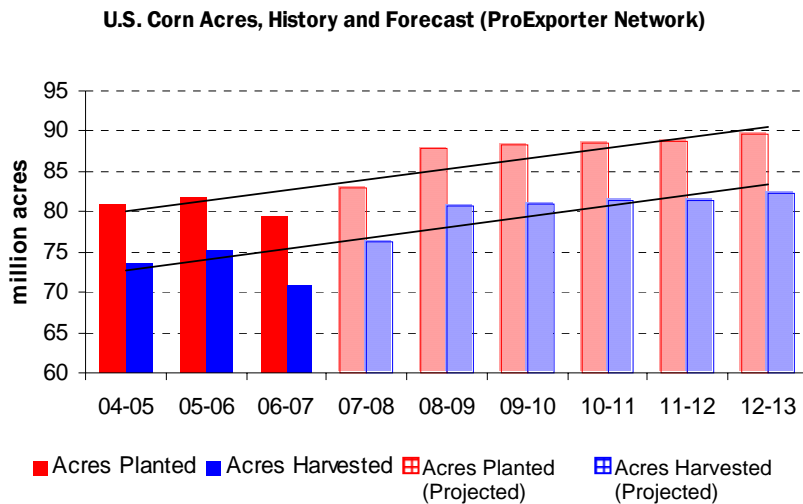
Advances in biotechnology and conventional plant breeding are likely to further accelerate yield growth. In addition to new hybrids designed to achieve higher yields, transgenic traits offering increased drought resistance and enhanced nitrogen utilization are among the many exciting new developments coming to market soon.



## 2. INCREMENTAL ACREAGE SHIFTS

As corn demand continues to increase because of ethanol, some acreage may be shifted to corn away from other

crops such as soybeans, and to a lesser degree cotton and wheat. U.S. farmers make their planting decisions based on demand signals from the marketplace. If demand for corn is high and projected revenue-per-acre is encouraging, corn acres will likely increase. Some portion of the 35 million acres currently dedicated to the Conservation Reserve Program might also be brought back into production. ProExporter Network projects 89.7 million acres may be planted to corn by the 2012-2013 crop year, an increase of about 9 percent from the 2005-2006 mark of 81.8 million acres.



For every additional 1 million harvested acres, roughly 150 million bushels of corn will be added to total supply (assuming a conservative future average yield of 150 bu./acre). In other words, 1 million harvested acres translates into an additional 420 million gallons of ethanol.

## 3. DEMAND FOR NON-ETHANOL CORN USE IS FLAT

Corn use for livestock feed is not projected

to grow significantly in the long term. Economists project livestock and residual use to average about 5.5 to 5.8 billion bushels between 2007 and 2016, down from an average of about 6.1 billion bushels between 2004 and 2006. Export use and non-ethanol processing use also are not expected to increase significantly. Many economists project export use to average 1.9 to 2.1 billion bushels between 2007 and 2016. It could be argued that total non-ethanol corn use is likely to flatline at about 9.1 billion bushels (high case) in the long-term. Accordingly, increased production can go to ethanol without radically affecting traditional markets.

## 4. DDGS WILL INCREASINGLY DISPLACE CORN IN FEED RATIONS

Increased ethanol production will generate increased supplies of distillers grains, often referred to as DDGS. These high-protein coproducts will increasingly displace corn in beef, dairy, poultry and swine rations. The nutritional quality and transportability of distillers grains products are steadily improving and future products will be more prescriptive in nature. ProExporter projects distillers grains will displace more than 1 billion bushels of corn for feed per year starting in 2008-09, freeing up this corn for other uses.



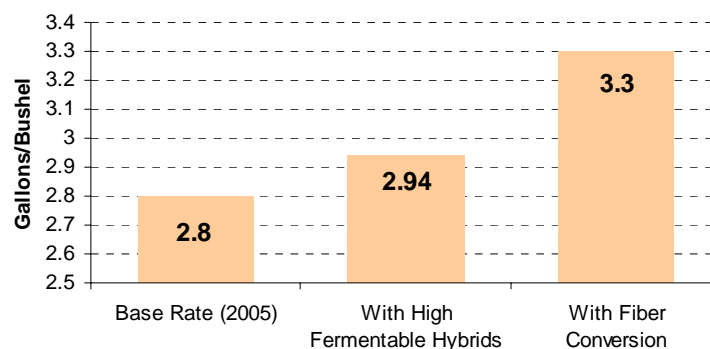
## 5. IMPROVED ETHANOL EFFICIENCY

The ethanol industry is driven by innovation. New technologies will “squeeze” more ethanol out of a

bushel of corn. The average ethanol conversion rate today is 2.8 gallons per bushel, up from 2.5 gallons per bushel several years ago. That conversion rate may soon be 3 gallons per bushel or higher because of the likely adoption of emerging processing technologies, two of which are detailed below.

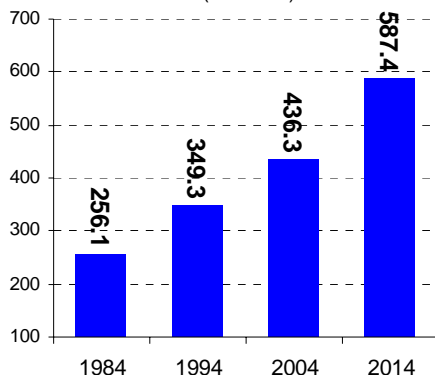
- **Corn fiber conversion** – Fiber accounts for about 10 percent of the corn kernel. The conventional ethanol process does not utilize this portion of the kernel. Fermentation of the fiber fraction can increase ethanol yield from a bushel of corn by approximately **10 to 13 percent**, according to the National Renewable Energy Laboratory.
- **High Fermentable Starch Hybrids** – Seed companies are producing ethanol-specific corn hybrids that contain higher levels of fermentable starch. A bushel of high fermentable starch corn is likely to yield **3 to 5 percent** more ethanol than a bushel of conventional corn, according to seed company literature.

Potential Ethanol Conversion Rates



Uniform application of these technologies across the industry would result in a dramatic increase in ethanol production without significantly altering corn acreage. The multiplying effect of increased ethanol conversion rates and increased corn yields results in a considerable gain in grain ethanol per acre. Furthermore, the prospect of converting corn stover to ethanol could potentially double the future ethanol yield of a single acre of corn.

Corn Grain Ethanol Yield Per Acre  
(Gallons)



	Yield (bu/acre)	Conversion Rate (gal./bu.)
<b>1984</b>	106.7	2.40
<b>1994</b>	138.6	2.52
<b>2004</b>	160.4	2.72
<b>2014*</b>	178.0	3.30

\*Theoretical Projection assuming 100% fiber conversion and 100% use of high fermentable hybrids

## So...how much ethanol can come from corn without disrupting other markets?

NCGA recently conducted an analysis of future corn use dynamics. Because of increasing yields, incremental acreage shifts, new technology and the displacement effect of distillers grains, it seems quite feasible that corn growers could harvest a crop of 14 to 15 billion bushels by 2015-2016. Under this scenario (medium case), approximately 5.5 billion bushels would be available for ethanol conversion. At a conservative conversion rate of 2.9 gal/bu, this would equate to nearly 16 billion gallons of ethanol—or roughly 10 percent of the United States' expected gasoline demand. As demonstrated in this paper, the ethanol conversion rate, average corn yield, and harvested acres all could be higher than these assumptions.

Crop Year 2015-16	Harvested Acres (mil acres)	Yield (bu/acre)	Total Production (mil bu)	Ethanol Use (mil bu)	Ethanol Conversion (gal/bu)	Ethanol Production (mil gal)
HI CASE	78.0	193.0	15,054	5,954	3.0	17,862
MED CASE	78.0	187.0	14,586	5,486	2.9	15,909.4
LO CASE	76.0	178.0	13,528	4,428	2.9	12,841.2

### Our assumptions:

- **Harvested Acres:** Harvested acres typically account for ~93% of planted acres. Thus, this model assumes planted acreage of 83 million acres for HI and MED and a "normal" weather year. Many economists project planted acres to be much higher than 83 million acres by 2015.
- **Yield:** Our high case yield is based on a 10-year trend line (1996-2005), which takes into account the adoption and proliferation of biotech hybrids. Medium case is based on 10-year trend line with volatility. Lo case is based on 15-year trend line (1990-2004).
- **Ethanol Use:** We assumed demand of 9.1 billion bushels for non-ethanol uses. The amount of corn available for ethanol use is the difference between 9.1 bbu. and total production. It is assumed that carryover has stabilized.
- **Ethanol Conversion:** These are conservative estimates. Many economists project the conversion rate to be 3.1 or higher by 2015-16. We assume early adopters will be using the new technologies described in this paper, but use will not yet be widespread by 2015.

## A NOTE ON THE "FOOD VS. FUEL" DEBATE

Ethanol critics often suggest using corn to make fuel will take corn away from human food markets. This argument is patently false and misguided, as U.S. producers will continue to adequately supply all markets with high quality corn. Consider that the industry easily met demand for all corn uses in 2005 and still finished the year with the highest surplus since the late 1980s.

Additionally, ethanol production currently utilizes only the starch portion of the kernel. Starch is abundant and relatively low in value. The remaining protein, fat, fiber and minerals are incorporated into DDGS, the high-value livestock feed produced at ethanol plants. Also, ethanol is produced from field corn fed to livestock, not sweet corn grown for humans. The amount of field corn used for human food processing (starch, sweeteners, and cereal) normally amounts to just 5-8 percent of total corn usage. Additionally, corn demand for food processing markets has been flat for the last 15 years. For more information on this issue, see NCGA's paper, *U.S. Corn Growers: Producing Food AND Fuel*.

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