Implications for US Corn Availability under a Higher Blending Rate for Ethanol:
How Much Corn Will Be Needed?

Summary

Increasing the amount of biofuel that can be blended into gasoline will contribute to dramatic growth in the demand for corn, and consequently the price of corn and other commodities can be expected to increase dramatically. This study concludes that corn prices will be much higher and more volatile if annual corn ethanol production increases to 17.7 (12% of gasoline consumption) or 22.1 billion gallons (15% of gasoline consumption). Unless corn acreage grows significantly, this study estimates that more than half of the US corn crop will be diverted from food and feed to fuel if corn ethanol production grows to 22.1 billion gallons.

Three existing factors already contribute to far greater ethanol production and use than is now mandated by federal law: a $4 billion-a-year tax credit to gasoline refiners who blend corn ethanol into gasoline, a tariff that limits the importation of sugar ethanol, and the slow development of advanced biofuels. As US and global economic conditions improve in the coming years, a fourth driver of increased ethanol production will be an increase in crude oil prices.

In combination, these factors will provide powerful incentives for gasoline refiners to increase the amount of corn ethanol blended into gasoline to the highest level possible, more than 22 billion gallons under an E15 standard. As a result of increased demand for ethanol, corn prices will increase and corn production will expand, displacing other crops, including soybeans and wheat.

The study considers the impacts of a proposal to EPA to increase from 10% to 12% or 15% the amount of biofuel that can be blend into gasoline. This study focuses on impacts to the US corn market and the amount of US corn production that would be required to produce 17.7 billion gallons ("E-12") or 22.1 billion gallons ("E-15") of ethanol. This study addresses two key questions:

- How many acres of corn would be needed to meet total rising ethanol production during 2010-2014 under higher blend rate scenarios, and

- If corn acreage remains consistent with current projections, what are the implications for the supply and price of corn and other food crops?

The conclusions of this study are dramatic – unless policymakers eliminate subsidies and trade barriers related to ethanol:

1. The existing mandates have already had a dramatic impact upon numerous markets – corn prices remain 60% above historic norms, dramatic acreage shifts have occurred in recent years, livestock producers are incurring the largest losses in at least 25 years, and food inflation during 2008 rose to highest level since 1982.

2. If the blending standards are expanded, leading to significant increases in ethanol production, corn acreage will need expand to near 100 mm acres under a 12% blending limit, and to as much as 110 million under the 15% allowable blend percentage.

3. If the blending standards are expanded, leading to significant increases in ethanol production, and corn acreage does not expand accordingly, corn ethanol would reach 56% of the corn crop at the expense of other uses- including animal feed and exports.

4. An increase to 100 mm acres or more of corn would lead to a significant increase in the price of corn, as well as other food related crops. The adverse impact upon livestock producers, as well as consumers, would become worse with more production being devoted to the production of corn-based ethanol.

During the acreage battle of 2007, corn futures prices rose from by more than 50% during a five month period – from less than $2.85 during September 2006 to over $4.25 by February 2007. Reaching even higher corn acreage levels, as implied by the E12 scenario and E15 scenario, would result in the price of corn (and other crops) increasing even more dramatically.

The corn market is at risk of a serious shortfall of availability during the coming years, and that risk becomes much greater if the blending standard is raised to 12% or higher and current tax and trade policies remain in place. The USDA stated the potential yield risks very well in their 2007 assessment of the impact of ethanol expansion:

> "Thus, overall demand in the corn sector is projected to become more inelastic as ethanol production grows. In combination, these factors will make the corn market more vulnerable to shocks, such as production shortfalls due to weather, pests, or other factors. Low stocks provide limited buffers to shocks. As demand for corn becomes more inelastic, a greater change in market prices would be needed in response to a shock to bring the market to equilibrium. Thus, overall price variability and market volatility in the agricultural sector are likely to increase."[1]

Mandated corn usage to produce ethanol has already dramatically altered the supply/demand balance for corn, leading to higher corn prices. The expansion of the allowable blending percentage to 12% or 15% would result in a much greater need for corn acreage, a more dramatic increase in corn prices, and higher prices for other grains, oilseeds and livestock.

---

[1] "U.S. Ethanol Expansion Driving Changes Throughout the Agricultural Sector", USDA Economic Research Service, December 2007

The Proposed Expansion of Ethanol Blends From 10% to 12-15%

The EPA has been petitioned to change the maximum allowable blend of ethanol in conventional gasoline from 10% to as high as 15%. There are numerous non-economic issues to consider in judging whether to raise the maximum allowable blend toward 15%. This study focuses strictly on the implications for the US corn market, and the US corn production that would be required to increase ethanol consumption to 12% or 15% of total gasoline consumption.

The EPA limits the allowable inclusion of ethanol in conventional gasoline to 10% (E10). With US total gasoline consumption totaling roughly 140 billion gallons,[2] this equates to a maximum potential market for ethanol in conventional gasoline of approximately 14 billion gallons.[3] The Energy Information Administration estimates that the U.S. will reach the 14 billion gallon "blend wall" in 2014. As a result the current E10 standard has placed a significant impediment to reach the mandated use of 15 B gallons of conventional (corn-based) ethanol by 2015.

As the market dynamics of recent years have clearly and painfully taught us, any significant catalyst that alters the corn supply/demand balance will also impact the other grain and oilseed markets, feed costs and profitability for livestock and dairy producers, and ultimately consumer food prices. Changes the blending standard to 12% or 15% has the potential to provide an even more dramatic rise in grain, oilseed, livestock and consumer food prices.

Study Methodology

During 2008, 9.2 B gallons of ethanol were produced and used in the United States, equal to 6.7% of US total gasoline consumption. The Energy Independence Security Act of 2007 mandates an increase in ethanol usage to 15 B gallons by 2015, equal to roughly 10% of US gasoline consumption.

In general, this study assumes that if the economics for blending ethanol are favorable, then gasoline refiners will have incentive to blend up to the statutory limit in order to reduce costs. In particular, if the Volumetric Ethanol Excise Tax Credit (VEETC) remains in place, the price of oil rebounds to at least $50 a barrel, and if the tariff on imported ethanol continues to prevent competition from abroad, oil refiners will blend more corn ethanol than required by the federal renewable fuels standard. This occurred during 2005-2007 when the price of oil surged and refiners blended volumes of corn ethanol far surpassing their statutory volumetric requirements.

The key questions to be answered are, "how many acres of corn would be needed to meet total rising ethanol production during 2010-14 under high blend rate scenarios and where will that acreage come from," and "if corn acreage remains consistent with current projections, what are the implications for the supply and price of corn and other food crops?"

---

[2] US Department of Energy, Energy Information Agency
[3] A very small share of the market utilizes a concentrated blend of ethanol (E85) in vehicles adapted to be able to use the higher blend.

In this analysis, three scenarios were compared:

- A baseline scenario, that assumes ethanol production rise at approximately the rate needed to meet the EPA renewable fuel mandates (15 B gallons by 2015)
- An "E12" scenario where production of ethanol expands to 12% of the gasoline supply in 2011 and beyond (17.7 B gallons by 2015).
- An "E15" scenario, where production of ethanol expands to 15% of the gasoline supply in 2011 and beyond (22.1 B gallons by 2015).

During 2008/09, the corn supply/demand is based upon the USDA World Agricultural Outlook Board estimates.[4] US gasoline consumption declined by 3% during CY2008, and is forecast by EIA to decline 1% in CY2009. In 2010 and beyond, a 1.5% gain in consumption is forecast (equal the 1998-2007 rate of growth), reaching 147.5 B gallons in CY2015.


In each
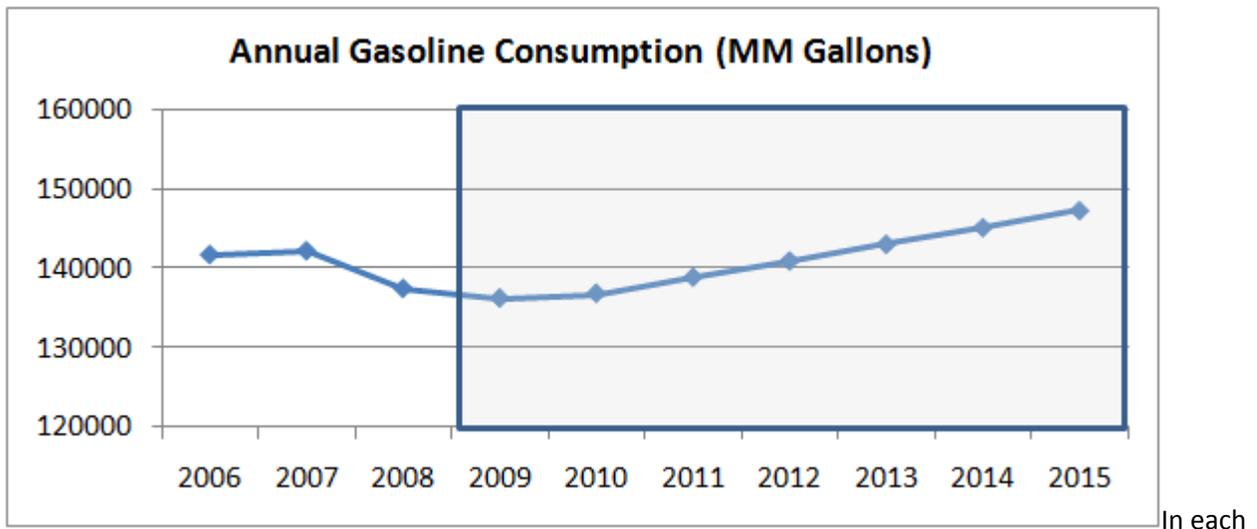
Ethanol production totaled 10.2 B gallons in CY2008, and under the baseline scenario is assumed to expand to 15 B gallons in CY2015, equal to the EPA's mandated usage levels. Under the E12 scenario, ethanol production is assumed to expand to 17.7 B gallons (12% of consumption), while the E15 scenario assumes ethanol production expands to 22.1 B gallons (15% of consumption).

---

[4] USDA, "World Ag Supply/Demand Estimates (WASDE)", March 2009

US Ethanol Production (MM Gallons)
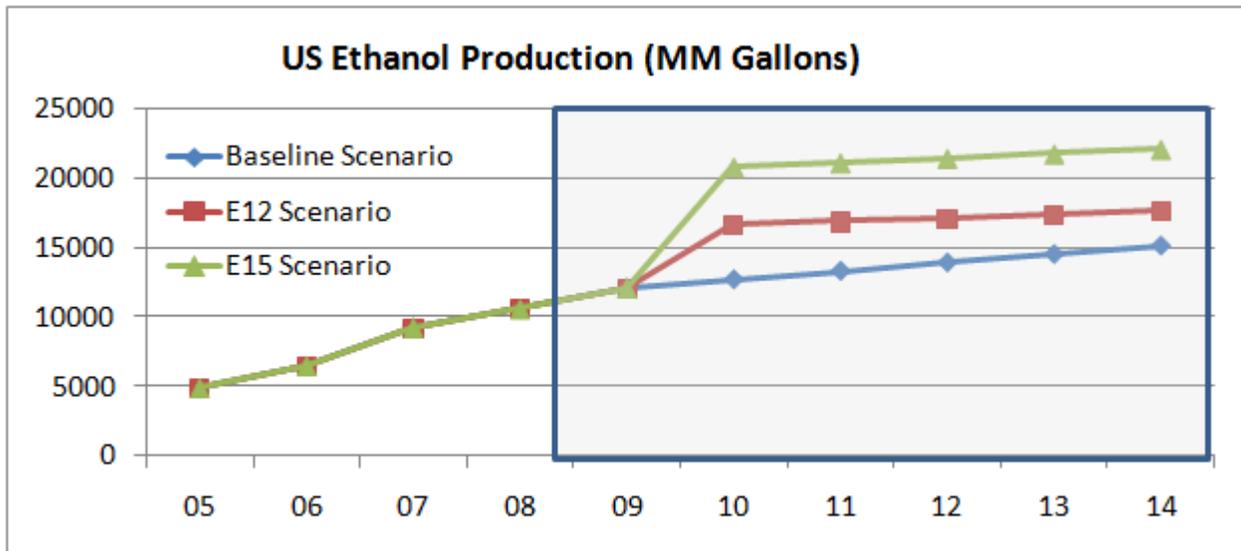
In each of these scenarios, corn use for the production of ethanol was increased to meet the projected ethanol usage. A yield of 2.75 gallons was assumed for every bushel of corn used to produce ethanol. Corn "crop years" begin in September and end in August, and thus span two calendar years; in this study the crop year corn grind was assumed to equate to 25% of the ethanol produced during the first year and 75% of the ethanol produced during the second year.

During the 2014/15 crop year, corn use for ethanol is projected to reach 5.5 B bushels in the baseline scenario, 6.4 B bushels in the E12 scenario and 8.0 B bushels in the E15 scenario.

**US Corn Used To Produce Ethanol (MM Bushels)**
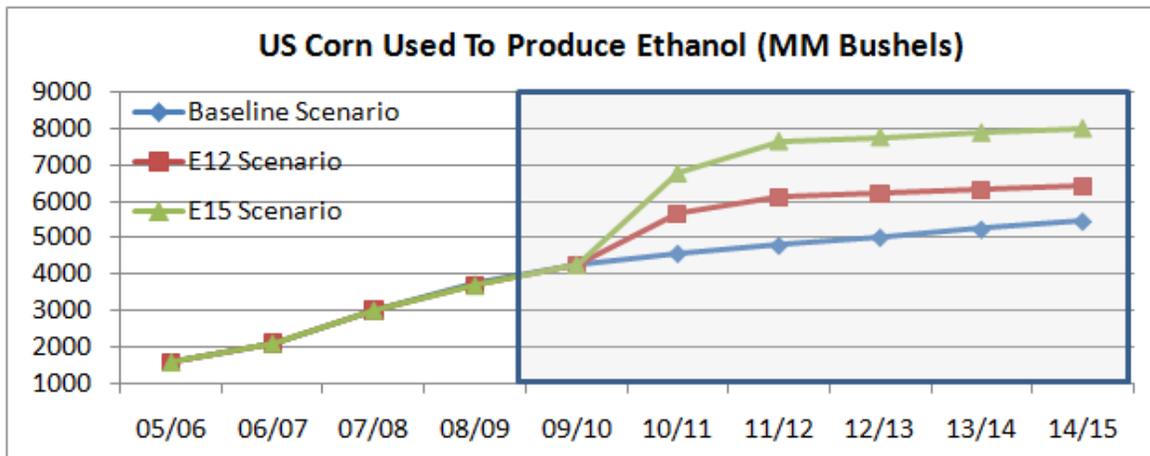
Annual feed and residual usage in the baseline scenario was estimated based on beginning supplies of corn and corn grind for ethanol. Over the past 17 years, a model forecasting feed usage as a function of beginning supplies and ethanol grind has a 94% R-squared. The relevance of ethanol grind in this equation is that for each bushel used for ethanol, around 17 pounds of dried distiller grain (DDG) is produced. In each of the scenarios, corn feed and residual remains in a 5.4-58 B bushels range.

Annual exports of corn are projected to total near 1.92 B bushels in the baseline scenario, 1.8 B bushels in the E12 scenario, and 1.64 B in the E15 scenario. The model assumes world trade of coarse grains will

total 104 million tonnes during 2009-14 (vs. 106 million during the previous ten years); the US share of world trade is expected to remain at the 10-year average of 47% in the baseline scenario, but decline to 44% in the E12 scenario and 41% in the E15 scenario.

Based upon these assumptions, total corn usage reaches 14.2 B bushels by 2014/15 in the baseline scenario, 15.2 B bushels in the E12 scenario and 16.7 B bushels in the E15 scenario.

Annual US Corn Usage (MM Bushels)
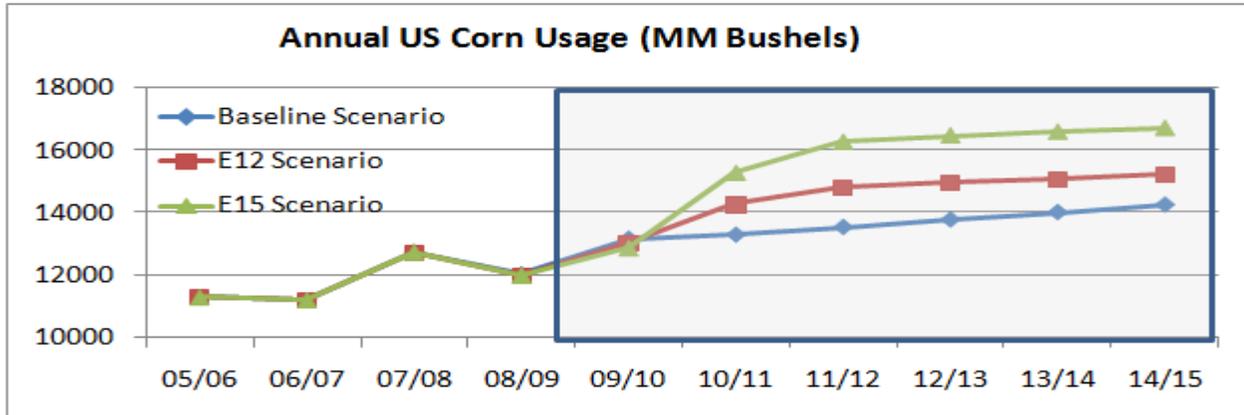
In order to meet demand each year, adequate corn must be planted and produced, or stocks drawn down from inventories. However there are only minimal inventories to draw from at present, and corn stocks are expected to remain very tight through 2014/15. Over the past 20 years, a benchmark minimal level of corn stocks equal to 5% of usage has been observed.[5] A decision rule used for this study was to adjust corn acreage planted (and thus production) adequately to maintain ending stocks at 4% to 6% of annual usage.

US Corn Stocks as a % of Usage
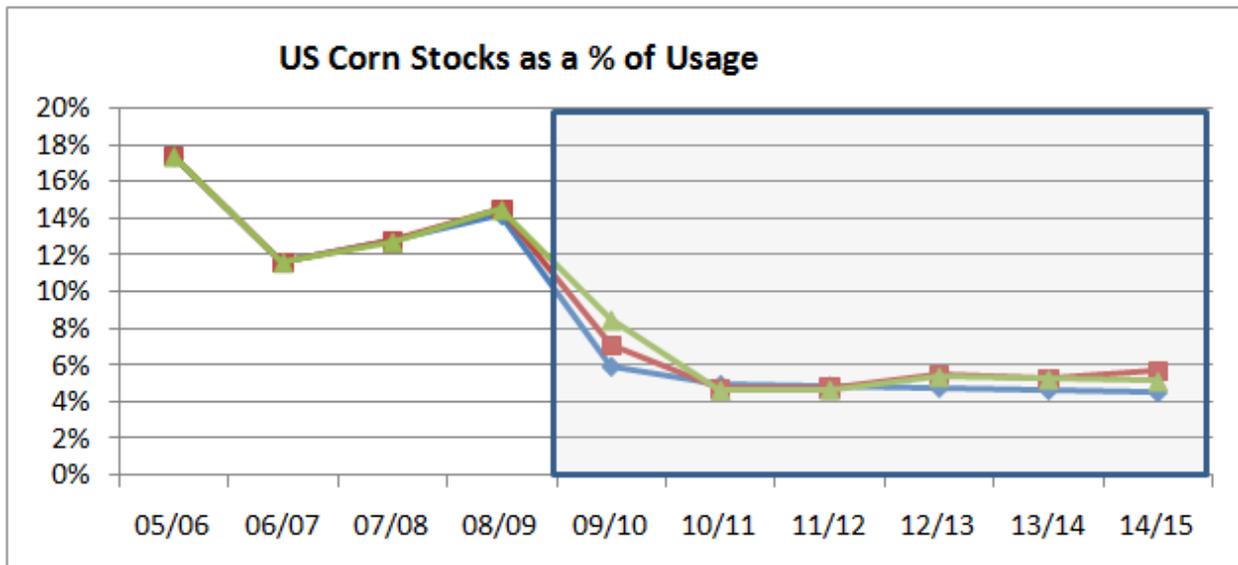
Corn production in any year can be calculated as: 1) the number of acres planted; 2) the percent of those planted acres that are harvested; and 3) the yield per acre harvested. In this study the yields are

---

[5] USDA Economic Research Service, "Feed Outlook"

assumed to increase by 1.7% per year, equal to the rate of gain observed for US corn during the past ten years (1999-2008), as well as during the past 20 years (1989-2008). The percent of harvested corn acreage is assumed to be 90.8%, compared to 90.8% during 1999-2008 and 90.3% during 1989-2008.

US Corn Yields (Bushels Per Acre)
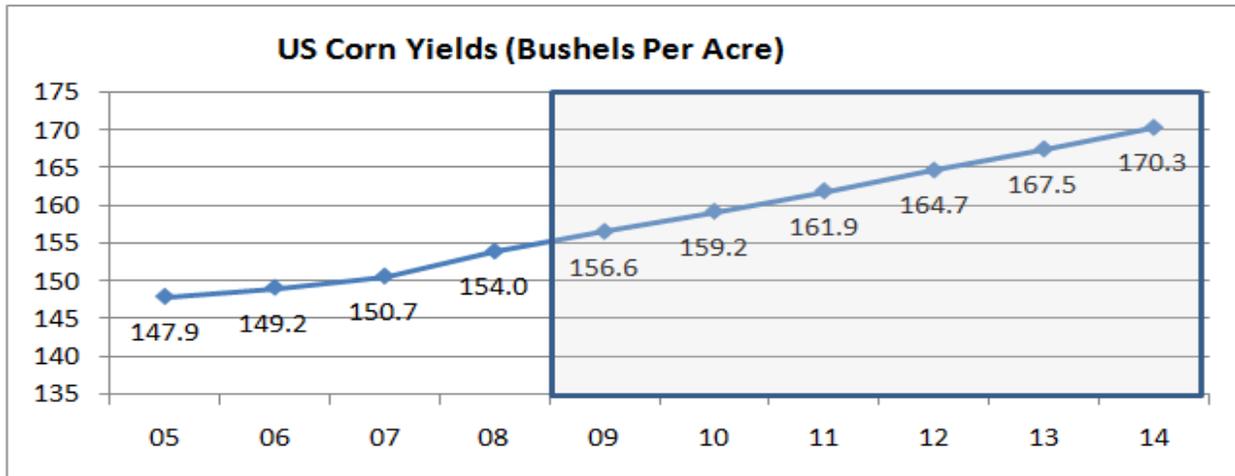
An estimate of US corn acreage can be derived by estimating demand, leaving a minimal level of stocks, and forecasting both yields and the percent of planted acreage that is harvested. The methodology used provides a tool to assess the impact of growing use of corn to produce ethanol under three scenarios, but does not address the year-to-year dynamics of changing feed and export demand, as well as variability in yields due to weather. While it has limitations, this analysis provides a reasonable assessment of the required acreage needed to meet demand under three different policy assumptions for ethanol blending allowances.

Results of The Analysis: How Much Corn Will Be Needed Under E12 and E15 Rules?

The baseline scenario, with ethanol production rising to the mandated level of 15 B gallons by 2015 (using 5.5 B bushels of corn annually), will result in the required number of corn acres rising to 91-92 mm acres in 2010-2015. Excluding 2007, this would be the largest number of corn acres planted in more than 60 years; note that US corn area planted averaged 76.5 mm acres during the previous 25 years (1983-2006).

The baseline scenario will require higher prices for corn in order to attract acreage away from other crops and encourage continued relative high levels of US corn production through 2014/15. However, expanding the ethanol market to 12% or 15% of total US gasoline usage will imply a much more extreme increase in corn acreage.

Under the E12 scenario (ethanol production equal to 12% of gasoline consumption in 2011-15, using 6.4 B bushels of corn annually), US corn acreage will need to expand to 97-101 mm acres during 2010-15. Under the E15 scenario (ethanol production rising to equal to 15% of gasoline consumption in 2011-15, using 8.0 B bushels of corn annually), US corn acreage will need to expand to 103 mm to 111 mm acres during 2010-15.

US Corn Acres (MM) Required To Meet US Annual Corn Demand Under 3 Scenarios
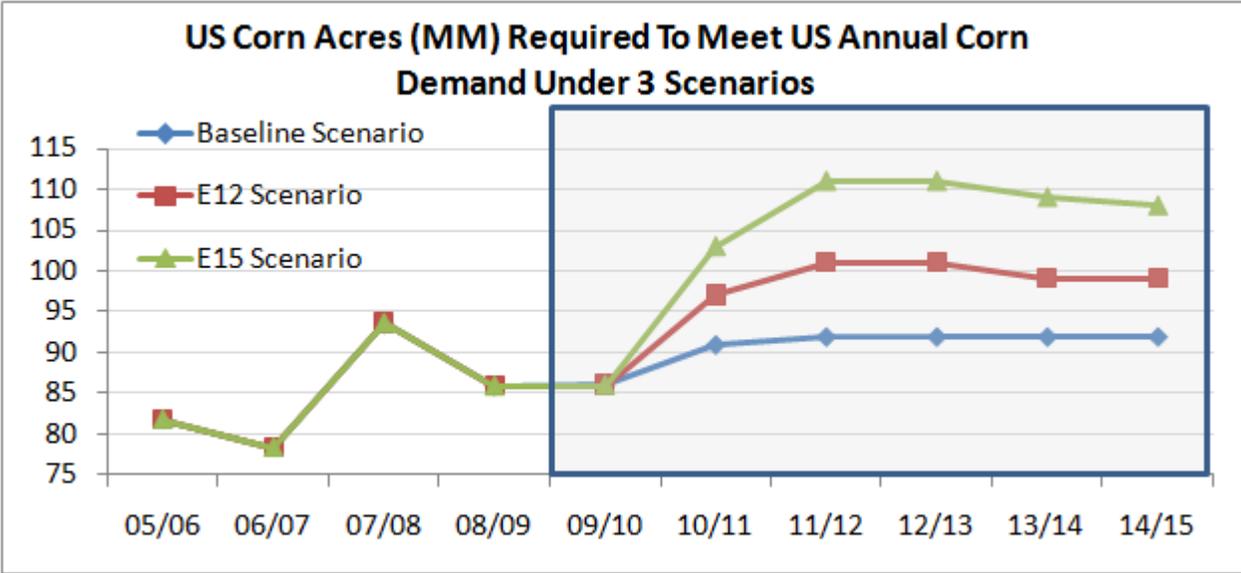
There are several limitations to this analysis that need to be recognized. First and foremost is the question of what prices would be required to drive corn plantings over 100 mm acres, as the model projects if E12 or E15 blending standards are employed. Second are the implications of weather, which will drive yields above and below trend in any given year. Third is the impact higher corn acreage will have upon other crops that compete for those same acres. Finally, the prospect for politically-driven changes to biofuels policy will impact the analysis, and is a key unknown that would change the number of corn acres required under the three scenarios modeled.

The table below summarizes the results of the analysis of the three scenarios:

Gasoline (CY, MM Gal.)	2007	2008	2009	2010	2011	2012	2013	2014	2015
US Gasoline Consumption	142,349	137,510	136,284	136,897	138,950	141,035	143,150	145,297	147,477
		-3.4%	-0.9%	0.4%	1.5%	1.5%	1.5%	1.5%	1.5%
RFS Ethanol Mandate	4,700	9,000	10,500	12,000	12,600	13,200	13,800	14,400	15,000
Corn S/D (Crop Year)	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
BASELINE (E-10)									
Acres Planted (MM)	78.3	93.6	85.9	86.0	91.0	92.0	92.0	92.0	92.0
Production (MM)	10531	13038	12101	12227	13157	13528	13758	13992	14230
Ethanol for Corn (MM)	2119	3026	3732	4270	4573	4793	5013	5234	5454
TOTAL USE (MM)	11206	12738	12032	13163	13294	13537	13776	14012	14249
Ending Stocks (MM)	1304	1624	1708	781	658	661	657	650	643
% of Use	11.6%	12.7%	14.2%	5.9%	4.9%	4.9%	4.8%	4.6%	4.5%
E12									
Acres Planted (MM)	78.3	93.6	85.9	86.0	97.0	101.0	101.0	99.0	99.0
Production (MM)	10531	13038	12101	12221	14018	14844	15097	15049	15305
Ethanol for Corn (MM)	2119	3026	3700	4270	5649	6132	6223	6317	6412
TOTAL USE (MM)	11206	12738	12000	13046	14281	14828	14999	15086	15240
Ending Stocks (MM)	1304	1624	1740	925	675	704	815	791	869
% of Use	11.6%	12.7%	14.5%	7.1%	4.7%	4.8%	5.4%	5.2%	5.7%
E15									
Acres Planted (MM)	78.3	93.6	85.9	86.0	103.0	111.0	111.0	109.0	108.0
Production (MM)	10531	13038	12101	12221	14885	16314	16592	16570	16697
Ethanol for Corn (MM)	2119	3026	3700	4270	6786	7664	7779	7896	8014
TOTAL USE (MM)	11206	12738	12000	12876	15281	16275	16480	16598	16721
Ending Stocks (MM)	1304	1624	1740	1095	713	765	889	874	863
% of Use	11.6%	12.7%	14.5%	8.5%	4.7%	4.7%	5.4%	5.3%	5.2%

Translating assumptions about the amount of corn needed to reach E12/E15, we can make some assumptions about ethanol's share of corn use if acreage were to remain consistent with current projections.

Ethanol Share of Total Corn Use (Assuming Corn Acreage Elasticity*)				Ethanol Share of Total Corn Use (Assuming No Corn Acreage Elasticity**)			
	E10	E12	E15		E10	E12	E15
04/05	12%	12%	12%	04/05	12%	12%	12%
05/06	14%	14%	14%	05/06	14%	14%	14%
06/07	19%	19%	19%	06/07	19%	19%	19%
07/08	24%	24%	24%	07/08	24%	24%	24%
08/09	31%	31%	31%	08/09	31%	31%	31%
09/10	32%	33%	33%	09/10	32%	32%	32%
10/11	34%	40%	44%	10/11	34%	42%	51%
11/12	35%	41%	47%	11/12	35%	45%	57%
12/13	36%	41%	47%	12/13	36%	45%	56%
13/14	37%	42%	48%	13/14	37%	45%	56%
14/15	38%	42%	48%	14/15	38%	45%	56%
* Corn area expands as ethanol production expands, to as high as 111 mm acres				** Corn area expansion is limited, reaching a peak of 92 mm acres; as ethanol production expands, other use of corn (exports, feeding) are reduced			

Implications of Raising Ethanol Production to 12% or 15% of the Gasoline Supply

Under the E12 and E15 scenarios (and to a lesser extent the baseline scenario), the burden of finding enough corn acres to produce the bushels required to meet demand will be a major focus of the corn market. However the implications of raising the blending standard will stretch well beyond simply raising the price of corn to attract more acreage.

In pushing corn to 100 mm acres and beyond will necessitate a large-scale shift away from other crops (most notably wheat and soybeans). The universe of productive land in the US is finite, and consequently an increase in corn acreage will largely be offset by a decrease in the acreage planted to other crops – most notably soybeans and wheat. Thus the impact of raising the allowable blending percentage to 12% or 15% will reach well beyond corn, increasing the price of any crop that competes for acreage in the US and abroad. As was observed during 2007 and 2008, the rapid increase in corn prices is likely to result in commensurate increases in the price of nearly all crops.

The higher corn prices will directly impact feed costs – roughly 50% of corn (5-6 billion bushels annually) is used by livestock and dairy producers as their primary feed ingredient. The higher price of corn required to attract additional acreage will first impact feed costs, and ultimately will impact the price consumers will be paying for beef, pork, chicken, turkey and dairy products.

The price of corn will need to rise significantly in both the E12 and E15 scenarios. However, there is no analog year that can be observed – raising ethanol production to 12% or more of the US gasoline supply would cause the most dramatic surge in corn acres the market has ever experienced.

The experience of 2007 may give us some idea of what we could expect. During late 2006, there was a realization that in 2007 there would be a need for over 90 million acres of corn to meet demand, up sharply from 78 million acres planted in 2006. The function of corn prices was to attract acreage away from other crops, and the price of corn began to respond dramatically. December 2007 corn futures prices rose from by over 50% during a five month period – from less than $2.85 during September 2006 to over $4.25 by February 2007.

Ultimately corn acreage rose to 93.6 million acres in 2007 – in part by "borrowing' acreage away from soybeans, which were in surplus at that time.[6] Reaching even higher corn acreage levels, as implied by the E12 scenario and E15 scenario, would result in the price of corn (and other crops) increasing even more dramatically.

The risk of weather-related yield losses cannot be overlooked. Beyond adequately increasing corn area planted to meet the increased use of corn to produce ethanol, the market faces the risk of lower corn yields in any given year. Since 1979, US corn yields have had an average deviation from trend of 7% (above or below); yields have been 7% or more below trend roughly one out of every four years during the past 30 years.[7] A 7% yield loss would equate to over 1 billion bushels, more than the projected carryout during 2010-15 in any of the three scenarios.

The corn market is at risk of a serious shortfall of availability during the coming years, and that risk becomes much greater if the blending standard is raised to 12% or higher. The USDA stated the potential yield risks very well in their 2007 assessment of the impact of ethanol expansion:

> "Thus, overall demand in the corn sector is projected to become more inelastic as ethanol production grows. In combination, these factors will make the corn market more vulnerable to shocks, such as production shortfalls due to weather, pests, or other factors. Low stocks provide limited buffers to shocks. As demand for corn becomes more inelastic, a greater change in market prices would be needed in response to a shock to bring the market to equilibrium. Thus, overall price variability and market volatility in the agricultural sector are likely to increase."[8]

The food inflation pressures will mount under the government mandates for increased use of corn to produce ethanol. Higher corn prices will translate to higher feed costs for livestock, and ultimately higher consumer prices for protein, dairy and egg products. Higher corn prices will lead to higher prices for other crops that compete for the same acreage – higher prices for crops such as soybeans, wheat, rice and durum will translate into higher prices for consumer products such as vegoil, wheat flour, rice and pasta. The connection between surging commodity prices and higher rates of food inflation was proven during 2008, when the consumer price index for food rose by 5.9%.[9] To suggest that further

---

[6] The 2006 US soybean crop was a record 3.2 B bushels, and US soybean inventories at the end of the 2006/07 crop year were a record 574 mm bushels.
[7] USDA National Agricultural Statistics Service
[8] "U.S. Ethanol Expansion Driving Changes Throughout the Agricultural Sector", USDA Economic Research Service, December 2007

[9] Bureau of Labor Statistics, November 2008

upward pressure on corn prices could occur without impacting consumer prices of food is inconsistent with what history has proven in the past and is again teaching us today.

The mandated corn usage to produce ethanol has already dramatically altered the supply/demand balance for corn, leading to higher corn prices. The expansion of the allowable blending percentage to 12% or 15% would result in a much greater need for corn acreage, a more dramatic increase in corn prices, and higher prices for other grains and oilseeds. Ultimately this will translate into higher livestock and dairy prices, and eventually further upward pressure on consumer food prices.

Policy Implications of Raising Ethanol Production to 12% or 15% of the Gasoline Supply
 The economic challenges of raising enough corn to meet an E-12 or E-15 standard are outlined above. An E-12 or E-15 standard will increase the US corn demand base to a point where the market will likely require over 100 million acres of corn. To attract this level of corn acreage, the largest in over 60 years, will require the price of corn to rise significantly, potentially well above the record level of $7.50 recorded during the summer of 2008.

Rising corn prices, driven by ethanol mandates, carries economic implications that will quickly develop into political trade-offs that will not be easily reconciled. This includes sharp reductions in the acreage available to produce other crops important to the US food supply, increased margin pressure and losses incurred by the US livestock industry, and escalating consumer food prices due to higher underlying commodity prices.

Under a higher blending standard, US politicians risk a perilous challenge that should be addressed sooner rather than later. If a higher blending rate (12% or 15%) is deemed to be scientifically plausible, it would be prudent for policymakers to consider ways to ensure the additional volumes under the cap are met with advanced and cellulosic biofuels rather than conventional biofuels that compete with food and feed. For instance, restoring market based economics by eliminating the VEETC and the import tariff would change the economic calculus and make it less likely that conventional biofuels will fill the new allowable volumes. Implementing limits on the amount of corn that can be blended into the fuel supply would also provide real relief in the case of shortfalls in production as outlined above.