U.S. AGRICULTURE: MEETING FUTURE DEMAND FOR FOOD, FIBER, AND FUEL

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Introduction Future food, fiber, fuel, and water requirements of a growing global population will place increasing stresses on our agricultural production systems. While all ecosystems are impacted by human intervention and management, meeting future global demands for resources will challenge societies to cooperatively manage and protect ecosystems. Over the next 40 years global demand for food and other products will increase by more than 50%. The increased global demand on agriculture will continue to support higher commodity prices than those experienced in past decades. This resurgence in the value and importance of production agriculture is driven by several factors including (1) increasing population pressure, (2) increasing non-agricultural land use, (3) global dependence on the U.S. for food security, (4) increasing non-food use of crops, and (5) increasing pressure on soil/water resources. Each factor will be evaluated relative to its impact on agricultural production.

Global Population Growth Since 1970, the global population growth rate decreased from 2% to 1% and is projected to decline to 0.5% by 2050. Despite declining population growth rates, total world population will still increase nearly 50% to approximately 9.5 billion people by 2050 (Figure 1). The substantial increase in global population over the next four decades will drive food consumption (Figure 2). These data illustrate that cereal consumption for food will increase about 50%, while meat consumption will double. Most of these projected increases will occur in developing nations, particularly China and India, whose economies are experiencing rapid growth in disposable income. As the percentage of animal products in the diet increases, cereal use for feed will increase (Figure 2). For example, China will nearly double its use of cereals for animal feed from 120 to 230 million Mt by 2020. As a result, China is projected to import 2 million Mt of corn per year over the next decade, whereas over the last decade China has exported corn.

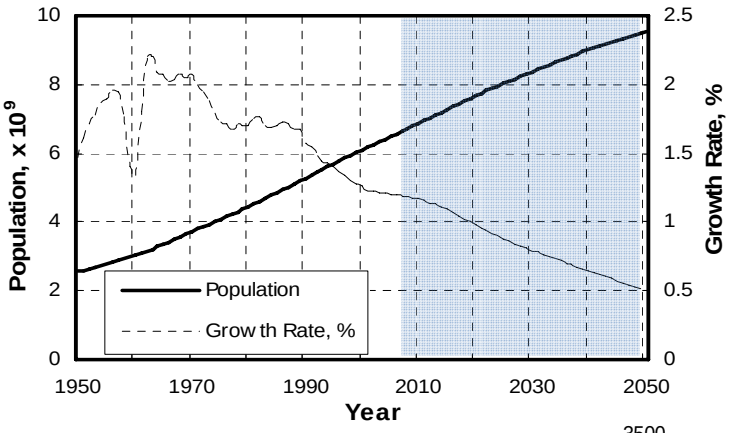

Figure 1. Actual and projected world population growth from 1950 to 2050 (UN, 2007).

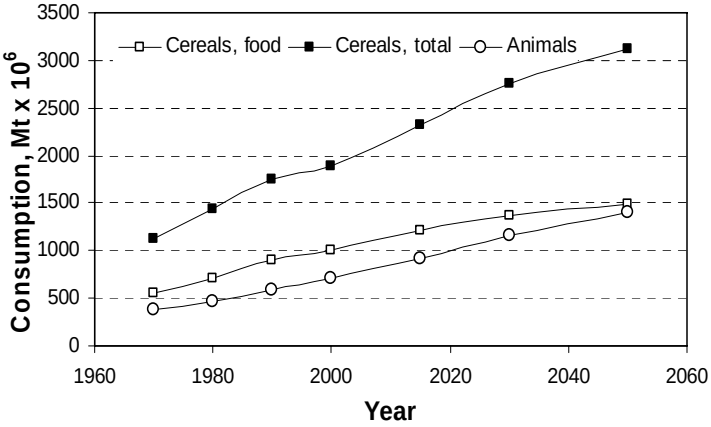

Figure 2. Actual and projected cereal and animal product consumption from 1970 to 2050 (FAO, 2008).

U.S. Role in Food Security The U.S. currently provides about 60% of global food aid (Figure 3). As global food demand and feed grain use increase, the U.S. will increasingly be asked to maintain or increase its role in world food security. Using corn as an example, Figure 4 illustrates that despite continued increases in production, domestic demand growth has resulted in a decrease in ending stocks, while exports have remained constant. While U.S. exports have been relatively constant since 1980, world import demand has increased nearly 50% (data not shown). Therefore, it is likely that world demand for grain must be met in part by increased U.S. production and export.

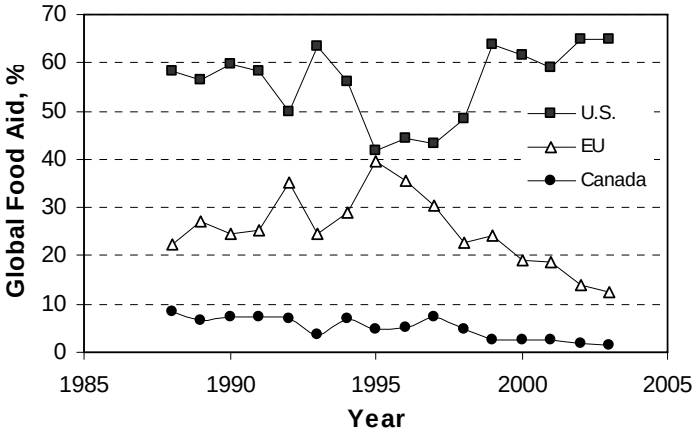

Figure 3. Major providers of world food aid (Shapouri and Rosen, 2004).

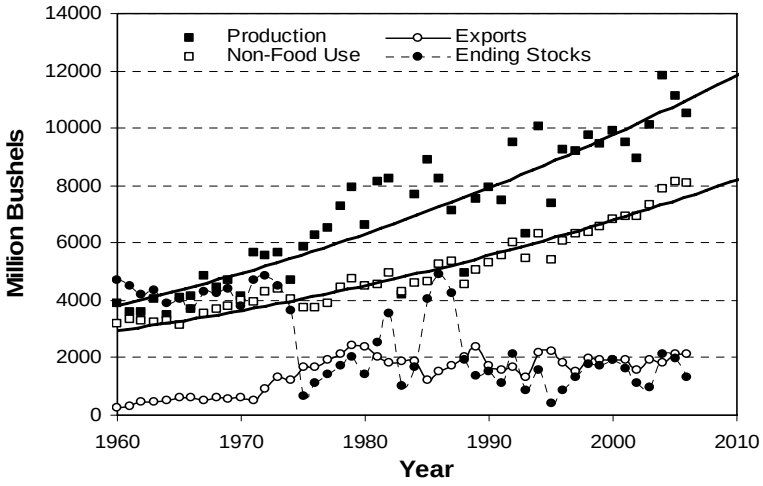

Figure 4. U.S. corn production, domestic use, exports and ending stocks (USDA, 2008).

The ability of the U.S. to assist in global food security programs, while meeting domestic demand, is challenged by increasing U.S. population growth and conversion of farmland to non-agricultural uses. While its current population is approximately 300 million, U.S. population will increase 50% to 450 million by 2050 (Figure 5). Depending on future immigration policy, the U.S. population could increase to 500 million.

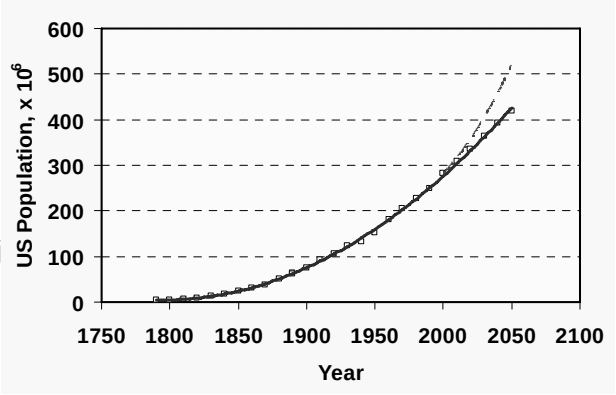

Figure 5. U.S. population growth from 1800 to 2050. Dashed line represents estimates including illegal aliens (US Census Bureau, 2008).

Increased population growth jeopardizes retention of agricultural land area needed to maintain and increase agricultural production output. Since 1950, U.S. cropland has decreased approximately 10% from 480 million to 435 million acres, with a proj decrease to about 350 million acres by 2050 (Figure 6). Urban land occupies only 3% of total U.S. land area (~80% of U.S. population); however, since 1980, rural residential land use increased 68% from 56 million to 94 million acres, with about 60% of t land in parcels of 10 acres or more (Figure 7). The projected rural residential land use in 2050 is

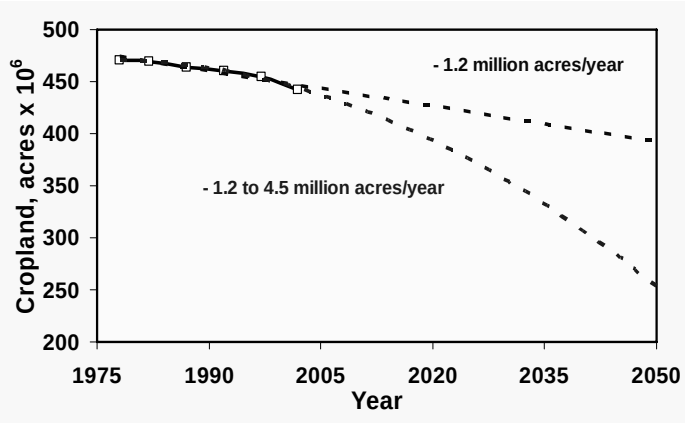

Figure 6. Trend in declining cropland in the U.S. (Lubowski et al., 2006).

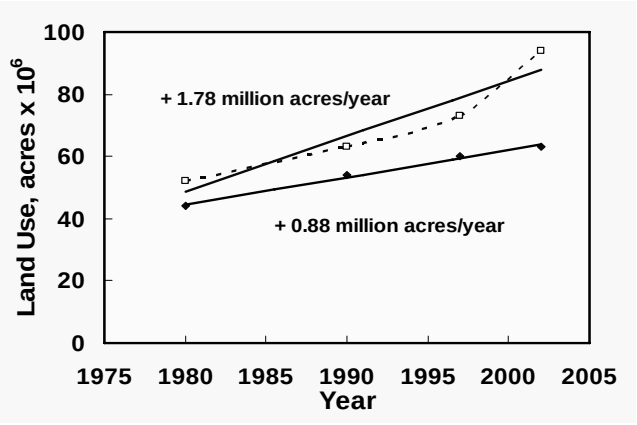

Figure 7. Trend in increasing urban (solid line) and rural residential (dashed line) land use in the U.S. (Lubowski et al., 2006).

160 million acres with the additional acres transferred from crop and forest lands. By 2050, the amount of per capita arable land in the U.S. will have decreased from about 1.6 to 0.7 acres per person. Over the same time period, global arable land will decrease from 0.56 to 0.39 acre per person (data not shown), increasing pressure in developed countries to meet their food and fiber demand. Meeting future grain demand in the U.S. and globally will require accelerated advances in yield per acre unless communities are willing to include agricultural productivity as a meaningful criteria in land use decisions.

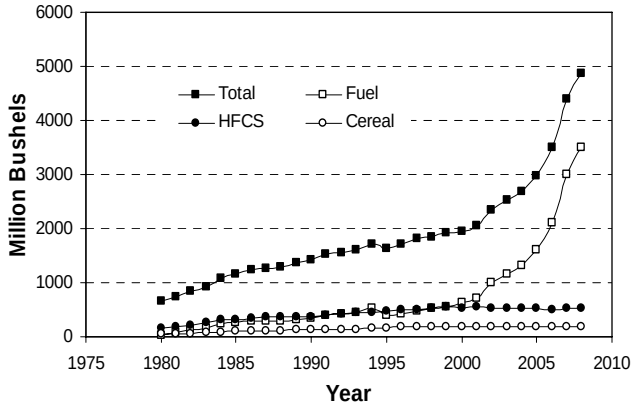

Figure 8. Total, fuel, cereal, and high fructose corn syrup use of corn grain in the U.S. (USDA-ERS, 2008).

<u>Utilizing Food Crops for Non-food Uses</u>

Increased consumption and cost of energy in the U.S. has driven policy and market decisions to utilize grain crops to produce ethanol. In the last decade, U.S. ethanol production has increased more than four fold (Figure 8). Using recent estimates of potential ethanol production capacity in 2010, approximately 10 billion gallons of production are possible which would require about 4 billion bushels, assuming a conversion of 2.5 gallons ethanol per bushel of corn. This level of ethanol production would utilize 30% of total U.S. corn production (Figure 4). If the 2005 Energy Bill goals of 35 billion gallons are realized, about 14 billion bushels of corn would be needed, which would consume the entire U.S. corn crop! Despite increases in grain yield and acreage planted to fuel dedicated grain crops, if 50% of the proposed ethanol production potential occurs (10 billion gallons), estimates of corn grain available for export range between 0 and 30%. Reducing the ability to support global food security goals is likely not a politically tenable position for the U.S.

<u>Declining Soil Productivity</u> Continued degradation of world soil productivity threatens our ability to meet future global food and fiber demand. Although soil degradation varies widely between regions (developed vs. developing), approximately 46% of the world's cropland has degraded due primarily to overgrazing, deforestation, and cropland soil erosion (Table 1). About

2 million hectares of rainfed and irrigated agricultural lands are lost to production every year due to severe land degradation, which increases the productivity demand on the remaining croplands.

Table 1. Cropland area degraded to levels that reduce crop productivity (FAO, 2008).

Continent	Cropland area	Degraded area †	% degraded
Africa	462	299	65
Asia	1324	808	61
Australia / Pacific	121	20	16
Europe	709	178	25
North America	583	156	26
Central America	94	69	74
South America	351	158	45
Total	3643	1687	46

† million acres

Since future increases in food production will come from increased yield per unit of land area instead of increased arable land area, it is imperative that efforts to sustain and enhance soil productivity be increased, especially in developing countries. Continued trends in soil degradation will jeopardize our capacity to meet future food demand. Removal of a significant proportion of field crop residues for fuel production may also reduce soil organic matter and accelerate soil degradation, which reduces soil productivity.

Analysis and Summary To evaluate increased food production needed to meet demand, U.S. corn production will be used as an example. Over the last four decades, corn yields increased from 60 to 150 bu/ac (Figure 9). Based on a relatively stable production acreage (~70 million ac.), total production increased from 4 to 12 billion bushels over the last 40 years. By 2050, using current corn production growth rates, total corn production will be about 18 billion bushels with an average corn yield of 229 bu/ac, which represents a 1.86 bu/ac/year increase in average corn yield (Figure 10).

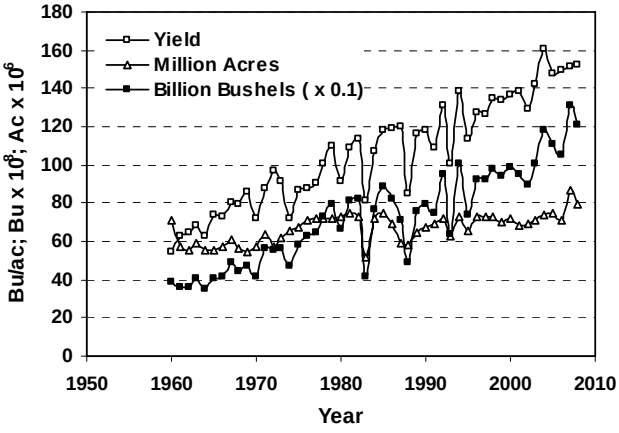

Figure 9. Total and per acre corn production and corn acres harvested in the U.S. (USDA-ERS, 2008). Total production expressed as bushels x 10^8 or billion bushels (x 0.1).

Assuming increased U.S. export demand (~4 billion bushels), corn utilized for ethanol (~10 billion bushels), and other current U.S. consumption (~6 billion bushels), we would need approximately 20 billion bushels by 2050. At this level of corn production, average corn yields will need to be about 286 bu/ac in 2050, assuming land area in corn remains at 70 million acres (Figure 11).

Table 2 provides an illustration of corn production potential under different demand levels and available acres. These estimates indicate that as corn demand increases above current levels projected in 2050 (18 million bu), corn yield will have to increase above 2050 estimates (229 bu/ac). Further increases in corn yield (323 bu/ac) will be needed if corn acreage is reduced by conversion of farmland to non-agricultural uses.

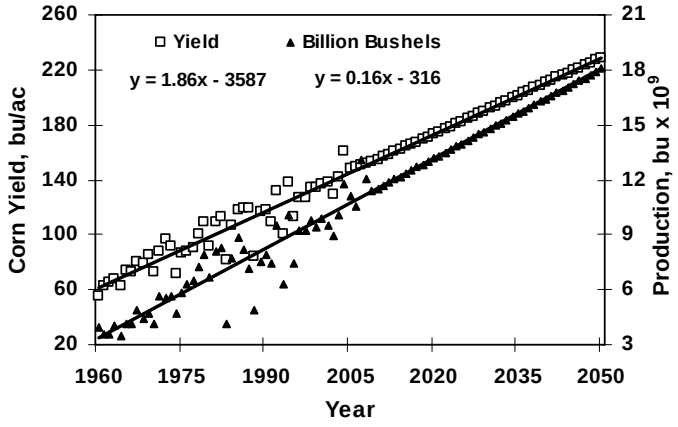

Figure 10. Current U.S. corn yield and total production projected to 2050

Using the projected corn yield needed to generate 20 billion bushels by 2050 (data shaded in Table 2), corn yield (bu/ac/yr) growth rates can be estimated (Figure 11). Assuming no change in current corn acreage, then current growth rate in corn yield of 1.86 b/ac/yr will need to increase about 70% to 3.19 bu/ac/yr (Figure 11). Current corn acreage of 70 million acres represents about 20% of total cropland. If we reduce cropland by an average of 1 million ac/yr over the next 40 years, then corn acreage will be reduced by 8 million acres to 62 million acres by 2050. Thus, sustaining estimated production at 20 million bushels would require an additional 25% increase in yield growth to 4.09 bu/ac/yr. These substantial increases in corn yield over the next 40 years can only be realized through continued advances in crop biotechnology, as well as continued investments in soil and crop management that result in increased productivity.

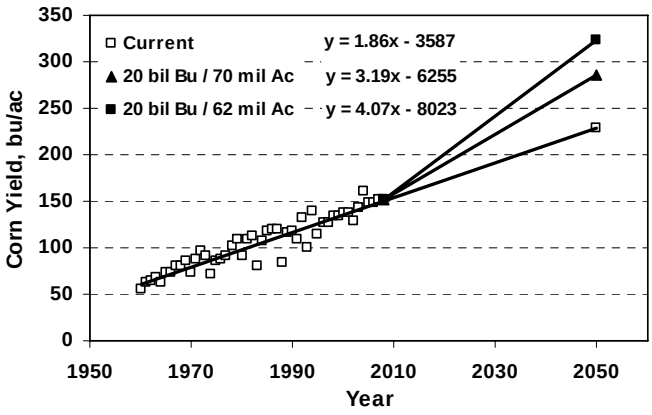

Figure 11. Projected increases in annual corn yield growth by 2050, assuming the parameters identified in Table 2.

Increasing global demand for food and other products requires enhancing agricultural productivity while maintaining healthy function of all ecosystems. We are increasingly challenged to meet this demand as arable land is lost to non-agricultural uses, and food crops are increasingly utilized for non-food uses. Attempts to compensate by expanding agricultural production into other areas, as in previous decades, are constrained by decreasing availability of suitable land and widespread land degradation. Ultimately, grain yield per unit of land area must be increased.

Table 2. Influence of potential corn demand on estimated total U.S. production and yield with current and projected corn acreage by 2050.

Additional bushels needed	Total bushels needed	Corn Yield @ 70 million Ac	Corn Yield @ 62 million Ac*
Billion bushels		*bu/ac*	
3	15	214	242
8	20	286	323
13	25	357	403

* 8 million ac of lost corn acres represents 20% of estimated 40 million acres converted farmland

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