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How U.S. Grain Export Projections from Large Scale Agricultural Sector
Models Compare with Reality

C. Phillip Baumel∗

EXECUTIVE SUMMARY

In recent years, agricultural industry groups, trade organizations, and government agencies have relied on agricultural production, consumption, and export projections as major inputs into long-term investment and policy decisions. Two sets of projections that have received most of the attention are the United States Department of Agriculture's (USDA) Agricultural Baseline and the Food and Agriculture Policy Research Institute's (FAPRI) Agricultural Baseline. The use of these two models as forecasting tools has become a topic of discussion as a result of the U.S. Army Corps of Engineers' (Corps) study of the Upper Mississippi River System.

Grain exports are the cornerstone for the evaluation of the benefits of extending the locks on the Upper Mississippi River from 600-feet to 1,200-feet. The Corps, in their Upper Mississippi River – Illinois Waterway Navigation System Feasibility Study, forecasts rapidly rising grain exports. The Corps analysis was criticized because it forecast rapidly rising corn and wheat exports at the same time that corn exports have been in a 20-year downtrend and wheat exports have fallen dramatically. This criticism prompted the Corps to revise their corn and soybean export forecasts by extrapolating one of several annual USDA baseline projections of grain exports out 40 additional years. This second forecast was also criticized.

USDA and FAPRI indicate that the basic purpose of their models is to evaluate the implications of alternative agricultural policies. Furthermore, the USDA and FAPRI reports clearly state that the model results are not intended to be forecasts, but rather are baseline projections to be used for national policy analysis. A careful review of the assumptions and techniques employed

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in these models shows major limitations as forecasting tools. As presently formulated, these models rarely predict stable or declining U.S. grain exports. Their tendency to predict increasing U.S. grain exports is directly related to the assumptions behind the model. Nevertheless, government agencies, trade associations, and agribusiness, increasingly use baseline projections as forecasts.

These baseline models were constructed to measure <u>changes</u> in agricultural production, income and exports under alternative policies rather than to forecast absolute levels of exports. The greatest barrier to correcting these problems may be the limited resources currently directed at developing and maintaining these models. If government agencies -- including the Corps -- trade associations, and agribusiness wish to have these models changed into forecasting models, they will need to provide funding to continually revise the models and maintain a current database.

How U.S. Grain Export Projections from Large Scale Agricultural Sector
Models Compare with Reality

C. Phillip Baumel*

INTRODUCTION

In recent years, U.S. agriculture -- industry groups, trade organizations, and government agencies -- have relied on production, consumption, and export projections as major inputs into long-term investment and policy decisions. Several agricultural baseline models are used to project the direction of the agricultural sector; most of these models are patterned after the USDA and FAPRI[1] models. Annually, these two models provide a ten-year baseline for the U.S. agricultural sector. USDA baseline projections have only been available to the public since 1996.

The use of agricultural baseline models as forecasting tools has become a topic of discussion as a result of the U.S. Army Corps of Engineers' (Corps) study of the Upper Mississippi River System. In a presentation before the National Research Council's Committee to Review the Upper Mississippi River - Illinois Waterway Navigation System Feasibility Study on June 20, 2000, a representative of the National Corn Growers' Association stated:

> *"Traffic Projections*
>
> *The methodology used by the Corps to project traffic levels into the next half of a century has unfairly come under intense scrutiny for being overly optimistic. In our opinion, the methodology employed by the Corps was not the best approach. A more preferable method would have been to forecast world food demand and then work backwards to an estimate of grain and food exports. However,*

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this methodology also relies upon assumptions of world population growth, yield increases and losses of arable land.

Irrespective of the methodology used, world population and global food demand is increasing. To support this rise, global grain, oilseed, and feed ingredient shipments will also increase. The U.S. Department of Agriculture estimates global corn, soybean, and wheat trades to increase by an annual rate of 2.6, 1.0, and 1.9 percent, respectively. Likewise, they estimate annual growth rate of U.S. corn exports at 2.6 percent, soybeans exports of 1.6 percent and wheat exports of 3.5 percent.[2] Another key forecasting group projects U.S. corn and soybean exports to rise between now and 2010 at annual rates of 2.4 and 1.5 percent.[3] By contrast, the Corps predicts an overall annual growth rate for U.S. corn exports of 2.0 percent between 1999-00 and 2050-51.

The Corps estimates were based on long-run yield and consumption trends. One complaint raised is that these trends do not factor in non-linear growth rates from the future applications of biotechnology. In our opinion, this omission minimizes the benefits arising from lock improvements."

The National Corn Growers statement that the Corps' methodology "has unfairly come under intense scrutiny for being overly optimistic"[4] may refer to an unpublished paper by C. Phillip Baumel entitled "Evaluation of the U.S. Army Corps of Engineers (Corps) Forecasts of U.S. Grain Exports." A short version of the Baumel article appeared in the July 17, 2000 issue of Feedstuffs.[5] The original article contains figures 1, 2 and 3. These figures show that U.S. corn, wheat and
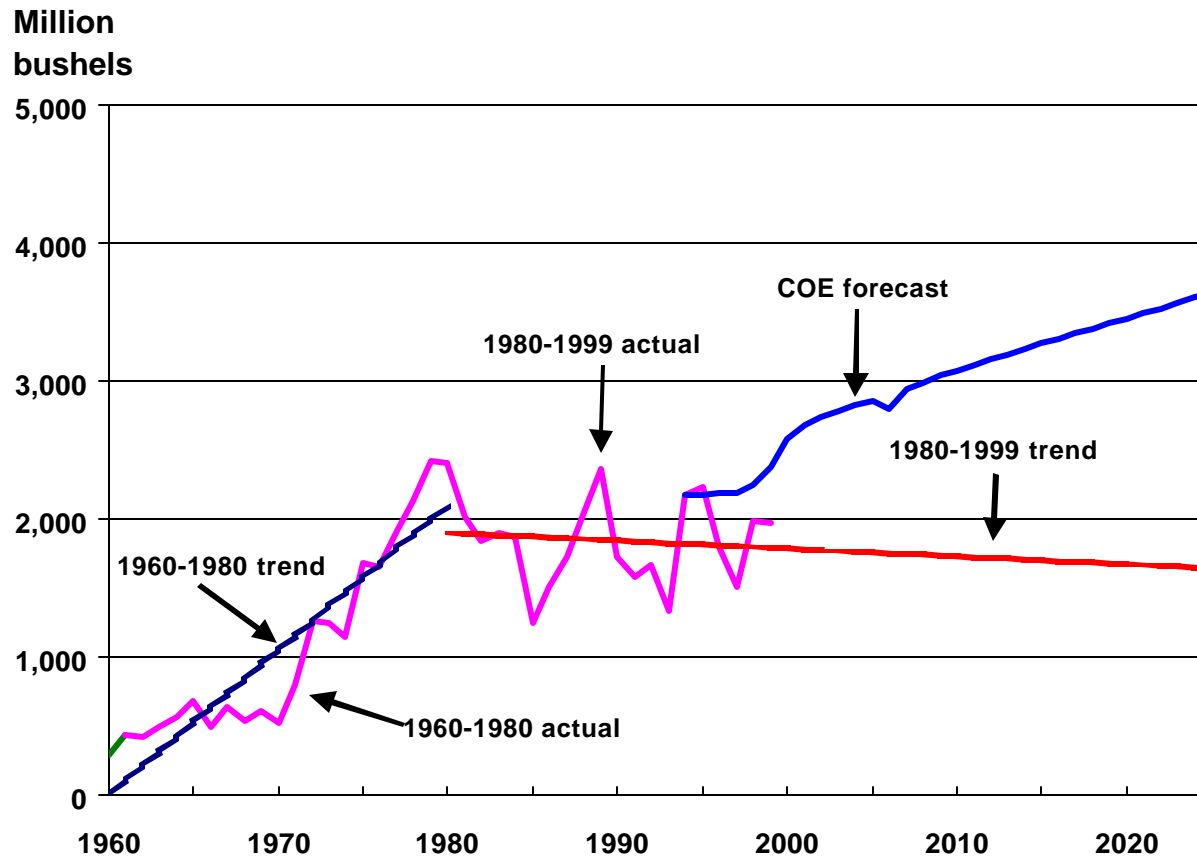
Figure 1. U.S. Corn Exports: 1960-2025.

Figure 2. U.S. Wheat Exports: 1960-2025.

Million
bushels

2,500

1980-1999 actual

COE forecast

2,000

1960-1980 trend

1,500

1980-1999 trend

1,000

1960-1980 actual

500

0

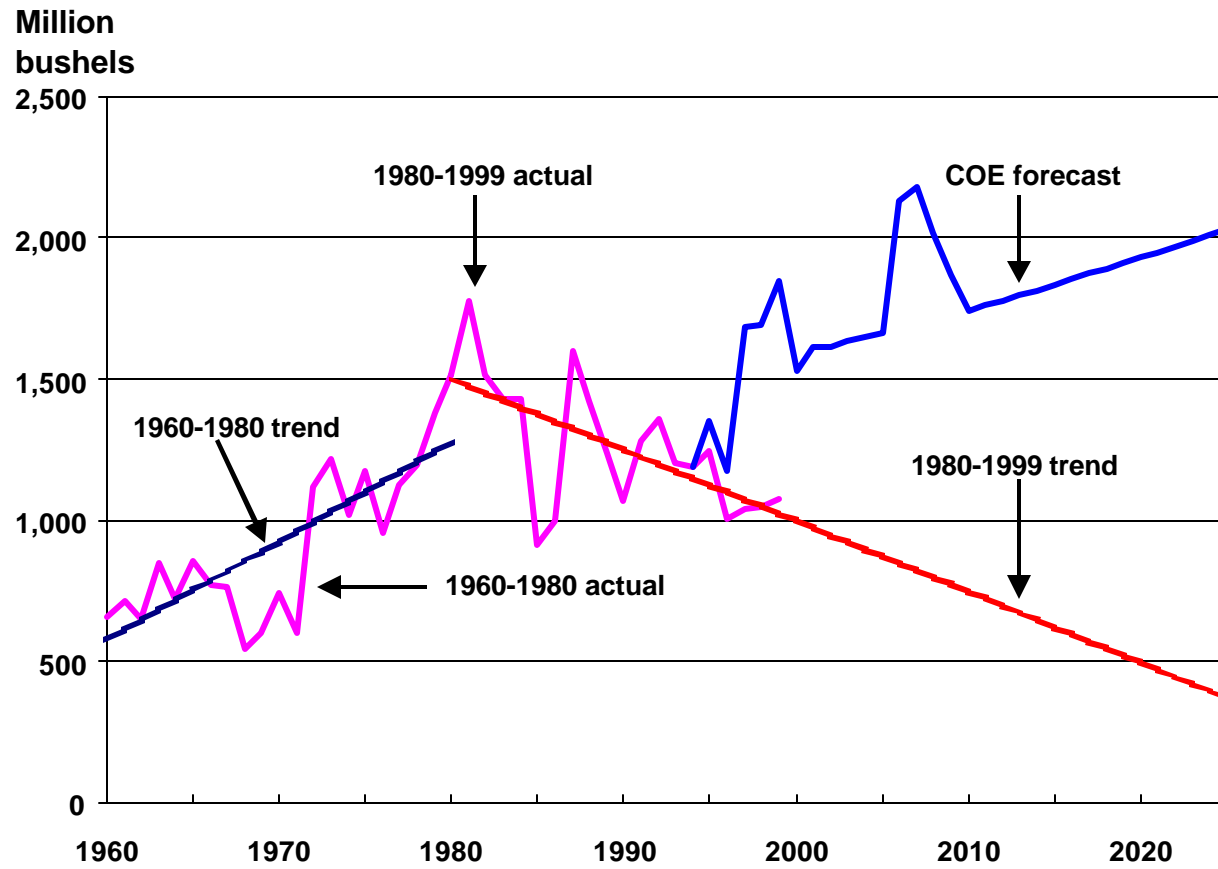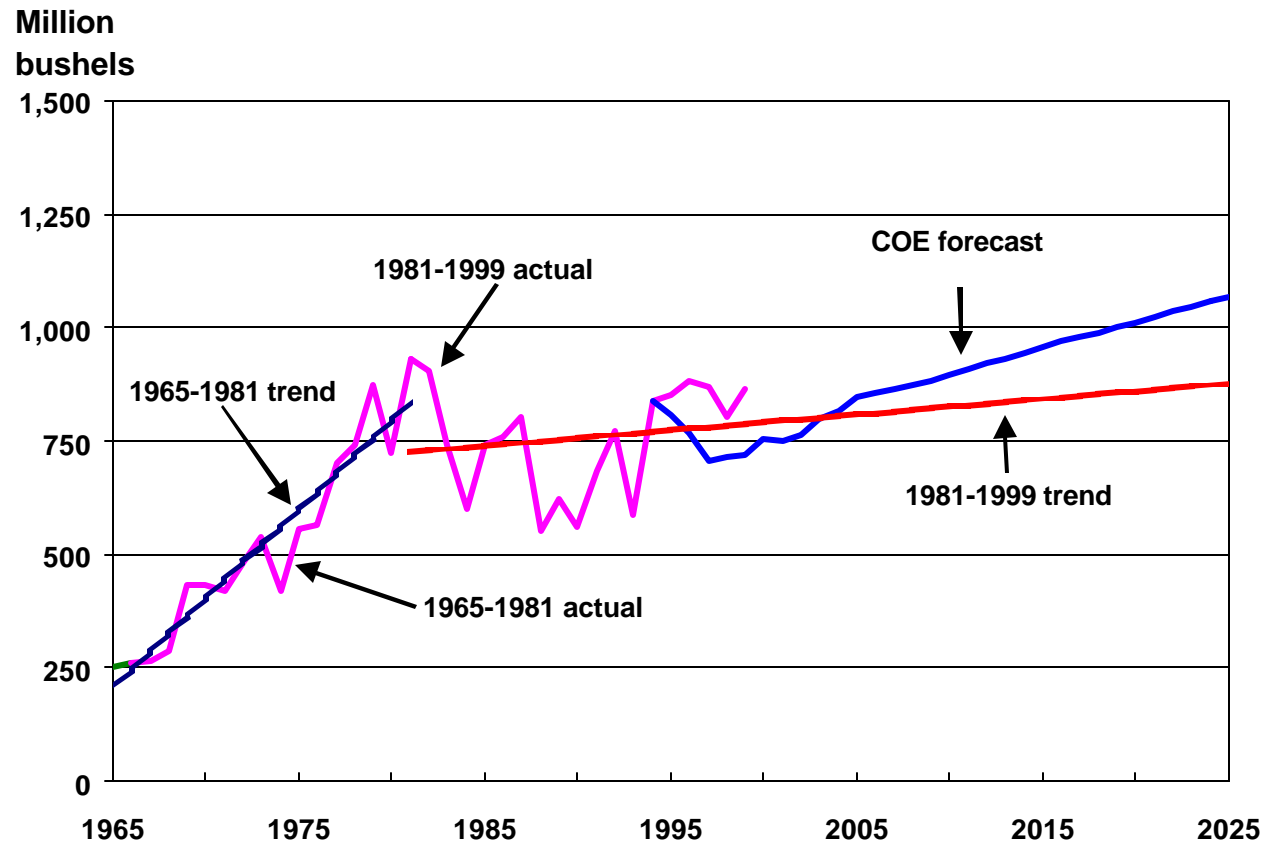1960   1970   1980   1990   2000   2010   2020

Figure 3. U.S. Soybean Exports: 1965-2025.

soybean exports increased exponentially during the 20-year period from 1960-1980. However, since 1980, corn exports have trended downward, wheat exports have declined dramatically, and soybean exports have trended slightly upward. Figures 1, 2 and 3 also show that the Corps forecasted sharp increases in corn and wheat exports and modest increases in soybean exports from 1995-2045. From 1995-1999, the Corps' export forecasts exceeded actual exports by over four billion bushels. Moreover, there is nothing on the horizon indicating that current export trends will change dramatically. This suggests that the gap between the Corps forecasts and actual exports is likely to widen over time.

Following the Baumel paper, the Corps asked Jack Faucett Associates (JFA) to review their original grain export forecasting methodology and to develop a set of revised forecasts, if appropriate. As a result, JFA abandoned their original corn and soybean export forecasts and developed a new set of forecasts based on USDA Agricultural Baseline Projections to 2009. They continue to use their wheat export forecasts shown in figure 2. The Corps then asked Bitzan and Tolliver (BT) to review the revised JFA methodology and forecasts.[6] BT were very critical of the revised methodology and forecasts. Specifically, BT stated, "We believe that the entire approach to the revised forecasts is flawed." Their conclusion is based on the following:

- USDA states that their projections are not intended to be a forecast of what the future will be,

- USDA revises their projections annually so the projections are not meant to be an ongoing trend, and

- Extrapolating these projections 40 years into the future is a flawed procedure.

This paper extends the BT analysis by comparing the projections from the USDA and FAPRI baselines with actual U.S. grain production and exports and foreign grain production and consumption. The paper then evaluates the usefulness of current agricultural baseline models, which

were designed for policy analysis, as forecasting tools. Finally, the paper suggests possible modifications to baseline models to make forecasts from these models useful in making long-term investment and policy decisions.

USDA MODEL

The USDA baseline model projections have been available to the public since 1996. Therefore, only four sets of USDA baseline projections were available for this analysis.

Figures 4, 5 and 6 show 1997 - 2000 USDA annual ten-year baseline projections for corn, wheat and soybeans and actual exports from 1980 to 2000. Projected trend lines were estimated using least squares regressions on actual U.S. exports from 1980-2000. The following observations can be made about figure 4:

- Almost all of the USDA corn export projections are monotonically increasing with approximately the same slope,

- Actual corn exports trended downward from 1980 to 2000, and

- The beginning year of each set of annual corn export projections shifted exactly with the actual level of exports.

Figure 5 shows the USDA annual baseline ten-year wheat export projections and actual wheat exports from 1987-1999. The following observations can be made about figure 5:

- Almost all of the USDA baseline wheat export projections are monotonically increasing, with approximately the same slope,

- Actual   wheat   exports   trended   downward   from   1980   to   2000,   and

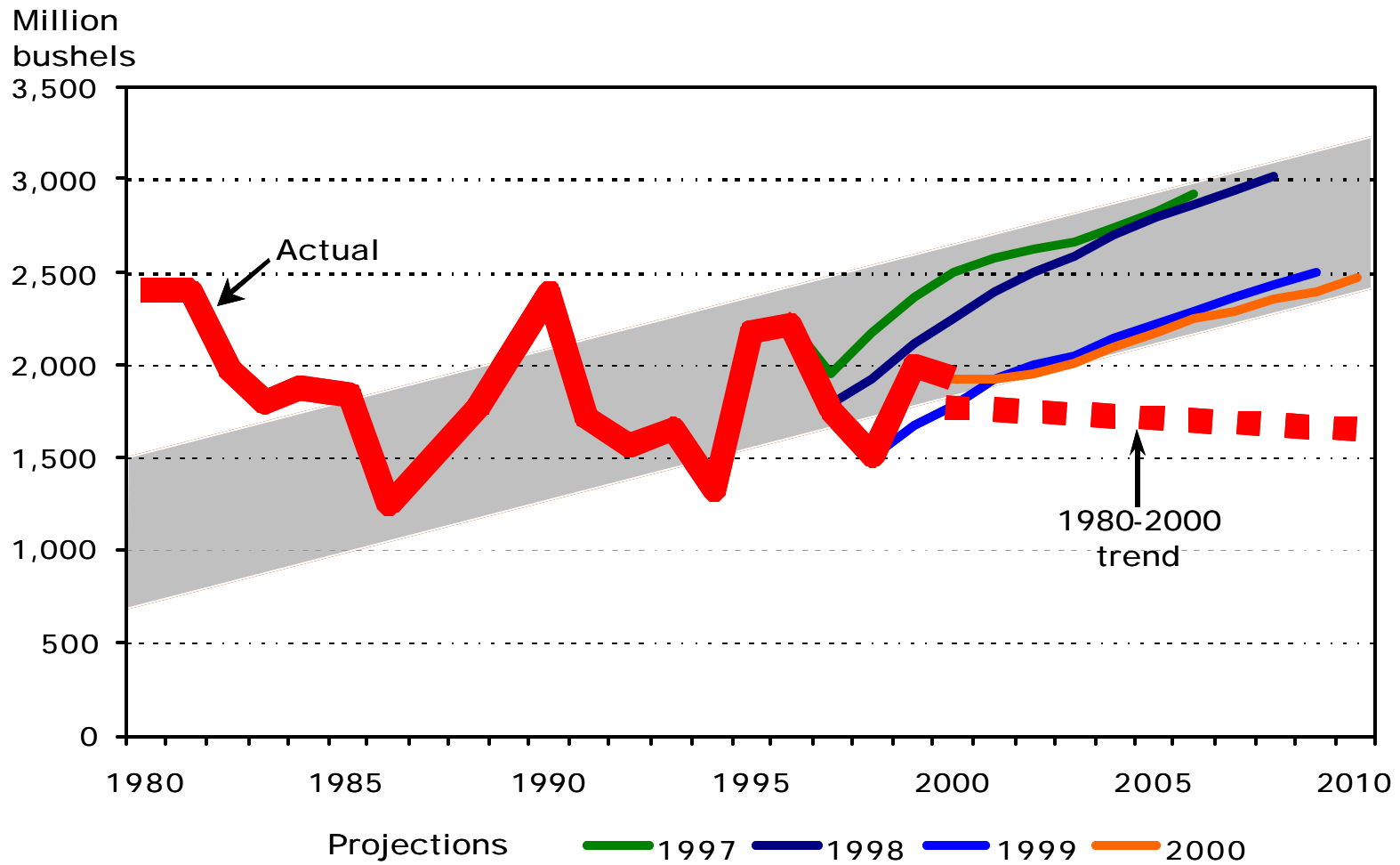# Figure 4. Actual and USDA projected U.S. corn exports, 1980-2009.

Million bushels

3,500

3,000

2,500

Actual

2,000

1,500

1,000

1980-2000 trend

500

0

1980   1985   1990   1995   2000   2005   2010

Projections   1997   1998   1999   2000

Figure 5. Actual and USDA projected U.S. wheat exports, 1980-2009.

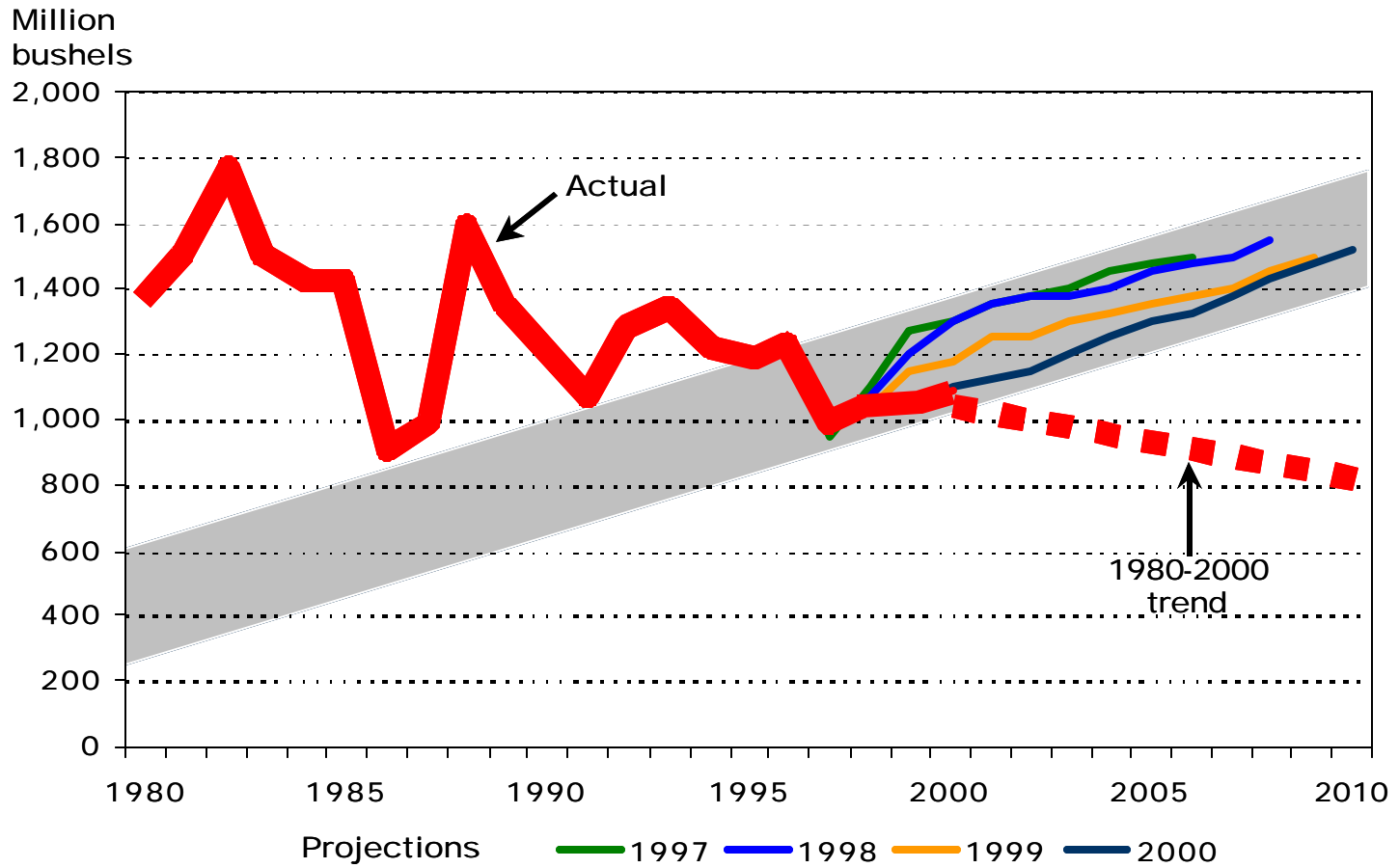**Figure 6. Actual and USDA projected U.S. soybean exports, 1980-2009.**
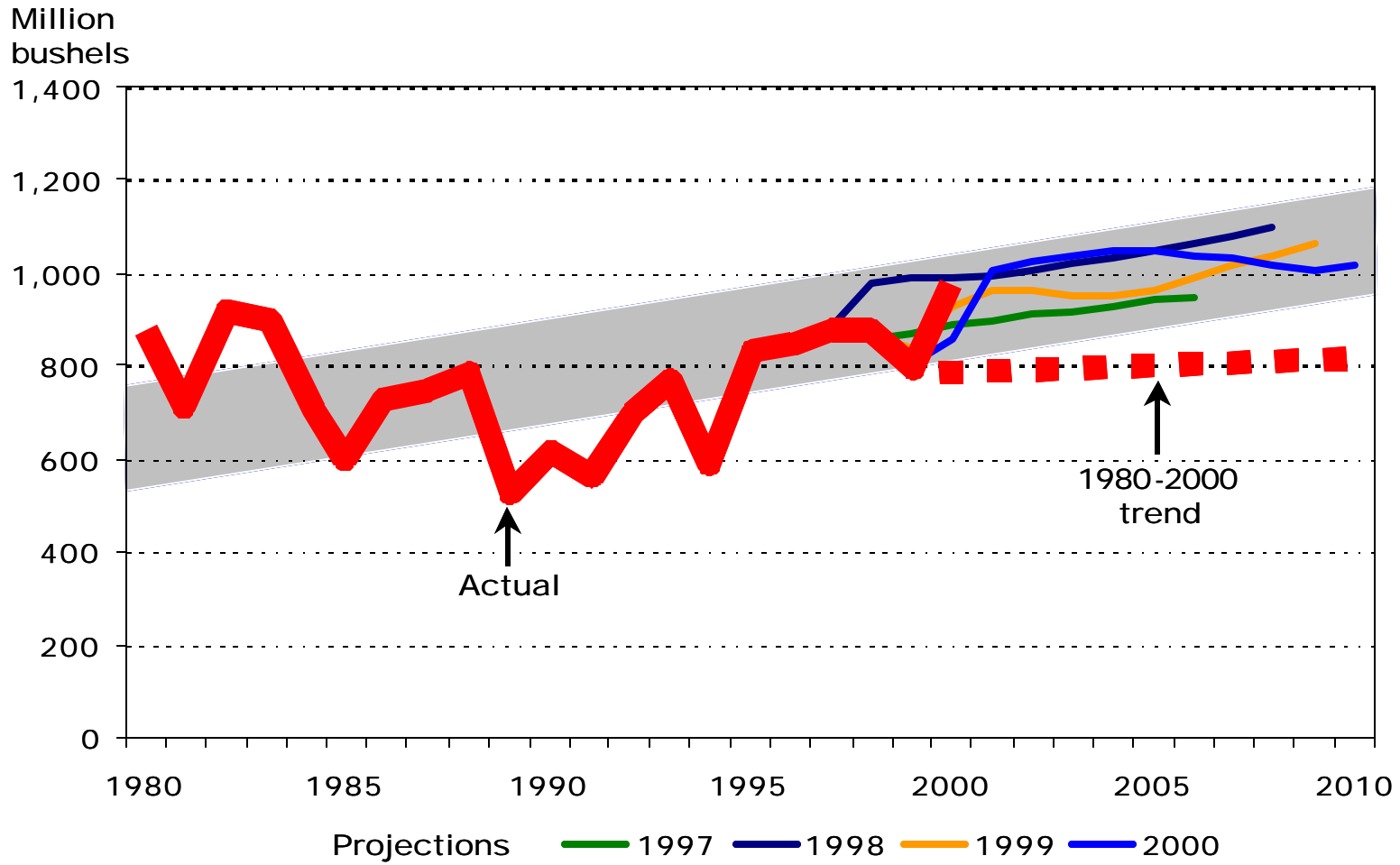

Million
bushels

Projections ▬ 1997 ▬ 1998 ▬ 1999 ▬ 2000

- The beginning year of each set of annual projections shifted exactly with actual exports.

Figure 6 shows actual U.S. soybean exports and the USDA baseline export projection. The following observations can be made from figure 6:

- Almost all of the baseline projections are monotonically increasing, with approximately the same slope,

- The 1980-2000 trend in soybean exports is slightly upward, and

- The beginning year of each set of annual projections shifted exactly with actual exports.

Figure 7 shows actual world corn exports and USDA 1997 and 1998 ten-year world corn export baseline projections. Only these two 10-year world corn export baseline projections have been published. It is clear that these two USDA corn export projections exceed the trend in world corn exports.

Figures 8 and 9 show some of the reasons why USDA world export projections exceed the trend in actual world exports. Figure 8 shows the USDA projected and actual corn imports by China. China imported substantial amounts of corn in 1994 and 1995 but since then has imported little or no corn. Yet the 1997, 1998, 1999 and 2000 USDA ten-year projections show China importing large quantities of corn. The 1998 USDA projections have China importing up to 560-million bushels of corn. To the contrary, in 1996, China exported about 160-million bushels of corn, rising to about 400-million bushels in 1999.

Figure 9 shows the USDA estimates of actual China corn consumption from 1961 to 2000 and projected corn consumption from the 1997 and 1998 USDA projections. Projected corn consumption is 25- to 30-million metric tons (1,000 to 1,200 million bushels) greater than 1997-2000 actual corn consumption.

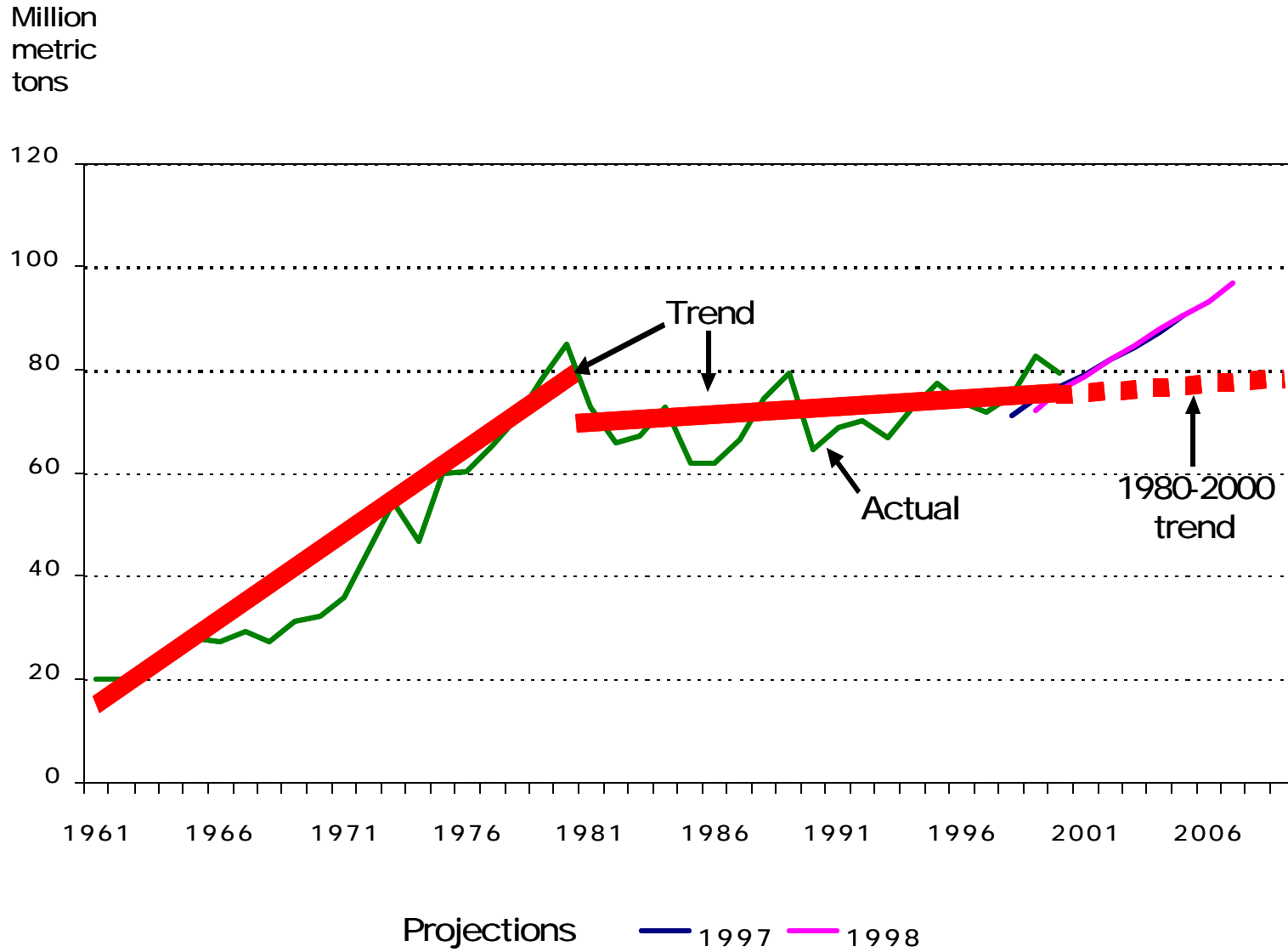**Figure 7. USDA actual and projected world corn exports.**

Million
metric
tons

Trend

Trend

Actual

1980-2000
trend

Projections   1997   1998

Figure 8. Actual and USDA projected China corn imports, 1961-2009.

Million
metric
tons

Actual

Projections   —— 1 9 9 7   —— 1 9 9 8   —— 1 9 9 9   —— 2 0 0 0

15
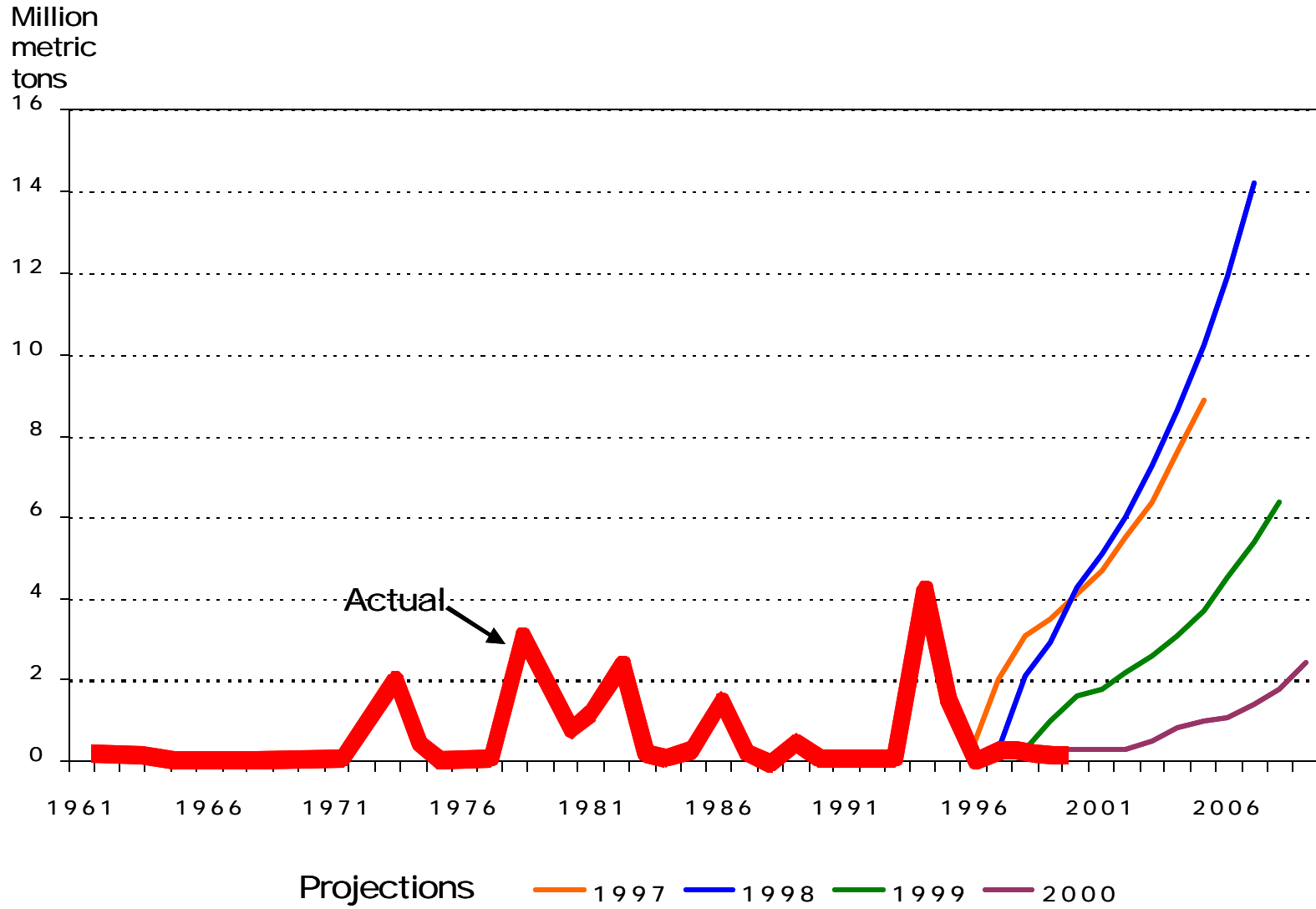
Figure 9. Actual and USDA projected China corn consumption, 1961-2007.

Million
metric
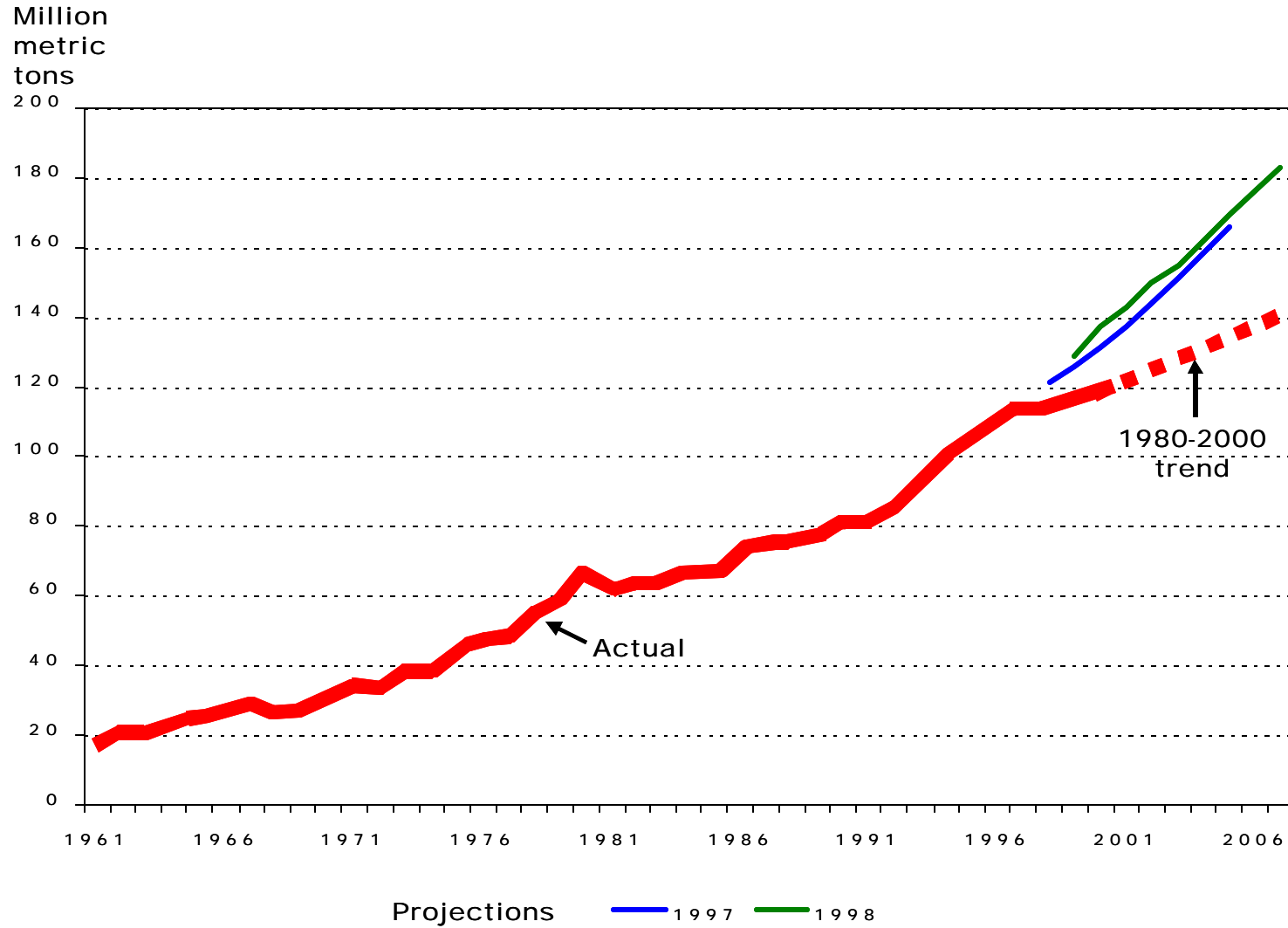tons

Projections —— 1997 —— 1998

Figure 10 shows the actual and USDA baseline corn imports by South Korea. The 1997 and 1998 USDA baseline projected corn imports by South Korea increased sharply; during the same period, actual South Korean corn imports peaked and then trended downward. The 1999 and 2000 USDA baseline projected corn imports by South Korea also had an upward trend but at a slower rate than the 1997 and 1998 projections. In 2000, South Korea suffered an outbreak of foot-and-mouth disease (FMD) in its swine herds, with some herds destroyed to control the disease. It is likely that the disease outbreak was the result of the inability of South Korea to manage the large amount of animal waste generated by its swine herds and poultry flocks. It is also likely that South Korea will rebuild its swine herds, but, because of environmental problems, it is unlikely that they will expand sharply. Environmental considerations suggest that, at best, South Korean corn imports will trend modestly upward in the years ahead.

Figure 11 shows the USDA estimates of actual South Korea corn consumption from 1961 to 2000 and USDA baseline projected South Korea corn consumption from 1997 and 1998. Baseline projected corn consumption is 3.7- to 8.6-million tons greater than 1997-2000 actual corn consumption. This is likely a major reason why USDA substantially overestimated U.S. corn exports to South Korea.

Taiwan also had a major outbreak of FMD in its swine herd in 1997. This resulted in about a one-third reduction in its total hog inventory. Figure 12 shows USDA estimates of actual corn consumption from 1961 to 2000 and baseline corn consumption from the 1997 and 1998 ten-year projected corn consumption in Taiwan. Both sets of projected Taiwan corn consumption are above recent trends in actual corn consumption. Thus, one reason for the deviation of the USDA baseline export projections from actual exports, is that the baseline projections substantially overestimated corn consumption in key importing countries. In recent years, Taiwan, South Korea, and Japan have accounted for over half of all U.S. corn exports.

Figures 13, 14, and 15 add perspective on environmental challenges in the livestock/poultry industries of these three countries. Figure 13 shows that the population per square mile is 28 times

Figure 10. USDA actual and projected South Korea corn imports.
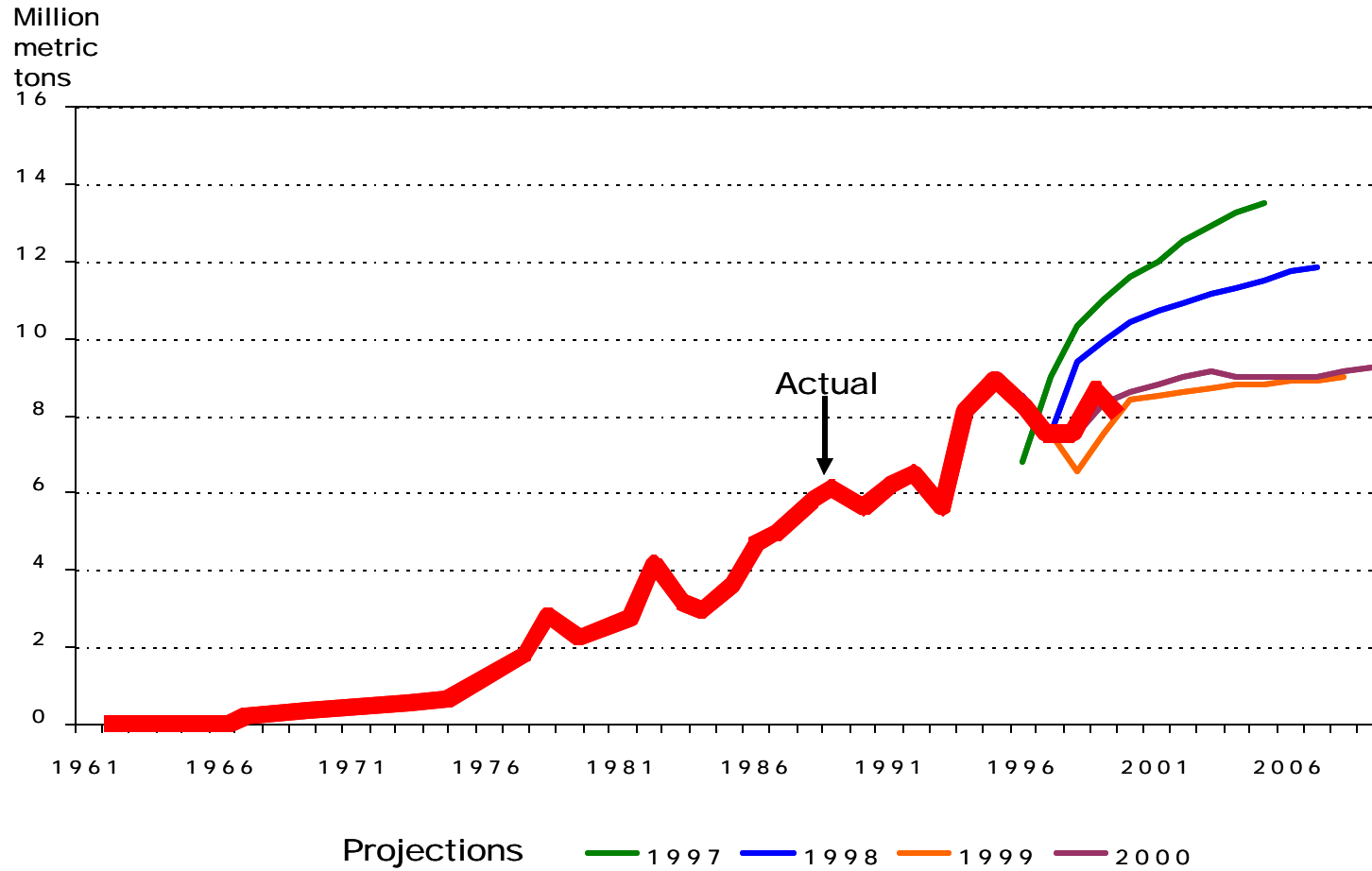
Figure 11. USDA actual and projected South Korea corn consumption.
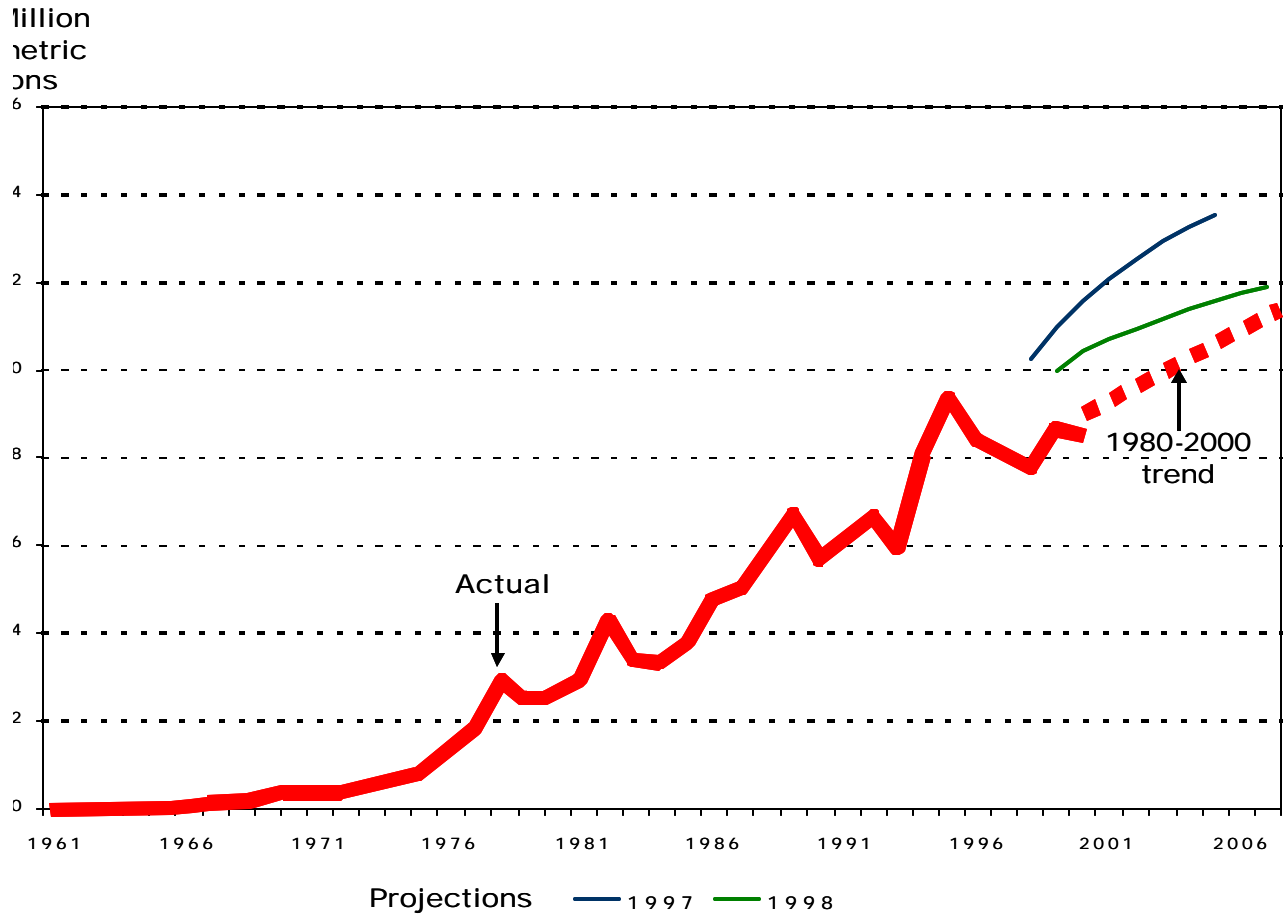
Figure 12. USDA actual and projected Taiwan corn consumption.
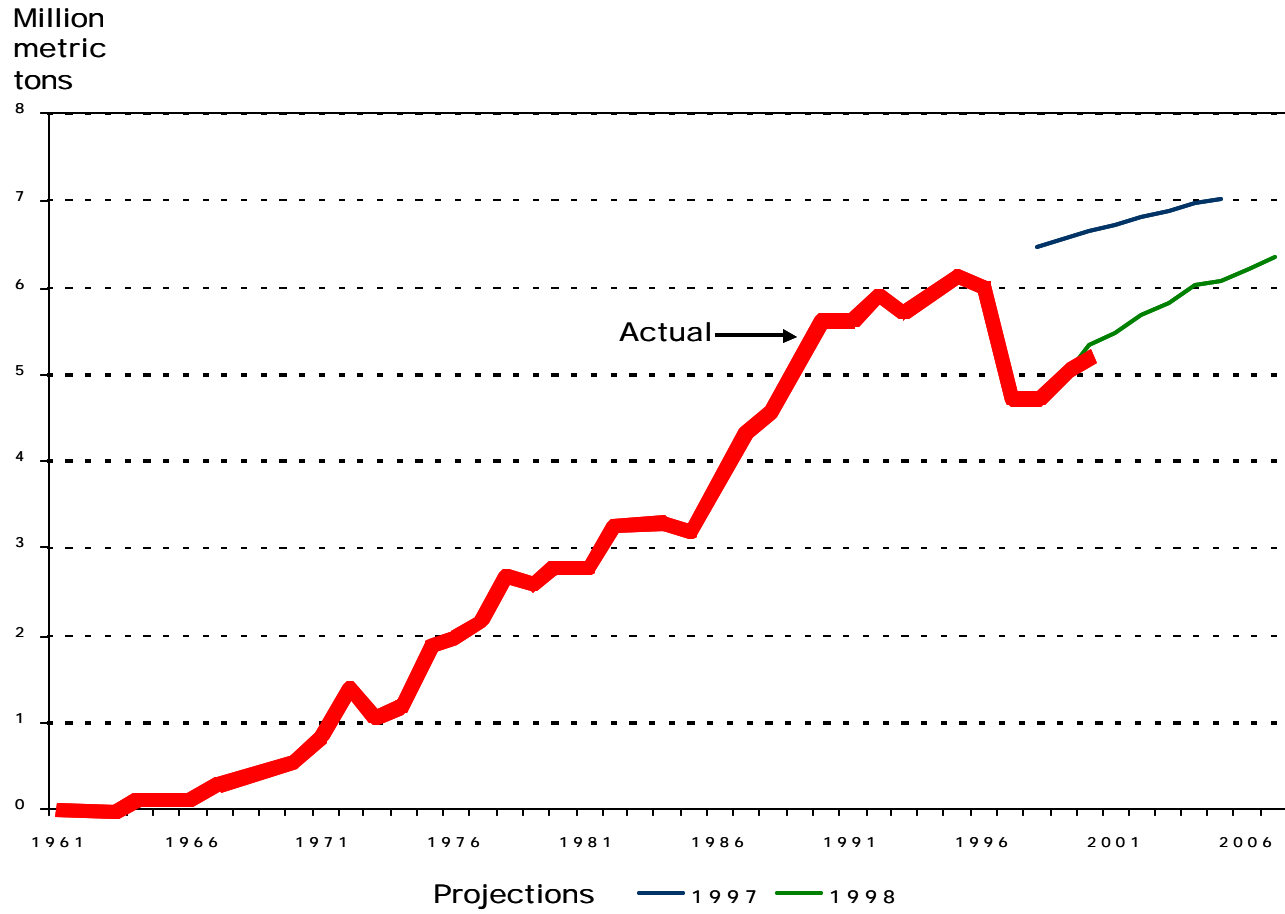
Figure 13. Population per square mile.
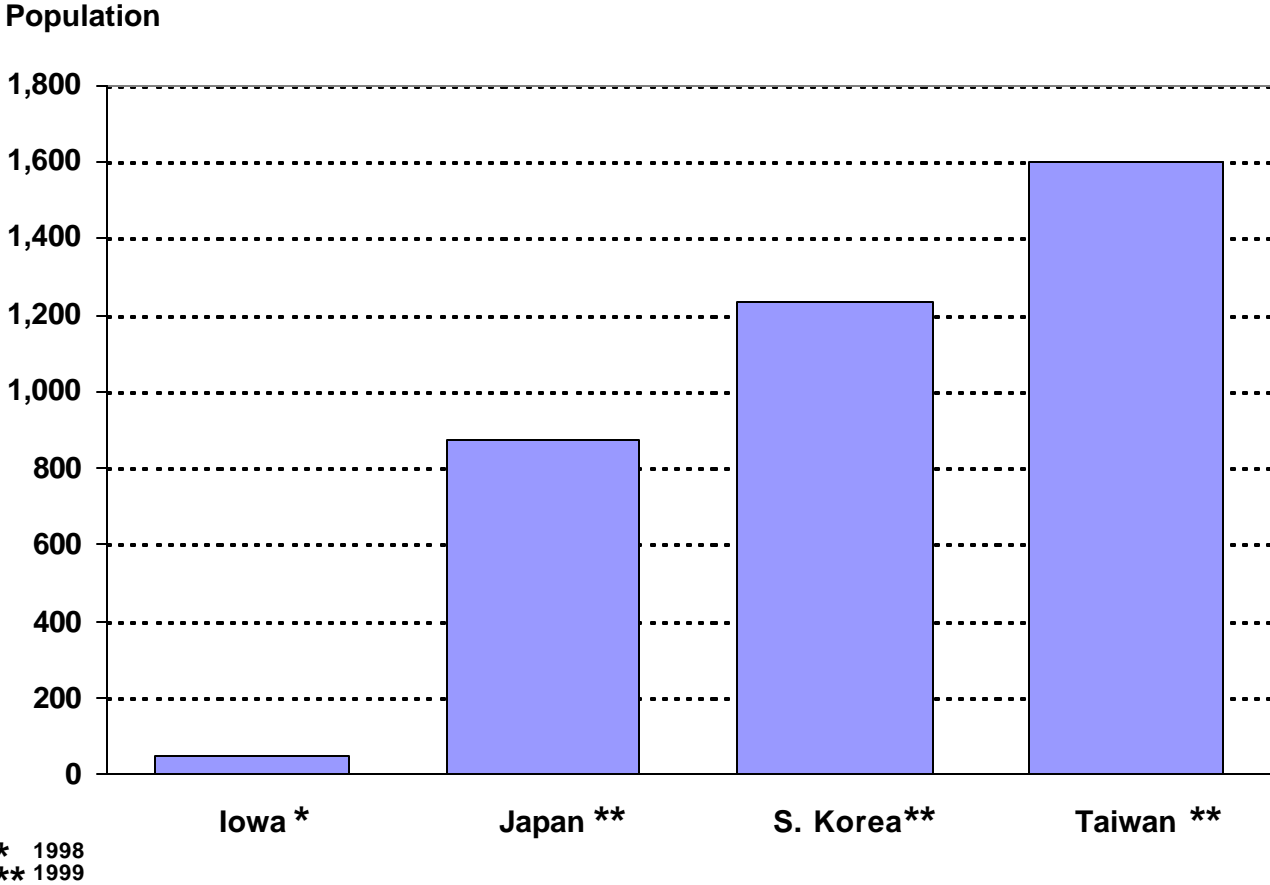
Population

* 1998
** 1999

Figure 14. Poultry birds per square mile, 1999.

Birds

*   Missing layers and ducks

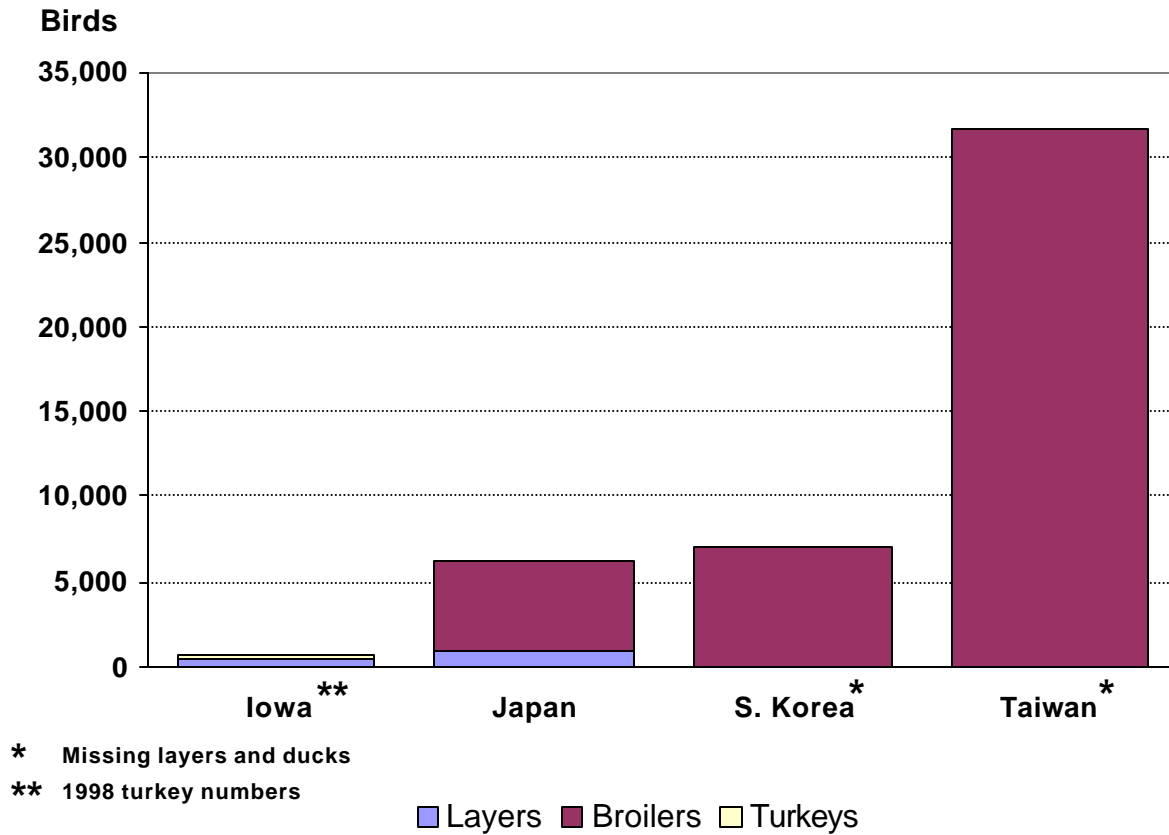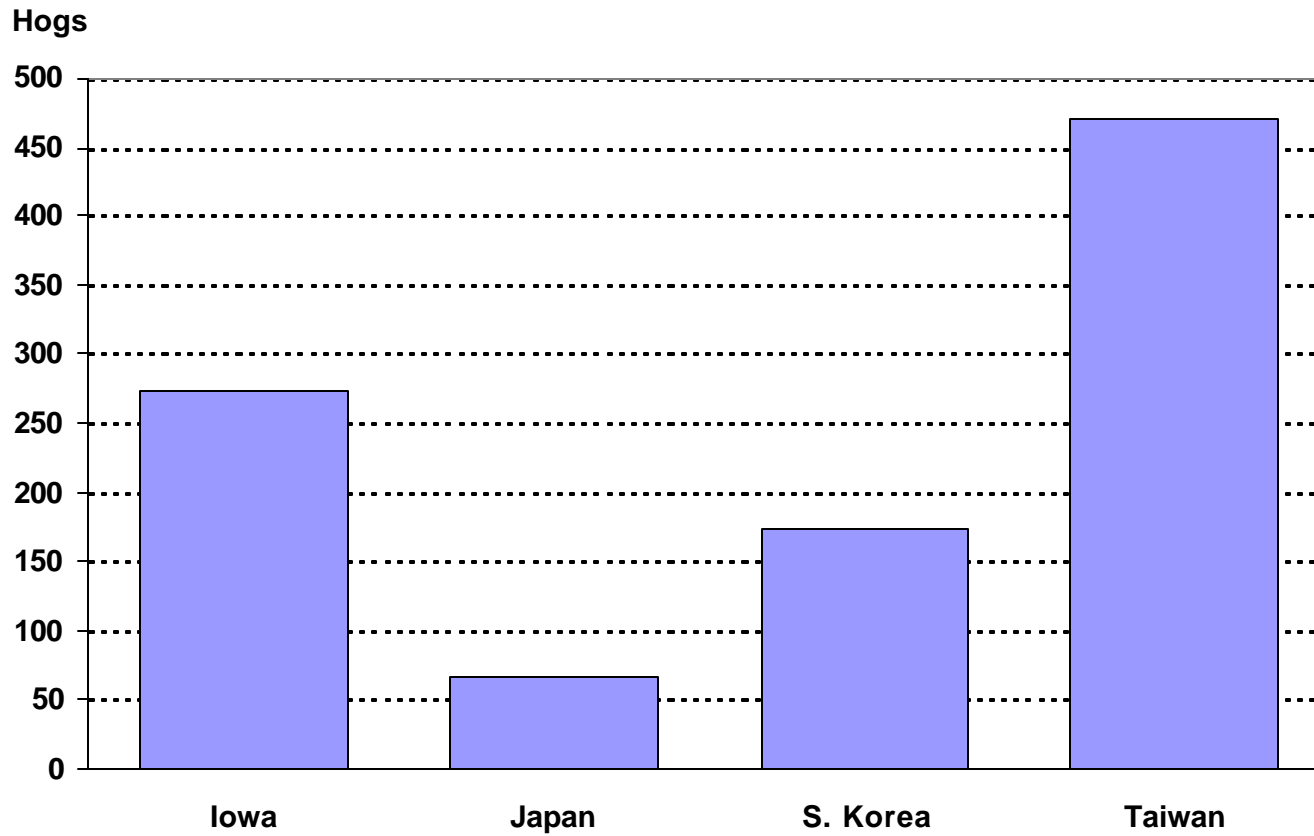**   1998 turkey numbers

Layers   Broilers   Turkeys

Figure 15. Hogs per square mile, 1999.

greater in Taiwan than in Iowa, 24-times greater in South Korea, and more than 16-times greater in Japan. Figure 14 shows that all three countries have huge numbers of poultry birds per square mile compared with Iowa. In addition, figure 15 shows that Taiwan has almost twice as many hogs per square mile as Iowa, while South Korea has about 65-percent as many hogs per square mile as Iowa. The large numbers of people, poultry, and hogs in these three countries make it very difficult to manage animal waste without outbreaks of disease.

In figures 13 through 15, human and animal densities are estimated by dividing populations by the total land mass of each geographic area. However, unlike midwestern states, these three large foreign markets for U.S. corn -- Japan, South Korea, and Taiwan – have large mountainous areas unsuitable for human residences, livestock production, or animal waste disposal. Thus, the actual animal and human population densities per unit of usable land in Japan, South Korea and Taiwan are considerably greater than shown in these figures.

USDA projections in 1997 also called for continued U.S. corn exports to the European Union (EU) at approximately 90-million bushels annually for the next ten years. By 1999-00, EU purchases of U.S. corn dropped to just over one million bushels and have continued near that level in 2000-01 in response to the transgenic grain (GMO) issues, which were not forecast by the model.

FAPRI MODELS

FAPRI projections have been published for many years. Figures 16, 17, and 18 show a series of 13 annual 10-year FAPRI export projections for corn, wheat and soybeans beginning in 1987. These figures also show the actual annual exports since 1987. The thick red line in figure 16 shows the trend -- estimated by least squares regression -- in actual corn exports since 1980. The following observations can be made about the 13 annual ten-year corn export projections:

- Almost all of the annual projections are monotonically increasing, with approximately the same slope,

24

Figure 16. Actual and FAPRI projections of U.S. corn exports.

Million
bushels

Actual

1980-2000
trend

Projections			
1987	1988	1989	1990
1991	1992	1993	1994
1995	1996	1997	1998
1999			

25
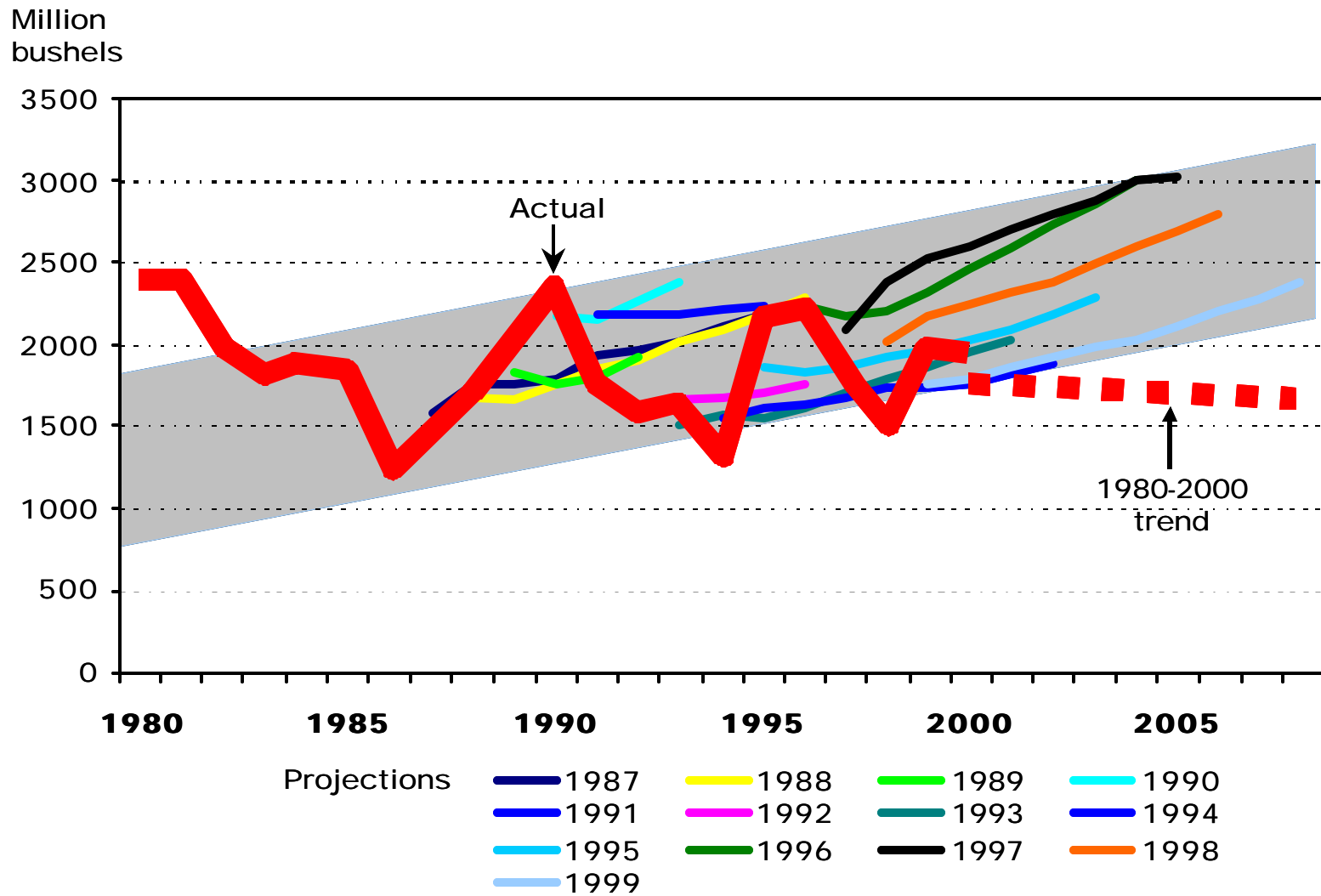
Figure 17. Actual and FAPRI projections of U.S. wheat exports.

Million
bushels

1980-2000
trend

Actual

ure 18. Actual U.S. soybean exports and FAPRI projections of U.S. soybean exports.

- Except for two short upward surges in corn exports in 1989-90 and 1995-96, actual corn exports trended downward over the period from 1980 to 2000, and

- The beginning year of each set of annual baseline projections shifts with actual exports with a one-to-two-year lag.

Basically the same observations can be made about the FAPRI baseline wheat export projections in figure 17:

- Almost all of the annual projections are monotonically increasing, with approximately the same slope,

- The trend in U.S. wheat exports from 1980 to 2000 was sharply downward, and

- The beginning year of each annual projection shifted with actual exports with a one-to-two-year lag.

Figure 18 shows the actual soybean exports and FAPRI baseline projections of U.S. soybean exports. The following observations can be made about figure 17:

- Almost all of the annual projections are monotonically increasing, with approximately the same slope,
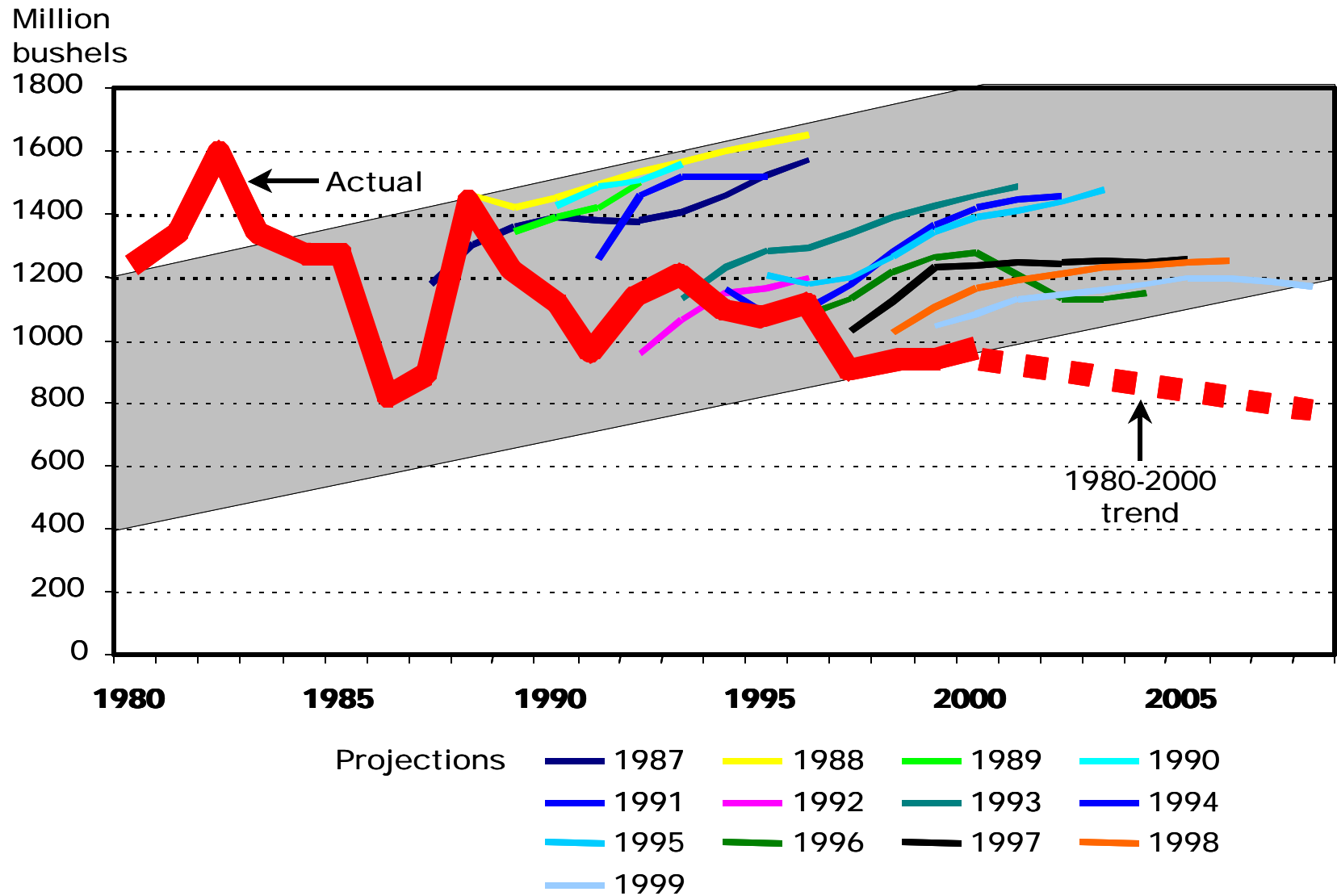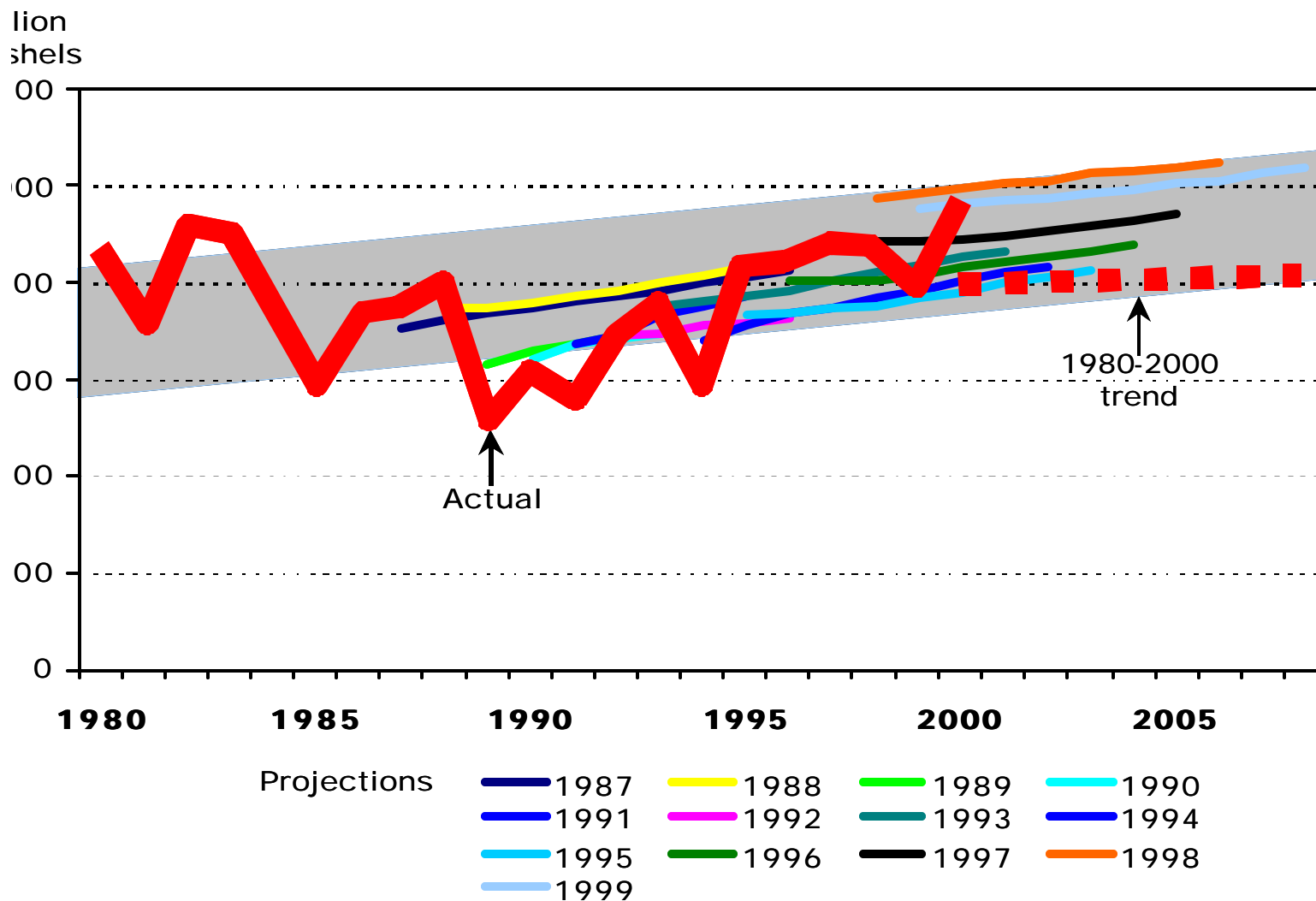
- Except for two sharp declines in exports in 1988 and 1993, soybean exports trended upward from 1980 to 2000,

- The beginning year of each set of annual projections shifts with actual exports with a one to two year lag, and

- Soybean export projections have been closer to the long-run trend than for either wheat or corn.

The basic conclusions from the FAPRI and USDA baseline projections of corn, wheat and soybean exports are:

- Almost all of the projections are monotonically increasing. The past four USDA

baselines (the only USDA baseline projections available for review) and the past

13 FAPRI baseline projections have failed to project the decline in U.S. corn and

wheat exports, and

- Except for the beginning year, the corn and wheat baseline projections have had little relationship with the declining corn and wheat exports.

The fundamental problem with the projections from these two agricultural sector models is that they rarely project declining exports in the face of a 21-year downward trend in grain exports. The following is a set of hypotheses of possible reasons why these models generally fail to recognize these downward trends.

EVALUATION OF THE FAPRI AND USDA MODELS

Table 1 compares FAPRI baseline U.S. corn, wheat, and soybean export projections from 1990 to 1999 with simple linear trend projections. Trend line projections were estimated by regressing actual U.S. exports on years, excluding the outlying highest and lowest exports over the regression period. The trend line projection utilizes the same set of information as the corresponding FAPRI baseline projection; annual simple trend forecasts were based on data from 1980 through the year prior to the forecast. For example, the 1990 trend line projection for corn exports is based on actual corn export data from 1980 through 1989, excluding the high and the low export years.

Table 1 presents the sum of squares deviations for the linear trend projections and the FAPRI baseline projections. The lower the sum of squares deviations, the "better" the projections fit the actual export data. In this analysis, the linear trend for grain exports provides a better forecast of U.S. corn than the FAPRI projections for five out of the ten years – 1990, 1992, 1996,

1997,and 1998 -- in the 1990s. Similarly for U.S. wheat exports, the linear trend projections provide a better forecast than the FAPRI baseline for eight out of the ten years in the 1990s. If the downward trend continues for U.S. corn and wheat exports, it is likely that the 1999 corn export projection and the 1998 and 1999 wheat export linear trend projections will be better forecasts than the FAPRI baseline projections, given the limited data available for calculating the sum of squares deviations. The final row in table 1 adds the sum of squares deviations across years and divides by the number of 10-year projections. Using this as a simple gauge for "goodness of fit," the simple trend analysis performed better as an overall forecast for U.S. corn and wheat exports.

Table 1. Comparison of "goodness of fit" of the linear trend and FAPRI baseline projections for U.S. grain and soybean exports, 1990-1999.

| | Sum of squares deviations | | | | | |
| | Corn | | Wheat | | Soybeans | |
Year	Linear	FAPRI	Linear	FAPRI	Linear	FAPRI
1990	605,289	1,210,511	76,167	304,828	36,291	18,859
1991	496,724	1,643,194	56,883	182,571	89,886	45,983
1992	461,247	349,830	59,118	196,955	236,579	49,329
1993	1,073,400	932,029	60,275	585,671	727,959	63,792
1994	1,167,676	865,307	47,254	335,690	458,592	96,112
1995	1,663,473	450,211	49,744	276,971	522,069	95,280
1996	588,210	1,022,464	47,206	155,869	286,222	33,132
1997	151,683	1,582,718	25,504	66,738	125,582	13,551
1998	151,693	396,443	9,655	9,145	78,851	45,090
1999	130,774	77,600	2,413	36	43,532	22,564
Average	649,017	853,031	43,422	211,477	260,556	48,369

Table 1 also shows that the FAPRI baseline was a better overall forecast than a linear trend for U.S. soybean exports. U.S. soybean exports from 1980 to 2000 follow a U-shaped path, with an upward trend throughout the 1990s. The linear trend projections trend downward through much of the 1990s, heavily influenced by the downward trending soybean exports in the 1980s. U.S. soybean exports demonstrate that USDA and FAPRI should not replace their models with

simplistic models such as linear trends. These simple models have very little economic theory in their assumptions, making it difficult to incorporate changes in relevant supply and demand variables. However, the comparisons in table 1 demonstrate the performance weakness of USDA and FAPRI baselines as forecast models. This suggests that modeling analysts use historical linear trends to check for the validity and calibration accuracy of the models.

The basic purpose of these agricultural sector baseline models is to evaluate the implications of alternative types of agricultural policies rather than to make forecasts. In essence, the models were constructed to measure changes in agricultural production and income under alternative polices rather than to forecast the absolute levels of exports. Thus, the baseline projections are designed to calibrate the model rather than to make forecasts. In fact, USDA states in its baseline report:

"A Note to Users of USDA Baseline Projections[7]

USDA long-term agricultural baseline projections presented in this report are a Departmental consensus on a long-run scenario for the agricultural sector. These projections provide a starting point for discussion of alternative outcomes for the sector. Baseline projections are typically made in conjunction with the President's Budget analysis.

The scenario presented in this report is not a USDA forecast about the future. Instead, it is a conditional, long-run scenario about what would be expected to happen under the 1996 Farm Act and specific assumptions about external conditions. The baseline reflects major agricultural policy decisions made through mid-November 1998 and includes short term projections from the November 1998 World Agricultural Supply and Demand Estimates report. Trade projections in this report for 1999/2000 incorporate long-term assumptions concerning weather, foreign trend yields, and foreign use and do not reflect short-term conditions which may impact trade that year. The baseline projections do not include the 5-year data revisions for agricultural commodities released by

USDA's National Agricultural Statistics Service in late-1998 and 1999. Also, the baseline does not reflect effects of the recent currency devaluation in Brazil."

FAPRI states that the baseline represents their best effort to determine the direction of the agricultural sector.[8] One definition of a baseline projection is that it is based on one out of many possible scenarios; the selected scenario assume exogenous variables such as population and income growth, exchange rates, technological change, weather, fixed agricultural policies and historical trends in production and consumption.

While appropriate for a policy baseline, these assumptions are not well suited for medium to long-run forecasts that are used to make investment decisions. In particular, the assumptions regarding economic growth, population growth, and weather, tend to lead to linear, upward-trending forecasts regardless of the recent history. In addition, empirical data suggest that these forecasts frequently overstate food demand and trade. This typically results in upward trending U.S. export projections. The following discussion focuses more closely on some of these assumptions and their implications for the projections obtained from the model:

- Macroeconomic forecasts used in the USDA and FAPRI models may demonstrate short-run adjustments to recent economic events, such as the Asian financial crisis or the Russian economic crisis, but rapidly gravitate toward long-run growth levels for all countries. Frequently, real gross domestic product (GDP) growth forecasts for developing countries are quite optimistic, with growth ranging from 4 to 6 percent annually. Depending upon how this growth is translated into consumer incomes, the demands for food products rise with income. For example, GDP growth is often used as proxy for consumer income growth, implying consumption steadily rises. Consequently, it is not surprising that the U.S. export projections have the approximately the same slope, regardless of the year of the annual baseline,

- Some demand equations are specified as linear, or linear in logarithms, which translate into a growth in food demand that does not diminish as income rises.[9] In this scenario, consumers will not reach a food consumption saturation level without intervention from the modeler,

- In the case of linear demand equations, the impacts of steady income growth are exacerbated by the fact that income elasticities gravitate to 1.0 as income rises. Thus, the income elasticity of a linear demand equation for wheat with an initial value of 0.2 will steadily increase as income rises, accelerating the growth of wheat demand,

- The economic growth forecasts used in policy analysis models typically do not project economic downturns. Consequently, the demand for food products will decline only in response to adverse relative price movements, or as a result of a negative trend that may be built into the demand equation, and

- Over short intervals (2 to 5 years), the upward bias of these factors is less worrisome than for longer-term projections. Over several years, the steady income growth assumption, combined with linear or constant elasticity demand equations, will substantially overstate food demands. As population grows, the impacts of the income assumptions are magnified. Moreover, as the world's labor force shifts from manual labor to mental labor, human caloric consumption, at best, will likely remain constant as people shift from meat and potato diets to more fruit and vegetable diets. This suggests that linear or constant income elasticities of demand may result in overestimation of the demand for food.

Other hypotheses to possibly explain the strong tendency to project increasing exports include:

- World grain demands

    The models rely heavily on income and population growth to project baseline world demands for raw grain products. However, the models may be weak in recognizing the changing forms of grain exports. In the past, almost all corn and soybean exports have been in the form of standard grades of bulk commodities. In recent years, there have been rapid shifts toward exporting these commodity-type grains in the forms of meat, poultry, eggs, and in containerized special human-food-quality grains. Some effort has been made to recognize the shifts to meat products in these models, but these shifts may not be fully recognized in the long series of historical data,

- Exchange rates

    Shifting exchange rates can have huge impacts on the demands for grains. For example, the release of the U.S. dollar from the international gold standard and its resulting devaluation in the early 1970s was one of several forces that sparked a huge boom in U.S. grain exports. Similarly, increases in the value of the dollar in the mid-to-late 1990s had a chilling impact on U.S. grain exports. The models may not include exchange rates for all countries, making the impacts from shifting exchange rates difficult to capture. For example, USDA acknowledged that the 1999 baseline projection did not include "the recent devaluation of the Brazilian real,"[10]

- Local supply and demand restrictions and incentives

    The models may not include a variety of individual-country forces that stimulate or restrict demand for imports and supplies of locally produced grains. A

case in point is that the models may not include environmental conditions that restrict potential long-term trends in animal production and hence imports of feed grains. These environmental forces -- for example, the inability to properly dispose of large amounts of animal waste in Japan, South Korea, and Taiwan -- have had a major dampening effect on imports of corn and soybeans by these three large buyers of U.S. grains. The models may not explicitly recognize incentives and motives for individual countries to become self-sufficient in food production. Such incentives include infrastructure investments like building dams on major rivers in China to provide irrigation water to stimulate grain production. Another incentive is local preferences for certain varieties and qualities of grains. A third example is European resistance to genetically modified grains, which has effectively caused the United States to lose the European corn market and may be a factor behind the severe decline in U.S. soybean meal exports to the EU in the last few years. The EU corn market may be permanently lost by U.S. agriculture,

- Failure to adequately include spatial equilibrium concepts in the agricultural baseline models.

The concept of spatial equilibrium recognizes that variations in commodity prices and transport rates are a major determinate of exports and imports from various regions. Yet, the USDA and FAPRI models may be weak in responding to these spatial forces. For example, the FAPRI model uses U.S. Gulf prices as world-clearing prices for corn, wheat and soybeans. The model – without multiple origins shipping to multiple markets linked together by commodity prices and transport rates – may not fully allow grain to trade worldwide in response to changing prices and transport rates,

- Failure to incorporate uncertainty into the base line projections.

    Infrastructure investments -- particularly river infrastructure -- have long lives of up to 50- to 100-years. No one can predict grain exports and demand for U.S. barge transport with certainty over these long periods of time. Yet, the published USDA and FAPRI baseline projections may not adequately deal with these uncertainties. While the models specify the assumptions underlying the projections, no sensitivity, Monte Carlo, or scenario analyses of grain export projections are published in the USDA or FAPRI baseline results,

- Baseline models, by necessity, do not anticipate changes in domestic agricultural and trade policies.

    The baseline projections are intended to be the basis from which to measure the impacts of changing policies. Therefore, the baseline results do not include potential changes in domestic and trade policies. The necessary omission of such potential events can have a dramatic effect on the validity of the baseline projections as forecasts,

- Most baseline models rely heavily on historical data.

    Access to new biotechnology is only a "click" of the send button away, even in remote areas of the world. The rapid rate of technological development and adoption dramatically increases yields and shifts the world supply curves so fast that the agricultural sector models, as currently formulated, may not keep up with world production. These technological developments may have a greater impact on the rest-of-the-world grain production than on U.S. production, because grain and livestock productivities are generally lower in the rest of the world than in the United States. New technology results in a rapid percentage rate of growth in agricultural

productivity in the rest-of-the-world. Failure to frequently update technology data in baseline models may mean that these models are relatively insensitive to rapid development and adoption of seed and production biotechnologies,

- With the rapid changes in technology in recent years, historical production relationships may not reflect current and future production realities.

Production forecasts, based on technology and economic relationships that existed over the past decade(s), will undoubtedly be subject to errors. These errors will generally be larger for developing countries where grain and animal production technologies are changing rapidly,

- Baseline models may not adequately recognize increasing grain production in some developing countries.

Supply equations typically are structured so that acres (hectares) of land planted in grain production are directly related to world prices. That is, planted acres increase with increasing world grain prices and decline with declining prices. Over the past several years, grain prices have been declining while actual acres in grain production have remained relatively constant in many countries and are increasing rapidly in countries like Brazil and Bolivia. This means that, because of declining world grain prices, the models may project declining planted acres in countries that are actually increasing planted acres. Moreover, the costs of production -- especially land, labor costs and some other input -- are lower in many developing countries than in the U.S.[11] In many of these developing countries, land may continue to be brought into production even in the face of declining world grain prices. In addition, the U.S. dollar appreciated by 42 percent relative to competitors from April 1995 to September, 2000.[12] So while U.S. agricultural prices have declined, local currency

output prices in other countries may have increased. This may result in projecting increasing U.S. grain exports even as world grain supplies continue to increase and actual U.S. corn and wheat exports decline. In fact, the U.S. enjoyed its peak grain exports 21 years ago in 1980.

Figure 19 shows four annual ten-year USDA projections of Brazilian soybean exports. The slopes of each of the four ten-year projections of Brazilian soybeans exports are almost flat, meaning that USDA projected essentially constant Brazil soybean exports. Since 1992, the trend in actual Brazil soybean production and exports has been sharply upward. Thus, the USDA model substantially underestimated Brazil soybean exports.

Figure 20 shows a set of 11 FAPRI baseline projections of hectares of land in Brazil harvested for soybeans. Except for the 1990 baseline, almost all of the other FAPRI baseline projections are below the actual hectares harvested.

Figure 21 shows 11 FAPRI baseline projections of Brazil's soybean production. Except for the 1990 and 1991 baseline projections, the FAPRI model underestimated Brazil's soybean production.

HISTORICAL PERSPECTIVE OF LONG-RANGE AGRICULTURAL SUPPLY

AND DEMAND PROJECTIONS

Malthus was one of the first economists to develop a model for long-range food supply and demand projections.[13] Studying the trend in world population in the 18th century, Malthus concluded that, over time, food demand, driven by an expanding world population, would increase more rapidly than the food supply. This expanding population would lead to widespread starvation

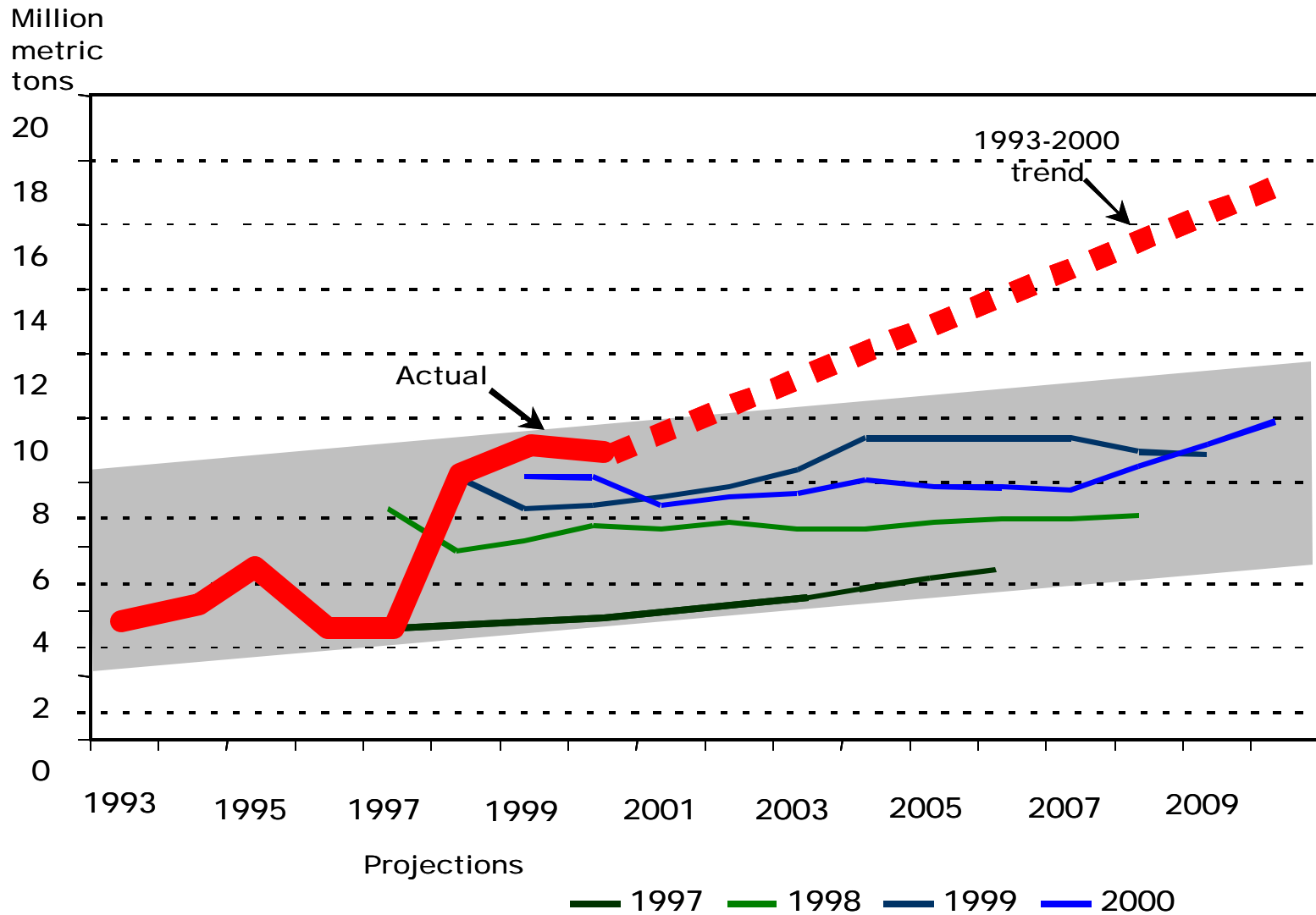# Figure 19. Actual and USDA projected Brazil soybean exports.

Million
metric
tons

20

18

16

14

12

10

8

6

4

2

0

1993-2000
trend

Actual

1993   1995   1997   1999   2001   2003   2005   2007   2009

Projections

━━ 1997   ━━ 1998   ━━ 1999   ━━ 2000

Figure 20. Actual and FAPRI projected Brazil hectares in soybean production.

Million hectares

1991-2000 trend

Actual

Projections

	1990		1991		1992		1993
	1994		1995		1996		1997
	1998		1999		2000		
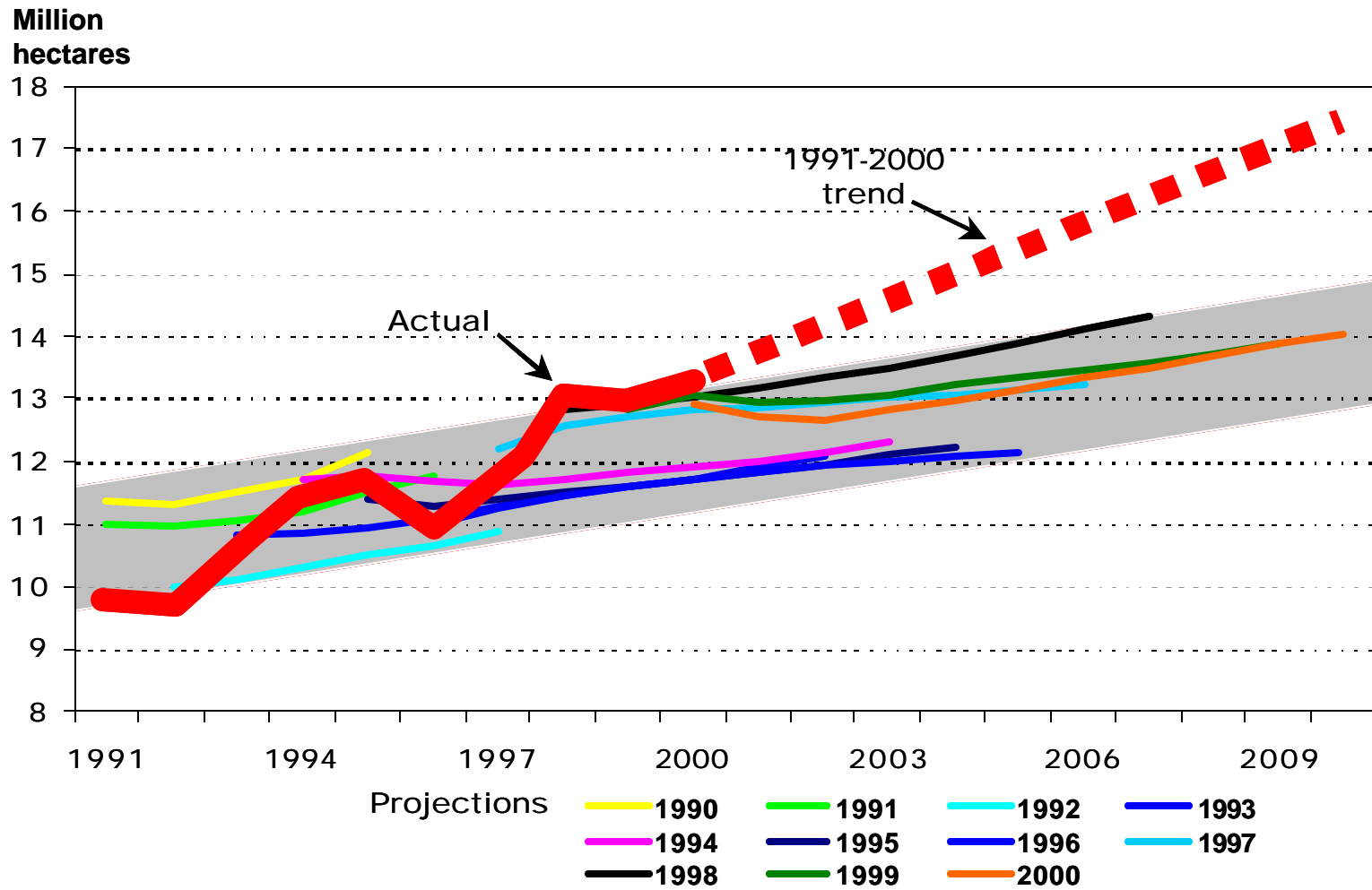
Figure 21. Actual and FAPRI projected Brazil soybean production.

Million
metric
tons

1993-2000
trend

Actual

Projections	1989	1990	1991	1992
	1993	1994	1995	1996
	1997	1998	1999	2000
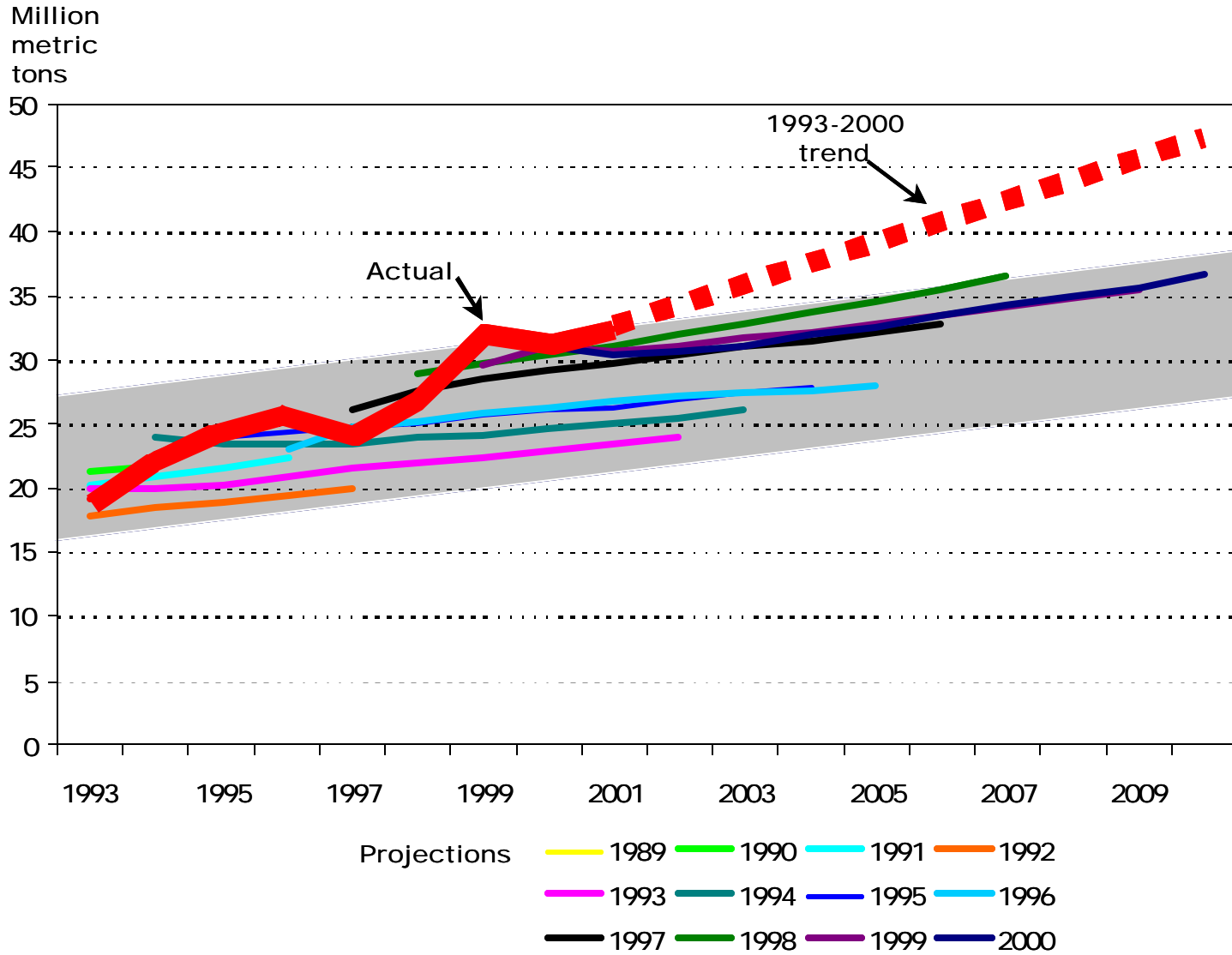
and very high food prices. His reasoning was that food production would reach an upper limit because of the finite quantity of land available for agricultural uses. In essence, his supply model was acreage times current yield. Malthus' painted a bleak picture of the future for consumers and the world in general, but a very optimistic one for landowners and farmers. Two centuries later, his dismal projections [14] stand in stark contrast to decades of rapidly increasing yields, declining real agricultural and food prices, and U.S. consumers spending a record low percentage of their incomes on food. Malthus' work was faulty because of his failure to recognize the role of technological change on the supply side.

Lester Brown, [15] in his 1995 book, Who Will Feed China?, also painted a bleak modern-day picture for the world's consumers, but an optimistic one for landowners and agricultural producers. His book, published in a year when China experienced serious crop problems and was a large importer of corn and wheat, portrayed a scenario in which China would consume most of the world's exportable supply of grains and oilseeds beginning in the late 1990s and early 21st century. Little food would be left to meet the needs of other importing countries. The net result of the Brown analysis was a rapidly growing export demand for U.S. grains, and high prices for crops worldwide. Brown's demand model incorporated population plus income growth. His supply model was acreage times yield, with declining total acreage as industrial and other urban uses absorbed additional cropland. Perhaps the Brown model was one reason for the nearly vertical USDA China import projections in figure 8. Brown's projection that China would become a huge permanent importer of grain has not materialized. Two years after his book appeared, China returned to its position as one of the world's largest corn exporters, and its wheat imports declined precipitously as its grain crop production resumed long-term upward trends. World grain production, fueled by biotechnology and by new land brought into production in South America, has increased sharply. The Malthus and Brown analyses and recent agricultural trade history are cautions that should be

seriously considered in developing long-range agricultural trade projections and U.S. export demand projections.

Projecting U.S. grain and soybean exports 30 to 50 years into the future is a major challenge that must include an in-depth analysis of U.S. and foreign supplies as well as demand. Major variables on the demand side include not only population and income growth, but also changing dietary compositions, animal feeding technology, increasing efficiency in converting grain and protein meal into meat and dairy products, and dietary changes resulting from changing age distributions of populations. Agricultural baseline models typically have focused extensively on the income and population growth variables. Other variables become critically important in long-run analyses and must be incorporated into the model. In fact, neither the USDA nor FAPRI models attempt to make projections beyond ten years.

TECHNOLOGY AND OTHER LONG-TERM INFLUENCES ON FOOD DEMAND

Dietary compositions that affect feed demand include the mix of cereals and plant and animal-based protein foods. In animal-based protein foods, the consumption shares of grain and grass-fed beef and mutton, pork, chicken, turkey meat, geese, ducks, fish, and other seafood, greatly affect the amount of grain used in individual countries, and their net grain export/import position. Each of these products has a different feed requirement per pound of human protein food produced. Feed requirements per pound of meat produced may range from a high of seven to eight pounds for grain-fed beef to a low of two pounds or less for some types of seafood and poultry. Over the last several decades, the mix of animal-base protein has shifted to a higher percentage of poultry meat relative to other meats in consumer diets, thus increasing the feed conversion efficiency.

In China, farm-produced seafood, including fish, shrimp, lobster, and other miscellaneous seafood, have a major role in consumer diets. Goose meat is a potential growth area in Chinese food

demand as consumer income rises, and it may be a future substitute for some other types of poultry and pork that require more grain. Geese require less grain for production than broilers; they mainly consume grass, and can assist in weed control.

Feeding technology is in a state of rapid change in the United States and abroad. Livestock specialists indicate that state-of-the-art pork production systems achieve a 20-percent or more improvement in feed conversion efficiency compared with traditional pork producing technology of less than a decade ago. New technology such as the "Paylean" feed additive promises even greater improvements in pork feed conversion efficiency, as well as reduced fat in pork and a higher percentage of the final product usable as food. The time lag in transferring U.S. feeding technology to countries such as Russia, Ukraine, Brazil, Argentina, China, and other Asian nations has been declining. It may decline further if China enters the WTO. In addition, changes in meat processing technology have small but significant effects on the usable amount of meat produced from a given amount of dressed-weight product. Finally, the populations of Europe, Japan, and the United States are aging, and that will reduce future food demand for that segment of the population. China has a strict population control program designed to cause its population to reach a peak by 2030, and to decline thereafter. This policy will also bring an increased aging of the Chinese population, which will eventually reduce per capita and total food demand.

Figures 22 and 23 show the relationship between feed grain feeding and production of pork and poultry meat over the last 40 years, for the world and non-U.S. countries as a group.[16] Figure 22 shows that shifts in production technologies have allowed for dramatic increases in world meat production with modest increases in world grain consumption. From 1964-1999, meat and poultry production increased 450-percent with only a 110-percent increase in feed grain consumption. Moreover, the rate of growth -- slope -- in feed grain consumption declined while the rate of growth in pork and poultry production remained constant. Figure 23 shows that for non-U.S. countries as

a group, combined pork and poultry production rose 518-percent while feed grain feeding increased

Figure 22. World feed grain feeding and combined pork and poultry production.
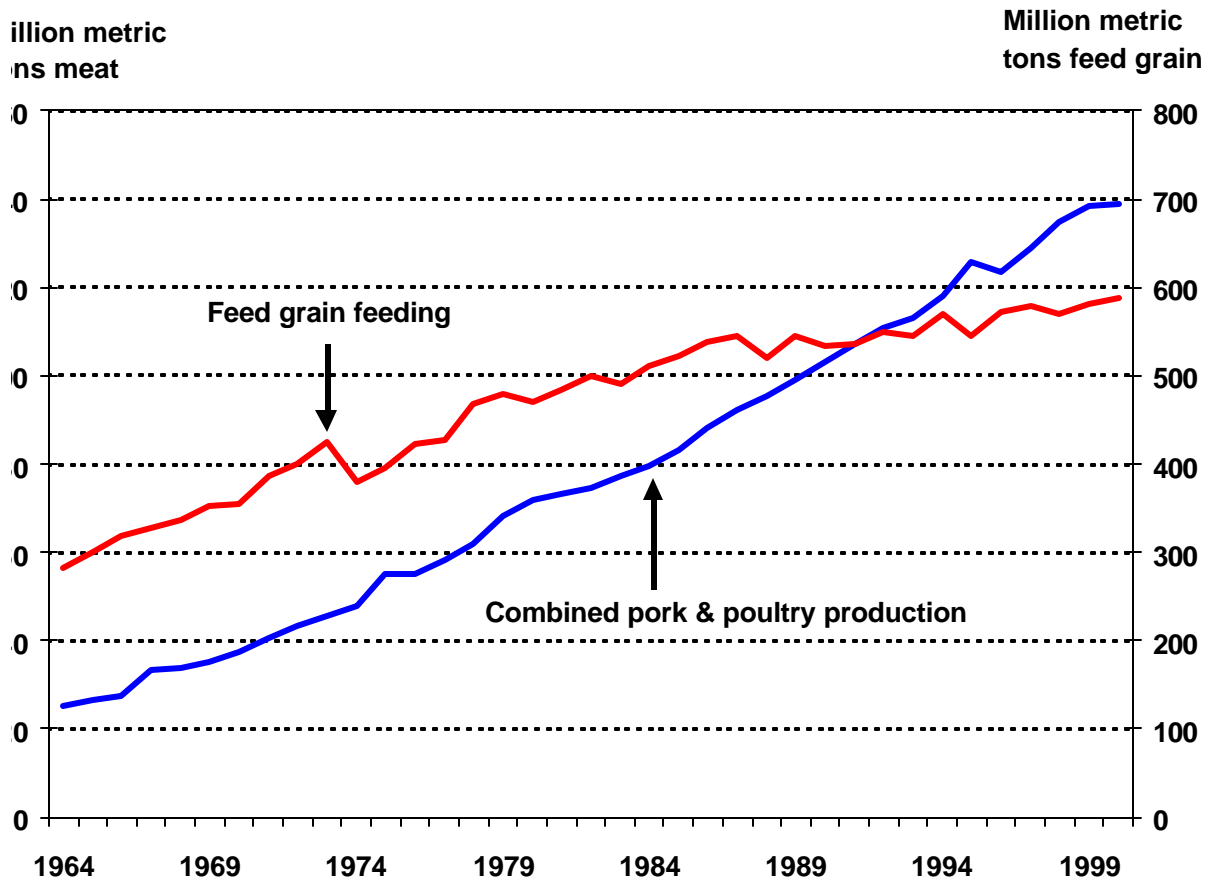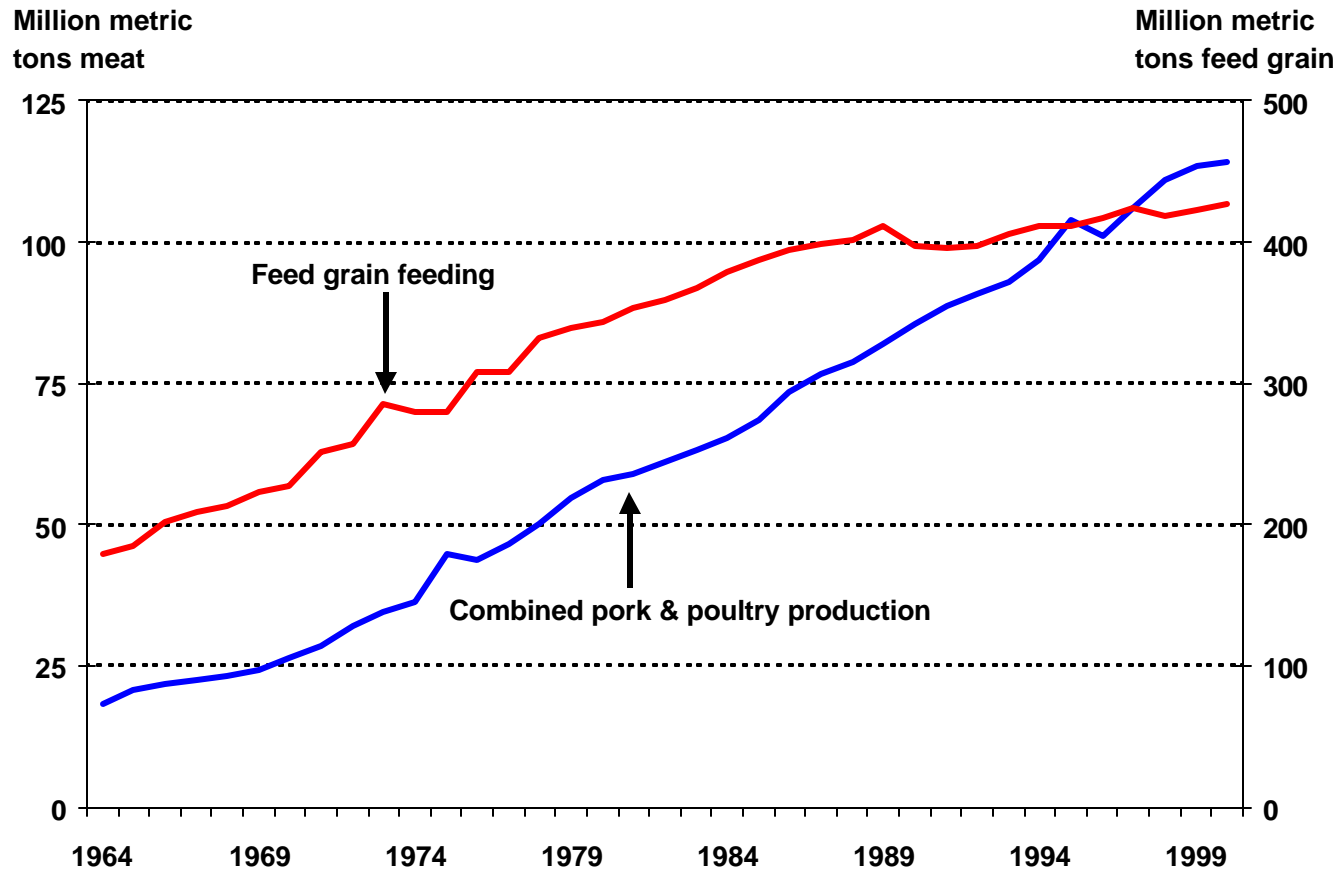
Figure 23. Non-U.S. feed grain feeding and combined poultry and pork production.

Million metric
tons meat

Million metric
tons feed grain

Feed grain feeding

Combined pork & poultry production

only 139-percent. Figure 24 was included because serious questions have been raised about the accuracy of China's grain, livestock and meat production data. Figure 24 excludes China; still the overall picture reveals a strong upward trend in foreign grain feeding efficiency. Feed grain feeding increased 85 percent, while combined pork and poultry meat production increased 319 percent. Failure to anticipate such dramatic increases in feed conversion efficiency may create a huge overstatement of export demand for U.S. grain. These complexities on the demand side are extremely important in forecasting the demand for food.

SUPPLY-SIDE COMPLEXITIES AND TECHNOLOGICAL CHANGE

World grain production is driven largely by new technology and interactions among major crops that compete for the same land. Agricultural baseline models that do not include a mechanism for projecting technology changes in the United States and major foreign producing areas are likely to underestimate world food supplies.

The rate of foreign technology innovation directly impacts U.S. grain and soybean exports. For example, figure 25 illustrates that, with U.S. production technology, China's current corn area harvested could produce three billion bushels more corn than is currently being produced. In today's global information economy, it is only a matter of time before U.S. technology will be transferred to that area.

Technology changes in other crops must also be considered. Planted corn hectares have been increasing in China over the past 30 years despite urban demands for land. This expanded corn acreage partly reflects shifts of land into corn from areas formerly planted to wheat and rice. Rising yields for these latter crops reduced the area needed for their production.

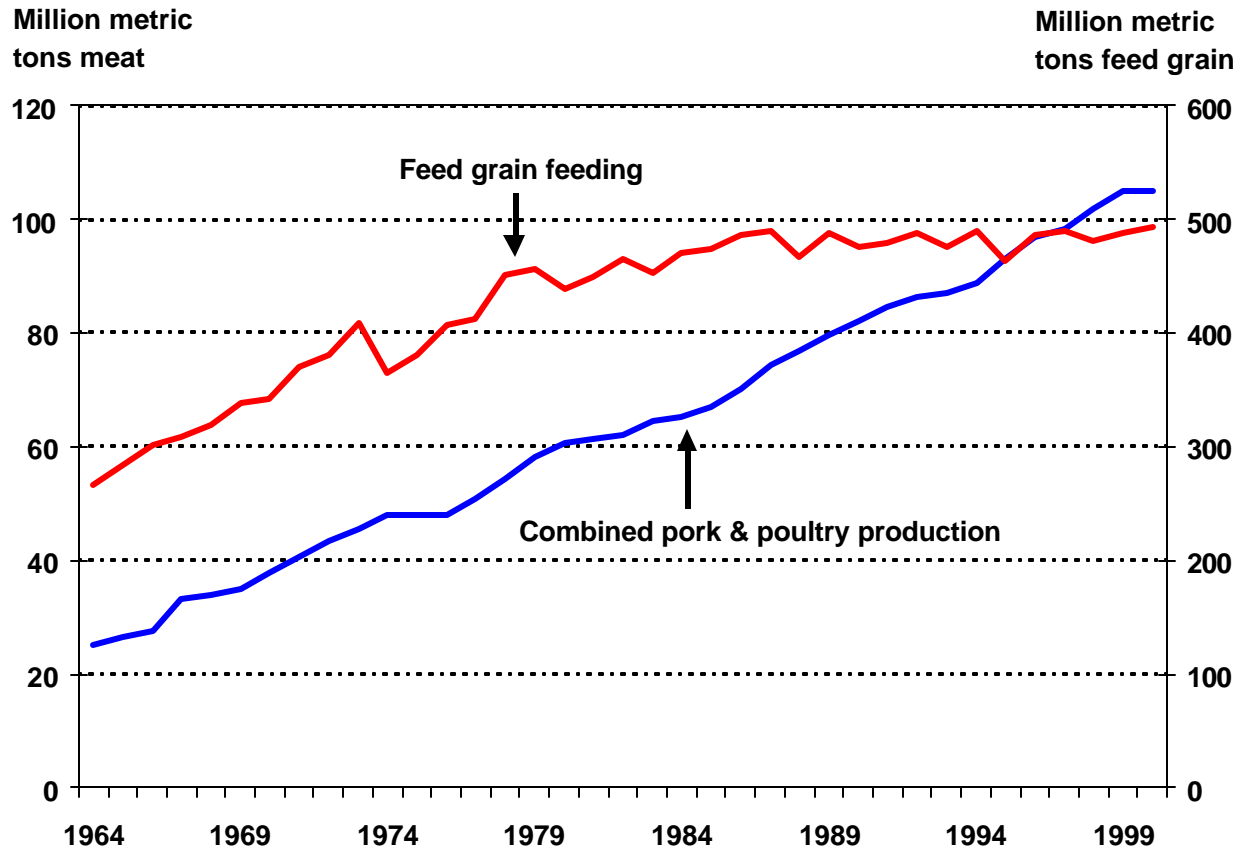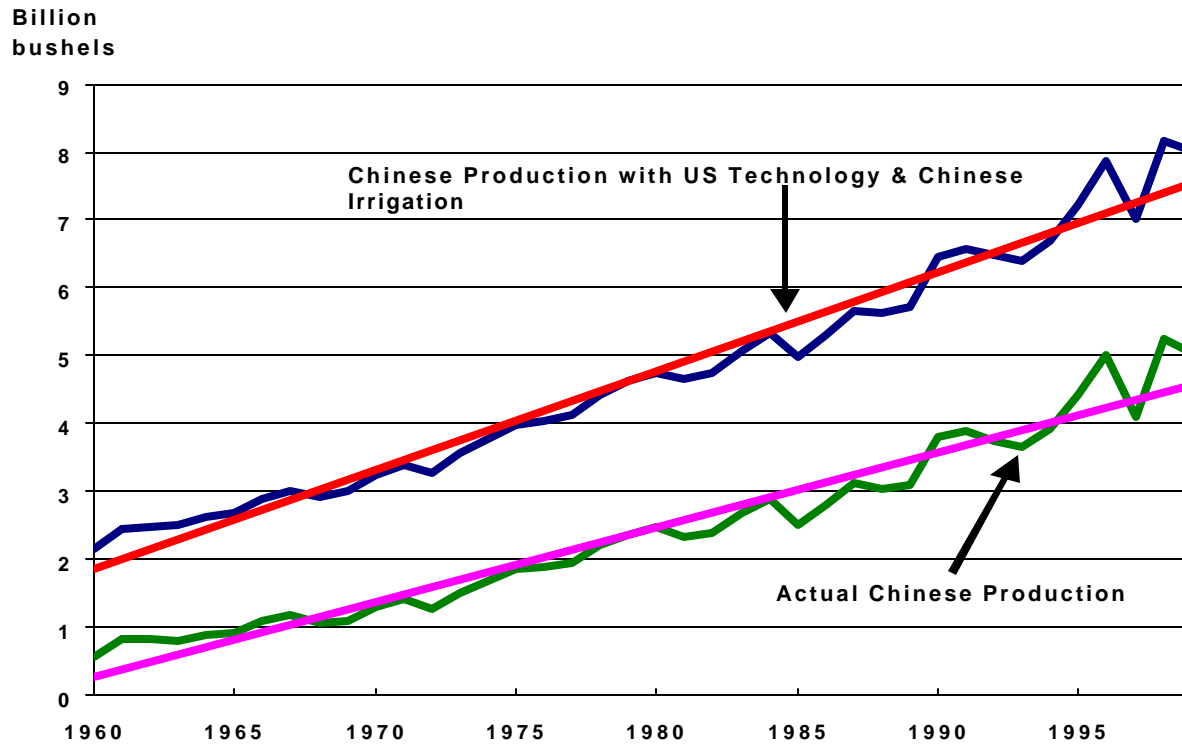**Figure 24. World feed grain feeding and combined pork and poultry production, excluding China.**

Figure 25. Potential China corn production using U.S. production technology.

Billion bushels

Chinese Production with US Technology & Chinese Irrigation

Actual Chinese Production

Political changes also can be important in a long-range model. It is clear that political instability, uncertainty about the ability of investors to capture potential benefits from investments in the agricultural sector, and inadequate infrastructure have severely retarded grain production in several former Soviet Union (FSU) republics. Western agricultural specialists working in these republics generally believe that several FSU republics could become large grain exporters.[17] With proper attention to feeding technology and improved livestock and poultry feed efficiency, substantial grain exports from these nations would be possible even with large increases in domestic meat production and consumption. While these supply-increasing complexities are difficult to capture, they must be included in agricultural baseline models that are to be used to forecast demands and supplies.

CONCLUSIONS

Several agricultural baseline models are designed to evaluate the production and income of alternative national and global agricultural policies. The two basic baseline models are the USDA and FAPRI models. These are the basic models because all other long-term models are more or less patterned after these two models. An evaluation of the baseline reports from these two models indicate the following:

- The USDA and FAPRI annual baseline reports clearly state that the model results are not intended to be forecasts; rather, the results are baseline projections intended for national agricultural policy analysis. Nevertheless, these baseline projections are increasingly used as forecasts by industry and baseline economists,[18,19]

- A comparison of the FAPRI and USDA baseline projections for U.S. grain exports indicates that almost all of the annual baseline projections are monotonically

increasing. Over the same time periods, actual corn exports have trended downward and wheat exports have trended sharply downward. Thus, there is a sharp discrepancy between the corn and wheat baseline projections and actual exports,

- It appears that the two basic agricultural sector models do not adequately recognize downturns in agricultural exports. Some possible reasons are:

  a. optimistic macroeconomic forecasts used by USDA and FAPRI typically result in upward trending grain export projections,

  b. some demand equations, specified as linear or constant elasticity, translate into growth in food demand that continues to rise as income rises. As the world labor force shifts from manual labor to mental labor, it is likely that individual human caloric needs will not increase as implied by the constant income elasticities,

  c. in today's rapidly changing environment, historical data used to estimate basic equations become obsolete within a few years. In some cases, data less than five years old are obsolete,

  d. failure to quickly recognize technological improvements in grain production and feeding efficiency in competing and underdeveloped countries,

  e. inability of the supply equations in the model to correctly project increases in the number of acres (hectares) planted to crops in competing countries, even in the face of declining prices,

  f. failure to adequately account for

  - shifting exchange rates,

  - shifting demands for grains in the form of meat and other high valued products and for non-GMO grains,

- environmental constraints on livestock production in importing countries,

- incentives to stimulate grain production in other countries.

- The basic conclusion from this analysis can be summarized by a statement from the director of one of these models: "In evaluating investment decisions, don't base the decisions on the projections from these models. They will be wrong!" Nevertheless, industry groups, trade associations, government agencies including the Corps of Engineers, and baseline economists still use these projections as forecasts.

While the USDA and FAPRI baseline models have generally failed to project declining exports during the long-term downward trend in exports, properly modified versions of these models have the potential to be useful forecasting tools. Below are several options that might improve the forecasting ability of agricultural baseline models and may make them useful in evaluating long-term investment and policy decisions:

- replace the largely linear regression equations with more modern forecasting equations like exponential smoothing, moving average equations and distributed lags. These latter equations place more weight on recent data. Regression equations, on the other hand, weight 10, 20 and 30 year old data as equal in value to current data,

- shift the focus of the models from policy analysis to forecasting. This means that those parts of the models required only for policy analysis be removed and replaced by more sophisticated and relevant forecasting equations,

- incorporate variables in supply equations to better recognize the rate of adoption and impact of new technologies on crop yields in the rest of the world,

- modify supply equations to more accurately project changes in land areas devoted to crop production in developing and underdeveloped countries,

- examine the forecasts from the macroeconomic models used in the baseline forecasts. If the macro forecasts are unrealistic, either modify or use alternative macro model outputs,

- modify supply equations to recognize the impact of production incentives like increased irrigation on grain production in the rest of the world, and

- modify demand equations to better account for:
  - declining income elasticities as income rises,
  - shifting exchange rates,
  - increasing demands for imported livestock and poultry products versus unprocessed grain,
  - environmental constraints on livestock production in importing countries,
  - changing mix of grain, livestock, and meat production in the rest of the world,
  - dramatic increases in feed efficiency in livestock production in the rest-of-the-world,

- more complete spatial equilibrium concepts and variables, and

- changing demographics of the world population.

In addition to modifying these baseline models, the researchers might improve the performance of these models by:

1.   Comparing agricultural baseline models with trend analyses.

Trend models rely on actual supply and demand data rather than on the theoretical relationships in econometric models. Several types of time-series models are available including Box-Jenkins, ARIMA (auto-regressive integrated moving average) and ECM (error correction models). These models typically consist of a time trend, a seasonal factor, a cyclical element, and an error term. Each of these models is likely to be superior to linear regression trends. The important point, however, is that the trend analysis must recognize peaks or valleys that signify a shift in the long-term trend.

This paper does not advocate trend or time series models as a replacement to agricultural baseline models; rather it recommends using trend model analyses to calibrate the baseline models. Neither trend nor time series analysis have detailed economic theory underlying their estimates, but their numbers do reflect historical economic shocks that most agricultural baseline models do not incorporate. Consequently, they provide a good benchmark against which to calibrate agricultural baseline models. If nothing else, these simple models may highlight projections that are directionally suspect.

One of the simplest ways to improve model accuracy is to compare forecasted values with actual data, and make adjustments when errors are large and

non-random. The actual data or values can be regressed on the forecasts and the R^2 can be used to measure accuracy.

A second method is to make forecasts with two or more models. Then select the sets of forecasts with the highest R^2s from regressing the forecasts on actual values. A final set of forecasts can be obtained by calculating a weighted average of the high R^2 forecasts.

A third alternative is to make multiple forecasts from the large-scale econometric model based on alternative assumptions, scenarios and/or sensitivity analyses. The forecast or set of weighted forecasts could be selected by regressing forecasted values on actual values.

2. Incorporating panel(s) of multidisciplinary experts.

USDA and FAPRI do enlist the help of industry experts to help them address issues related to growth rates in yields and technology. However, a large portion of these groups consist of representatives of trade organizations. Given that the goal of many trade organizations is to increase the sales of their member organizations, they often have a financial or political stake in the results of the model and frequently prefer optimistic forecasts.

Regardless of the actual forecasting method selected, an independent panel - or a set of panels - of multidisciplinary experts with no financial or political stake in the model results, should be formed to provide in-depth information on several areas. The most important of these is technological change. This area could be strengthened by the use of a multi-disciplinary private- and public- sector technology panel to guide the incorporation of technology change into the model. The panel or panels should address all areas of technology that affect the demand for and the

supply of grains and oilseeds in the United States and major foreign countries. These areas include feeding, crop production, processing, marketing, transportation, and consumer technology.

It would also be desirable to have other advisory panels to address population growth trends, changing age distributions of populations, dietary consumption patterns, and alternative demands on consumer incomes. These panels could make a major contribution in strengthening long-term demand projections. BT made a similar recommendation to the Corps. It is essential that the evaluation panels consist primarily of members who have no economic or political stake in the results.

The projections -- or forecasts -- from these models should continuously be compared with real world production, consumption and exports. Figures 1, 2 and 3 illustrate how these comparisons can be used to identify weaknesses in the models.

3.   Finally, it is important to make forecasts under several alternative scenarios.

Given that U.S. grain exports have had a downward trend for the past 2 decades, it is inconsistent to forecast increased exports until grain exports show sustained upward trends. Short-term increases in exports of these commodities over the last 21 years typically have been driven by temporarily reduced foreign production. Meanwhile, models can be modified and data collected to provide sharply improved forecasts compared with those provided by the current agricultural baseline models.

Given the problems associated with the current assumptions underlying policy analysis baselines, USDA and FAPRI continue to use these assumptions

because the primary purpose of their models is to conduct policy analysis and not to provide the most accurate forecast. Projected levels matter even in policy analysis, so USDA and FAPRI analysts do seek to develop plausible forecasts. Likewise, policy analysts deliberately exclude anticipated policy changes in their baseline projections, so that they can better isolate policy impacts. This may be a fundamental reason why USDA and FAPRI advise readers to not interpret baseline projections as forecasts.

The purpose of the modeling exercise drives the assumptions chosen. The large scope of these models, both in commodity and country coverage, have caused analysts to adopt fairly simple functional forms for equations, like linear and constant elasticity forms, to make the market solution mechanism more tractable and stable. However, with the rapid advances in the computational power of personal computers, the cost of incorporating functional forms that will limit the upward bias in food demand is falling. Probably the greatest barrier to correcting these problems is the limited resources currently directed at maintaining and developing these models. If government agencies including the Corps, agribusiness and trade associations wish to have these models changed into forecasting models, they need to provide funding to continually revise the models and maintain a current database.

ENDNOTES

[1] Food and Agricultural Policy Research Institute jointly staffed by Iowa State University and the University of Missouri.

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[3] PRX, The ProExporter Network®, World Economy & Trade, Olathe, KS, May 12, 2000.

[4] Jack Faucett Associates "Waterway Traffic Forecasts for the Upper Mississippi River Basin, Volume II - Grain," Appendix D, Bethesda, Maryland, April 18, 1997.

[5] Baumel, C. Phillip, R. N. Wisner, Marty J. McVey and Curtis W. Fulcher, "Trends, COE Projections Not Supportive of River Project," Volume 72, Number 30, Feedstuffs, July 17, 2000.

[6] Bitzan, John D. and Denver D. Tolliver "Review of Waterway Grain Traffic Forecasts for the Upper Mississippi River Basin." Available in Appendix A of the September 20, 2000 Draft Report "Review of Historic and Projected Grain Traffic on the Upper Mississippi and Illinois Waterway: An Addendum." Contract No. DACW72-95-D-0004.

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[11] For example, see Marty J. McVey, C. Phillip Baumel, and Robert N. Wisner, "U.S. Upgrade Unlikely to Reduce Competition From Brazil," Feedstuffs, Vol. 72(4), September 25, 2000.

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[14] Malthus is credited as the stimulus of the description of economics as the "dismal science."

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[17] Personal communication with Phillip Hufferd, former Extension Farm Management Specialist, Iowa State University, Ames, Iowa, and Dr. Lynn Lutgen, Associate Professor, Department of Agricultural Economics, the University of Nebraska, Lincoln, Nebraska.

[18] Schuff, Sally, "Economists Predict Costs Up, Income Down." *Feedstuffs*, Vol. 73, No. 9, February 26, 2001.

[19] *Iowa Farmer Today*, "FAPRI Expects Price Recovery to Fuel Ag Export Increase." February 24, 2001.