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# 2013 Outlook of the U.S. and World Corn and Soybean Industries, 2012-2022

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**Outlook of the U.S. and World Corn and Soybeans Industries, 2013-2022**
**Richard D. Taylor and Won W. Koo**

## ABSTRACT

This report evaluates the United States and world corn and soybean markets for the 2013-2022 period using the Global Corn and Soybean Policy Simulation Model. This analysis is based on a series of assumptions about general economic conditions, agricultural policies, weather conditions, and technological change.

Corn-based ethanol production has influenced thenUnited States corn industry. As long as the production of corn-based ethanol remains strong, corn prices will likely remain at a level higher than the long term average. However, changes in the Federal fuel mandates could significantly impact the world corn market. Under the current assumptions in the model, corn price is expected to remain in a range between $4.30 and $6.50 per bushel over the 2013-2022 period.

Chinese soybean import is a leading factor influencing the world soybean market. China currently imports 66% of soybean trade in the world market, and that is expected to increase to about 70% by 2022. Major exporters will continue to be the U.S., Brazil and Argentina. However both Brazil and Argentina could increase exports, while U.S. exports will remain at the current level. Soybean prices are expected to remain near $12.00/bushel over the time period.

**Keywords**: corn, soybeans, production, exports, consumption, ethanol, ending stocks

## HIGHLIGHTS

World corn trade is projected to increase by 17% between 2012 and 2022. U.S. exports are expected to increase 22.1% by 2022, however much of that increase is due to the small corn crop in 2012 which limited exports. Both Argentina and Brazil would increase exports, while China is expected to become an importer of corn by 2020.

World soybean trade will increase by 66% between 2012 and 2022. China is expected to increase imports by 56% in 2022 from the 2011-2012 average. Argentina has been increasing soybean production rapidly and Brazil will continue to increase soybean exports to satisfy Chinese soybean demand.

World corn production is expected to increase by 28%, from 31 billion bushels in 2011-2012 to 39 billion bushels in 2022. The U.S. and Argentina will both increase corn production by 28%. Brazil is expected to increase corn production by 16%.

The U.S. is projected to increase soybean production about 19% by 2022. U.S. production growth is limited because of land constraints. Argentina and Brazil are expected to increase soybean production by 38% and 25%, respectively.

U.S. corn yields are expected to increase in all states/regions. Harvested acres in the U.S. are expected to decrease from 87 million acres in 2012 to 81 million acres in 2022. The largest corn harvested acres are in the South region, followed by the West region and the Northeast region. Iowa has the largest corn harvested acres in the United States, followed by Illinois and Minnesota.

Total U.S. corn production in 2012 was 9.5 billion bushels and is expected to increase by 28% to 14.0 billion bushels by 2022. The fastest growth is expected to be in Illinois (67%), followed by Indiana (65%), and the north east region (39%). The large growth is due to the small crop in 2012.

Corn exports are expected to increase from 0.8 billion bushels in 2012 to 1.7 billion bushels in 2017 before decreasing to 1.5 billion bushels in 2022. The feed use of corn is projected to increase by 20% from 4.5 billion bushels in 2012 to about 5.4 billion bushels in 2022. Ethanol use of corn is expected to increase by 31% from 4.5 billion bushels in 2012 to 5.9 billion bushels in 2022. Other industrial uses are projected to decrease by 44% between 2012 and 2022. Total U.S. consumption of corn is expected to increase by 22% during the forecast period.

The U.S. planted 74.0 million acres of soybeans in 2012 and harvested acres are expected to increase to 75.0 million acres by 2022. U.S. soybeans yields are expected to increase in most states/regions in the country.

U.S. exports of soybeans are expected to increase during the forecast period from 1.3 billion bushels in 2012 to 1.7 billion bushels in 2022. U.S. domestic processing is projected to increase by 22% from 1.6 billion bushels in 2012 to about 2.0 billion bushels in 2022. Feed and other uses are expected to increase by about 31%. Total domestic consumption is expected to increase by about 23% during the forecast period.

Corn price is expected to decrease to $4.37 per bushel in 2016 and then increase to $6.51 by 2022. Soybean price is expected to be about $12.00 per bushel between 2013 and 2016 before falling to the $11.70 in 2022.

# 2013 Outlook of the U.S. and World Corn and Soybean Industries, 2012-2022

Richard D. Taylor
Won W. Koo

## INTRODUCTION

World corn and soybean production is concentrated in a few countries unlike other agricultural crops. The U.S. produces 39% of the world's corn and 27% of the world's soybeans. In contrast, the U.S. produces only 9% of the world's wheat. China is the next largest corn producer followed by Brazil and the European Union. Over the past three years, these four areas produce over 60% of the world's corn. Brazil produces 23% and Argentina produces 15% of the world soybeans compared to 28% for the U.S.

Increased ethanol production under the Energy Independence and Security Act of 2007 resulted in a significant increase in the price of corn which also impacted soybeans along with most other commodities. The increased price of corn led to major structural changes in the corn industry in the U.S. as well as other corn producing and consuming countries. Corn production in the U.S. and other countries increased in response to higher prices in 2007. Prices and production returned to normal levels in 2008 and 2009, however prices increased again in late 2010 and early 2011. The main reason for the increase in corn price is due mainly to the small carry-over stocks in the United States. In 2010 US corn production fell 4% while consumption increased 6% which resulted in a reduction of carry-over stocks by 60% from 1.7 billion bushels to 675 million bushels between 2009 and 2010. Changes in corn prices affect prices of other commodities, especially soybeans, mainly because they are close substitutes in production. Production of both corn and soybeans were much smaller in 2012 because of the drought.

Argentina had a small soybean crop in 2008. Argentine soybean production fell by 31% in 2008 compared to 2007, but soybean production returned to normal levels in 2009. Both Brazil and Argentina had smaller soybean corps in 2010 compared to 2009, but the United States soybean crop was slightly larger.

Industrial use of corn has increased dramatically during the past two decades. The most recent increases are due mainly to rising ethanol production, which is expected to grow slower than in the past since the United States have reached the RFS mandate. High fructose corn syrup (HFCS) production, used as a substitute for sugar in the soft drink industry, caused a major increase in demand for corn during the 1980s, utilizing 500 million bushels of corn per year. During the late 1990s and early in the 2000s, the corn required for ethanol production increased to approximately 5.3 billion bushels in 2011 before falling to 4.5 billion bushels in 2012. These two non-traditional uses of corn account for almost 40% of the current U.S. corn crop. Ethanol production is likely to increase given recent federal legislation mandating increased ethanol use.

World soybean production has increased in recent years due mainly to the introduction of soybeans into Argentina and Brazil in the mid-1980s. Soybean production in those two countries reached 4.2 billion bushels in 2009, compared to 3.1 billion bushels in the U.S. Soybean consumption in China is the main reason for increased world soybean production. In 1995, China consumed 517 million bushels of soybeans and produced 640 million bushels. In 2012, China consumed 3.0 billion

bushels and produced 493 million bushels and imported 2.4 billion bushels which was almost 66% of the soybeans traded in the world market.

## WORLD CORN INDUSTRY

Figure 1 shows the world corn production in the major corn producing countries. U.S. corn production has decreased by 27% between 1998 and 2012 due to the drought although harvested acres increased by 13%. China's corn production increased by 28% while Brazil and the EU increased production by 57% and 19%, respectively, during the same time period.

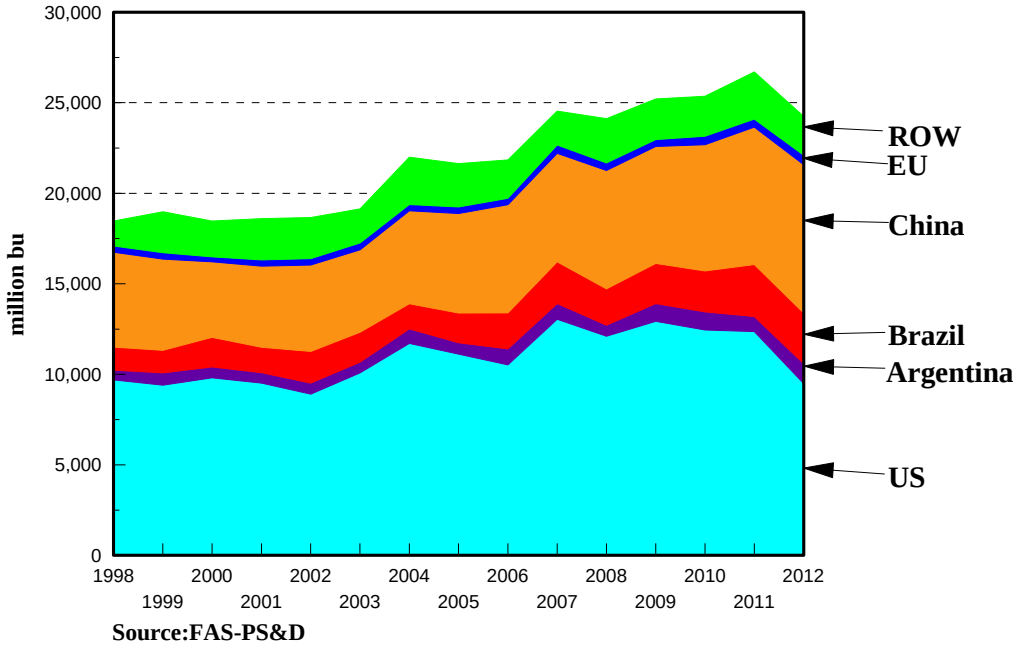


**Figure 1. World Corn Production, 1998-2012**

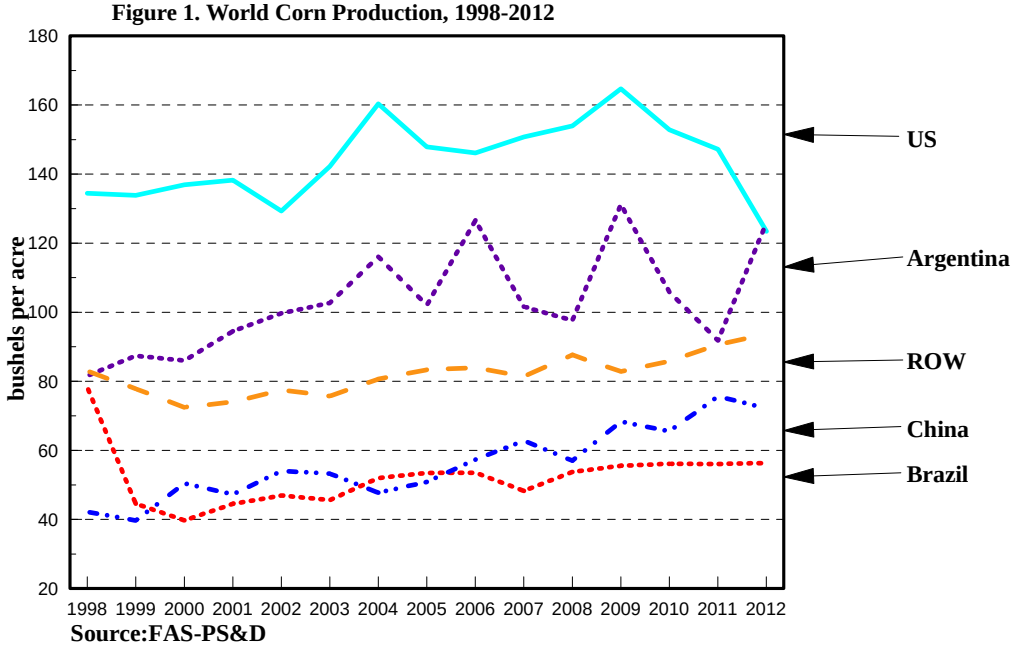


**Figure 2. World Corn Yields, 1998-2012**

In addition to larger world corn acres, world average corn yields have increased by 34% between 1998 and 2012. Corn yields in the U.S. decreased from 134 bushels per acre in 1998 to 109 bushels per acre in 2012, however corn yields increased in other countries. Chinese corn yields increased by 12%, while corn yields in Brazil and the European Union increased by 56% and 67%, respectively. Brazil's corn yield is low because corn is a secondary, low input crop rotated with soybeans.

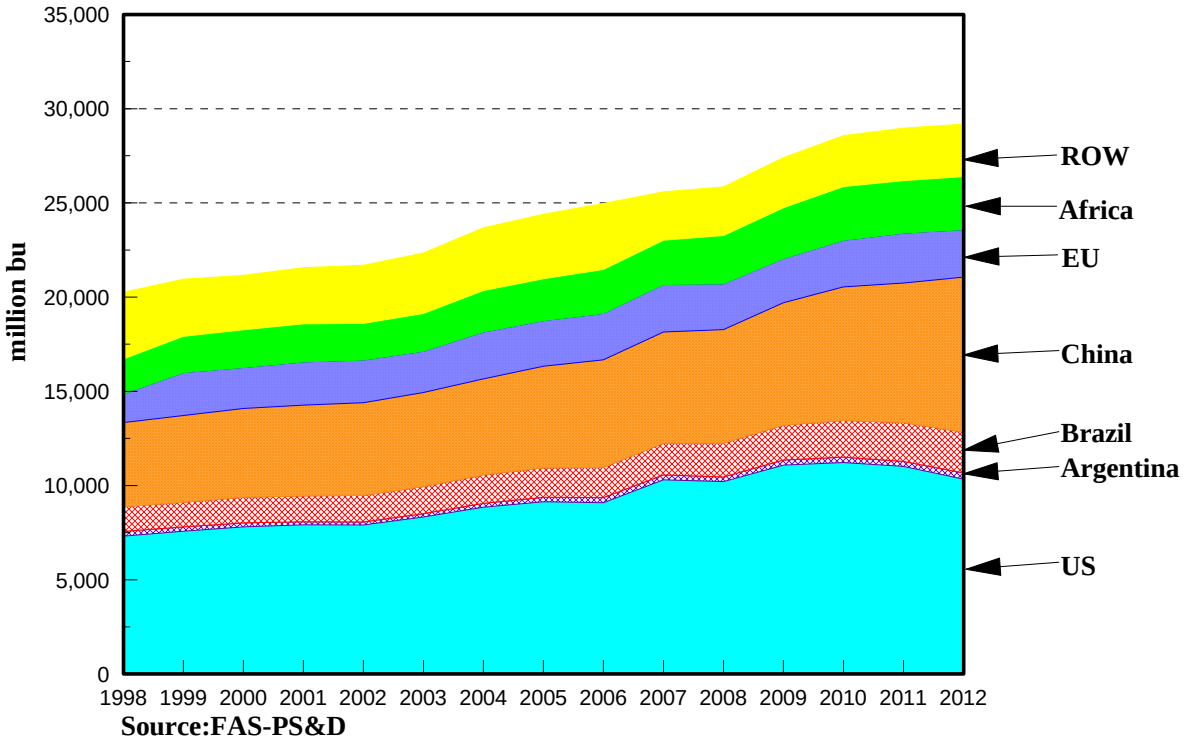


**Figure 3. World Corn Consumption, 1998-2012**

World corn consumption increased by 52% between 1998 and 2012 (Figure 3). The countries with the largest growth in corn consumption have been the EU, the U.S. and China. China's consumption growth is due mainly to growth in the livestock sector and in the United States growth is a result of corn based ethanol production. Corn consumption in China increased by 56% between 1998 and 2012, while that in the U.S. increased by 47% during the same time period. Corn consumption in the European Union increased by 60% while the Rest of world (ROW) region increased by 30% during the same time period.

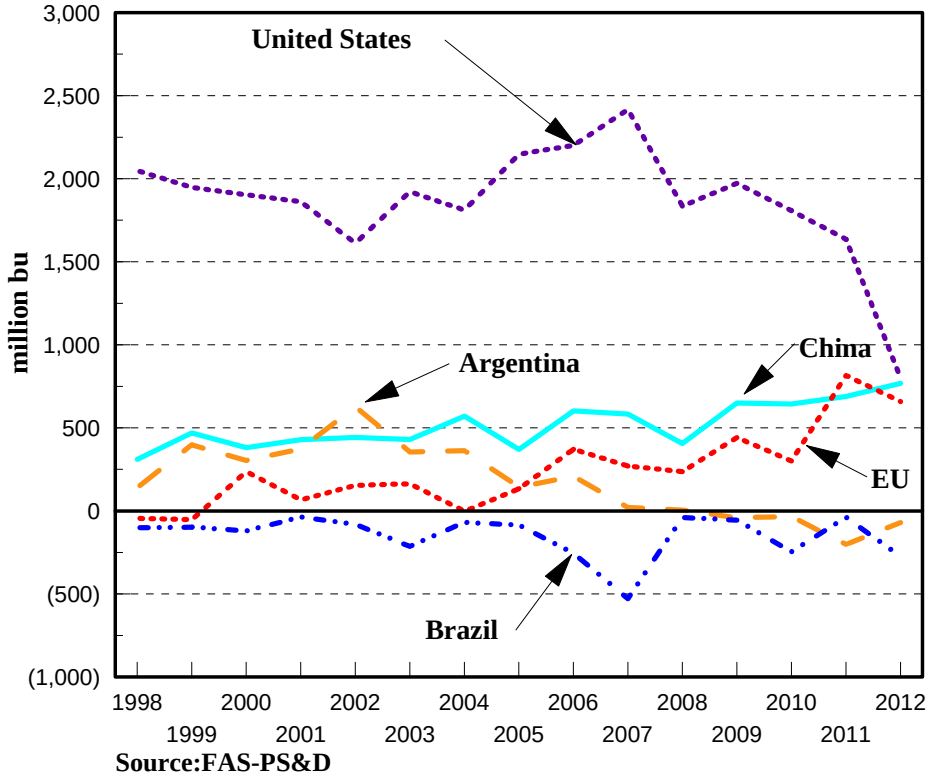


**Figure 4. World Corn Exports, 1998-2012**

The U.S. is the main exporter of corn for the 1998-2012 period, although China, the EU, and Argentina exported corn most years. During the past 15 years, corn exports in the U.S. have remained relatively flat until 2011 and 2012. Exports were 1.6 billion bushels and 800 million bushels, respectively in the two years. The ROW region significantly increased imports of corn from less than 1 billion bushels in 1998 to 2.5 billion bushels in 2012.

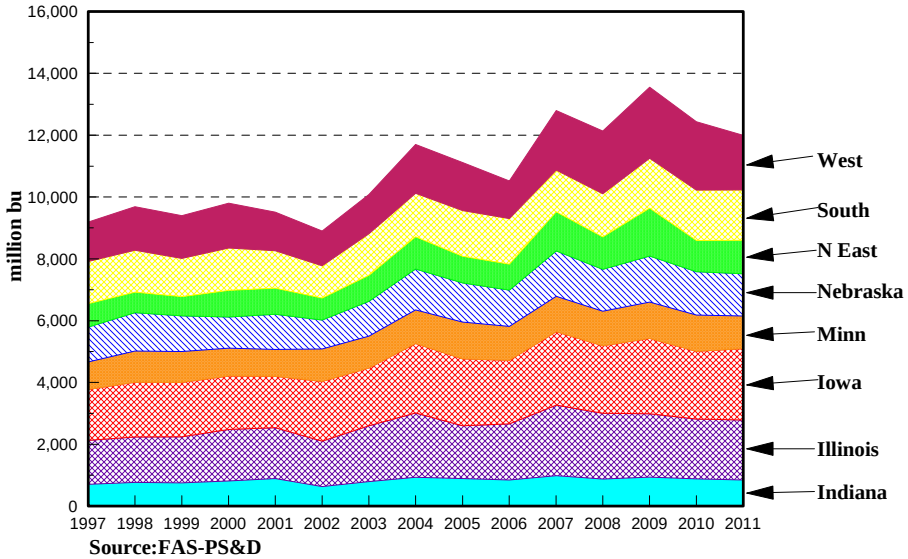


**Figure 5. US Corn Production by Region/State, 1998-2012**

Corn Production in the U.S.

In 2012, The five largest corn producing states in the U.S. are Iowa (1.9 billion bushels), Minnesota (1.4 billion bushels), Illinois (1.3 billion bushels), Nebraska (1.3 billion bushels), and Indiana (0.6 billion bushels). Those five states produced 60% of the total quantity of corn production in the U.S. Iowa increased corn production by 6% between 1998 and 2012, while Illinois and Indiana decreased corn production by 13% and 21%, respectively, during the same time period. Minnesota and Nebraska increased corn production by 36% and 4%, respectively. The other regions of the country also increased corn production. The North East, South and West increased corn production by 8%, 56%, and 30%, respectively.

Table 1 shows the states that are included in the three corn growing regions of the U.S. Several states have no corn production and are not listed in the table. Area harvested for corn increased in most regions/states between 1998 and 2012. Corn acres increased by 25% in the West region because of profit incentive and the 1996 Farm Bill which did not require planting wheat and barley program acres. Illinois and Iowa increased corn acres by 7% and 12%, respectively, while Nebraska and Indiana increased corn acres by 6% and 8%. The North East region reduced corn acres by 7% and the South region increased acres by 14%.

**Table 1. Corn Producing States Divisions by Regions**

| Major | North East | South | West |
|---|---|---|---|
| Iowa | Delaware | Alabama | Arizona |
| Illinois | Maryland | Arkansas | California |
| Indiana | Michigan | Florida | Colorado |
| Minnesota | New Jersey | Georgia | Idaho |
| Nebraska | New York | Kentucky | Kansas |
| | Ohio | Louisiana | Montana |
| | Pennsylvania | Missouri | North Dakota |
| | Virginia | Mississippi | New Mexico |
| | Wisconsin | North Carolina | Oklahoma |
| | West Virginia | South Carolina | Oregon |
| | | Tennessee | South Dakota |
| | | | Texas |
| | | | Utah |
| | | | Washington |
| | | | Wyoming |

Table 2 shows corn yields by states/regions in the U.S. for the years 1997 through 2000 and 2010 through 2012. Iowa had the highest average corn yield for the years 1997-2000 at 144 bushels per acre, compared to Nebraska at 136 bushels per acre. For the 2010-2012 time period, Minnesota had the highest average corn yield at 166 bushels per acre followed by Iowa at 158 bushels per acre. The fastest growth region for yields was in the South region, 37%, followed by the North East, 33%, and Nebraska, 15%. Yields decreased in Indiana and Illinois due to the 2012 drought.

**Table 2. U.S. Corn Yields by Region/State**

| | 1997-2000 | 2010-12 | % Change |
|---|---|---|---|
| | ----------bushels per acre---------- | | |
| Indiana | 134.3 | 134.0 | -0.2 |
| Illinois | 140.3 | 139.7 | -0.4 |
| Iowa | 144.0 | 158.0 | 9.7 |
| Minnesota | 145.0 | 166.0 | 14.5 |
| Nebraska | 135.5 | 156.0 | 15.1 |
| South | 83.9 | 114.8 | 36.9 |
| North East | 106.8 | 142.4 | 33.4 |
| West | 107.1 | 122.7 | 14.5 |

Figure 6 shows the U.S. utilization of corn for the years 1998 through 2012. The largest increase was corn for ethanol production, an increase of 901%, from 526 million bushels in 1998 to 5.3 billion bushels for 2012. Feed use decreased by 10%, other industrial uses increased by 9% and exports decreased by 61% due to the drought. Total utilization increased by 41% during the time period.

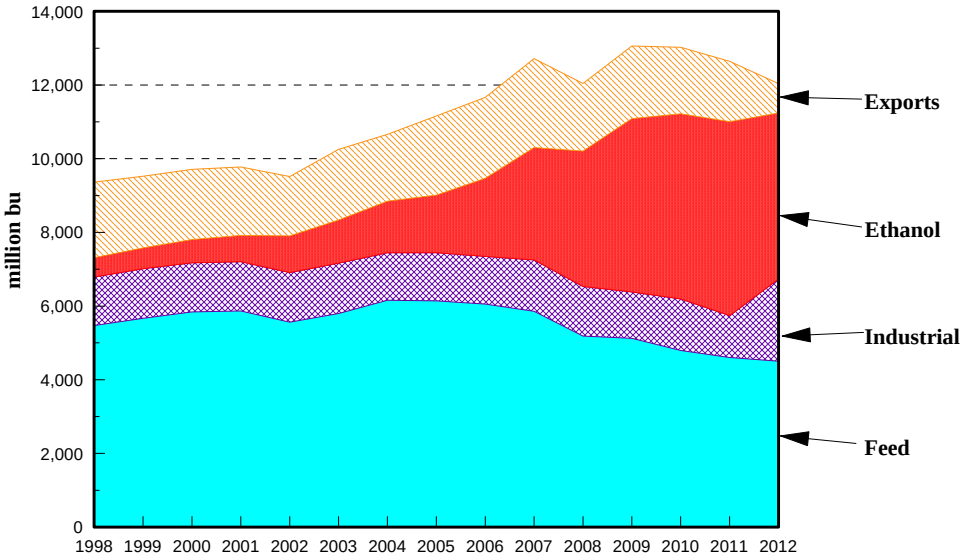


**Figure 6. US Corn Utilization, 1998-2012**

## WORLD SOYBEAN INDUSTRY

Figure 7 shows the world soybean production by country/region. World soybean production has increased by 68% from 5.9 billion bushels in 1998 to 9.8 billion bushels in 2012. Argentina and Brazil increased soybean production by 351% and 147%, respectively, during the same time period. The U.S. increased soybean production by 9% between 1998 and 2012. Soybean production increased by 98% in the ROW region. Most of that increase took place in South American countries.

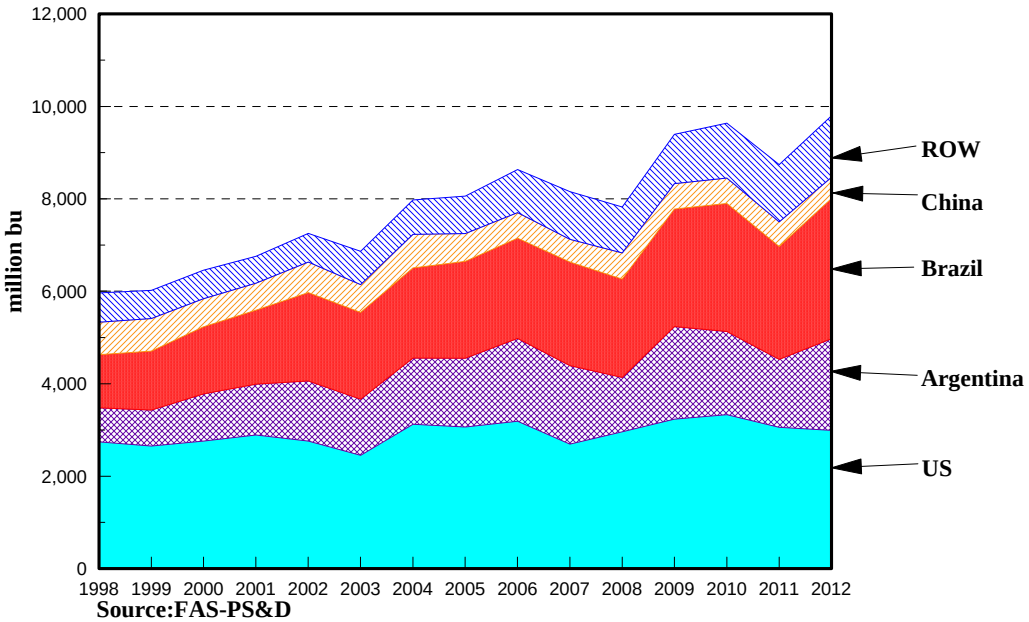


**Figure 7. World Soybean Production, 1998-2012**

World soybean yields have increased by 21% in the last 15 years. Soybean yields in the U.S., Brazil and Argentina are very similar throughout the time period as shown in Figure 8. In 1998 they ranged between 36 bushels per acre and 39 bushels, increasing to between 41 bushels and 44 bushels per acre in 2012. Soybean yields in China have remained at about 25 bushels per acre and ROW soybean yield increased from 21 bushels per acre to 27 bushels per acre for the same period.

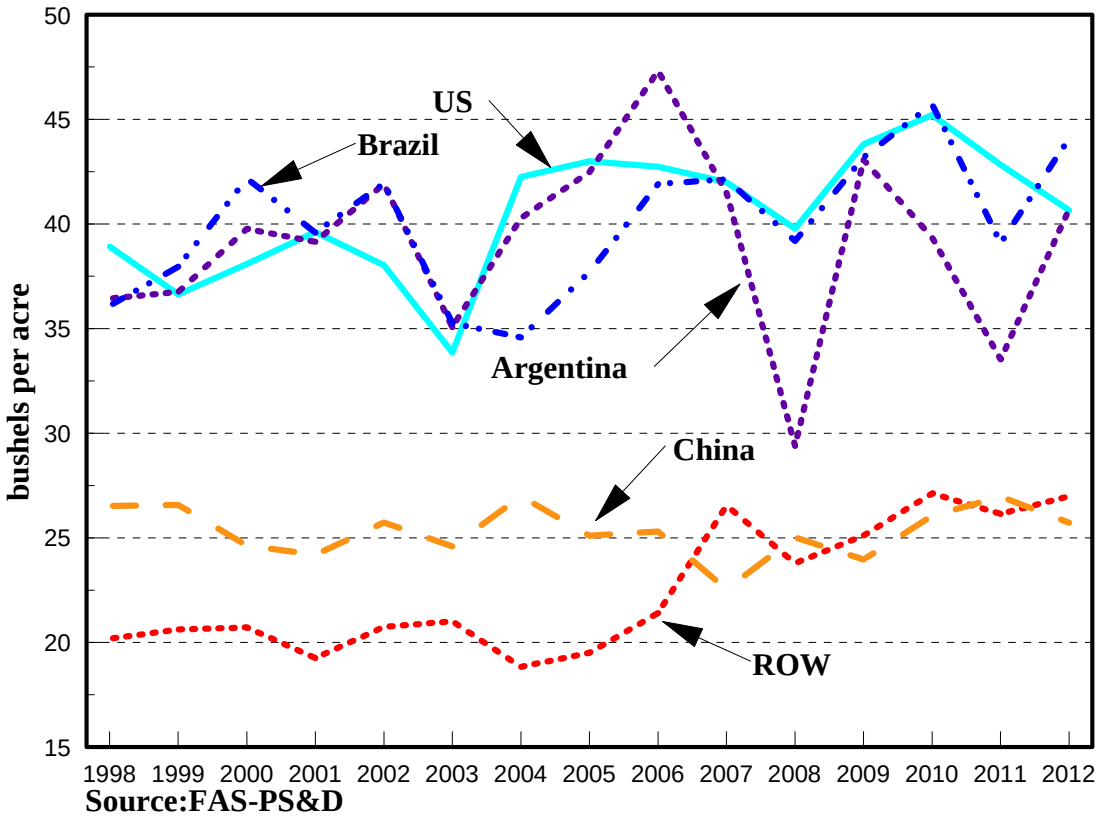


**Figure 8. World Soybean Yields, 1998-2012**

World soybean consumption increased by 60% between 1998 and 2012 (Figure 9). Soybean consumption in China increased from 732 million bushels in 1998 to 2.8 billion bushels in 2012. In 2008 China became the largest soybean consumer in the world, passing the United States. Soybean consumption increased by 75% in Brazil and 118% in Argentina for the 1998-2012 period. U.S. consumption decreased by 3% from 1.8 million bushels in 1998 to 1.7 million bushels in 2012.

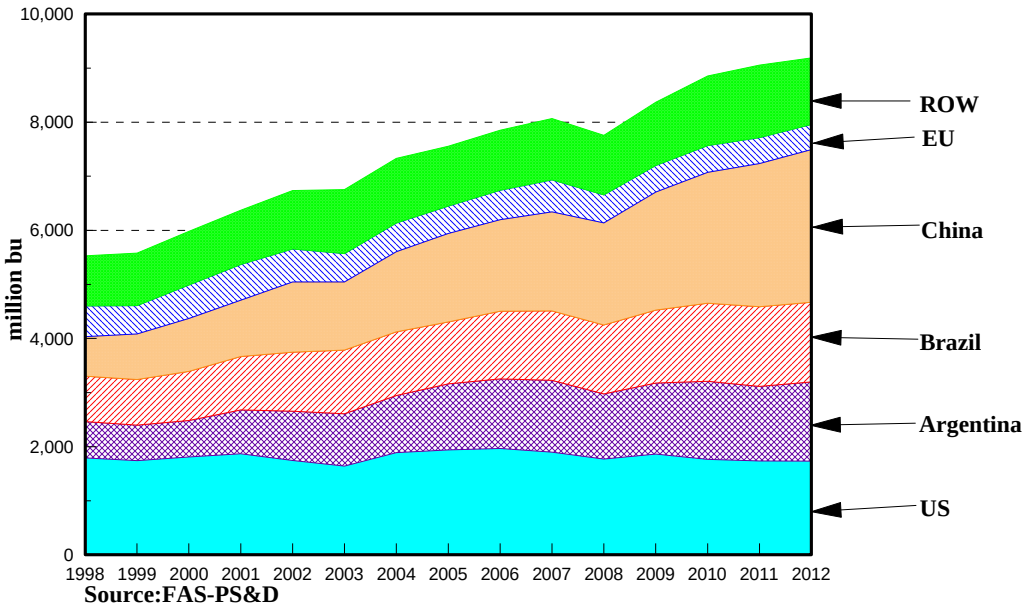


**Figure 9. World Soybean Consumption, 1998-2012**

The U.S., Brazil and Argentina export over 90% of the soybeans traded in the world market (Figure 10). China imports about 66% of the world's exportable supplies of soybeans. The U.S. was the largest exporter of soybeans until 2011. In 2011 Brazil exported 1.3 billion bushels compared to 1.2 billion bushels from the United States and 276 million bushels from Argentina. In 1995, the U.S. exported 84% of the soybeans traded in the world market. In 2012 the United States exported 1.3 billion bushels compared to 1.54 billion bushels from Brazil.

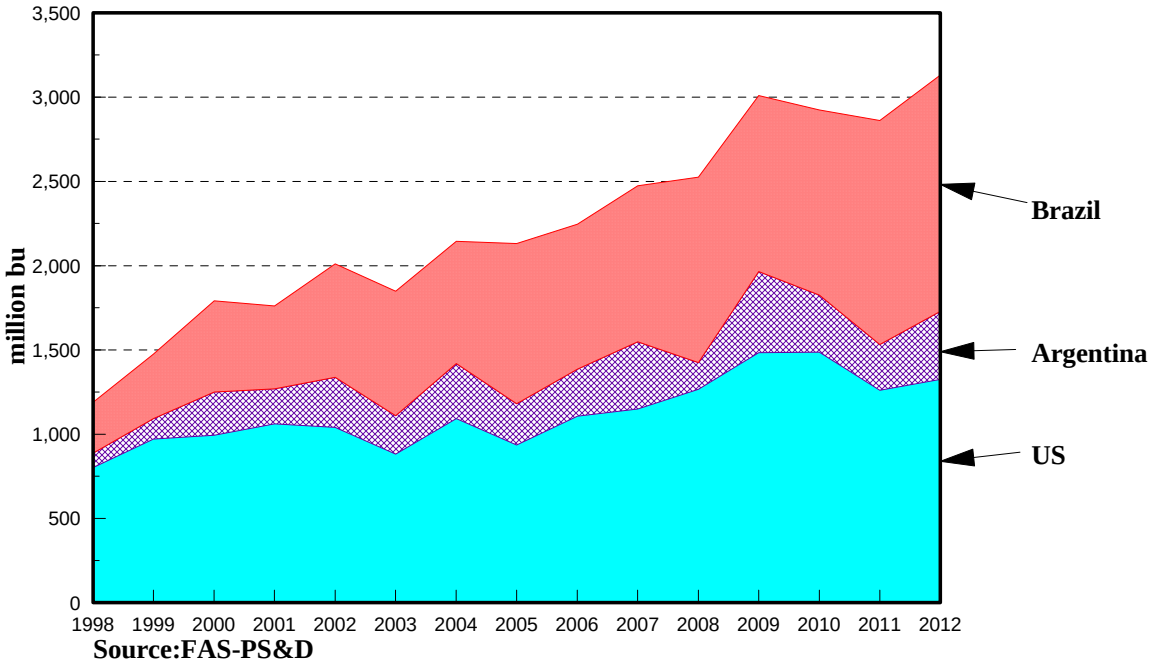


**Figure 10. World Soybean Exports, 1998-2012**

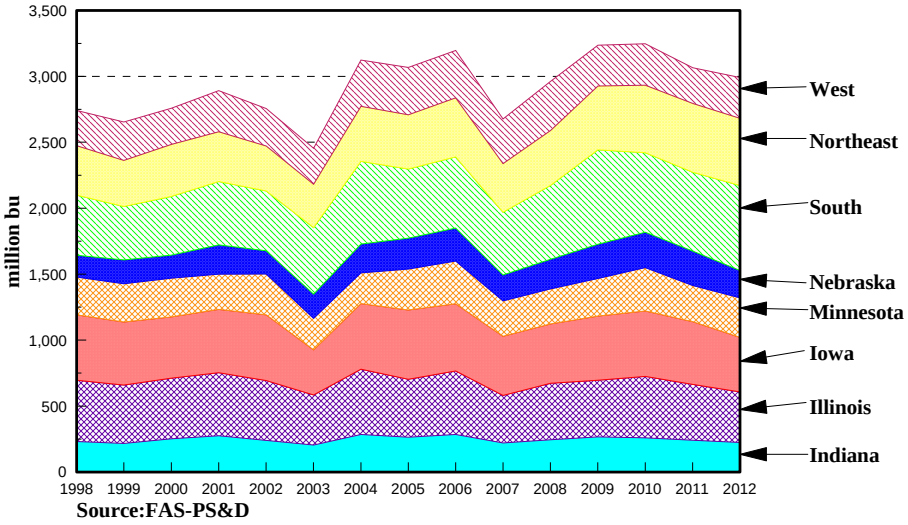


**Figure 11. US Soybean Production, by Region/State, 1998-2012**

## U.S. Soybeans

Figure 11 shows the U.S. soybean production by state/region. Iowa is the largest producer of soybeans (414 million bushels), followed by Illinois (384 million bushels), and Minnesota (301 million bushels). The fastest growth has been in Nebraska (64%), followed by the West (42%) and South (41%) regions.

Much of the production growth has been caused by increased harvested area rather than yield growth (Table 3). Highest soybean yields are in Nebraska, followed by Iowa and Illinois. The yield growth is fastest in the South region (29.3%), followed by the Nebraska (16.1%), and the North East region (15.5%).

**Table 3. U.S. Soybean Yields by Region/States**

| | 1997-2000 | 2010-12 | % Change |
|---|---|---|---|
| | ----------bushels per acre---------- | | |
| Indiana | 41.5 | 45.8 | 10.4 |
| Illinois | 43.0 | 47.3 | 10.1 |
| Iowa | 46.2 | 49.0 | 6.1 |
| Minnesota | 41.0 | 42.2 | 2.8 |
| Nebraska | 42.3 | 49.2 | 16.1 |
| South | 28.3 | 36.6 | 29.3 |
| North East | 39.3 | 45.4 | 15.5 |
| West | 33.4 | 33.0 | -1.1 |

In spite of the increased production of soybeans in Argentina and Brazil, US exports of soybeans have increased by 65% between 1998 and 2012. The production of bio-fuels from soybeans has not been a major factor influencing the U.S. soybean industry. Biodiesel makes up a very small percentage of diesel use in the U.S. Domestic crush of soybeans has decreased by 15% and feed, seed, and waste have decreased by 6% between 1998 and 2012.

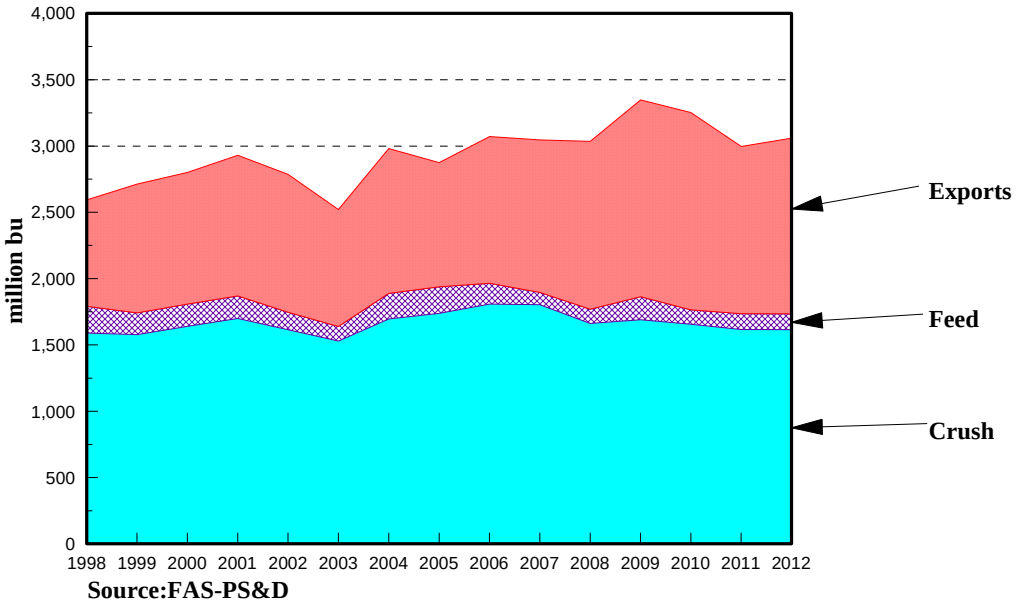


**Figure 12. US Soybean Utilization, 1998-2012**

## AN ECONOMETRIC SIMULATION MODEL FOR CORN AND SOYBEANS

The empirical model for this study is a global corn and soybean econometric policy simulation model. The basic structure of the model is similar to the global wheat model by Benirschka and Koo. The world is divided into six regions in the model, the U.S., Argentina, Brazil, China, the European Union (EU) and the rest of the world (ROW). Commodities considered in this study are corn and soybeans, which compete with each other for crop-land. Wheat also competes with corn for crop-land. However, it is not included in the model since the competition is limited in only Plains states in the U.S. Supply, demand, and carry-over stock equations are estimated for the crops in all the countries/regions. The behavioral equations are equated, based on changes in the prices of the crops, so that the aggregated demand for all the countries/regions is equal to the aggregated supply for each crop. The model is used to forecast production, consumption, exports, and price of each crop over the next 10 years. It is assumed that U.S. and world agricultural policy remains unchanged, normal weather patterns continue, and there are no dramatic macroeconomic or political changes in the future simulation period.

The behavioral equations of corn and soybeans are estimated for the countries/regions and included in the model. The behavioral equation is supply, demand and carryover stocks of each crop.

Supply of Corn and Soybeans

Supply of corn and soybeans consists of production, beginning stocks, and imports. Harvested area of corn or soybeans is affected by the lag of the real prices of the crop and competing crops. The real price of corn or soybeans is expected to have a positive impact on the harvested area of the crop. The prices of the competing crops are expected to have a negative impact on harvested area. In addition, lagged harvest area ($HA_{t-1}$) is included as an independent variable to capture dynamics in a producer's response. The harvested area equation is specified as:

$$HA^n_t = f(HA_{t-1}, P^n_{t-1}, P^w_{t-1}) \quad n= 1, 2. \tag{1}$$

Where n is index for crop; n = 1 for corn and n = 2 for soybeans. $HA^n_t$ = harvested area of crop n in time t, $P^n_{t-1}$ = real prices of crop n in time t-1 and $P^w_{t-1}$ = wheat price in time t-1. The lagged dependent variable is used as an independent variable to capture dynamics in corn production based on the partial adjustment hypothesis (Nerlove).

The yield equation of each crop includes the real price and a trend variable to account for advances in farming technology. The yield equation is specified as:

$$Y^n_t = f(P^n_t, T_t) \tag{2}$$

where $Y^n_t$ = yield of crop n in time t, $P^n_t$ = price of crop n in time t, and $T_t$ = trend.

Total U.S. production of each crop is harvested area times yield as follows:

$$Pd^n_t = HA^n_t * Y^n_t \tag{3}$$

where $Pd^n_t$ = U.S. production of crop n in time t.

Demand for Corn and Soybeans

Domestic demand for corn and soybeans is comprised of domestic consumption and carry-over. These two crops are used for different purposes in the U.S. Corn is mainly used for animal feed and industrial uses including ethanol production, while soybeans are used for producing edible oil, soybean meal and bio-energy.

Demand for Corn for Feed

Corn used for feed is the total feed used for beef, pork, poultry, turkey and dairy production.

Feed use for livestock is specified as a function of the price of corn, the price of livestock, and a trend variable, as follows:

$$FD^l_t = f(P^c_t, P^l_t, T_t), \quad l= 1,2,\ldots.5. \tag{4}$$

where $FD^l_t$ = the quantity of corn used to feed livestock l in time t, $P^c_t$ = real price of corn in time t, $P^l_t$ = real price of livestock l in time t and $T_t$ = trend variable. l= 1 for beef, 2 for pork, 3 for poultry, 4 for turkey and 5 for dairy.

It is expected that all feed use will have a negative relationship with corn price and a positive relationship with livestock price. The total feed use is:

$$FD_t = \sum_{l=1}^{n} FD^l_t \quad (5)$$

When ethanol is produced from corn, by-products can be used for animal feeding, thus, the quantity of by-product (*BP*) from ethanol should be subtracted from $FD_t$ as:

$$NFD_t = FD_t - BP_t . \quad (6)$$

where $NFD_t$ is net consumption of corn for feed use. $BP_t = a(b*E_t)$ where $E_t$ = corn used for ethanol, $a$ = conversion rate from by-product to animal feed, and $b$ = conversion rate from corn to by-product.

We assumed that $a$=70%, $b$=30%, and the by-products (BP) are being fed to cattle. One pound of corn used in ethanol production will produce about 0.3 pounds of BP that can be fed to livestock (FAPRI 2005, Lardy 2003, Iowa Beef Center 2002). One pound of BP can substitute for about 0.7 pounds of corn (FAPRI 2005, Oleson 2005).

Corn Used for Ethanol Production

It is expected that high corn prices will have a negative impact on ethanol production, while high gasoline prices are expected to have a positive impact on ethanol production. Government subsidies are expected to have a positive impact on ethanol production. A dummy variable is used to represent the year in which California mandated the removal of MTBE from gasoline within the state, which created an immediate increase in demand for ethanol. Demand for corn for ethanol use is specified as:

$$E_t = f(P^c_t, P^g_t, E_{t-1}, G^c_t, D^{mtbe}) \quad (7)$$

where $E_t$ = corn used for ethanol production in time t, $P^c_t$ = real price of corn in time t, $E_{t-1}$ = corn used for ethanol production in time t-1, $P^g_t$ = gasoline price, $G^c_t$ = government subsidy, and $D^{mtbe}$ is a dummy variable for removal of MTBE in California. The government subsidy was removed at the end of 2011. The lagged dependent variable is used as an independent variable to capture dynamics in the use of corn for ethanol production based on the partial adjustment hypothesis (Nerlove).

Corn Used for Other Industrial Purposes

It is expected that a high corn price will have a negative impact on other industrial use of corn such as HFCS, starch, glucose, and dextrose, and higher price of these industrial goods will have a positive impact on the industrial use of corn. The demand model for other industrial use is specified as:

$$I^c_t = f(P^c_t, P^o_t) \quad (8)$$

where $I_t$ = the quantity of corn used for other industrial uses in time t, $P^c_t$ = real price of corn in time t, $P^o_t$ = real average price of other industrial goods.

Demand for Soybeans for Industrial and Other Uses

Domestic soybean crush is specified as a function of the price of soybeans and a trend variable, as follows:

$$CD^s_t = f(P^s_t, T_t) \quad (9)$$

where $CD^s_t$ = the quantity of soybeans used for domestic crush in time t, $P_t$ = real price of soybean in time t, and $T_t$ = trend variable.

Other uses of soybeans include, food, seed, and bio-energy. It is specified as a function of the price of soybeans and a trend variable, as follows:

$$OD^s_t = f(P^s_t, T_t) \quad (10)$$

where $OD^s_t$ = the quantity of soybeans used for other purposes in time t, $P^s_t$ = real price of soybean in time t, and $T_t$ = trend variable.

The total demand for industrial and other uses are:

$$I^s_t = CD^s_t + OD^s_t \quad (11)$$

Carry-over Stocks for Corn and Soybeans

Crop price should have a positive impact on carry-over. As the price of a crop increases, total production of a crop increases while demand for a crop decreases, resulting in increases in carry-over. The opposite will occur as the price of a crop decreases. Thus, the carry-over stocks equation is specified as a function of the price of a crop, and lagged carry-overstock as follows:

$$CS^n_t = f(P^n_t, CS^n_{t-1}) \quad (12)$$

where $CS^n_t$ = carry-over stocks of crop n.

ROW Import Demand and Export Supply

ROW import demand is the summation of the import demand from other countries (Canada, Taiwan, Mexico, Japan, South Korea, Algeria, Egypt, and Latin American countries). The price of a crop is expected to have a negative impact on import demand. In addition, consumer income has a positive relation with demand for crop n. The import demand model for the ROW is specified as:

$$ED^{Wn}_t = f(P^n_t, Y_t) \quad (13)$$

where $ED^{Wn}_t$ = ROW import demand for crop n in time t, $P^n_t$ = real world price of crop n in time t, and $Y_t$ = weighted average real per capita income in t.

ROW export supply is a function of export price and a trend variable to capture changes in technology. The ROW excess supply equation is specified as:

$$ES^{Wn}_t = f(P^n_t, T_t) \quad (14)$$

where $ES^{Wn}_t$ = ROW excess supply in time t, $P^n_t$ = real price of crop n in time t, and $T_t$= trend variable. It is expected that the export price of each crop and trend variable will have a positive impact on excess supply of individual crop.

Corn to Soybean Price Ratio

Harvested acres of corn and soybeans, traditionally, have followed the corn to soybean price ratio. Since the land area is limited, producers make planting decisions based on the prices of both crops. If the corn price is high compared to soybeans, more corn is planted and vice-versa. Historically the ratio has varied between 2.2 and 2.7 (USDA 1998). The corn to soybean price ratio and the area of corn and soybeans are determined for each region and country in the model. The forecasted area for corn and soybeans is required to be less than the maximum available land area planted to the two crops during the past 10 years. If the estimated areas for the two crops were greater than the maximum area, both crops are reduced based on the estimated corn soybean ratio for that year.

Equilibrium Condition

The equilibrium conditions for crop n are established in such a way that the aggregated excess supply of crop n equals the aggregated demand for the crop. Excess supply of crop n ($XS^n_t$) equals beginning stocks ($CS^n_{t-1}$) plus production ($Pd^n_t$) minus domestic use for feed ($NFd^n_t$), domestic use for bio-energy production ($EN^n_t$), other industrial use ($I^n_t$), and carry-over stocks $CS^n$ of the corresponding crop in country/region as follows:

$$XS^n_t = CS^n_{t-1} + Pd^n_t - NFd^n_t - EN^n_t - I^n_t - CS^n_t \quad (15)$$

where $XS^n_t$ = export supply of crop n in time t.

The aggregated excess supply of each crop for all countries/regions (m) and ROW should be equal to zero under the equilibrium condition, as follows:

$$\sum_{m=1} XS^{nm}_t + (ES^{Wn}_t - ED^{Wn}_t) = 0.0, \text{ n=1,2.} \quad (16)$$

Equation 16 represents two equilibrium conditions; one for corn and the other for soybeans.

These equations are a function of prices of corn and soybeans. The equations, therefore, are solved for the prices of corn and soybeans. Equilibrium demands, supply and carry-over stocks of corn and soybeans are determined simultaneously. Since the base year for the simulation is 2012, the simulation is continued for 10 years until 2022. The simulation results in 2022 represent the full effects of the Energy Act of 2007 which requires the production of 15 billion gallons of corn-based ethanol.

Data

Historical harvest area, yield, production, feed use, import demand, domestic consumption, and carry-over stocks data were obtained from the PS&D database from the Economic Research Service (ERS) for the years 1980 to 2012. Corn and soybean prices and corn use for ethanol were obtained from ERS. Actual gasoline prices, as well as forecasted prices were obtained from the U.S. Department of Energy, and cattle on feed numbers were obtained from the National Agricultural Statistics Service (NASS). All price data were converted to real terms using the GDP deflator (International Monetary Fund). Ethanol production data were obtained from ERS and the Renewable Fuels Association website .

## OUTLOOK FOR THE CORN AND SOYBEAN INDUSTRIES

World Trade of Corn and Soybeans

World corn trade is projected to increase by 17% between 2012 and 2022 (Table 4). U.S. exports are expected to increase from the low levels of 2012. Both Argentina and Brazil will increase exports and China is expected to continue to import small amounts of corn.

World soybean trade will increase by 66% between 2012 and 2022. China is expected to increase imports by 56% in 2022 from the 2011-2012 average (Table 4). U.S. soybean exports are expected to increase slightly as cultivated acres are limited in the U.S. Since 2007, Argentina has been increasing soybean production rapidly due to restrictions on the exportation of beef. Pasture land is being converted to soybean production. That trend is expected to continue into the near future. Brazil will continue to increase soybean exports to satisfy Chinese soybean demand.

**Table 4. World Corn and Soybean Trade**

| | 2011-2012 | 2012 | 2022 | Change |
|---|---|---|---|---|
| | ----------million bu---------- | | | % |
| Corn | | | | |
| US | 1,218 | 800 | 1,486 | 22.1 |
| Arg | 729 | 768 | 986 | 35.3 |
| Brazil | 737 | 658 | 809 | 9.9 |
| China | -137 | -71 | -208 | 105.3 |
| EU | -158 | -276 | 724 | NA |
| ROW | -1,695 | -1,262 | -3,482 | 105.3 |
| Soybeans | | | | |
| US | 1,293 | 1,325 | 1,476 | 14.2 |
| Arg | 338 | 404 | 763 | 126.0 |
| Brazil | 1,366 | 1,402 | 1,875 | 37.3 |
| China | -2,235 | -2,304 | -3,482 | 55.8 |
| EU | -424 | -414 | -501 | 18.2 |
| ROW | 21 | 300 | 201 | 899.3 |

Positive number represents exports while negative number represents imports.

Figure 13 shows the projected corn exports for the U.S., Brazil, Argentina and Ukraine. U.S. exports are expected to increase through 2016 leveling out towards the end of the forecast period. The exports for Argentina and Ukraine are expected to remain relatively constant until 2017. Their exports are expected to increase 26% and 25% for Argentina and Ukraine, respectively, for the 2013-2022 period.

Figure 14 shows the projected soybean exports for the major exporting countries. Brazil is currently the largest exporter of soybeans. The U.S. soybean production is expected to remain near current levels until later in the forecast period which allows Brazil to increase soybean exports to satisfy world demand. Argentina is also expected to increase soybean exports throughout the forecast period.

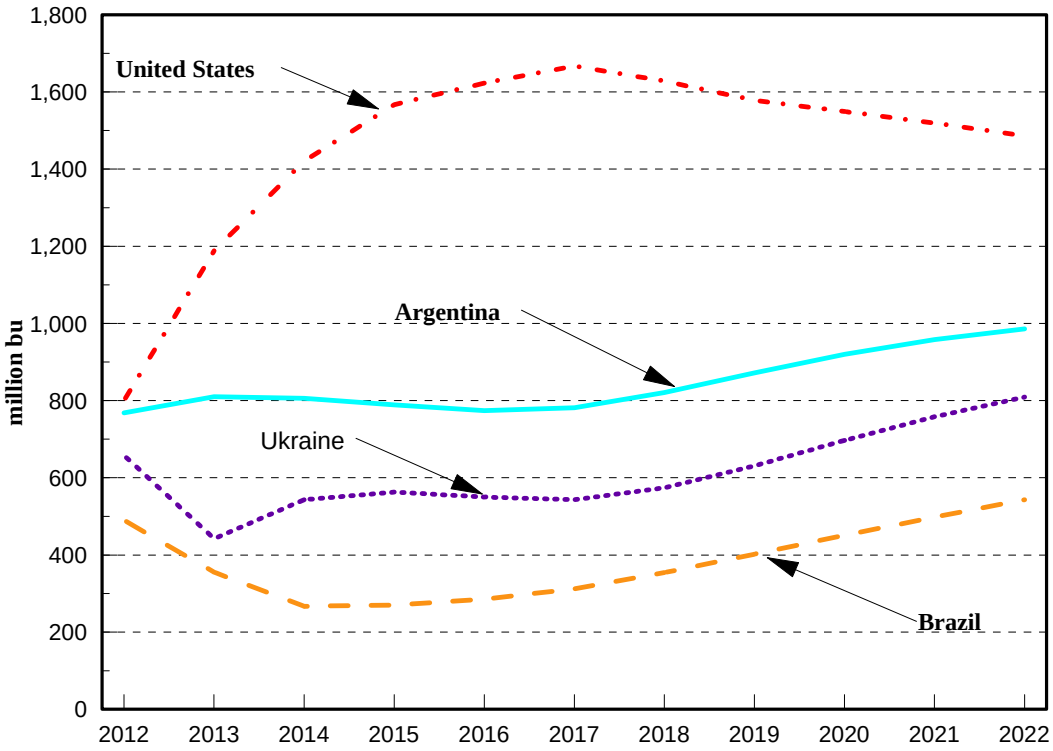


**Figure 13. Projected Corn Exports by Major Exporters**

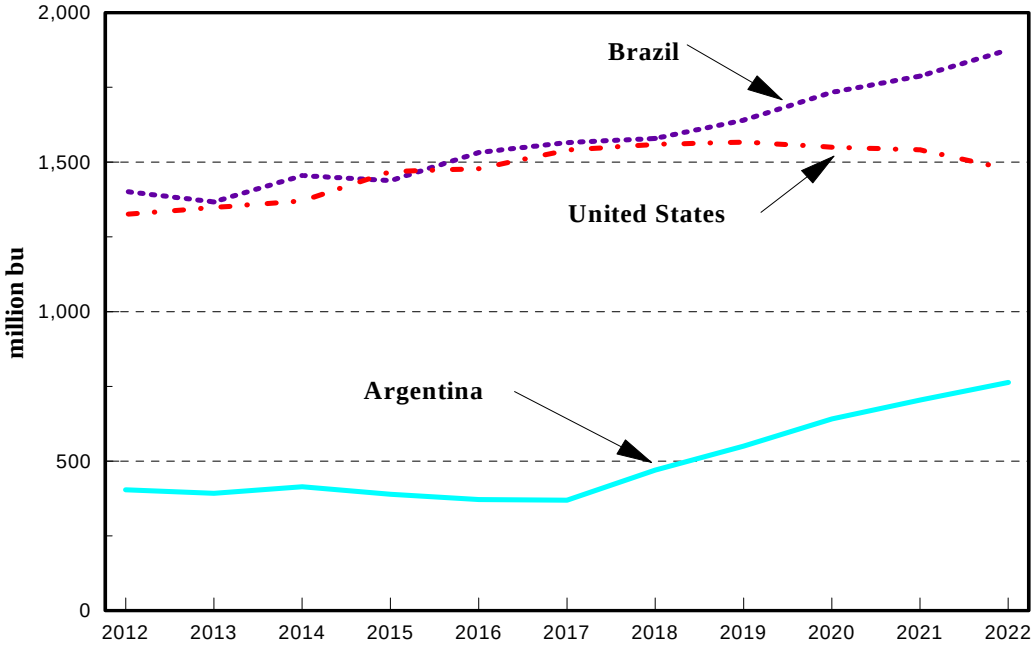


**Figure 14. Projected Soybean Exports by Major Exporters**

World Production of Corn and Soybeans

World corn production is expected to increase by 25%, from 28 billion bushels in 2011-2012 average to 35 billion bushels in 2022. The U.S. and Argentina will both increase corn production by 28% (Table 5). Brazil's production in 2022 is expected to be larger than the 2011-2012 average. Historically, Brazil has produced about 2 billion bushels of corn per year. Chinese corn production is expected to increase by about 24% to 9.8 billion bushels by 2022 but not enough to prevent the importation of corn for domestic use. Corn production in the European Union is expected to increase from 2.4 billion bushels in 2012 to about 3.6 billion bushels in 2022 which will satisfy domestic needs. Corn production by the major producing countries is shown in Figure 15. U.S. corn production is expected to increase sharply in 2013 and slightly during the remaining forecast period. Argentine corn production has ranged between 1.102 million and 1.232 million bushels per year and it is expected to remain near that level.

**Table 5. World Corn and Soybean Production**

| | 2011-2012 | 2012 | 2022 | Change |
|---|---|---|---|---|
| | ----------million bu---------- | | | % |
| Corn | | | | |
| US | 10,922 | 9,487 | 13,992 | 28.1 |
| Arg | 965 | 1,102 | 1,232 | 27.7 |
| Brazil | 2,835 | 2,795 | 3,277 | 15.6 |
| China | 7,889 | 8,189 | 9,814 | 24.4 |
| ROW | 5,540 | 5,725 | 7,078 | 27.8 |
| Soybeans | | | | |
| US | 3,023 | 2,991 | 3,610 | 19.4 |
| Arg | 1,729 | 1,984 | 2,373 | 37.3 |
| Brazil | 2,737 | 3,031 | 3,430 | 25.3 |
| China | 498 | 463 | 562 | 12.9 |
| EU | 41 | 35 | 52 | 26.2 |
| ROW | 1,284 | 1,329 | 1,723 | 34.2 |

The U.S. is projected to increase soybean production by about 19% in 2022. U.S. production growth is limited because of land constraints. However, the U.S. is the largest producer of soybeans and will remain during the forecast period. Production is expected to increase from about 3.0 billion bushels in 2012 to about 3.6 billion bushels in 2022. Argentina and Brazil are expected to increase soybean production by 37% and 25%, respectively. Brazil has range and pasture land available for conversion and Argentina is converting pasture land into cultivated land due to government regulations concerning beef exports. Argentine soybean production should increase from 2.0 billion bushels to 2.4 billion bushels between 2012 and 2022. Figure 16 shows the projected soybean production for the major producing countries. China's soybean production will increase during the forecast period but remain below 1 billion bushels.

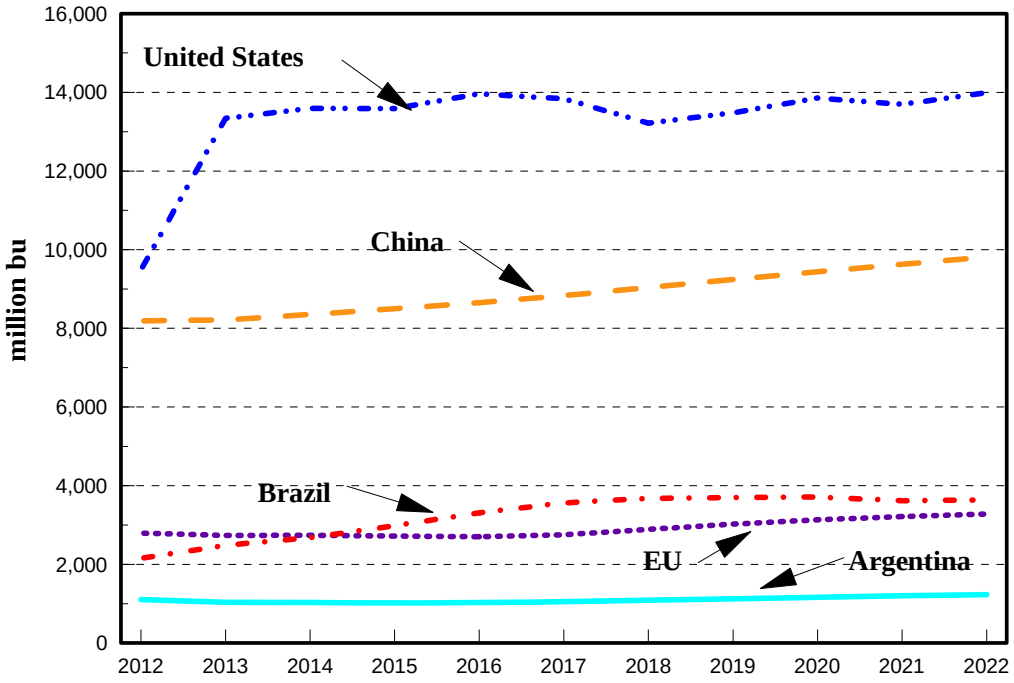


**Figure 15. Projected Corn Production by Major Producers**

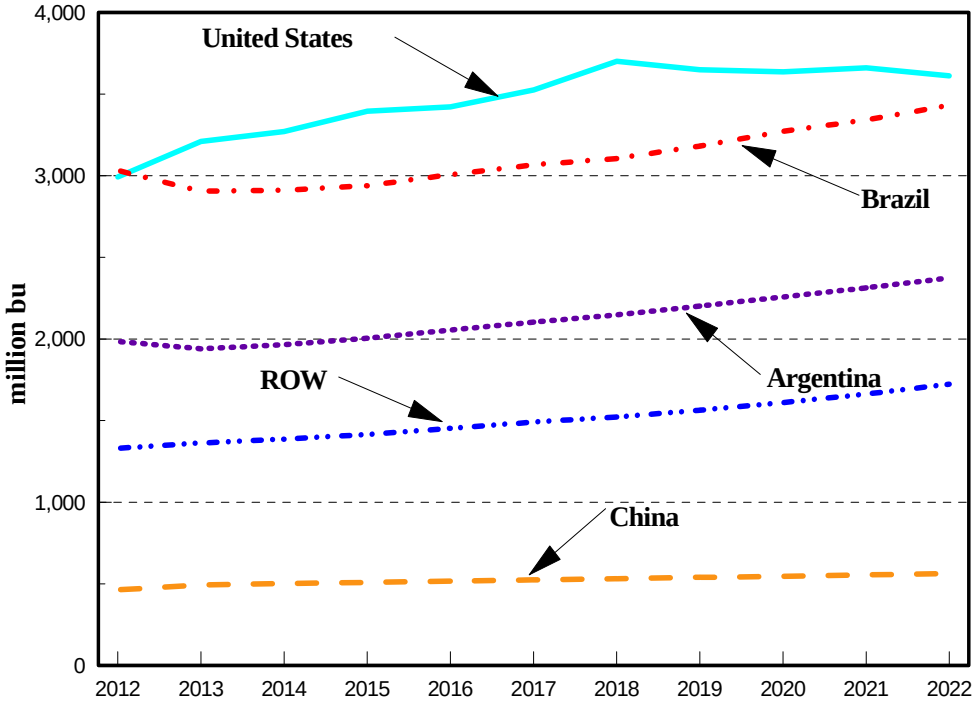


**Figure 16. Projected Soybean Production by Major Producers**

Corn and Soybean Production in the U.S.

Table 6 shows the yield and harvested acres for the states/regions in the United States. In 2012, Minnesota has the highest average yield of 165 bushels per acre followed by Nebraska and Iowa. Outside of the major corn producing states, the northeast has the highest yield at 126 bushels per acre. Yields are expected to increase in all states/regions. Harvested acres in the U.S. are expected to decrease from 87.3 million acres to 81.2 million acres in 2022. Historically, U.S. corn producers planted around 80 million acres of corn. They responded to high corn prices in 2011 and 2012 to increase corn acres between 84 million and 87 million acres. With the lower forecasted corn prices harvested acres should return to a normal range.

Table 7 shows yields and harvested acres for U.S. soybeans. Soybean yields are expected to increase in most states/regions in the United States. Yields for West are projected to be 3.0% lower in 2022 than in 2011-2012. The main reason is that the west had abnormally high soybean yields in 2011. The largest harvested acres are in the south region followed by the north east and west. Iowa has the largest harvested acres followed by Illinois and Minnesota. The U.S. planted 73.6 million acres of soybeans in 2012 and harvested acres are expected to increase to 74.9 million acres by 2022.

Figure 17 shows the production of corn by state/region for the U.S. Iowa is the largest corn producing state in 2012 (1.9 billion bushels), followed by the west region and the north east region. Total U.S. corn production in 2012 was 10.8 billion bushels and is expected to increase by 30% to 14.0 billion bushels by 2022. The fastest growth is expected to be in Illinois (67%), followed by Indiana (65%), and the north east region (39%). The reason for the large increases are the reduced production in 2012.

In Figure 18 shows the production of soybeans by state/region. The south region was the largest soybean producing region in 2012 with 644 million bushels, followed by the northeast region, Iowa, and Illinois. The fastest increase in soybean production is projected to be in the Indiana (44%), followed by Nebraska and Iowa.

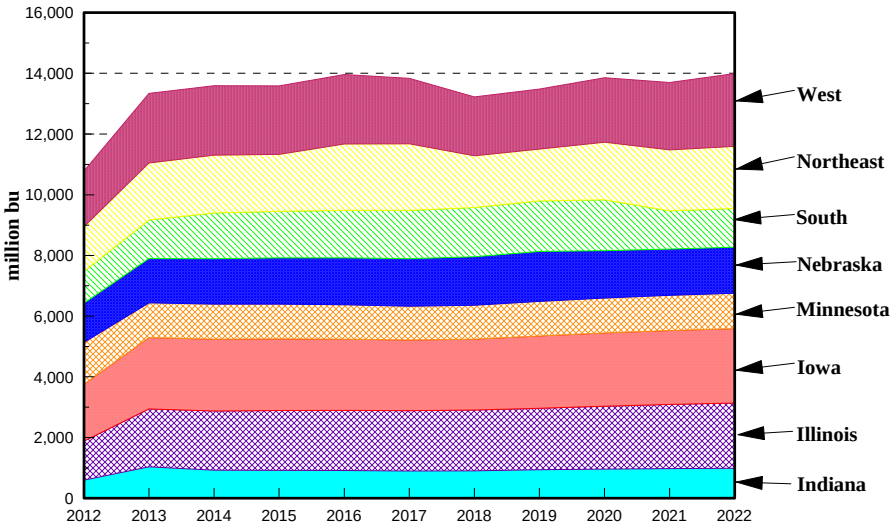


**Figure 17. Projected US Corn Production by State/Region**

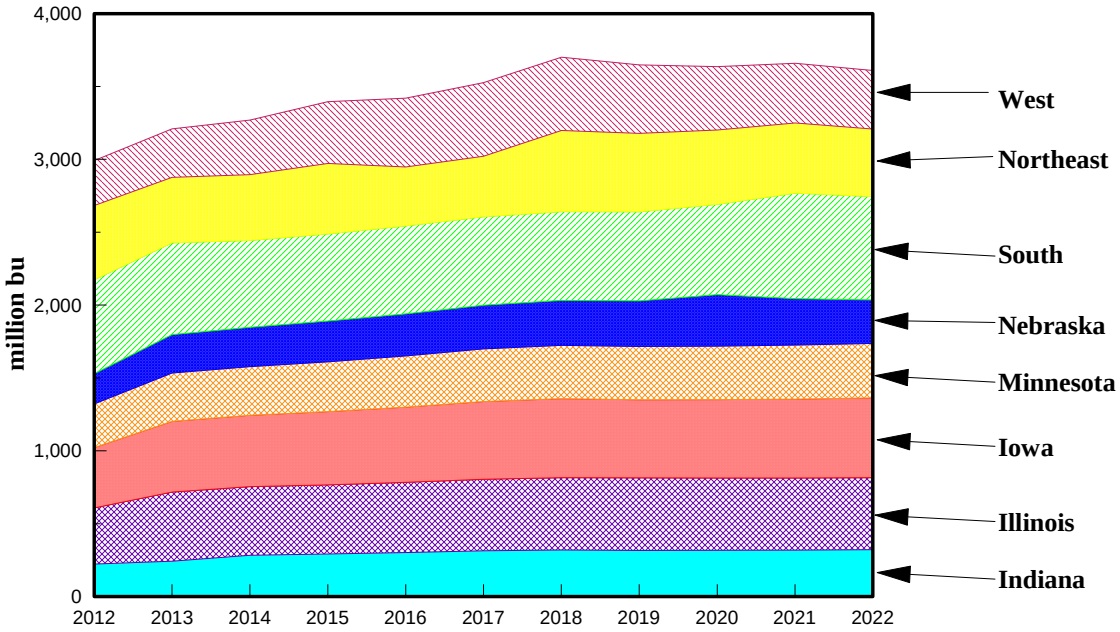


**Figure 18. Projected US Soybean Production by State/Region**

**Table 6. U.S. Corn Yields and Harvested Acres**

| Yields | 2011-2012 | 2012 | 2022 | change |
|---|---|---|---|---|
| | ---------bushels per acre-------- | | | % |
| Indiana | 123 | 99 | 186 | 51.6 |
| Illinois | 131 | 105 | 176 | 34.4 |
| Iowa | 155 | 137 | 189 | 22.2 |
| Minnesota | 161 | 165 | 184 | 14.7 |
| Nebraska | 151 | 142 | 186 | 23.1 |
| South | 112 | 105 | 148 | 31.4 |
| Northeast | 137 | 126 | 170 | 24.3 |
| West | 116 | 113 | 148 | 27.7 |
| | | | | |
| Harvested acres | | | | |
| | ----------million acres---------- | | | |
| Indiana | 5,890 | 6,030 | 5,314 | -10.8 |
| Illinois | 12,325 | 12,250 | 12,214 | -0.9 |
| Iowa | 13,700 | 13,700 | 12,974 | -5.6 |
| Minnesota | 8,015 | 8,330 | 6,332 | -26.6 |
| Nebraska | 9,350 | 9,100 | 8,177 | -14.3 |
| South | 9,489 | 9,973 | 8,656 | -9.6 |
| Northeast | 11,361 | 11,718 | 12,003 | 5.4 |
| West | 15,552 | 16,272 | 16,190 | 3.9 |

**Table 7. U.S. Soybean Yields and Harvested Acres**

| Yields | 2011-2012 | 2012 | 2022 | change |
|---|---|---|---|---|
| | --------bushels per acre--------- | | | % |
| Indiana | 45 | 44 | 54 | 17.8 |
| Illinois | 45 | 43 | 53 | 15.6 |
| Iowa | 47 | 45 | 56 | 17.1 |
| Minnesota | 44 | 43 | 48 | 7.8 |
| Nebraska | 44 | 42 | 52 | 18.1 |
| South | 42 | 38 | 43 | 1.2 |
| Northeast | 41 | 45 | 47 | 11.9 |
| West | 39 | 31 | 38 | -3.0 |
| | | | | |
| Harvested acres | | | | |
| | ----------million acres---------- | | | |
| Indiana | 5,215 | 5,140 | 5,946 | 12.3 |
| Illinois | 8,915 | 8,920 | 9,286 | 4.0 |
| Iowa | 9,265 | 9,300 | 9,746 | 4.9 |
| Minnesota | 7,061 | 6,990 | 7,768 | 9.1 |
| Nebraska | 4,938 | 4,990 | 4,979 | 0.8 |
| South | 16,716 | 16,990 | 16,565 | -0.9 |
| Northeast | 11,328 | 11,450 | 9,863 | -14.9 |
| West | 9,097 | 9,809 | 10,724 | 15.2 |

Prices of Corn and Soybeans in the U.S.

Figure 19 shows the projected corn and soybean prices for 2012 through 2022. Corn price is expected to decrease to $4.37 per bushel in 2016 and then increase to $6.51 by 2022. Soybean price is expected to be about $12.00 per bushel between 2013 and 2016 before falling to the $11.70 range in 2022. The decreases in corn and soybean prices are due mainly to projected increases in production on the two crops.

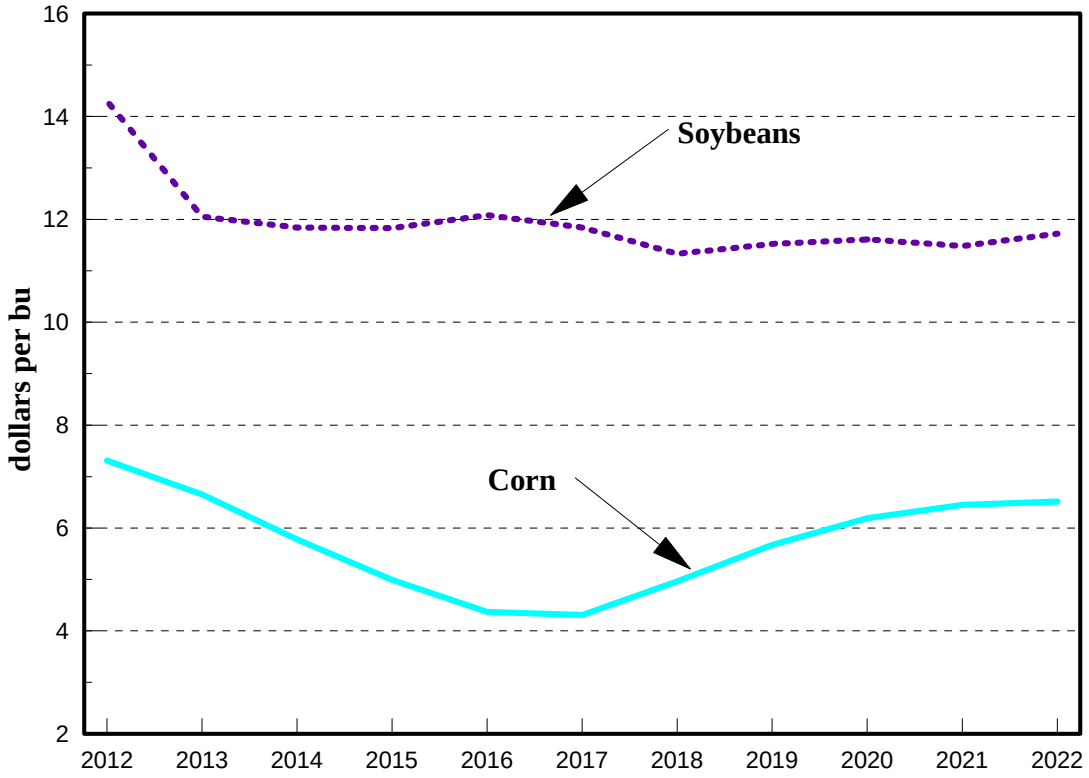


**Figure 19. Projected Corn and Soybean Prices**

U.S. Export and Utilization of Corn and Soybeans

Figure 20 shows the projected utilization for U.S. corn. Exports are expected to increase from 800 million bushels in 2012 to 1.7 billion bushels in 2017 before decreasing to 1.5 billion bushels in 2022. The feed use of corn is projected to increase by 20% from 4.5 billion bushels in 2012 to about 5.4 billion bushels in 2022. Ethanol use of corn is expected to increase by 31% from 4.5 billion bushels in 2012 to 5.9 billion bushels in 2022. Other industrial uses are projected to decrease by 44% between 2012 and 2022. Total U.S. consumption of corn is expected to increase by 22% during the forecast period.

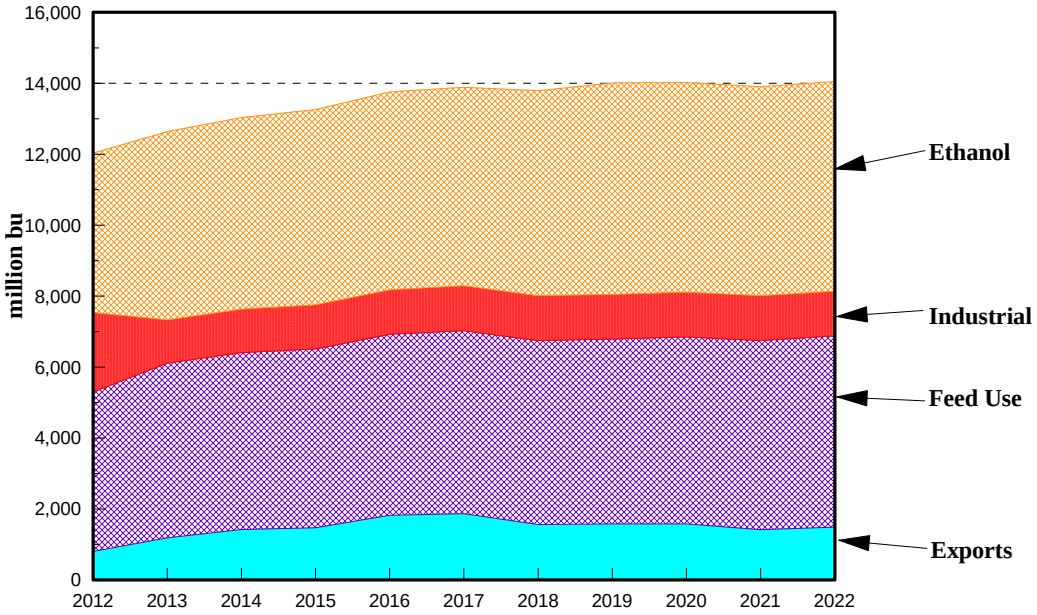


**Figure 20. Projected US Corn Utilization**

U.S. exports of soybeans are expected to increase during the forecast period from 1.3 billion bushels in 2012 and 1.7 billion bushels in 2018 before falling slowly to 1.5 billion bushels in 2022 (Figure 21). U.S. domestic processing is projected to increase by 22% from 1.6 billion bushels in 2012 to about 2.0 billion bushels in 2022. Feed and other uses are expected to increase by about 31%. Total domestic consumption is expected to increase by about 23% during the forecast period.

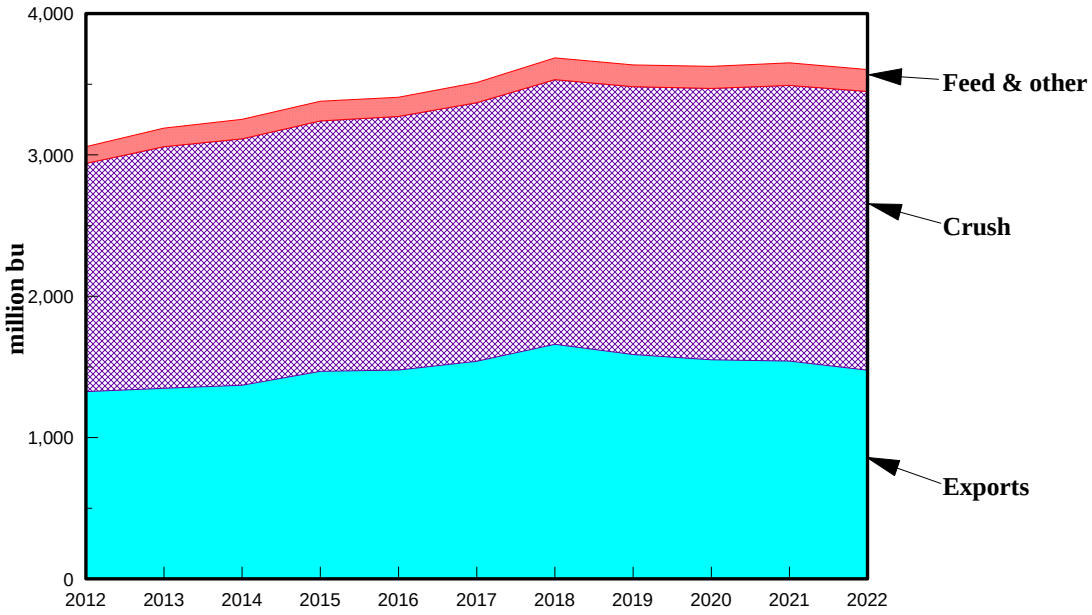


**Figure 21. Projected US Soybean Utilization**

## CONCLUSIONS

Recently, commodity markets experienced price increases which were caused, in the most part, by forces outside of agriculture. Late 2005 and early 2006 the price of crude oil doubled which drove up the price of energy. Increased energy prices increased the demand for and price of ethanol. The high price of corn caused by increases in ethanol production impacted all other commodities. During 2008, commodity prices reached historical levels. Prices again increase for most commodities in late 2010 and early 2011. The United States experienced a near record drought in 2012. The dry weather conditions reduced the corn crop by 19% and soybeans by 10%. The decreases in production increased commodity prices substantially.

In spite of high commodity prices, world trade of corn and soybeans remained strong, due mainly to the weakening of the U.S. dollar against major currencies. China, the largest importer of soybeans, continued to import increasing amounts of soybeans for its domestic use.

Until 2012, the U.S. was the largest exporter of corn, however, because of the drought in the United States, Argentina and Brazil exported similar amounts of corn. U.S. exports should return to normal levels in future years. Feed use for corn will also increase, but only moderately. Some of the increased demand for feed use will be absorbed by DDGs.

The ethanol industry in the U.S. will continue to grow but at a slower rate than in the past. The processing capacity of corn-based ethanol will not continue to increase since profit margins have narrowed in the past 2 or 3 years. The Energy Independence and Security Act of 2007 requires 36 billion gallons of ethanol to be blended with the U.S. gasoline supply with about 11 billion gallons from corn-based ethanol and 25 billion gallons coming from bio-mass based ethanol by 2025. The corn based ethanol industry currently producers about 11 billion gallons. Bio-mass ethanol production has not moved beyond the testing and research stage due to high production costs. The U.S. ethanol industry is expected to continue to grow but at a slower rate than in the past. In 2012, 4.5 billion bushels of corn was used for ethanol production and by 2022 it is projected that 5.9 billion bushels of corn will be used for the production of ethanol.

China’s demand for soybeans continues to increase into the future as increases in consumer income continue to change dietary patterns in the country. In 2012, China imported 2.3 billion bushels of soybeans. By 2022, it is projected to import about 3.5 billion bushels of soybeans. Most of the additional soybeans demand in China will come from the South American nations since the U.S. does not have additional land to increase soybean production.

The price of corn is expected to fall from the current price of $7.31 to $4.31 in 2017 before increasing to $6.51 in 2022. Soybean price is expected to slowly fall throughout the forecast period. By 2022 soybean price is expected to be $11.72 per bushel.

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