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The following spreadsheets have been updated on the AgMRC Renewable Energy web site, http://www.agmrc.org/renewable_energy/.

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- fuel vs. grain (monthly)

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Can the World Feed Nine Billion People by 2050?

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Much attention has recently been focused on the milestone of the world's population reaching seven billion people. The milestone has raised concerns about the continued rapid increase in world population and the ability of world agriculture to feed the additional people. The answer to this question has important implications for renewable energy derived from biomass. The impact is not only the direct competition between corn for food and corn for ethanol, but also competition for farmland between food crops (e.g. wheat) and energy crops (e.g. switchgrass). Even if the energy feedstock is the by-product of a crop (e.g. corn stover) it may still impact food supply.

In this article I will examine the trends in world population growth, the track record of world agriculture in providing increased food production over recent decades and the potential for world agriculture to meet world food needs in the first half of the 21st century. Although of extreme importance to agriculture's long-term ability to feed the world, I will not include the environmental issues and sustainability aspects.

Table 1. World Population Milestones (historic and projected)

Population	1	2	3	4	5	6	7	8	9
Year	1804	1927	1960	1974	1987	1999	2012	2027	2046
Years Elapsed		123	33	14	13	12	13	15	19

Source: United States Census Bureau estimates

Historic and projected world population milestones, along with the year in which these milestones were reached, are presented in Table 1. In the year Lewis and Clark embarked on their historic journey, world population reached one billion people. World population continued to increase but didn't reach two billion until 1927, 123 years later. At this point, population started to grow rapidly reaching three billion people in 1960, only 33 years later. Four billion was reached only 14 years later. The rate of increase seems to have reached its peak at the turn of the century and began a slow decline in the rate of increase. It is projected that it will be 15 years before we reach eight billion and an additional 19 years before we reach nine billion.

Population changes due to the relationship between births and deaths. If the number of births equals the number of deaths, population does not change. However, if births exceed deaths, the population grows. Historically, the world had a high birth rate but the population grew slowly because it also had a high death rate (e.g.

high infant mortality). With improvements in world health and more people living through their reproductive years, population started to increase because the high level of births continued but the death rate dropped.

If this situation is maintained over a long period of time, population will grow exponentially. Essentially it is the same concept as compound interest for a savings account in a bank. The annual rate of increase is applied against a larger and larger base number. This has caused the explosion in population over the 20th Century.

This relationship between births and deaths is called the “fertility rate”. Essentially it is the number of children the average woman will give birth to in her lifetime. If the woman has two children, she will have replaced herself and her husband. If she has more than two, population will grow and if she has less than two, population will decline. To calculate the replacement fertility rate we must also take into account mortality from birth to reproductive age. The replacement fertility rate for industrialized countries is about 2.1 but higher for developing countries because their mortality rate is higher. The world average replacement fertility rate is estimated to be about 2.3 births per woman.

World fertility rates are shown in Figure 1. The fertility rate declined from 4.95 births per woman in 1950 to a projected 1.61 births per woman 100 years later in 2050. The current fertility rate is approaching the replacement fertility rate. However, population will continue to grow well into the future.

It may take several generations for a change in the fertility rate to be fully reflected in the rate of population growth. If the world has been in a period of high population growth, the number of young people of child bearing age will comprise a disproportionately large portion of the

World Historical and Predicted Total Fertility Rates (1950 – 2100)

Years	TFR	Years	TFR	Years	TFR
1950–1955	4.95	2000–2005	2.62	2050–2055	1.61
1955–1960	4.89	2005–2010	2.52	2055–2060	1.54
1960–1965	4.91	2010–2015	2.34	2060–2065	1.47
1965–1970	4.85	2015–2020	2.19	2065–2070	1.38
1970–1975	4.45	2020–2025	2.10	2070–2075	1.32
1975–1980	3.84	2025–2030	2.02	2075–2080	1.26
1980–1985	3.59	2030–2035	1.95	2080–2085	1.25
1985–1990	3.39	2035–2040	1.82	2085–2090	1.24
1990–1995	3.04	2040–2045	1.74	2090–2095	1.24
1995–2000	2.79	2045–2050	1.67	2095–2100	1.23

Source: United Nations, medium variant, 2010 revised.

population. So population will continue to grow even if the fertility rate drops because the fertility rate will be applied to a disproportionately large number of people. Population will not stabilize until the age distributions within the population reach equilibrium. This is called the “population lag effect” or “population momentum”.

The fertility rates by region are shown in Table 2 and vary greatly among regions. The fertility rate of Europe is well below the developed country replacement rate of 2.1. Populations in these countries are shrinking. This will cause a significant problem in these countries because the number of retired people is disproportionately large compared to the number of working individuals. This situation can be ameliorated through immigration from other countries. The opposite end of the spectrum is Africa where the fertility rate is well over the replacement rate and population growth is expected to continue into the future.

The fertility rate also varies greatly among countries. Figure 2 shows the fertility rate of countries of the world. Most of the

countries in Sub-Saharan Africa have very high fertility rates.

Table 2. Fertility Rates by Region of the World

Region	Fertility Rate
Europe	1.53
North America	2.03
Asia	2.03
Latin America	2.30
Oceania	2.49
Africa	4.64

Source: The Economist

Agriculture’s Track Record in Feeding the World’s Population

World agriculture has been successful in keeping up with world population growth over the last half of the 20th Century. In fact, agriculture’s food production has increased faster than population during this time period. As shown in Figure 3, the value of food production has increased

Figure 2. World Fertility Rates (2005 – 2010).

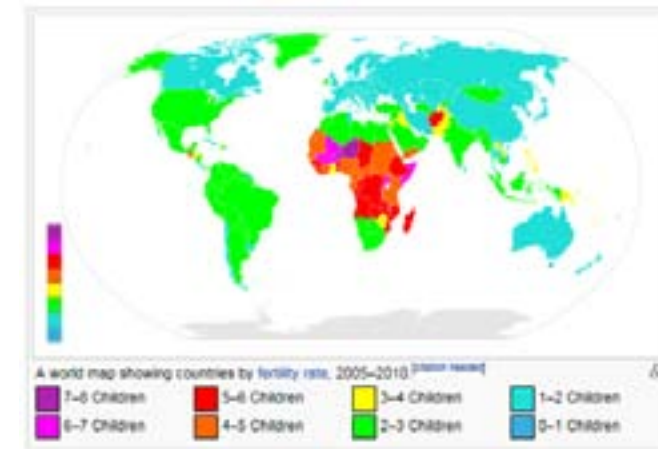


Table 3. Increase in World Production of Top Ten Major Commodities (1969 - 2009) (metric tons)

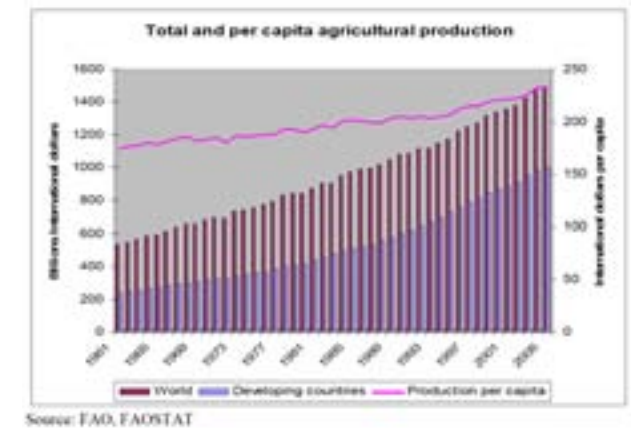
Crop	1969	2009	Percent Increase
Sugar Cane	538	1661	209%
Maize	270	819	203%
Wheat	309	686	122%
Rice, paddy	296	685	131%
Cow Milk	358	583	63%
Potatoes	278	330	19%
Vegetables	71	249	251%
Cassava	95	234	146%
Sugar Beets	217	227	5%
Soybeans	42	223	431%

Source: FAO

rapidly during this period, most of which occurred in the developing countries. The figure also shows the upward trend in the value of food production per person during this time period.

The increase by commodity varied greatly. As shown in Table 3, the top ten (by level of production) commodities in the world increased during the last 50 years. Wheat and rice more than doubled in production. Maize experienced a twofold increase and soybeans a fourfold increase. Cassava, an important commodity in developing countries, more than doubled during this time period. Vegetable production increased by

Figure 3. Total and Per Capita Agricultural Production



Source: FAO, FAOSTAT

250 percent while potatoes experience just a modest increase.

Although world agricultural production has increased faster than population growth, resulting in an increase in production per capita, the increases have not been distributed evenly across the globe. Production growth rates per capita for selected regions of the world are shown in Figure 4. The turquoise colored bars on the right of each grouping show the growth rate for the entire 1961 – 2004 period. East

& South East Asia shows almost a 1.5% annual increase. However, Sub-Sahara Africa shows a decline in per capita agricultural production during this period. Average caloric intake per person per day for Sub-Saharan agriculture averaged about 2,100 calories while developing countries as a whole averaged about 2,650 calories per person.

Although the average situation in Sub-Saharan Africa showed a modest decline over the time period, the situation among African countries varied greatly. Of 26 Sub-Saharan African countries, 10 experienced food production declines from 1990

to 2004. The Democratic Republic of Congo declined the most with an average decline of 4.5 percent per year.

As shown in Figure 5, 37 out of 70 developing countries are considered food insecure countries. A food insecure country is a low income country where over 40 percent of the population is considered food insecure. Most food insecure countries are located in Sub-Saharan Africa, the same region that has the highest fertility rate as shown in Figure 2.

Can Agriculture Meet Future Food Needs?

World agriculture has met the food needs of an increased population and expanded world economy during the last half of the 20th Century, agriculture’s ability to meet the needs of an additional two billion people during the first half of the 21st Century is an open question. The World Bank estimates that agricultural productivity will need to increase by two-thirds over the next 50 years. Below I will discuss ways of increasing agricultural production and some of the issues involved in these methods.

Figure 4. Growth Rate in Total Agricultural Production Per Capita in Different Regions

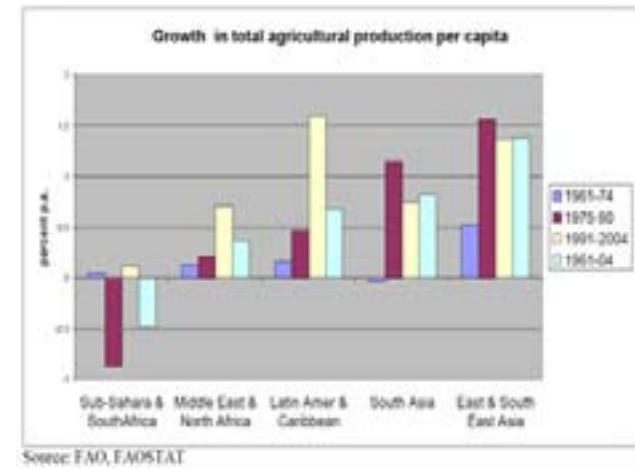


Figure 5. Food Insecure Countries

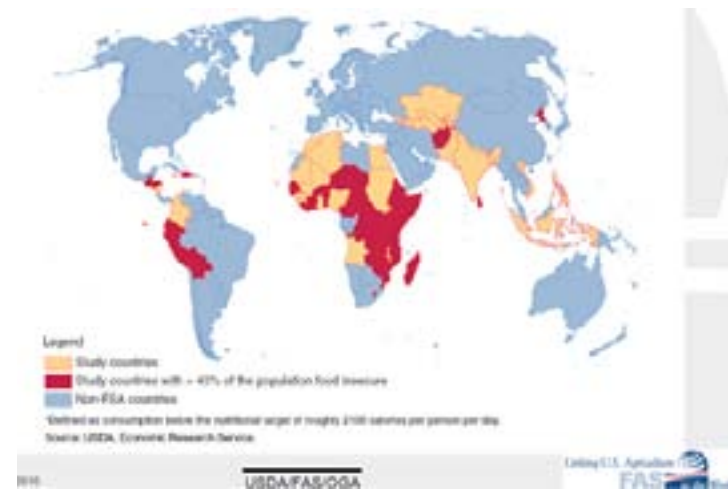


Figure 6. 2010 Global Production, Area & Yield (for Wheat, Soybeans and Corn)

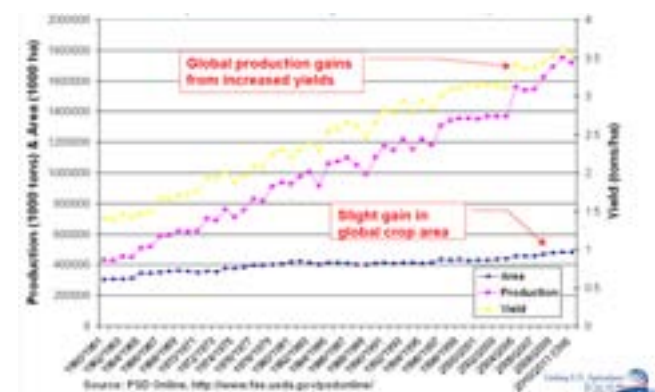


Figure 7. Historic Corn Yields



Increase Yields and/or Expand Cropland Area

The traditional approach to increasing world food production has been by expanding production area and increasing yields. The historic increase in world production of the three major commodities of wheat, corn and soybeans is shown in Figure 6. Production increased from just over 400 million metric tons in 1960 to over 1,700 million metric tons in 2010. Almost all of the increase came as a result of yield increases. Cropland area expanded only modestly over the time period.

Looking forward to 2050, the lion's share of the production increase will need to continue to come from increasing yields.

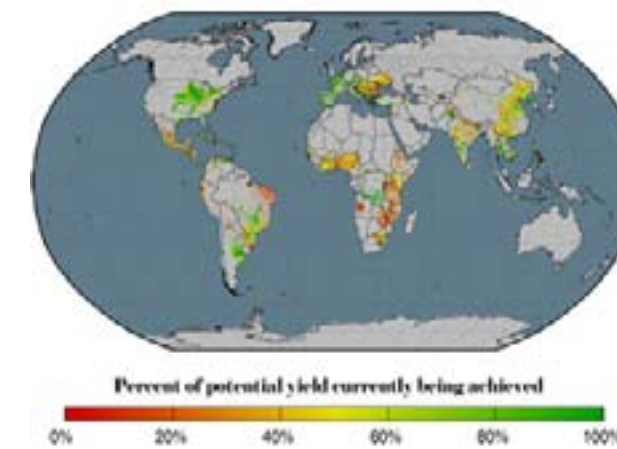
The ability to significantly increase farmland area is limited. In addition, the environmental damage and greenhouse gas emissions from expanding land area are great as discussed in AgMRC newsletter article, "Agricultural Research Combats Global Warming." So the focus will continue to be on increasing yields to meet world food demand. Concerns have been raised about the ability of the U.S. and other parts of the world to continue to increase yields due to reduced expenditures for research and technology, and rising input costs as more countries expand their use of fertilizer and other key inputs. Another major impediment is the impact that global warming and climate change will have on agriculture production levels as discussed in AgMRC newsletter article

"Climate Change Beginning to Impact Global Crop Production."

Yield Gaps

Historically, yield increases have not been consistent across the planet. Let's use corn yields as an example. As shown in Figure 7, the U.S. has led the world in corn yield increases. This is followed by more modest increases in the European Union. After being stagnant during the 1960s and 1970s, the Middle East and South America have experienced significant yield gains. The former Soviet Union and Sub-Saharan Africa yields have lagged the rest of the world.

Figure 8. Yield Gap for World Maize Production



Source: Can We Feed the World and Sustain the Planet? Scientific American

Yield gaps involve focusing on parts of the world where yields are not at the level they should be considering the current state of technology. Continuing the corn example, Figure 8 shows regions of the world where the yields gaps occur. Most noticeable are areas of Eastern Europe, Africa and Eastern Asia.

Researchers at the Institute on the Environment at the University of Minnesota have estimated that closing the yield gap for the top 16 crops worldwide could produce 50 to 60 percent more food. This would involve raising crop yields of the world's most ineffective farms to 95 percent of the best yields attained by farmers in similar climates. So another way of increasing production is by filling yield gaps.

A dimension of filling yield gaps and/or increasing yields overall is the additional crop production inputs needed to achieve these increases. Of special importance are the added fertilizer requirements and the demand on the world fertilizer industry to source of these fertilizers.

Reduce/improve Meat Production

Increased food demand over the next forty

Table 4. Changes in Consumption of Animal Products

	Developing countries				Developed countries			
	1970	1980	1990	2003	1970	1980	1990	2003
Annual per capita meat consumption (kg)	11	14	19	29	65	75	82	80
Annual per capita milk consumption (kg)	28	34	38	48	188	194	201	202
Total meat consumption (million MT)	29	47	74	143	70	88	103	107
Total milk consumption (million MT)	74	112	152	240	203	227	253	268

Source: FAO, FAOSTAT 2007

years will come not only from the two billion person growth in world population but also from low income people in developing countries moving into the middle class. As people make this transition, they demand better diets. A large portion of this improvement is moving from direct consumption of grains to meat consumption. Because it takes multiple pounds of grain to produce a pound of meat, the amount of grain consumed increases as people make this transition.

Of the two-thirds total growth in agricultural productivity needed over the next 50 years, the World Bank estimates that it will need to increase by a quarter just to meet the needs of improved diets from people with rising incomes. So diet improvement is an important part of the equation for meeting future food demand. However, there may be a silver lining. The fertility rate tends to drop as incomes rise. Rising incomes across the globe may eventually slow or even stop population growth.

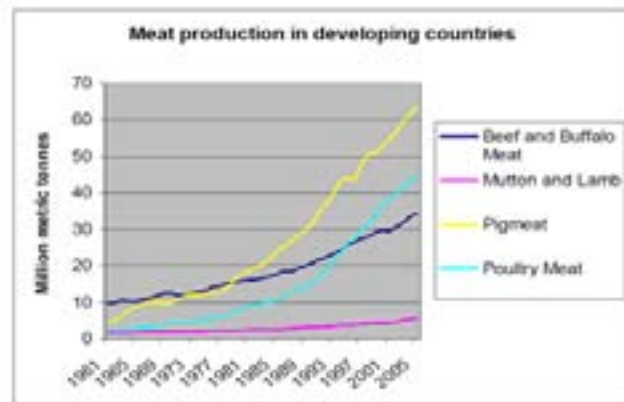
Changes in the consumption of animal products for both developing and developed countries are shown in Table 4. Although per capita consumption of both meat and milk has increased for both developing and developed countries over the 33 years, the increases among developing countries have occurred more rapidly. When combining the increase in per capita

consumption with population growth, the increase in animal product consumption in the developing world is huge (e.g. meat consumption increased from 29 million metric tons to 143 million metric tons). Even with this large increase in animal product consumption, there is room for additional large increases in animal product consumption before the developing countries catch up with consumption in the developed countries (e.g. 48 kilograms per capita milk consumption to 202 kilograms per capita). Of course the future increase in animal products consumption in developing countries depends on their rate of economic growth.

Due to the increased demand for meat products in developing countries, the supply of meat production in these countries has also been expanding rapidly as shown in Figure 9. Poultry and pork production have expanded the most rapidly. These two meat sources are among the most efficient in converting grain into meat, although some types of sea food production may be even more efficient. However, the pounds of grain fed to animals still exceed the pounds of edible meat produced by the animals.

The ability of the world to meet the increased food needs by 2050 could be improved if the world reduced its consumption of animal products. Reduced meat consumption would free-up large quantities of grain to be consumed directly. Dietary studies indicate that reduced meat

Figure 9. Meat Production in Developing Countries



Conclusion

Although world agriculture has met the food demand of growing populations and expanding economies over the last half of the 20th Century, it faces a continued challenge to meet the continued growth in food demand over the last half of the 21st Century. In this article I have attempted to outline the issues involved and discuss ways of meeting this challenge. We must be diligent in meeting this challenge and make the necessary public and private investments of resources. We cannot simply assume that, although we met the food needs of the last 50 years, we will easily meet the food needs of the next 50 years.

The inclusion of renewable fuels from biomass sources further complicates the situation. In general, biofuels may have a difficult time competing with food demand from developed countries. Conversely, the food demand of developing countries may have a hard time competing with biofuels. This may be particularly evident for Sub-Saharan African populations that have low incomes, high population growth rates, stagnant economies and dwindling food production per person.

Rising incomes of people in developing countries allows them to compete for food more effectively, but it also increases overall world food demand making the competition between food and biofuels more intense. Rising incomes will also increase the demand for energy, which will in turn impact biofuels demand.

The corn ethanol industry has been criticized for moving corn from food to fuel uses. However, we must remember that even producing non-food energy crops

consumption may lead to greater health in the developed countries. However, it is unlikely that per capita animal product consumption will decrease significantly in developed countries and meat consumption will continue to increase in developing countries. The way to impact the situation is to increase the efficiency of converting grain to animal products. The concepts of increasing yields and correcting yield gaps in grain production (discussed earlier) can be applied to animal product efficiency. However, this will require the world to make greater investments in research and outreach.

Reduce Food Waste

Generally it is assumed that all of the food that is produced is consumed. This is a faulty assumption. In the U.S. and other developed countries about 30 percent of the food is wasted at the point of consumption as discussed in AgMRC Article, "Domestic Perspectives on Food versus Fuel." To realize this you only need to think of buffets and other retail outlets of prepared foods to understand the level of waste. In the developing countries the waste occurs early in the supply chain due to failed crops, poor storage methods and problems transporting commodities. Efforts to reduce food waste in both developing and developed countries could make a substantial impact on our ability to feed nine billion people by 2050.

(e.g. switchgrass) impact food production. Total cropland area is relatively fixed and increasing the acres of energy crops will displace acres of food crops. So the competition between food and fuel continues.

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Arriving at the Ethanol Blend Wall: Will 2011-12 Corn Use for Ethanol Reach Current Projections

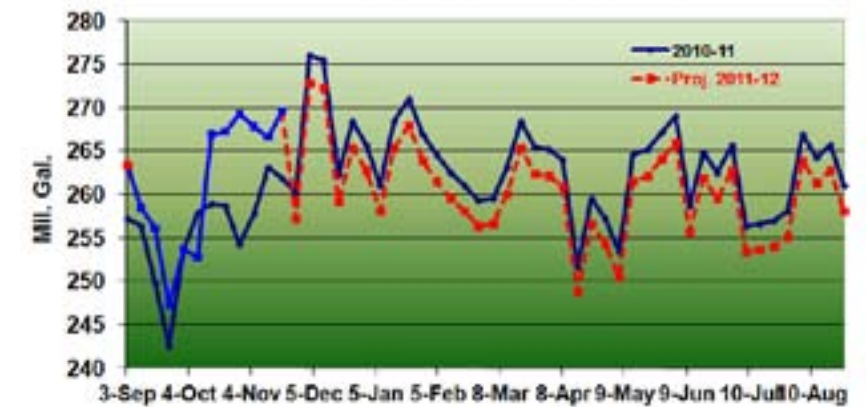
by Robert W. Wisner, agricultural economist, rwwisner@iastate.edu

A recent report by the Environmental Protection Agency (EPA) indicates the U.S. national average blend of ethanol with gasoline for the last several months has slightly exceeded 10%. For the ethanol industry, 10% is a special number believed to represent the "Blend Wall" at which the domestic ethanol market becomes saturated or almost saturated. The saturation point stems from the 10% ethanol-gasoline blend that is allowable for all gasoline-powered vehicles regardless of age. A small additional ethanol market is available through sales of E-85, a blend of 70% to 85% ethanol and 15% gasoline. However, this market is limited by (1) the very small percentage of retail gas stations that sell E-85, (2) the limited number of flex-fuel vehicles (the only type EPA has approved for its use), and (3) lack of price competitiveness of E-85. In many E-85 stations, E-85 has not been priced low enough relative to gasoline to offset the sharp decline in fuel mileage that occurs with E-85.

With the U.S. average ethanol-gasoline blend now at or very slightly above 10% ethanol, can ethanol use meet the mandated increases for 2012 and in the next four years?

EPA also has recently approved the use of E-15 in 2001 or newer gasoline-powered vehicles. E-15 is a blend of 15% ethanol and 85% gasoline. However, gasoline retailers have been reluctant to begin selling E-15 for a number of reasons including (1) concerns about liability issues since it is not acceptable for all vehicle model years, (2) needed investments in additional tanks and pumps, and (3) in some cases limited space for more tanks. Some consumers also are concerned about auto warranty issues if they use this fuel in non-flex-fuel vehicles. Retail blender pumps that can

Figure 1. Weekly U.S. Ethanol Production, 2010-11 and Needed 2011-12 for USDA Projection



provide various ethanol blend levels may avoid some of the extra expenses otherwise required for marketing E-15 and may facilitate gradual opening up of this market. However, the main market for fuel ethanol is E-10.

With the U.S. average ethanol-gasoline blend now at or very slightly above 10% ethanol, questions are being raised about whether ethanol use will be able to meet the mandated increases for 2012 and in the next four years. These increases are spelled out in the 2007 Energy Independence and Security Act (EISA). In this article, we address the question of whether the 10% average blend will prevent the ethanol industry from processing 5.0 billion bushels of corn into ethanol and distillers grain (DGS) in the current 2011-12 corn marketing year, as projected in the latest USDA supply-demand report. (4)

Weekly Ethanol Production

Figure 1 shows weekly U.S. ethanol production in millions of gallons, as reported by the Energy Information Agency (EIA)

of the Department of Energy. These data are available only for 2010 and 2011. The data show a different total than implied by using the most recent Economic Research Service (ERS), USDA data on corn processed into ethanol and a 2.78 gallons per bushel ethanol yield commonly used by grain analysts and USDA. This implies that (1) either the weekly data understate actual production by 2.5% or (2) the ethanol yield per bushel of corn has been lower than widely believed, at 2.71 gallons per bushel. We have no explanation for the difference in ethanol yields although denaturing might be a factor. In this article, for bushels of corn used for ethanol and distillers grain (DGS) production, we will continue to rely on USDA data. For the weekly and annual ethanol production and production change from last season, we will continue to use EIA data and convert USDA corn bushels to ethanol with a 2.71 conversion factor. In Figure 1, we calculate needed ethanol production for the rest of the year using 2.71 gallons per bushel to convert USDA's annual 5.0 billion bushels of corn use for ethanol to annual ethanol production. Figure 1 indicates average weekly ethanol production so far this season has been about 2.1%

Figure 2. Brazil Ethanol Exports

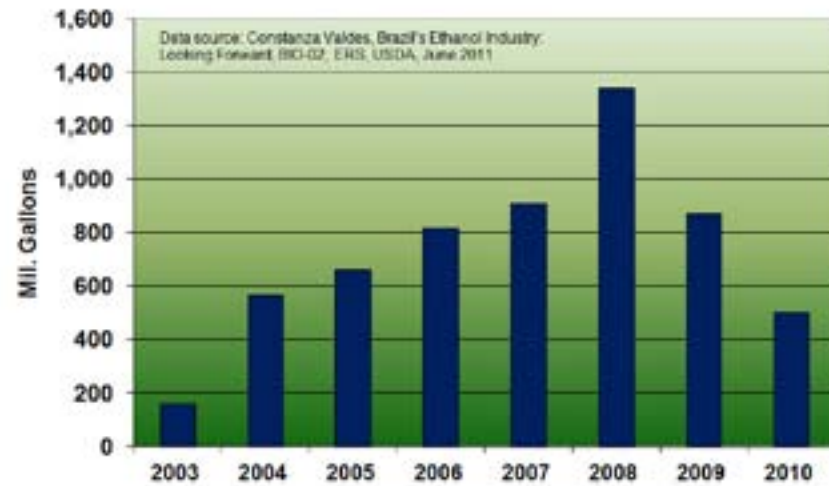


Figure 3. Monthly Denatured U.S. Ethanol Exports



above the same weeks last year. For the remainder of the current September 1, 2011-August 31, 2012 corn marketing year, average weekly ethanol production will need to be about 0.94% below a year earlier to reach USDA projections, as indicated by the dashed red line. The ethanol industry, faced with exceptionally good economic returns this fall and a strong likelihood of losing both the blenders' tax credit and the ethanol import tax by year-end, has moved production above a year earlier and may continue to do that for the rest of this calendar year. Production levels from the beginning of 2012 onward

are more uncertain because of the likely change in government ethanol incentives.

Ethanol Exports

Ethanol exports are one way the biofuels industry may continue its growth even with a domestic blend wall and loss of domestic blenders' tax credits – at least for the short term. Starting in February 2010, the U.S. became a net exporter of ethanol. (5) Since then, U.S. ethanol exports have been relatively strong. However, for the longer term -- barring unfavorable weather

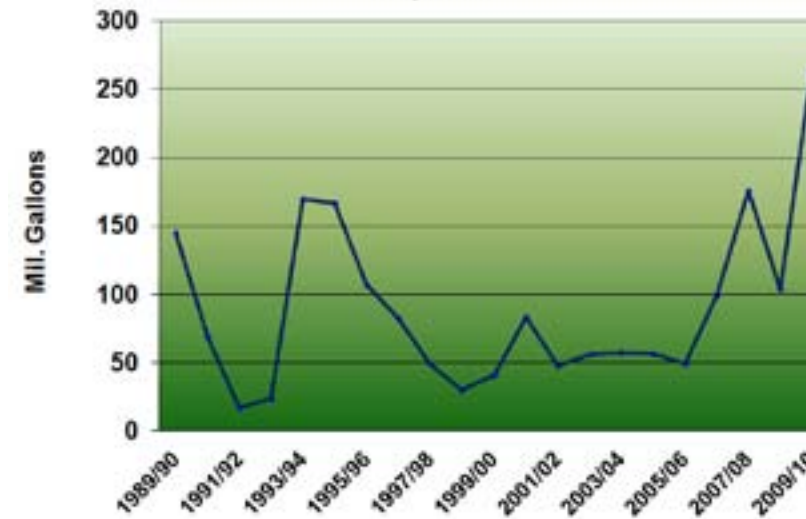
in major foreign sugar-producing areas-- expansion of U.S. ethanol exports may be more difficult. Brazil has been the major competitor in the global ethanol market, but growing world demand and less than ideal weather in India and Brazil have tightened sugar supplies and sharply increased world sugar prices in the last two years. These two countries are the world's largest sugar cane producers. (6) Tight sugar supplies in turn have encouraged Brazilian sugar processors to use more of their production for sugar and relatively less for ethanol. As a result, high sugar prices have tightened Brazil's ethanol supply and reduced its exports. In addition, Brazil's domestic demand for ethanol is continuing its upward trend as consumer incomes increase. This year, the U.S. has exported small quantities of ethanol to Brazil. (7)

Figure 2 shows Brazilian ethanol exports since 2003. After increasing rapidly from 2003 through 2008, its exports reached a peak of 1.34 billion gallons. Since then, Brazilian exports have fallen by 63% or nearly 840 million gallons. That's equivalent to the ethanol from about 310 million bushels of corn. (8) Reduced Brazilian ethanol exports have paved the way for increased U.S. ethanol exports. From 2008 to 2011, assuming October-December 2011 exports continue at the average of the first nine months of this year, U.S. ethanol exports will have increased by a corn-equivalent of approximately 290 million bushels. At that rate, the 2011 calendar year annual U.S. ethanol exports would be approximately 955 million gallons or 350 million corn-equivalent bushels.

For the year ahead, recent sugar and ethanol data from Brazil suggest sugar supplies will continue to be tight and likely will prevent a major increase in its ethanol production.

U.S. ethanol exports also are being helped by foreign government mandates that require increased ethanol blend levels in

Figure 4. Total Marketing Year U.S. Ethanol Exports



gasoline, especially in the EU and Canada. Figure 3 shows U.S. monthly fuel ethanol exports so far this calendar year and comparisons with last season. Export data from the U.S. Energy Information web site are only available for 2010 and 2011. Monthly ethanol exports so far this year have been well above 2010 levels but have fluctuated in a wider range. These data are identified as fuel ethanol exports and do not include ethanol exported as beverages or for use for other industrial purposes.

Marketing year ethanol exports continuing at an annual rate of 920 to 970 million gallon range for 2012 would allow the U.S. ethanol industry's production to modestly exceed EISA mandates, thus moving ethanol production and corn use for ethanol above the domestic blend wall.

Figure 4 provides a longer term perspective on U.S. September-August marketing year ethanol exports. Before 2009-10, exports were much lower than now and sometimes showed large year to year swings. Tight world sugar supplies and reduced Brazilian exports are the major factor in the sharply higher U.S. ethanol exports in the last two years. Underlying tight global sugar supplies are a caution

that for the longer term, some weakness in U.S. ethanol exports is a strong possibility.

EISA Corn-starch Ethanol Mandates

Mandated levels of ethanol blending in U.S. gasoline are shown in Table 1, along with equivalent corn bushels and corn use for ethanol in the last few years. Equivalent corn bushels are calculated using 2.71 gallons of ethanol per bushel of corn, the ethanol yield used above to reconcile USDA data on corn bushels used for ethanol with EIA data on ethanol production.

The ethanol mandates increase each year through calendar year 2015. In that year, they reach a peak of 15 billion gallons and remain constant through 2022. For the 2011-12 marketing year, the mandate increases by 0.60 billion gallons. On a marketing year basis for 2011-12, that would be equivalent to an increase to ethanol produced from approximately 4,798 million bushels of corn. Last season's corn-equivalent mandate was approximately 4,576 million bushels of corn, although USDA data indicate the industry processed 5,021 million bushels into ethanol and distillers grain. In other words, the industry processed approximately 445

million bushels or 10% more corn into ethanol than mandated by EISA. Ethanol exports account for about 300 million bushels of the excess beyond the mandated level.

It should be pointed out that our calculations of the marketing year mandates are approximations. For example, we combine four months of the 2010 calendar year mandate with eight months of the 2011 marketing year mandate to arrive at the 2010-11 marketing year total mandate. As an example of potential limitations from this approach, corn processing for ethanol in the first part of the calendar year may have been below the monthly equivalent of the mandate, thus leading to a need to produce above the monthly average mandate for the remaining months of the calendar year. In that case, the following marketing year's effective mandate might be above (or sometimes below) our estimated marketing year mandate.

RINs Requirements

Renewable Information Numbers (RINs) are the mechanism for enforcing ethanol blending mandates. Each gallon of ethanol is issued a RIN that is submitted to the EPA when the ethanol is blended to fill mandated requirements. For ethanol blending which exceeds the mandates, RIN credits can be carried over to the next year and used in place of actual blending for that year. (9) RINs also are required for unblended ethanol that is exported, but unblended exports do not count toward the mandates. Most U.S. fuel ethanol exports are unblended.

2010-11 and 2011-12 Corn Processing for Ethanol and DGS vs. the Mandate

Adding the marketing year corn equivalent mandate for 2010-11 of 4,576 million bushels and 300 million bushels corn equivalent of ethanol exports gives a total

of 4,876 million bushels corn equivalent of ethanol which would have required RINs being submitted to EPA, theoretically leaving about 145 million corn equivalent bushels of excess RINs may have been generated in the 2010-11 marketing year. A portion of these excess RINs might be used in place of actual blending in 2012. If so, they would tend to slightly reduce ethanol demand and could contribute to slightly less corn being processed than implied by the mandates.

With 2012 ethanol exports continuing at the 2011 monthly average, the increased mandate and exports together would require the alcohol from about 5.1 billion bushels of corn. That's 100 million bushels above USDA's current projection for the 2011-12 marketing year. Whether actual corn use for ethanol reaches that level will depend on availability of excess RINs that can be substituted for actual ethanol blending with gasoline, as well as ethanol exports.

Data on RINs issued, already used, and assigned or available for use can be accessed on an EPA web site. <http://www.epa.gov/otaq/fuels/rfsdata/2011emts.htm> These data suggest that on October 24, 2011 about 145 million bushels corn equivalent of ethanol (D6) D6 is the other renewable fuel category, which is primarily corn starch ethanol along with small amounts of ethanol from other feedstocks, including grain sorghum, potato and dairy wastes from facilities that do not qualify as advanced biofuels. RINs had not yet been used. It is uncertain what this total may be at the end of December. Recent weekly ethanol production rates suggest the total may increase some. Whether that is the case will depend partly on U.S. ethanol exports for the rest of this year. With no change in exports, some or all of these RINs might be used to reduce corn processing for ethanol later in the current marketing year to or slightly below USDA's 5.0 billion bushel projected level.

For 2012-13, the mandated level of ethanol blending in gasoline will increase by another 600 million gallons or in corn equivalents, an additional 220 million bushels. If ethanol exports continue at the 2011 rate, theoretical corn processing for ethanol would be about 5.32 billion bushels. However, with the U.S. average ethanol gasoline blend already slightly exceeding 10%, it is questionable whether this level of ethanol production can actually be reached. Unless the retail gasoline sector moves quickly to market E-15 or more E-85, the blend wall may become a restraint on corn processing and ethanol production.

Looking beyond 2012-13, the marketing year equivalent corn-starch ethanol mandates increase by an additional 1.4 billion gallons in the following three years, at which they reach a maximum 15 billion gallons that remains constant through 2022. At the current annual gasoline consumption rate, the national average gasoline blend at the 15 billion gallon level would be about 11 to 11.3%. An average blend at that level is possible but will depend on industry moves to market E-15 and/or competitive pricing of E-85 to make it economical for consumers. Without an increase in the blend wall, demand for corn at ethanol processing plants might start to level off in 2012 or even decline if ethanol export demand weakens.

Summary and Conclusions

The ethanol industry is facing prospects for three important developments that relate to future size of its market. One is related to government mandated ethanol blending requirements for motor fuel. The other two are (1) exports and (2) the "blend wall". For the last three years, the corn-starch ethanol industry has anticipated that a "blend wall" would be reached, at which time the domestic fuel ethanol market would become saturated. Until the blend wall was raised or removed, further growth in demand for ethanol would be limited mainly to (1) growth in domestic

motor fuel consumption, (2) growth in ethanol exports, and/or (3) growth in the E-85 market through increased availability at retail stations, an expanded flex-fuel vehicle fleet, and competitive pricing of E-85. EPA's approval of E-15 for 2001 and newer vehicle models was intended to raise the blend wall. However, so far the retail petroleum industry has been slow to accept and market E-15, so that this source of market growth has been minimal. EPA data indicate the domestic blend wall has now been reached.

Unless higher gasoline-ethanol blends become more widely accepted soon, increases in mandated levels of ethanol blending may be on a collision course with the blend wall. This prospect raises important questions for both the corn-starch ethanol industry and the infant cellulosic ethanol industry that is expected to emerge in the next few years. Differential ethanol policies that vary by feedstock and technology are reflected in the number of RINs gallons issued per actual gallon of ethanol as well as in the cost to the petroleum industry for purchasing credits that will allow it to bypass mandated blending levels. These policies may become important in determining which type of ethanol has greatest ability to access a limited domestic market. Costs of purchasing RINs to fulfill mandated obligations without actual ethanol blending also may become increasingly important to the industry. These are possible topics for future articles.

Arrival of the blend wall also has important implications for corn demand. Our analysis suggests that with continued relatively strong ethanol export demand, corn processing for ethanol and DGS may be close to USDA projections for the 2011-12 marketing year. However, because of availability of some excess RINs, actual corn use for ethanol has some potential to be slightly below USDA projections. For the 2012-13 and later marketing years, growth in corn demand for ethanol appears likely to be restrained unless E-15 and/or E-85 become widely accepted soon

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November Update - Will There be Enough Corn?

by Robert W. Wisner, agricultural economist, rwwisner@iastate.edu

In September we looked at corn availability for the year ahead, based on the USDA September 12 crop report. Although the production forecast was well below total corn use in the marketing year ending August 31 and was lower than indicated in August, corn prices have fallen sharply since then. The price decline has been due primarily to (1) heightened concern about the European sovereign debt crisis, with fears that some countries may default on debt, placing large international banks and the world economy at risk, and (2) USDA's September 30 U.S. corn and wheat stocks report. The stocks report showed 160 million bushels more U.S. corn in storage on September 1 than anticipated by the grain trade and less wheat feeding than expected. Thus, U.S. corn supplies will not be as tight as previously anticipated. The reported stocks suggested domestic corn feeding has already been sharply curtailed, a conclusion that looks out of line with other indicators. The October 12 USDA crop report showed an additional 64 million bushel decline in expected 2011 corn production, along with an additional 123 million bushel decline in the November 9 crop report.

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8 Data are from Constanza Valdes, Brazil's Ethanol Industry: Looking Forward, BIO-02, FAS, USDA, June 2011.

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10 Office of Transportation and Air Quality, US Environmental Protection Agency, National Renewable Fuel Standard Program - Overview April 14 - 15, 2010

The reported stocks suggested domestic corn feeding has already been sharply curtailed, a conclusion that looks out of line with other indicators.

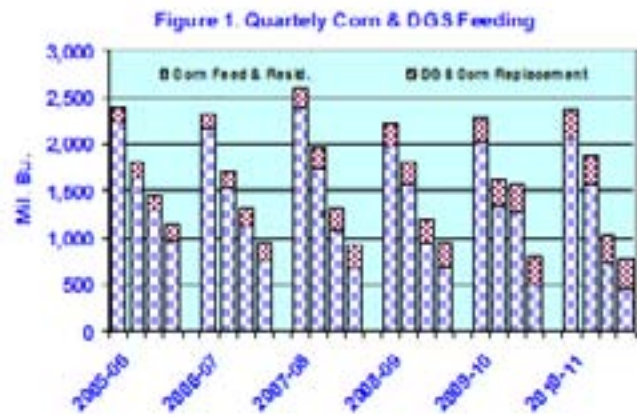
Analysts use quarterly grain stocks to calculate corn and wheat feeding. Feed use is not measured directly but is calculated as a statistical residual. Known uses indicated by processing and export data are subtracted from beginning supplies. Then, after subtracting ending supplies, the difference is termed "feed and residual disappearance." The "residual" portion reflects spoilage, handling losses, and possible statistical errors.

Analysts are puzzled at the relatively low summer quarter corn feed and residual disappearance for the second consecutive year. Large livestock numbers and severe drought with lack of pasture and forage for cattle feeding in the southern Great Plains were believed to have boosted grain feeding. The lower-than-expected wheat feed and residual number would be expected to support June-August corn feeding.

In this article, we provide an updated look at corn availability for feed and other uses in the year ahead and potential reductions in use, taking into account USDA's November 9 crop production estimates and the September 30 grain stocks report.

Summer quarter corn feeding

The amount of corn fed domestically can be influenced by a number of factors including (1) corn quality, (2) availability of other grains at competitive prices – primarily sorghum and wheat, (3) livestock and poultry marketing weights and numbers, (4) availability of forage and pasture for cattle, and (5) more recently availability of large quantities of distillers grain (DGS). Quality of the 2010 U.S. corn crop was quite good, thus tending to slightly reduce the amount of corn needed per pound of animal products produced when compared to the lower quality 2009 crop. Sorghum supplies appeared to be relatively tight, but a plentiful supply of competitively priced soft red winter wheat was expected to have replaced some corn



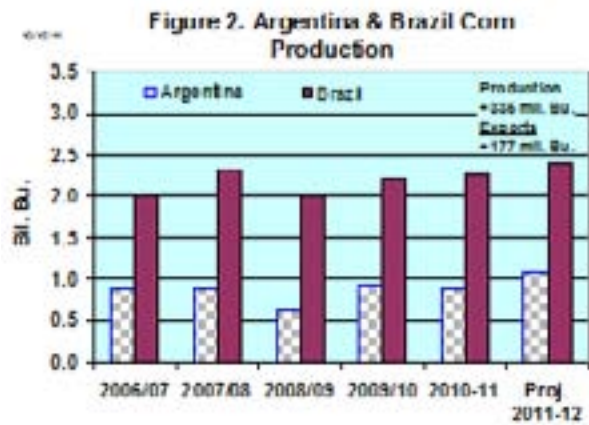
feeding during the summer. However, wheat production and stocks data showed less wheat feeding than expected. These developments and livestock numbers indicate corn feeding should have been modestly above a year earlier. Distillers grain (DGS) supplies increased modestly from a year earlier during the summer quarter, as anticipated by the grain trade, but could not account for the difference between actual and expected stocks.

Figure 1 shows USDA estimates of quarterly corn feed and residual disappearance for the last few years and our estimates of the amount of domestic corn feeding replaced by DGS after deducting exports. We assume 23% of 2010-11 DGS production was exported. Estimated substitution of domestic DGS feeding for corn is based on corn replacement ratios that vary by livestock species. The highest replacement ratio is for beef cattle feeding, with substantially lower corn replacement ratios but higher soybean meal replacement ratios for dairy, hogs, and poultry. In Figure 1, the first vertical bar in each annual set moving from left to right represents the September-November quarter. The second represents December-February, the third March-May, and the last shorter bar is the June-August quarter. The lower part of each bar is USDA's estimated corn feed and residual disappearance while the upper part is our estimate of corn replaced by DGS. Note the substantially lower summer quarter bars for the past two years when compared to earlier years. In the

preceding three years, the average summer quarter total for corn and DGS was 940 million bushels, ranging from a low of 920 million bushels to a high of 952 million. For the last two years, summer quarter totals averaged 776 million bushels, with last year being 17 million bushels above the average and this year being 16 million bushels below it. The difference is even more pronounced when summer wheat feeding is included. June-August combined corn, DGS, and wheat feeding totaled an estimated 965 million bushels, down 22% from the 2007-2009 summer quarter average.

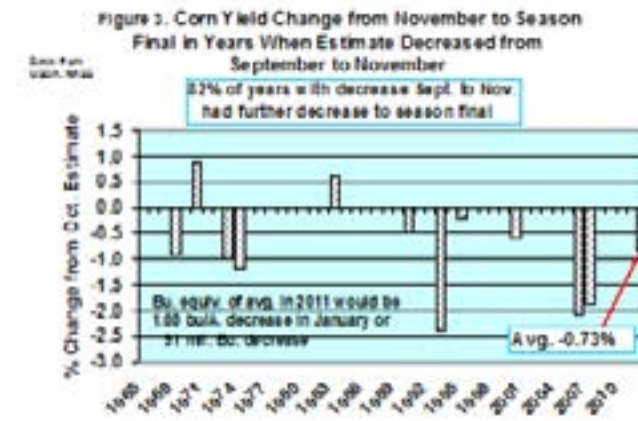
Wheat feeding almost always is greatest in the summer quarter and is quite light later in the year. September 1 stocks data indicate this year's summer wheat feeding was much less than expected at 21% less than a year earlier. Soft red wheat cash prices were below corn for most of the summer and should have encouraged wheat feeding. However, some analysts believe the large carry in Chicago wheat futures from nearby contracts to spring delivery months would encourage wheat storage rather than using it for feed. Others argue that the wheat basis could be very weak in the spring, thus possibly eliminating much of the storage return reflected in the market carry.

This sharp decline in indicated summer quarter corn and wheat feeding creates much more uncertainty than usual in



projecting corn feed and residual use for the year ahead. Animal numbers and other conditions suggest June-August grain feeding should have been substantially larger. Is the lower summer use a pattern that will continue in the current marketing year? Or is it a statistical problem, perhaps indicating last year's corn crop was under-estimated by around two bushels per acre? Others have raised questions about the accuracy of the September 1 stocks estimates. Historically, analysts have considered the grain stocks data to be more accurate than production numbers. A number of analysts a year ago indicated the unusually low summer 2010 corn feed and residual use may have been due to aggressive feeding and exports of early harvested new-crop corn in southern states. This year, the volume of early-harvested corn likely was lower than a year earlier. Early harvested 2010 corn that was fed before September 1 (essentially substituting for old-crop corn) would allow old-crop stocks to be larger on September 1. The September 1 stocks report includes only old-crop corn to avoid double-counting of new-crop corn that might otherwise be reported both in the stocks and production numbers.

We take the view that last year's corn crop may have been modestly under-estimated. If so, September 1 corn stocks provide a larger initial corn supply than previously expected, but don't reflect sharply reduced corn feeding in the 2010-11 marketing year. Last year's corn feed and residual



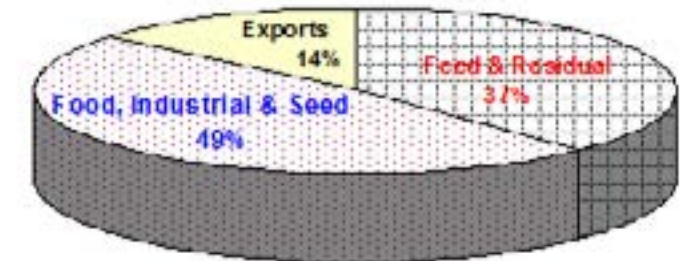
disappearance is a base for projecting corn feeding in the year ahead. Our assumption, if correct, suggests corn prices need to be high enough to reduce domestic corn feeding by about 4 to 5 percent from actual 2010-11 feed and residual use after taking into account tighter supplies of other feed grains and forage than a year ago. Expected adjustments to cut corn feeding include reductions in poultry numbers, and cattle on feed in the last half of the marketing year, as well as lighter livestock marketing weights.

Corn export prospects

In the international picture, corn faces strong competition from feed wheat from former Soviet republics (FSU) that harvested much better crops than a year ago. Also, the Ukraine will be a moderate corn exporter. World wheat stocks at the end of the current marketing year are projected to be a fully adequate 15.6 weeks' supply. Ending stocks are projected to be 6.47 million tons higher than a year earlier, with China and FSU stocks up 8.77 million tons. In other words, China and FSU account for essentially all of the projected increase in global wheat stocks. Forty six percent of global stocks are projected to be held by China and FSU, where the accuracy of stocks is questionable.

Global corn stocks are projected to decline by 10% or 590 million bushels, to a tight 8

Figure 4. Relative Shares of Major Uses of U.S. Corn, Projected 2010-11



weeks' supply. Forty one percent of these stocks are projected to be held by China. China will want to continue holding large stocks as a reserve against possible weather-induced short crops. Also note that accuracy of Chinese corn stocks is questionable.

Official USDA and Chinese government projections indicate China had a record 2011 corn crop and has adequate corn supplies. However reports from Chinese grain trade sources and the U.S. Grains Council continue to indicate China is likely to be a significant corn importer this season. At this writing, USDA reports their total 2011-crop purchases of U.S. corn at 88 million bushels, 616% above a year earlier.

The largest source of competition for U.S. corn is South America. Projections in USDA's November 9 World Crop Supply-Demand report show moderately increased corn production for that region next spring, assuming normal weather. However, as a caution in South American crop prospects, weather specialists indicate a La Niña weather pattern is present and could possibly intensify in the months ahead. Note from Figure 2 that Argentine and Brazilian corn production were reduced significantly by a La Niña drought in 2008-09. A repeat of 2008-09 weather in the South American growing season could increase export demand for U.S. corn in the last 2/3 of the current marketing year.

China also is reported to have an agreement to import two to three million tons of Argentine corn (80-120 million bushels) that normally would be shipped to other countries.

Based on estimated and projected foreign crops, we expect U.S. corn exports for the current marketing year to be 9 to 11% lower than last season but slightly higher than the latest USDA projection. U.S. corn export sales to date are up 1.2% from a year earlier. Eleven weeks into the new marketing year, an unusually high 53% of USDA's projected marketing year total exports is already sold. Crop prospects in South America and Chinese purchasing activity should be carefully monitored in the next three months for updated indications of export demand. Larger exports than currently projected would necessitate a further reduction in domestic corn feeding.

U.S. corn production

This year's combination of weather events has taken a serious toll on U.S. grain and oilseed crops. That picture was reinforced by USDA's National Agriculture Statistics Service in its November 9 crop production estimates. The U.S. average corn yield at 146.7 bushels per acre was down 1.4 bushels per acre from the October forecast. The average yield is estimated to be down from a disappointing

152.8 bushels last year, 153 bushels per acre in the August forecast, and a 1990-2008 trend yield of about 162 bushels per acre. Total production is forecast at 12.31 billion bushels. This estimate indicates production will be about 744 million bushels or 5.7% below reported corn utilization in the year ended August 31, 2011. The production estimate is still somewhat tentative and will be updated in the early January season-final crop report. At this writing, a considerable amount of corn remains to be harvested in Michigan, Ohio, Indiana, and Pennsylvania because of continued rains. That region produces about 1.7 billion bushels of corn.

About half of the adjustment to the smaller crop can be made by reducing corn carryover stocks, although that will eliminate any reserve supply to offset possible weather-reduced production next year. That leaves about 350 to 375 million bushels of cuts needed in corn use from last season. Important questions facing corn users are (1) which users will cut back in response to inadequate supplies, (2) what prices will be required to generate the required cuts in use, and (3) what adjustments will be needed to bring the reductions in use.

More changes ahead in crop estimates?

History indicates and January season-final USDA crop report could show an additional yield change, although any change is expected to be small.

Figure 3 provides additional insight into crop report changes from November to the season final estimates in years when the U.S. corn yield estimate declined from September to November. The average corn yield change from November to the season final estimate in these years was -0.73%. With no change in harvested acreage, that percentage yield change would cut an additional 90 million bushels from this year's production, with all of the decrease having to be adjusted for through

a further reduction in corn use. Most analysts do not expect a decrease of that amount, but no further change in the final corn crop estimate.

Will corn use for ethanol be reduced?

As indicated above, we expect corn feeding and exports to decline modestly this marketing year. Our projections place exports at 185 million bushels less than last season and domestic feed and residual use down about 42 million bushels from USDA reported 2010-11 feed and residual use (although we anticipate the cut from total use of all feed grains will be more like 160 to 200 million bushels). These two uses of corn are the third and second largest sources of demand, respectively. The largest source of demand is corn food and industrial use, which is strongly influenced by government ethanol blending mandates.

Figure 4 shows the relative sizes of these three corn use categories in the 2010-11 marketing year ended August 31. The composition of demand for corn has changed dramatically in the last seven years, with rapid growth of corn processing for ethanol and DGS. Food, industrial, and seed use has expanded to almost 1/2 of the total demand for U.S. corn. A key question in corn-user adjustments to this year's reduced supplies is whether corn use for ethanol will be reduced. USDA October 12, 2011 projections show only a 20 million bushel reduction from last season in that use category. If so, livestock feeding and/or exports will need to be reduced more than we are projecting.

The ethanol-DGS portion of the demand is strongly influenced by (1) the price of gasoline, (2) government ethanol blending volume mandates from 2007 energy legislation, (3) the ethanol blenders' tax credit, and (4) the price differential between gasoline and ethanol. Recent political developments and federal budget pressures strongly suggest that the 45 cents per

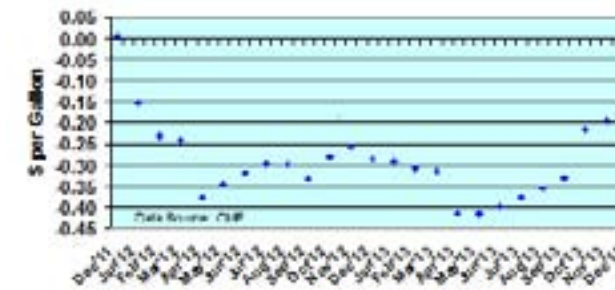
gallon ethanol blenders' tax credit will not be renewed when it expires at the end of this year. Thus, one major incentive for blending ethanol with gasoline will likely disappear. However, the mandates are expected to remain in effect. When corn supplies are extremely tight, the mandates create a perfectly price-inelastic demand for corn used by ethanol plants -- at certain minimum volumes. In other words, the amount of corn used for ethanol becomes insensitive to corn prices. At plentiful corn supplies and lower prices, the ethanol industry tends to produce ethanol above mandated levels if infrastructure permits it. If corn supplies become tight, the motor fuel industry is required to blend the mandated volumes of ethanol into gasoline, paying whatever price is needed to obtain the ethanol. This, in turn, would allow ethanol processors to pay whatever price is needed to obtain the required volume of corn for mandated ethanol blending.

The ethanol industry has been producing above mandated levels in the last few years. Excess production generates excess RINs, the renewable information numbers for each gallon of biofuel produced. These excess RINs can be substituted for actual ethanol blending with gasoline, provided their useable life hasn't expired and provided they haven't been used for ethanol exports. Ethanol exports don't count toward the mandates but do require RINs. Ethanol export demand has been increasing in the past two years. In corn-equivalent terms, the ethanol from about 310 million bushels of corn appears to have been exported in the marketing year ended August 31. For further detail on potential ethanol industry adjustments to a changing policy situation, see our article, "Arriving at the Ethanol Blend Wall: Will 2011-12 Corn Use for Ethanol Reach Current Projections?" in this newsletter.

Factors affecting blending economics

Without a blenders' tax credit, the economics of blending more ethanol than

Figure 5. RBOB Gasoline-Ethanol Price Spread in Futures 11/8/11 (Discount of Ethanol to RBOB)



mandated will depend partly on the premium of gasoline prices over ethanol. Premiums reflected by nearby and distant futures markets on November 8 are shown in Figure 5. The ethanol discount to gasoline is small or non-existent in the nearby futures months but increases gradually in distant futures to 30 to 40 cents per gallon in some months. This relationship is not a forecast, but is an approximate pricing opportunity for blenders, although it should be cautioned that the distant contracts are thinly traded. Large-volume trading might alter the relationship. Basis relationships will be another factor influencing blenders' decisions. Incentives for blending ethanol with gasoline vary over time and may also be influenced by potential reductions in costs of the enhancing gasoline octane content with ethanol blending. At times, the fuel industry may have incentives for blending more ethanol than required by EISA mandates, even without the blenders' tax credit.

Conclusions: where will corn use be reduced by tight supplies?

Corn processing for ethanol and DGS could possibly be reduced in this marketing year by 25 to 75 million bushels from 2010-11. However, that number should be viewed as very tentative. Whether a reduction materializes will depend on ethanol export demand, the price spread between gasoline and ethanol, the cost of corn, and the amount of unused RINs

that can be substituted for blending. Recent margins for processing corn into ethanol and DGS in efficient plants have been well above shut-down levels, based on data from the USDA's Agricultural Marketing Service and variable ethanol production costs from the AgMRC ethanol model. These returns and ethanol blending mandates suggest lower ethanol prices and/

or higher corn prices probably would be needed if corn use for ethanol and DGS is to be reduced moderately from the current USDA projection of 5.0 billion bushels.

Most of the required reduction in corn use appears likely to occur in livestock feeding and exports. Our updated corn balance sheet contains detail on projected supplies, utilization, and prices and is available at: <http://www.extension.iastate.edu/agdm/crops/outlook/cornbalancesheet.pdf>.

Season average prices for 2010-11 as well as for 2011-12 reflect a weighted average of farmer cash-market sales and forward contracted grain. Early forward contract sales of 2010-crop corn kept the weighted average price below the cash-market average. For 2011-12, early forward-contracted sales may raise the weighted average price above the cash market average.

Price implications

The corn, soybean, and soybean meal markets will likely remain quite volatile this fall, winter, and next spring as grain users and other market participants adjust to updated supply and demand information, South American crop prospects and a likely battle between corn, wheat and soybeans for more U.S. acres this winter and next spring. October-December

volatility, however, appears likely to be less than in the past 5 months. Concern about the European sovereign debt crisis and potential negative impacts of the global economy may slightly temper price volatility or skew it to the down-side in price movements.

Early indications point to a potential need for a combined 4 or 5 million more U.S. planted acres of corn and soybeans next spring, along with some increase in planted wheat acres.

The harvest-time basis (cash-futures price spread) for corn has been extremely strong, with eastern and western Corn Belt cash prices much closer to December futures than would normally be expected. The strong basis reflects limited old-crop supplies, limited farmer new-crop marketings, and steady purchases of corn. Increased farmer marketing for cash-flow needs and slowing user purchases may bring a steady to slightly weaker corn basis at times during the early winter, barring weather problems in South America. Mid-February through late April old and new-crop prices will likely again reflect South American crop prospects and the battle among U.S. corn, soybeans, and other crops for 2112 planted acreage. Early indications point to a potential need for a combined 4 or 5 million more U.S. planted acres of corn and soybeans next spring, along with some increase in planted wheat acres.

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