94-09

FORECASTING CROP ACREAGES AND YIELDS IN THE FACE OF AND IN SPITE OF FLOODS

Rich Allen, Deputy Administrator for Programs
National Agricultural Statistics Service (NASS) 1/

JULY 1994

INTRODUCTION

The 1993 growing season presented some of the most difficult challenges ever for forecasting United States crop production. This paper will describe on-going crop forecasting and estimation programs and procedures of the National Agricultural Statistics Service (NASS) of the United States Department of Agriculture along with modifications that were made in 1993 because of weather concerns. Performance of the 1993 procedures will be analyzed, both as far as consistency throughout the season and compared to end-of-season estimates.

To briefly summarize, NASS procedures did work extremely well for estimating crop acreage not planted and planted acreage lost to flooding and for forecasting the acreage expected to be harvested and the numbers of corn ears and soybean pods to be harvested. Timing of the floods in the midwest was such that usual survey timing could be used. The Secretary of Agriculture agreed to wait for NASS regular report dates rather than early evaluations which could not be as statistically based. Increases in sample sizes were made to improve precision of acreage data published in August and additional questions on acreage plans were added each month throughout the growing season. What did not perform as well as desired were forecasts of weight of fruit at harvest, particularly corn weight of grain per ear. The paper will present some reasons that the weight forecasts were not better.

CROP ESTIMATION HISTORY

The USDA has been issuing agricultural statistics since its founding in 1862. One original reason for creation of the Department was compilation and dissemination of statistics. The

---

1/ Any opinions or judgements expressed in this paper are those of the author and do not necessarily reflect those of the National Agricultural Statistics Service or the United States Department of Agriculture. Reference to any commercial products is for completeness only and does not constitute an endorsement of these products.

Special thanks are extended to Tom Birkett, Mike Craig, Bill Dowdy, Gary Keough, and Charles Van Lahr for their suggestions and assistance with examples and to Mary Ann Higgs for typing and editorial assistance.

first crop report was issued in July 1863. Monthly reports up to about 1911 reported crop condition compared to normal. End-of-season production estimates were based on comparisons to the Censuses of Agriculture conducted at 10 year intervals.

In the early 1900's, USDA was able to produce end-of-season estimates based on large samples of reports and improve on earlier procedures since both acreage harvested and yield per acre were estimated. Starting in 1911, monthly crop condition data were converted to yield per acre forecasts by comparison with 10-year condition averages. By 1925 the monthly Farm Report survey was implemented which was a fixed panel of farmers representing all producing areas. The Farm Report provided monthly livestock and labor information as well as yield forecasts. Larger samples were selected at planting and harvest to better measure actual acreages and production.

In the early 1960's, "objective yield" surveys were introduced for crops such as corn, soybeans, wheat, and cotton in States with the greatest acreages. These surveys establish small sample units in randomly selected fields which are visited monthly to determine numbers of plants, numbers of fruit (wheat heads, corn ears, soybean pods, etc.), and weight per fruit. Forecasting models are based on relationships of samples of the same maturity stage in comparable months during the past 5 years in each State. Those surveys are currently conducted in States which account for about 70-80 percent of the crop acreage.

Also in the early 1960's, the Agency implemented a mid-year Area Frame survey. This enabled creation of probability based acreage estimates for the first time. Sampling errors for major crops are as low as 1 percent at the U.S. level with levels of 2 to 3 percent in the largest producing States. Table 1 presents the 1993 corn and soybean planted acreage coefficients of variation for selected States and the U.S.

Matching area frame operations against list frame samples since the early 1970's allows the creation of multiple frame estimates. Table 2 presents the 1993 corn and soybean acreage coefficients of variation from the midyear multiple frame survey for selected States and the U.S.

The Farm Report panel survey was used up to the late 1980's in all States. However, testing of a probability selected, integrated sampling and survey approach which combined hog and pig, grain stocks, and crop acreage and production surveys, including monthly yield forecasts, began in 1985 and was implemented for all States by 1990. After a period of overlap in each State, the Farm Report sample was discontinued.

Table 1.--Precision of 1993 June Enumerative Survey Planted Acreage Expansions

Summary Level	Number of Segments	Coefficients of Variation	
		Corn	Soybeans
		- Percent -	
Illinois	389	2.5	2.8
Indiana	294	3.5	3.6
Iowa	437	1.9	2.6
Kansas	456	11.1	7.9
Minnesota	343	4.0	4.7
Missouri	387	6.3	4.2
Nebraska	390	3.9	5.3
North Dakota	376	13.6	17.9
Ohio	289	4.5	4.1
South Dakota	352	6.1	7.5
Wisconsin	310	4.7	12.6
10 OY Corn States	3,503	1.2	---
8 OY Soybean States	2,924	---	1.3
U.S.	15,462	1.1	1.2

Table 2.--Precision of 1993 June Multiple Frame Planted Acreage Expansions

Summary Level	Coefficients of Variation	
	Corn	Soybeans
	- Percent -	
Illinois	1.9	2.0
Indiana	2.3	2.7
Iowa	2.0	2.3
Kansas	6.4	6.2
Minnesota	2.7	3.2
Missouri	4.7	4.2
Nebraska	2.5	3.3
North Dakota	6.7	9.0
Ohio	3.2	3.7
South Dakota	3.0	4.0
Wisconsin	2.8	6.3
10 OY Corn States	0.8	---
8 OY Soybean States	---	1.1
U.S.	0.7	0.9

CROP ESTIMATING/FORECASTING CYCLE

NASS is known for ontime delivery of its statistical reports. By November of each year, release dates and times are published for the nearly 400 reports which will be issued by its Agricultural Statistics Board the next year. It is a rare occurrence if NASS has to delay the release of any scheduled reports.

For spring planted crops, the annual estimating/forecasting cycle starts with Prospective Plantings. Data are collected the first two weeks of March on farmers' current intended plantings. This report, issued at the end of March, is the first solid information on how farmers plan to adjust to current market conditions, government farm programs changes, and other information.

An interesting and much used report which relates to the spring planted crops is the Weekly Weather and Crop Bulletin. A relatively small panel survey is conducted each week from planting through harvest. Reporters fill out questionnaires on Fridays which are summarized on Monday mornings in order to provide an update on crop progress and crop conditions. A tabular summary of crop progress and conditions in the most significant States of major crops is released late on Monday afternoon. This weekly report does not create acreage estimates or yield forecasts.

The June Agricultural Survey provides information on actual acreages of spring planted crops. Most planting of major crops has occurred by early June but there is always some planting left, particularly for soybeans planted after harvest of winter wheat in some States. Farmers are asked to report actual plantings to the time of the interview and their intentions for the rest of their acreage. The Acreage report, with U.S. and State data, is issued at the end of June. There often is not much flexibility to shift planting plans since preparation for corn planting may involve chemicals that would prohibit the planting of soybeans. If planting is delayed too much due to bad weather (including conditions being too dry to plant soybeans after wheat harvest) some intended acreage might not be planted.

It might be helpful to point out the relationship of other USDA reports to NASS reports. Corn and soybean crops (and many other spring planted crops) are not advanced enough to statistically measure and forecast yields until about August 1. However, there is a need in USDA to have an earlier working figure on potential crop size. That figure is provided by the World Agricultural Outlook Board (WAOB) starting in its May World Agricultural Supply and Demand Estimates report issued concurrently with the NASS Crop Production report. The WAOB uses an expert panel approach to assimilate all information available for major crop producing, importing, and exporting countries. Data sources include agricultural attache reports, official foreign country statistics, weather data, computer models, and some remote sensing interpretations. In May, the WAOB uses the Prospective Plantings planted acreage figures as a base and interprets acreage to be harvested and trend yields. In July, WAOB updates its projections by using the Acreage report for acreage and modifying trend yield models for observed weather. Only U.S. yields are projected by the WAOB. Starting in August, NASS forecasts State yields as well as U.S. averages.

NASS forecasts the yields of most spring planted crops monthly from August to November. (Cotton forecasts continue through January.) Data collection starts about the 22nd of the preceding month for objective yield samples and about the 25th for farmer interviews. Data collection must be finished by about the third of the month in order to edit, process, and interpret all data in time for the monthly Crop Production report which by law must be issued between the 8th and 12th of the month.

NASS policy is that monthly forecasts are based on data collected about the first of the month and assuming "normal" weather after data collection. Saying that another way, NASS staff members do not change indicated forecasts based on assumptions about weather for the rest of the season.

NASS does not revise monthly yield forecasts since no new data will ever be collected for that forecast. Instead, the forecast based on conditions as of the first of this month will be replaced by next month's forecast based on conditions at the end of this month. NASS covers all producing States the first month of the forecast season. However, some "limited forecast" States are designated for most crops. Limited forecast States individually have less than one-half of 1 percent of the U.S. acreage and collectively have about 3 percent or less of the total acreage. The data collection, analysis, and interpretation costs are saved in those States after the first month since the first forecast is carried forward until the end of the season.

The end-of-season survey for most spring planted crops is the Agricultural Survey in December. Again, information is collected during the first half of December but in this case, the Crop Production - Annual is not issued until the January Crop Production release about the 10th of January. One reason for this delayed release timing is the holiday season at the end of December and early January. However, the more important agricultural reason is that several important crop related reports are all released at the same time: Crop Production - Annual, Grain Stocks, January Crop Production report which has the updated cotton forecast, Rice Stocks, and Winter Wheat and Rye Seedings plus the January World Agricultural Supply and Demand Estimates. Issuing all reports at one time allows NASS staff members to perform improved interpretation across reports and gives data users a full picture of information at one time.

The discussion above describes each year from a logical crop phenology standpoint. However, the NASS survey cycle actually starts in June. That is the one time each year when NASS visits all 15,000 plus area frame segments. These segments are typically about one square mile in size in intensively cultivated areas. Each State has been stratified by land use and segment sizes and sampling rates vary considerably by strata. This June Enumerative Survey is one of the most effective ongoing government surveys. Boundaries of sampling units are shown on aerial photographs so nearly all nonsampling errors can be avoided. All fields within sampling units are sketched on the aerial photos which again controls nonsampling errors. This survey collects precise field-by-field information on crops planted or other utilization. Most objective yield samples are selected from the area frame. Table 3 shows the area frame stratification, average sampling unit sizes, and number of sampling units in the survey for Ohio. The strata definitions and sampling rates for Ohio are fairly typical. Nationally, between one-third and one-half of 1 percent of the agricultural sampling units are selected.

Table 3.--1993 Area Frame Sample for Ohio

Stratum Definition	Average Segment Size	Segments in Population	Segments in Sample
	- Sq. Miles -		
>75% Cultivated	1.00	14338	105
51-75% Cultivated	1.00	6276	55
15-50% Cultivated	1.00	6625	30
Agri-Urban:>20 Home/Sqmi	0.10	12229	10
Resort:>20Home/Sqmi	0.25	345	2
<15% Cultivated	1.00	6205	10
Non-Agricultural	0.50	143	2
Total Sample			289

Typically, about 130,000 total tracts (areas of land within a segment under one operator) are found in this June Enumerative Survey with over 50,000 being agricultural tracts. The list frame sample in June is about 75,000 operators. Stratification is done on a State-by-State basis to allow each State to properly reflect the relative importance of medium and large hog operations and cover specific crops that are of particular importance in the State. Table 4 shows the list frame strata and sampling rates for Ohio in June 1993. Table 4 indicates that hogs are given much of the higher priorities in this integrated design; most of the larger hog farms would also have sizable crop acreages.

Table 4.--List Sampling Frame Sample for Ohio, June 1993 1/

Stratum Definition	Number in Population	Number in Sample	Sample Interval
Hogs 4000+	16	16	1.000
Capacity 450K+	5	5	1.000
Cropland 4000+	19	19	1.000
Hogs 2500-3999	32	15	2.133
Hogs 1000-2499	292	80	3.650
Hogs 400-999	855	220	3.886
Hogs 200-399	871	170	5.123
Hogs 100-199	885	135	6.555
Capacity 50K-449999	1066	140	7.614
Hogs 1-99	2817	250	11.268
Cropland 500-3999	3706	285	13.003
Capacity 20K-49999	828	75	11.040
Cropland 100-499	14833	625	23.732
Capacity 1-19999	4238	125	33.904
Total	30463	2160	---

1/ Stratification is a sequential, mutually exclusive classification, taking the above definitions in order.

Most data collection for the June list frame sample is done by telephone, with a constantly increasing percentage of Computer Assisted Telephone Interviewing. Some States make effective use of mail questionnaires by mailing them to half the total sample and focusing telephone calls the first few days on the other half of the sample. Operations which cannot be reached by telephone, and those requiring special handling, are sent to personal interviewers for followup along with area frame interviews.

The June survey provides area frame information for all not-on-list operators and results in the greatest precision of the year for multiple frame estimates. For subsequent quarterly surveys, about 60 percent of not-on-list tracts are used to estimate for list incompleteness. (The other 40 percent is used for measuring incompleteness for economic surveys such as production expenditures and agricultural labor.)

The list frame samples are replicated for sampled strata. There is normally a 40 percent rotation from quarter to quarter except for strata with sampling rates of more than 1 in 4. List operations which are sampled in June and rotated out for September become the sampling frame for monthly yield surveys. Stratification and sampling for yield surveys are based on the specific crops that each operation will be producing in the current year.

Since June acreage information is available for all operations in the monthly yield survey, reinterviews for the August 1 Crop Production report provide a natural planted acreage update. The August 1 survey also estimates the amount of acreage intended for harvest for corn for grain and for soybeans. Since there is usually little abandonment of acreage during the season, the acreage questions are normally not repeated after August. Farmers are asked each month to report their expected average yield or their total production.

For corn and soybean objective yield States, a self-weighting sample of fields is drawn from the expanded June area frame data. This ensures a good geographic dispersion within each State and simplifies summary calculations.

The September Agricultural Survey does not collect any corn and soybeans production information but focuses on small grain end-of-season production data plus grain stocks and hogs and pigs. The December Agricultural Survey collects actual acreages harvested and production data for corn, soybeans, and other spring planted crops. The U.S. sample size in December is normally about 82,000 with 75,000 coming from the list sampling frame and 7,000 area not-on-list operations. Part of the December list sample will have been surveyed in June and part in September so identicals can be calculated but the major indication is the direct expansion.

The March Agricultural Survey completes the survey cycle. It has a total sample size of about 77,000, collecting intended plantings information in addition to grain stocks and hogs and pigs.

1993 EARLY SEASON WEATHER

For most of this paper, comparisons will be made to averages from recent years with specific comparisons made to the 1992 season. This is because the 1992 season itself was one of the most unusual in memory. It was a cool year with crop progress being quite slow. However, killing frosts did not occur until later than normal and record level yields were produced. The 1992 season had to be an influence in farmer yield forecast evaluations during 1993 and the 1992 results were built into objective yield forecasting models along with the previous four years.

The 1993 growing season was cool and moist throughout most of the midwest States. Planting did not get off to an early start and it progressed much slower than normal, particularly in the States of Iowa, Minnesota, and South Dakota. Planting average for the U.S. was about 2 weeks behind normal in early May and still a week behind at the end of May. Figures 1 to 4 present the planting progress in the States of Illinois, Iowa, Minnesota, and for the 17 corn producing States with comparable data.

1993 CORN PLANTING PROGRESS 1/

Figure 1 United States

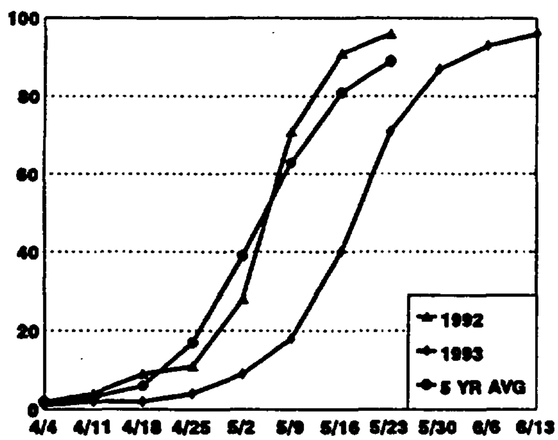


Figure 2 Illinois

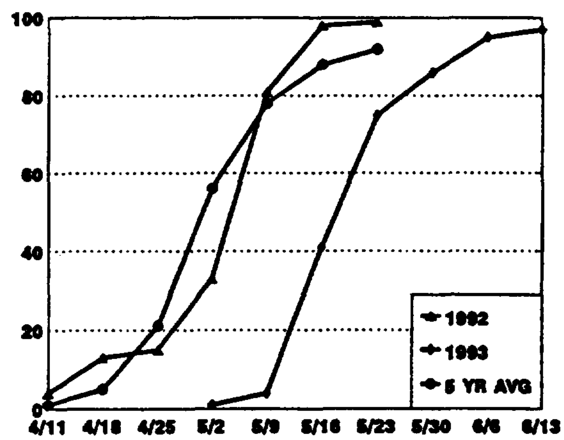


Figure 3 Iowa

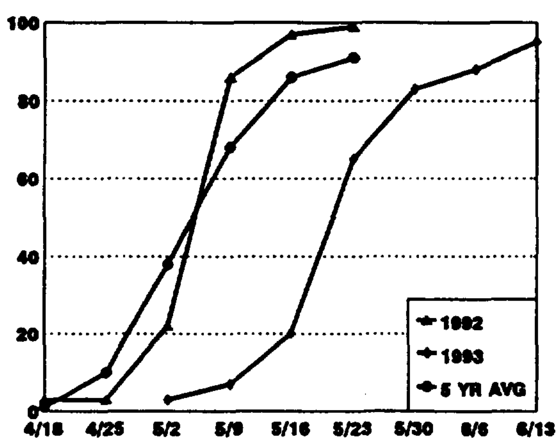
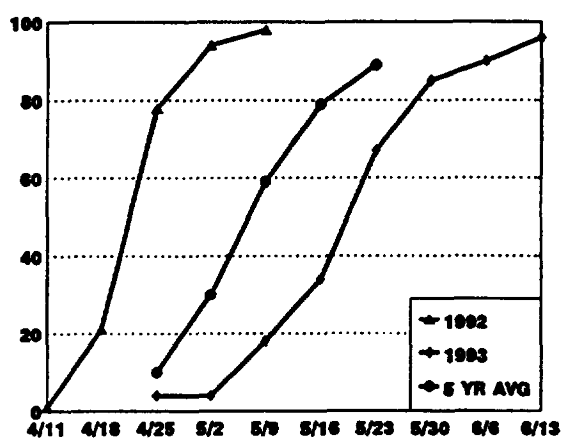


Figure 4 Minnesota



1/ Based on Weekly Weather Crop Survey.

At the time of the 1993 June Enumerative Survey interviews, 95 percent of the U.S. corn crop and 65 percent of the U.S. soybeans were planted. These figures match up well with indications from the Weekly Weather Crop during the same period.

The cool, damp early season weather turned to heavy rains and flooding in at least nine States (South Dakota, Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, Illinois, and North Dakota). The North Dakota flooding was more isolated than in the other States. North Dakota will not be included in some of the comparisons in this paper since it has limited corn and soybean acreages and is not in the objective yield program for either crop. These nine States produced 77 percent of the 1992 U.S. corn crop and 64 percent of the 1992 U.S. soybean crop.

At the time of the Acreage report on June 30, there were few questions about the numbers published. However, there were concerns that some acreage intended to be planted had not and would not be planted. Ever since 1980, the June acreage estimates of corn planted acres had been within plus or minus 1 percent of the final planted acreage estimate. Even soybeans, which can be affected by double cropping decisions made after mid-June, had exceeded a 1 percent change only twice since 1980.

AUGUST 1 ACREAGE ESTIMATES

Since 1990, the normal NASS survey program collects additional information on plantings by including those questions on the monthly yield survey in August. All operators in that sample did report in the list portion of the June Agricultural Survey so direct comparisons can be made.

Because of weather concerns in late June and July, NASS expanded its data collection for the August 1 survey. For the nine flood States, all area frame tracts (operations) which had not completed planting in June were recontacted. This area frame update was part of usual procedures until 1987 when the start of the June Enumerative Survey was moved from about May 20 to June 1. There has not been a great need for an acreage update since.

In order to strengthen information from the list frame, an extra replicate was selected to be contacted August 1 along with the normal monthly ag yield survey sample. All corn and soybean objective yield sample interviews (which include acreage update information) were conducted about August 1 instead of the usual pattern of starting half of the samples August 1 and the remainder September 1. An additional objective yield like sample which was scheduled for interviews in September or October for agricultural chemical use data was also contacted for August 1 acreage data. Table 5 presents the total contacts designated for August 1.

Table 5.--August 1 Survey Contacts Made to Update Planted Acreage Information 1/

State	Area Frame Operations	Growers Subsampled from June List Survey	Corn Objective Yield Survey	Soybean Objective Yield Survey
Illinois	307	1,576	531	497
Iowa	680	1,317	585	430
Kansas	156	1,562	110	155
Minnesota	201	1,333	390	347
Missouri	342	1,165	245	309
Nebraska	124	1,764	445	237
South Dakota	200	1,343	246	163
Wisconsin	188	981	323	0
Total	2,198	11,041	2,875	2,138
Usual Sample	0	8,695	760	420

1/ Some duplication could occur between the area frame operations with planting intentions fields and those operations selected in the objective yield samples.

In addition to the increased sample sizes for August 1, extra emphasis was placed on contacting all selected operations. Almost all monthly ag yield interviews are normally conducted by telephone. Any operations not contacted by telephone early in the 1993 survey period were turned over to personal interviewers who were doing the objective yield survey and area frame followup.

The Agency wanted to be sure that no bias was introduced through missing operations that could not be reached by telephone because of flooding. In many cases, interviewers had to be very inventive in finding alternative roads to contact some operations, had to battle mud to get to interviews, and sometimes had to help with flood related activities while collecting data.

The combination of survey efforts about August 1 yielded three indications for planted and harvested acreage of the major crops. These were the updated area frame indications, the acreage estimates from the monthly ag yield survey, and the objective yield acreage adjustment from beginning interviews. These indications were quite consistent.

Table 6 is a data table taken from the August Crop Production report. It utilized all survey data in estimating acreage prevented from being planted and the acreage planted but expected to be abandoned. One way of visualizing the decreases in acreage is the fact that the corn and soybean declines were comparable to the respective acreages of those crops in the State of Ohio. It was felt that detailed data tables such as Table 6 were needed, particularly for corn. Some acreage in each State is always harvested for corn silage instead of corn for grain and NASS wanted to be sure that people unfamiliar with the data did not subtract the acreage intended for grain from total planted and assume that the entire remainder was abandoned.

NASS figures on acreages not planted and acreages abandoned after planting were lower than most numbers which had been mentioned in the press or calculated by other agencies trying to assess flood damage. There were at least three reasons for the differences. First was the normal tendency to overestimate losses. Second was misunderstandings about acreages affected by flooding or excessive moisture compared to acreage lost due to those factors.

The third reason gets into complications of government farm programs. NASS measured changes from the Quarterly Agricultural Survey in early June. By the June interviews, some farmers might have already changed their minds from March about what corn acreage would be planted. Also, if they were enrolled in the 1993 Feed Grain Program, they were required to not plant 10 percent of their corn base acreage. There would be a tendency to calculate unplanted acreage from the base, not from the level of planned plantings in early June. (It should be pointed out that soybeans are not included in the government farm programs.)

USE OF SATELLITE DATA

Many people assume that NASS can now utilize satellite imagery for much of its data needs. There were some interesting applications of satellite data in 1993 but they were not major factors in the creation of statistical forecasts and estimates.

Other agencies in USDA use satellite imagery very successfully for monitoring agriculture in areas of the World for which statistical data are not available. Particularly if most production is of one crop, all green areas can be classified as being that crop and imagery during the season can give a relative impression of healthiness and yield potential. These rough, unverifiable procedures would not help to improve or replace present U.S. acreage and production estimates which have strong statistical underpinnings. Instead, sophisticated training and processing techniques are required to utilize remote sensing.

Table 6.--Acres for Harvest, August 1993 with Comparison to June 1993, Nine Selected States

State	Acres for Harvest		Decreases from June Harvested Acres		
	June 1/	August 2/	Total	Not Planted 3/	Lost After Planting 4/
			- 1,000 Acres -		
			Corn for Grain		
Illinois	10,300	10,000	300	0	300
Iowa	11,800	10,900	900	100	800
Kansas	1,850	1,800	50	0	50
Minnesota	5,600	5,100	500	0	500
Missouri	2,100	1,800	300	0	300
Nebraska	7,700	7,650	50	0	50
North Dakota	430	380	50	0	50
South Dakota	3,100	2,600	500	200	300
Wisconsin	3,000	2,550	450	300	150
9 States	45,880	42,780	3,100	600	2,500
			Soybeans		
Illinois	9,200	8,700	500	200	300
Iowa	8,750	8,000	750	300	450
Kansas	2,150	1,800	350	300	50
Minnesota	5,700	5,000	700	300	400
Missouri	4,350	3,600	750	200	550
Nebraska	2,560	2,450	110	100	10
North Dakota	590	520	70	20	50
South Dakota	2,260	1,600	660	500	160
Wisconsin	650	580	70	70	0
9 States	36,210	32,250	3,960	1,990	1,970
			8 Major Crops 5/		
Illinois	22,470	21,660	810	200	610
Iowa	22,625	20,950	1,675	400	1,275
Kansas	20,935	20,235	700	500	200
Minnesota	17,355	16,150	1,205	300	905
Missouri	12,350	11,036	1,314	260	1,054
Nebraska	17,712	17,492	220	100	120
North Dakota	19,435	19,115	320	20	300
South Dakota	13,348	12,188	1,160	700	460
Wisconsin	7,221	6,801	421	371	50
9 States	153,451	145,627	7,825	2,851	4,974

1/ From Acreage report released June 30, 1993.
2/ August 1, 1993, Crop Production report released August 11, 1993.
3/ Acres intended for harvest in June that were not planted.
4/ Acres planted that will not be harvested.
5/ Includes corn for grain, soybeans, sorghum for grain, oats, barley, all wheat, all hay, and dry beans.

Imagery from two different satellite series is commonly used. One is information from the Advanced Very High Resolution Radiometers (AVHRR) aboard the NOAA weather satellites. These sensors have one visible band and one near infrared band. Data from weather satellites are very coarse with each data element, or pixel, representing about one square kilometer on the ground. The weather satellite advantage is that observations are taken every day. The normal way of examining weather satellite data is to calculate a vegetative index from a ratio of the two bands of data. Much data are lost each day due to clouds so the usual technique is to extract the highest noncloud readings for each data point and each band across a 2-week period and use those values for calculations. The United States Geological Survey organization does create a picture product for the U.S. from the data sensed every 2 weeks.

During the 1993 growing season, NASS acquired the AVHRR data on a priority basis, including the preliminary information for the first week of every 2 week period. NASS developed routines for processing the entire file on a Sun Sparc-2 work station and creating map products at several different scales. Individuals in the NASS Research Division also loaded the entire file of 1992 AVHRR vegetative index data. Once that was done, a series of biweekly crop vegetative difference images was created which compared 1993 conditions to 1992. Areas which were primarily noncrop were masked as a neutral color and all other points were classified into five colors representing "much-lower vegetative index" up to "much-higher vegetative index." Figure 5 illustrates in black and white the types of product that were created in color during the growing season.

The vegetative difference images were very helpful for a visual perspective on the extent of the flooded area and were of great interest to USDA policy officials. However, proper interpretation of them depended on a good understanding about previous growing season conditions and it was not possible to convert information to a yield per acre judgement.

The other significant satellite data source for agriculture purposes is the Landsat series. The Landsat 5 which is still in orbit contains the Thematic Mapper (TM) sensor which collects reflectance in seven different wavelengths. NASS was the early leader in developing procedures to process entire frames (about 100 nautical miles on a side, containing 40 million data points in each band) of digital satellite data. Proper utilization of Landsat data requires samples of known ground data within each scene and precise registration of satellite data points to the correct fields on the ground. For the TM, each pixel represents 30 meters on the ground so much more precise interpretations can be made than with AVHRR data. However, the repeat cycle of the satellite is 16 days and the sensor is very susceptible to cloud problems so many desired agricultural targets are often missed during the peak parts of the growing season.

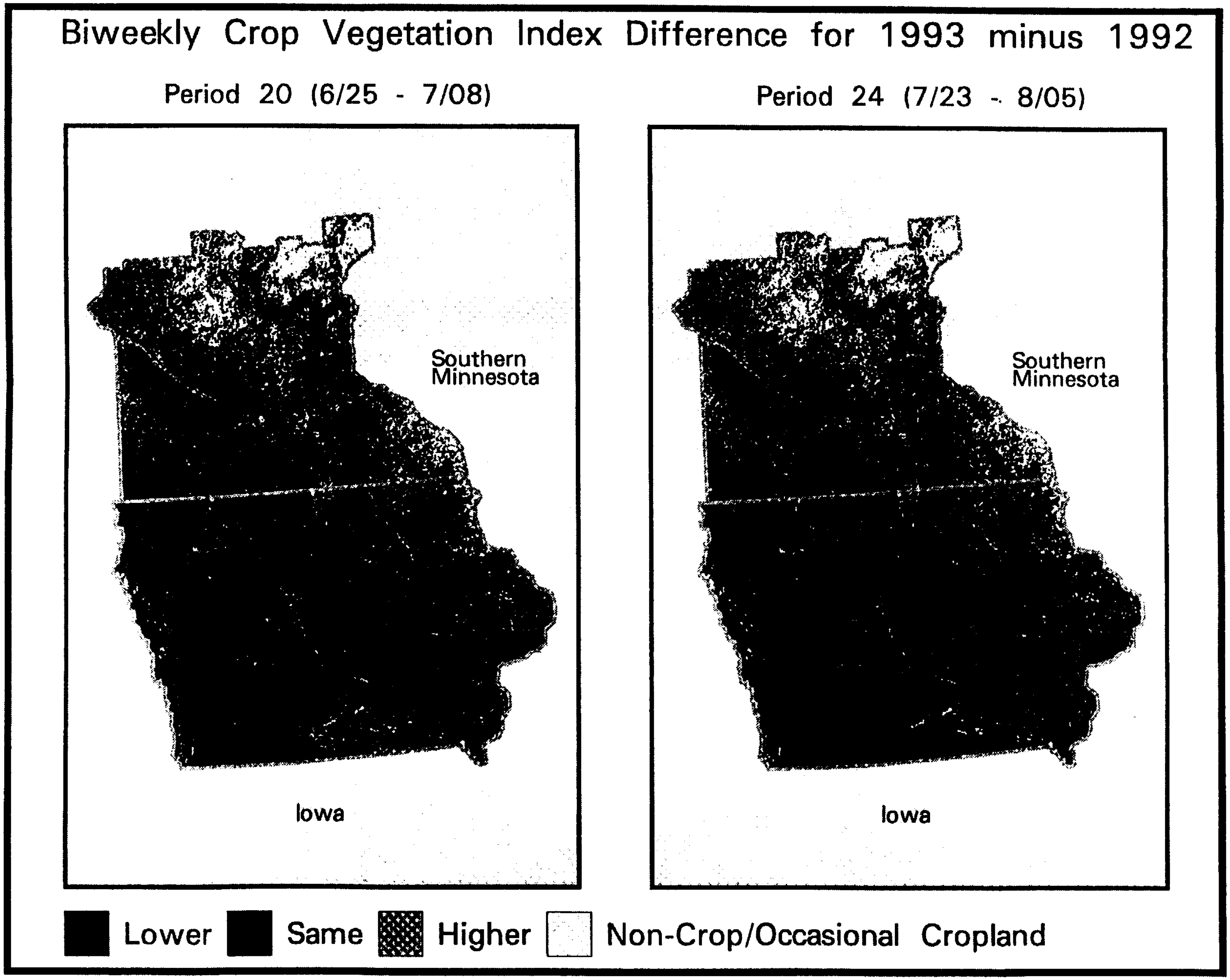


FIGURE 5 WEATHER SATELLITE DATA EXAMPLES

NASS studies with Landsat have shown that cloud free images, which are reasonably optimum in time of acquisition, yield relative efficiencies of three or higher. That is, combining the satellite classifications with the area frame survey data used for training improves precision of acreage estimates as much as if three times as many ground observations were added.

Landsat data do not offer any timing benefits for NASS. NASS issued the Prospective Plantings report at the end of March and the Acreage report the end of June but the earliest time for differentiating corn from soybeans with Landsat data is mid to late August. It is also not likely that Landsat data interpretation can tell corn silage fields from those for corn for grain or differentiate marginal corn fields that won't be harvested from those that will.

USE OF CROP CONDITION DATA

The Weekly Weather Crop Survey, which monitors crop progress, also collects crop condition data from the panel of reporters. A five adjective scale of "excellent," "good," "fair," "poor," and "very poor" is used for each crop. Those data are summarized each week as weighted State averages. Each State is divided into Agricultural Statistics Districts (ASD's) which are contiguous groupings of counties in the State. Crop acreages within each ASD are used for weighting.

Although NASS would caution individuals to not put much confidence in these condition data which come from such a small panel (usually less than 100 reporters per State or about 12 or fewer per ASD), weekly reports are closely followed. Many people have created naive yield prediction models from the data series and NASS has explored the use of condition as one variable in early season multiple regression models for wheat yield forecasting. Figures 6-9 illustrates a simple approach that assigns a numeric value to each adjective to create a weighted State average index. The Iowa condition data about August 1 indicate an average yield of 100 bushels per acre when the actual forecast based on objective yield and grower supplied data was 115. About October 1, the indication of slightly below 100 bushels does more closely match the Iowa October 1 forecast of 105 bushels per acre. Figures 6 and 7 indicate the Iowa final yield actually turned out to be only 80 bushels per acre--more about the reasons for that later. Figures 8 and 9 show that the Ohio corn crop condition did decline during the season when drought was experienced. In this case, the August 1 and October 1 conditions did indicate quite closely the official forecasted levels for the two periods (128 and 113).

COMPARISON OF CROP CONDITIONS AND YIELDS 1/

Figure 6

Iowa August Condition vs Corn Yield

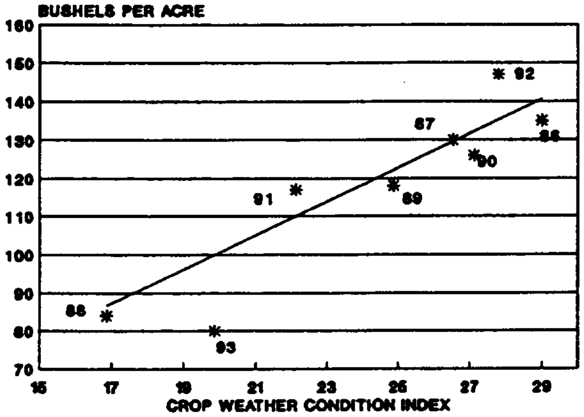


Figure 7

Iowa October Condition vs Corn Yield

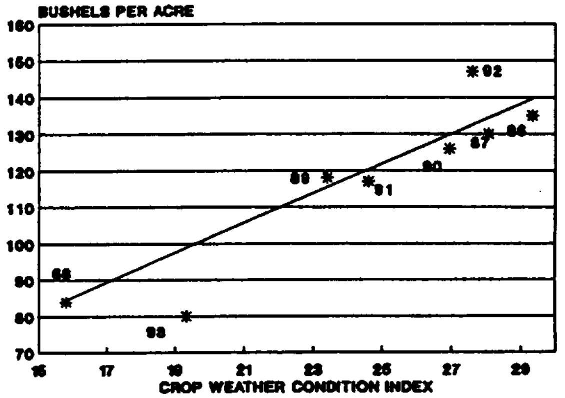


Figure 8

Ohio August Condition vs Corn Yield

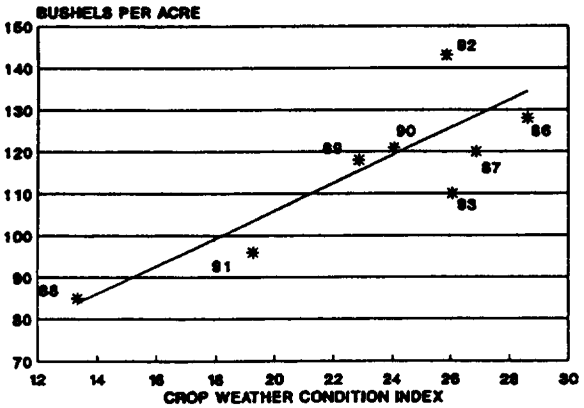
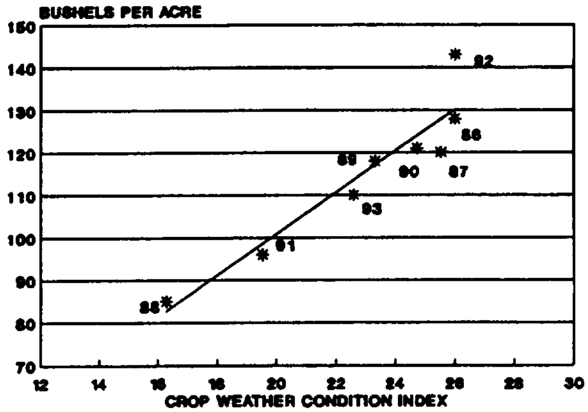


Figure 9

Ohio October Condition vs Corn Yield



1/ Based on Weekly Weather Crop Survey and Official Yield Estimates.

YIELD FORECAST PROCEDURES

NASS maintains strict security procedures for all of its estimating programs to ensure that no one outside the Agency has access to any information ahead of time. For monthly <u>Crop Production</u> forecasts of the yields of corn, soybeans, wheat, cotton, and sweet oranges, additional security procedures, which include total isolation of the staff which prepares final State and U.S. forecasts, are used. One key feature is that a few leading producing States, which usually make up about 80 percent of production, are specified as the "speculative" States. The State Statistical Office recommendations for those States cannot be examined except under lockup conditions in the final hours as the current report is being prepared. Some comparisons to follow in this paper are based on totals or averages for these speculative States which are normally all States which have objective yield surveys. Figures 10 and 11 show the objective yield States for corn and soybeans, along with the limited forecast States and the "full forecast" States which have a grower survey each month.

Yield indications that NASS receives are biased and the process in State Statistical Offices and Agricultural Statistics Board (ASB) deliberations is aimed at interpreting the current amount of bias. Reports of yield received from farmers during the growing season will be biased on the low side of final yields. Farmers tend to be conservative in early season reporting since it is easy to visualize the number of things that can happen in the upcoming months before harvest to limit the final yield per acre. This amount of underreporting reduces each month as the crop comes closer and closer to maturity. The survey indication from the December Agricultural Survey, when most harvest is completed, is usually at the final average yield level.

Objective yield indications for yield are usually somewhat above the final average yield level. Objective yield procedures forecast biological yield and it is not possible to account for all harvesting losses which is one reason for the bias. Another factor is that the objective yield interview process asks such detailed questions on acres in a field, acres planted in that field, acres not now in production, etc., that the farmer's concept of the objective yield field becomes smaller than they would report on a mail or telephone inquiry. Thus, there may not be much bias between total production and objective yield <u>production</u> in a field but the <u>yield</u> indication will have an upwards bias.

Since NASS conducts the same surveys each year, the past history of each month's indications compared to final State yields is used to adjust for biases. In recent years, a combination of time series data plots and numeric calculations of these differences have been used to be sure that State office statisticians are using the same interpretation approach as the ASB in Headquarters.

Figure 10 States in the Corn Forecasting Program

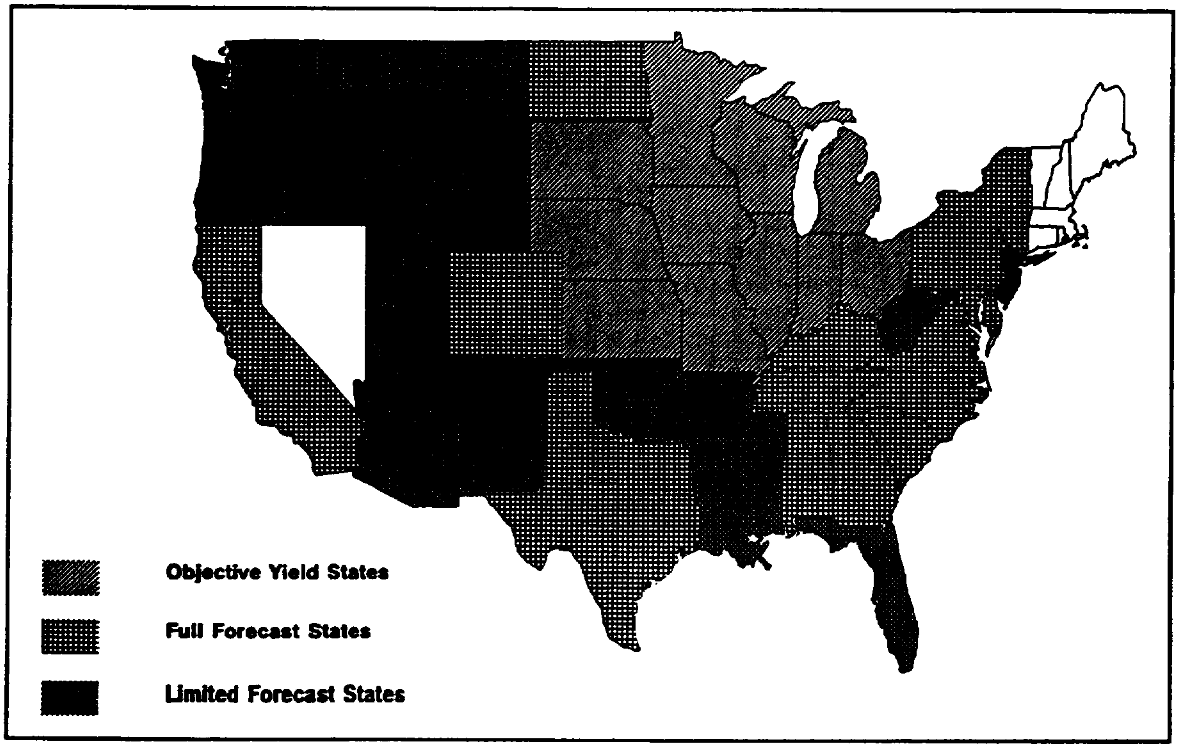
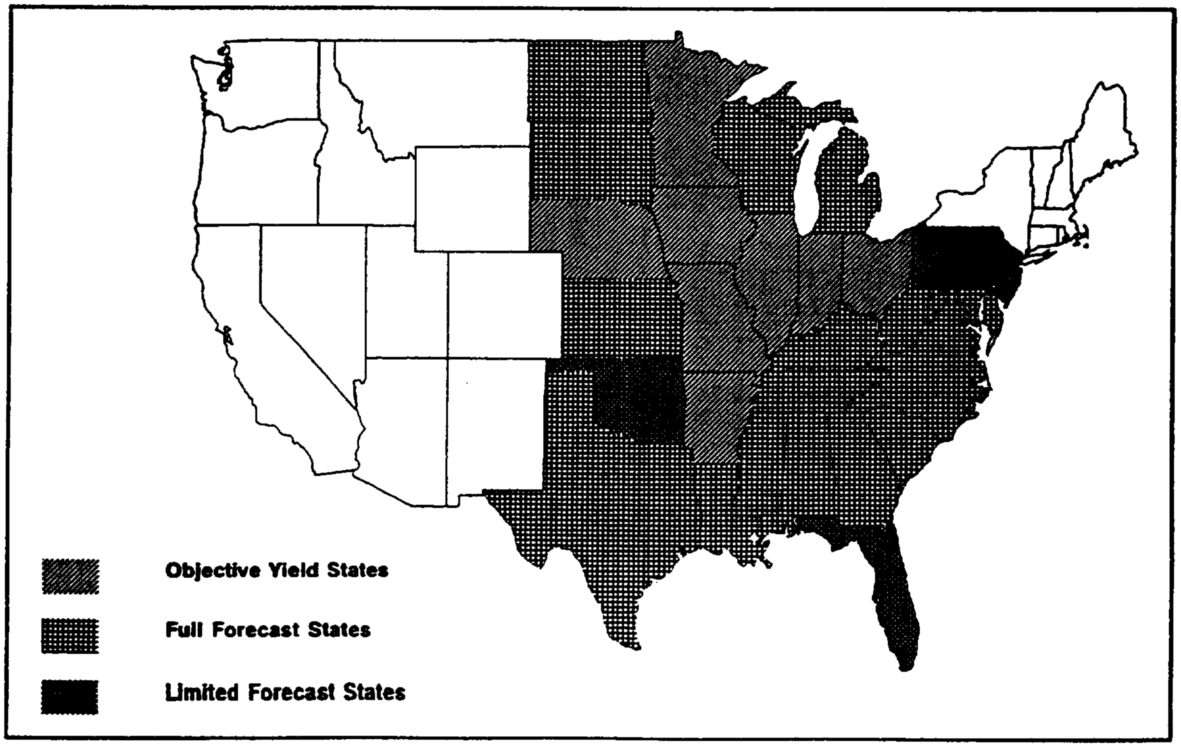


Figure 11 States in the Soybeans Forecasting Program



The ASB meets the morning that the Crop Production report is to be released to consider the yield for the speculative States. Yields have been adopted for all other States and are being held in locked files. The encrypted State office recommendations have been stored in a safe until the work area is secured and an armed guard posted.

The ASB for each crop normally consists of about eight members with at least two from State offices. The ASB concentrates on adopting the region average yield. Both the farmer yield and the objective yield are probability surveys with greater precision at the regional level than the State level. All historic results and current indications are properly weighted to the region.

Each ASB member reviews and interprets the regional indications and past relationships and determines their recommendation. The ASB Chairperson openly polls the members and all can see the differences in interpretation, if any. Differences are discussed and the Board preliminary target is set. The commodity statistician for that crop and one or two other statisticians then review individual State indications and recommendations and "set" the State yields while the ASB moves to other crops. If the resulting weighted average regional yield is not within rounding of the target, the Board may be reconvened. However, this is rarely needed.

OBJECTIVE YIELD MODELS

All NASS objective yield programs are designed to forecast the number of fruit (ears of corn, wheat heads, soybean pods, oranges, etc.) at harvest time and weight per fruit. In most cases, the number of fruit can be forecast well ahead of harvest but an accurate forecast of weight per fruit is often the limiting factor.

NASS uses two types of forecasting model approaches. Traditional forecasting models are based upon data from objective yield samples for the past 5 years and they calculate a yield for each current sample. Data are limited to 5 years since cultural practices and seed quality are constantly changing and older data might not be as beneficial for forecasting current characteristics. For instance, in the past 3 years, NASS has observed a much higher rate of soybean pod retention from pod forming to harvest, probably due to varietal improvement.

The other modelling approach examines past August and September relationships of individual components and combinations of components to determine those which are well correlated with final yield. For example, September number of ears per acre multiplied by kernel row length is better correlated with final yield than the average calculated yield of all samples from the traditional approach.

Monthly forecast models for corn and soybeans are based on upon maturity stages. The corn stages are the biological stages shown in Table 7. For soybeans, modelling is actually based on detailed maturity categories which are determined from relationships among various fruit counts. NASS research showed that relationships between early season fruit counts and final pods with beans varied greatly depending upon exactly which maturity stage was observed on the day of data collection. For example, since not all blooms on the plant go on to form pods, there is a great difference in data relationships when pods make up only 25 percent of the blooms and pods compared to when pods make up 75 percent. Some maturity categories last only a few days so NASS uses a very small count unit in order to ensure accurate counts.

Table 7.--Corn Maturity Categories for Traditional Forecast Models

Code	Definition
1	No ear shoots present.
2	Pre-blister.--Little or no watery, clear liquid present in spikelets (unpollinated kernels).
3	Blister.--Most spikelets have partially formed kernels that are enlarged and full of liquid.
4	Milk.--Most kernels are full of milk-like substance, but kernels are not fully grown.
5	Dough.--Kernels are full grown. About one-half of kernels showing dent with some dough-like substance in all kernels.
6	Dent.--Kernels are fully dented with no milk present in most kernels. Kernels may be hard to scratch at surface.
7	Mature.--Maturity line on the kernels at mid ear has advanced down to the cob.

Forecast models are single variable regression equations of the form:

$$Y = a + bX$$

where:

Y = component to be forecasted,
a = the intercept,
b = regression coefficient for X,
X = the independent variable from field counts or measurements.

Separate forecasts are calculated for number of ears per acre and average grain weight per ear. Table 8 lists the variables which are used for each model, by maturity code.

Table 8.--Corn Forecasting Model Variables

Maturity Code	Model 1	Model 2
	Number of Ears	
1	Number of Stalks	No model
2-4	Number of Stalks	Stalks with ears or ear shoots to total stalks; number of ears and ear shoots 1/
5-7	Ears with kernel formation	No model
	Grain Weight per Ear	
1-2	Historic average	No model
3-6	Average kernel row length	Average length over husk
7	Average field weight	No model

1/ Two different sub models are calculated and weighted together.

The traditional objective yield forecasting approach calculates a yield for each sample and averages all of the samples. After September 1 and harvest of ears begins the traditional forecasting approach and the new alternative procedures converge. The final objective yield indication for each sample is based on actual counts of fruit (ears, pods with beans, etc.) and actual weights. Before that time, the ASB process is improved by having multiple indications to consider.

Use of this additional modelling approach, plus the graphing of early season indications versus final weight or other indications, has made Board members more cognizant of factors that lead to higher or lower fruit weights. This emphasis on studying yield components was a factor in improving forecasts in 1991 and 1992 over the approach of only examining the sample forecast averages.

The objective yield models create very precise forecasts at the State and regional level. Coefficients of variation for average yield or the yield components are usually 1 to 2 percent at the State level and 1 percent or less for the region. The coefficients of variation are similar for the monthly ag yield survey. Thus, the sampling error is very small compared to the forecasting error. Since weather conditions can change tremendously between a monthly survey and the end of the season, the observed changes are much higher than the survey error. The easiest measure of forecast error is the root mean square error of the monthly forecasts. Deviations from the monthly forecast to final yield are expressed as percentage changes. The average of the squared percentage deviations for the past 20 years is presented in the reliability writeup for each monthly publication. For corn, the root mean square errors in 1993 were: August, 7.6 percent; September, 4.7; October, 3.6; and November, 2.4. For soybeans, the root mean square errors were: August, 6.0; September, 5.3; October, 4.0, and November, 2.9.

AUGUST 1 YIELD FORECASTS

The August 1 data from the farmer surveys and objective yield observations pointed to an extreme mixture of yield potentials. Plant population and projected corn ears per acre were very high for most objective yield States. The States of Illinois and Indiana had tremendous increases in soybean plants per acre from a significant move to narrower row plantings. Iowa corn yield was forecast to be down 32 bushels from the record yield of 1992. However, Illinois and Indiana were both forecast at 140 bushels per acre, down only 9 and 7 bushels, respectively, from their 1992 records. The U.S. production forecasts of 7.42 billion bushels for corn and 1.90 billion bushels for soybeans were fairly well in line with the production levels of 1989-1991. Both figures were down from trend yield projections that the World Agricultural Outlook Board had made in July using June Acreage data and consideration of various trend and weather models.

One interesting agriculture phenomenon in recent years is that one news service publishes a number of market analysts' estimates two days or so ahead of major NASS reports. With rare exceptions, these analysts, from commodity trading firms or advisory services, do not have any survey data but use prior government reports, weather, and market interpretations. The average of these figures probably does represent the general expectation of the "industry" ahead of a report. These "guesstimates" in August averaged 7.51 and 1.86 billion bushels with respective ranges of 6.96 to 7.79 and 1.75 to 1.90. Thus, the NASS soybean forecast was somewhat higher than expected, probably due to high pod counts in the Objective Yield Survey.

Forecasted production levels were down 22 percent for corn and 13 percent for soybeans from 1992. After the Crop Production report was published and absorbed, there was an acceptance of those levels, given that normal weather might occur the rest of the growing season.

SEPTEMBER AND OCTOBER FORECASTS

There wasn't anything normal about the 1993 season. There was a season long drought in the Southeast States that greatly reduced yield potentials and caused some abandonment of corn acreage. The drought conditions spread into Ohio which had started with very good yield prospects. The Ohio yield forecast went from 128 bushels per acre in August to 115 in September.

The objective yield counts continued to support the very high ear counts and projected pods per acre from August. The pods counts, however, were mixed between States. In the September 1 survey, Illinois and Indiana had pod counts 14 and 20 percent above their previous record levels, respectively, due to the adequate moisture and high plant populations. However, Iowa and Minnesota had pod counts equal to and 13 percent lower, respectively, than their previous low counts during the 1988 drought year.

A new factor in September and October forecasts was additional speculation about the amount of corn acreage for harvest. One 1993 Feed Grain Program provision was referred to as "0-92." This meant that a person who had a corn acreage base could sign up and plant no corn at all and still get 92 percent of maximum program payments. Because of the flood, farmers were given an extension of the time period for enrolling in 0-92. The final date had originally been April 30 but subsequent extensions allowed farmers to make decisions as late as September 17 <u>if</u> they had signed up for regular provisions by April 30. This caused concern that a sizable portion of acreage might be destroyed and NASS forecasted acreages for harvest at grain might be too high.

There also was a scare in Illinois when articles were written about Sudden Death Syndrome which was reported to affect and quickly kill entire fields of soybeans. There are scattered disease, insect, hail, and other problems each year. The forecasted soybean acreage for harvest for each State provides for abandonment due to those factors. The end-of-season surveys for Illinois did not show any drop in soybean harvested acres <u>over</u> what NASS had already forecast.

NASS did keep the questions on acreage intended for harvest on the monthly ag yield survey each month instead of dropping them after August. There were some small adjustments in the October report: Minnesota corn acreage for grain harvest was lowered 500,000, Iowa 100,000, and Missouri, Nebraska, and South Dakota 50,000 each.

Each monthly survey, while supporting the acreage levels, did show lower and lower yields. In addition to the corn crop being later than average, pollination was not good and kernel row lengths of ears were shorter than average. These shorter kernel rows provided indications by October 1 of Iowa and Minnesota ear weights nearly as low as the drought years of 1983 and 1988.

Figures 12-15 illustrate some of the information available from the monthly Objective Yield Survey. Figure 12 depicts the September 1 linear relationship between a yield "proxy" (number of ears per acre multiplied by average kernel row length) and the final yield in earlier years.

Figure 13 depicts a response surface of yield projected onto the distribution of numbers of ears and length of ears. The response surface is shown as contour lines for various yield levels (100 bushels per acre, 110 bushels per acre, etc.). Figure 13 illustrates that the high ear counts in 1993 provided the potential for more than an 110 bushel per acre average, even with the short average kernel length.

Figures 14 and 15 compare ears per acre available weight data, and yield projections in October and November. Figure 15 indicates that the average weight has come down almost 10 percent from October and indicates an average yield only sightly above 100 bushels per acre.

Figures 16-19 present comparable relationships for Iowa. Figures 17 and 18 illustrate that the yield potential based on average kernel row length and the weights from the earliest harvested samples was in the 105 to 112 bushel per acre range. However, Figure 19 indicates that, after an early October frost, the potential dropped to the low 80's.

NOVEMBER 1 YIELD FORECASTS

The 1993 growing season came to a sudden conclusion in early October. Killing frost occurred in Minnesota, Northern Iowa, South Dakota, and Wisconsin October 2 and 3 and moved across most of the Corn Belt by mid-October.

Once frost has occurred, the moisture content of corn kernels and soybeans usually drops quickly, allowing harvest to occur. By the end of October, 50 percent of the corn acreage and 80 percent of the soybean acreage had been harvested.

In much of the flood affected area, farmers were shocked with their actual corn yields. Kernel weights were much lower than normal with resultant drops in yield. A bushel of corn is defined as 56 pounds at 15.5 percent moisture. Crops are sold on a weight and moisture basis. Price is normally discounted for low test weight and for every percent moisture above a standard. The yield declines from expectations were particularly severe in Iowa. Soybean yields in Iowa also turned out lower than farmers had anticipated.

Figure 12. -- Comparison of September 1 Corn OY Indications to Final Yield

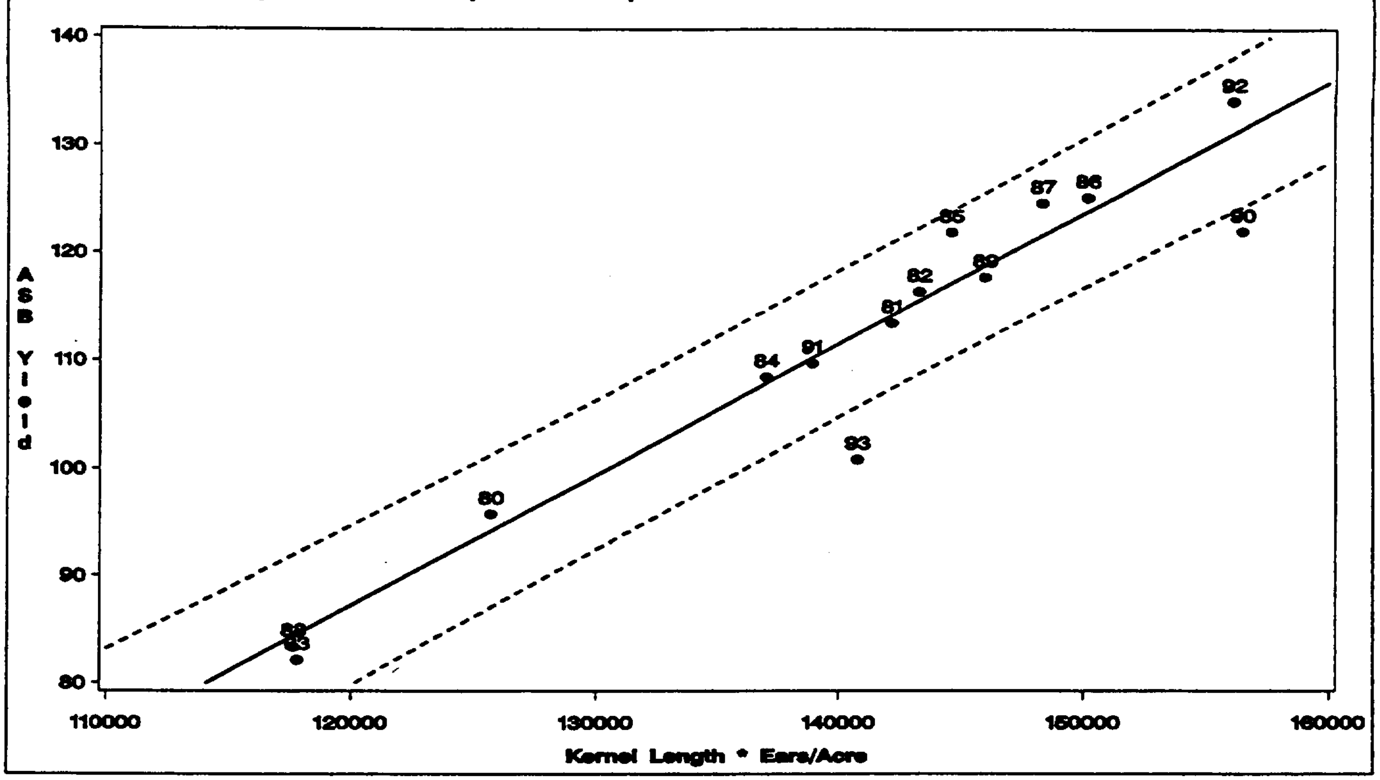
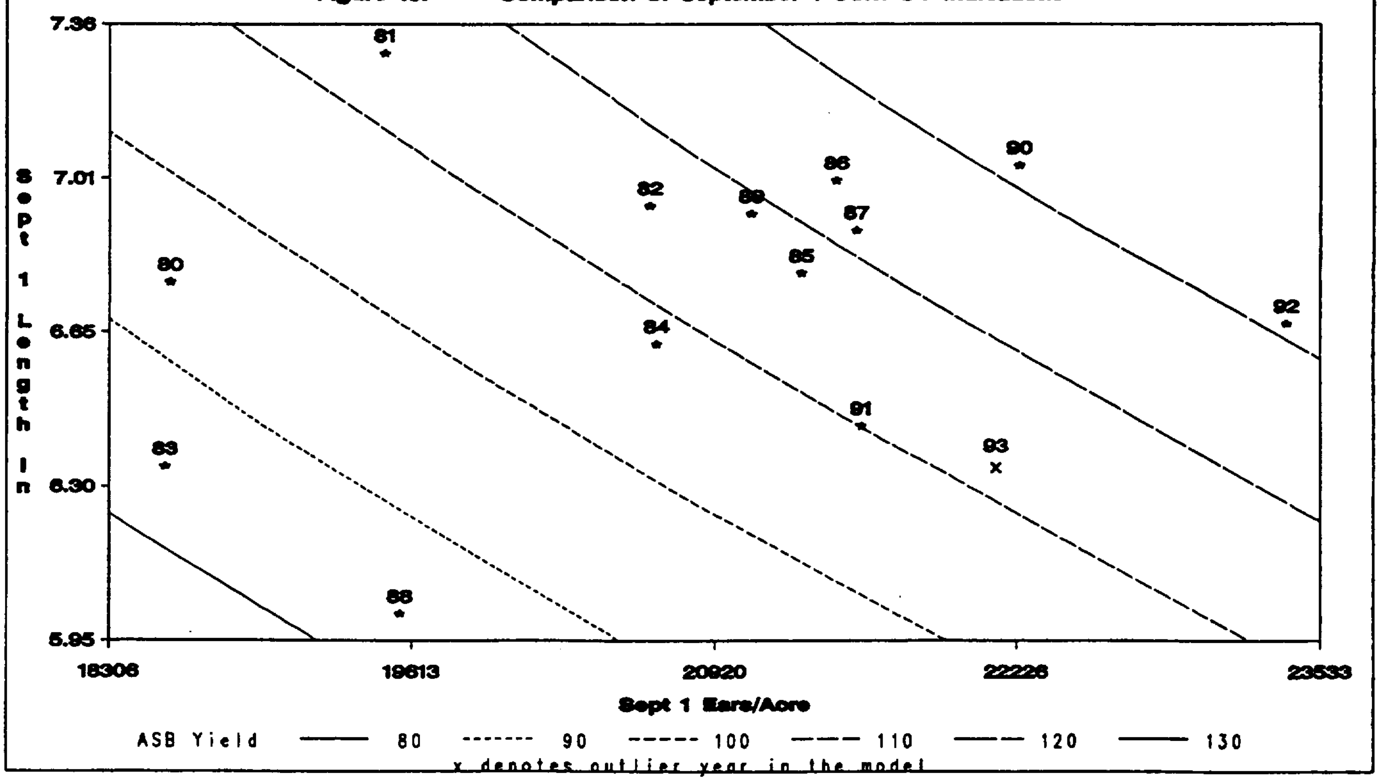


Figure 13. -- Comparison of September 1 Corn OY Indications



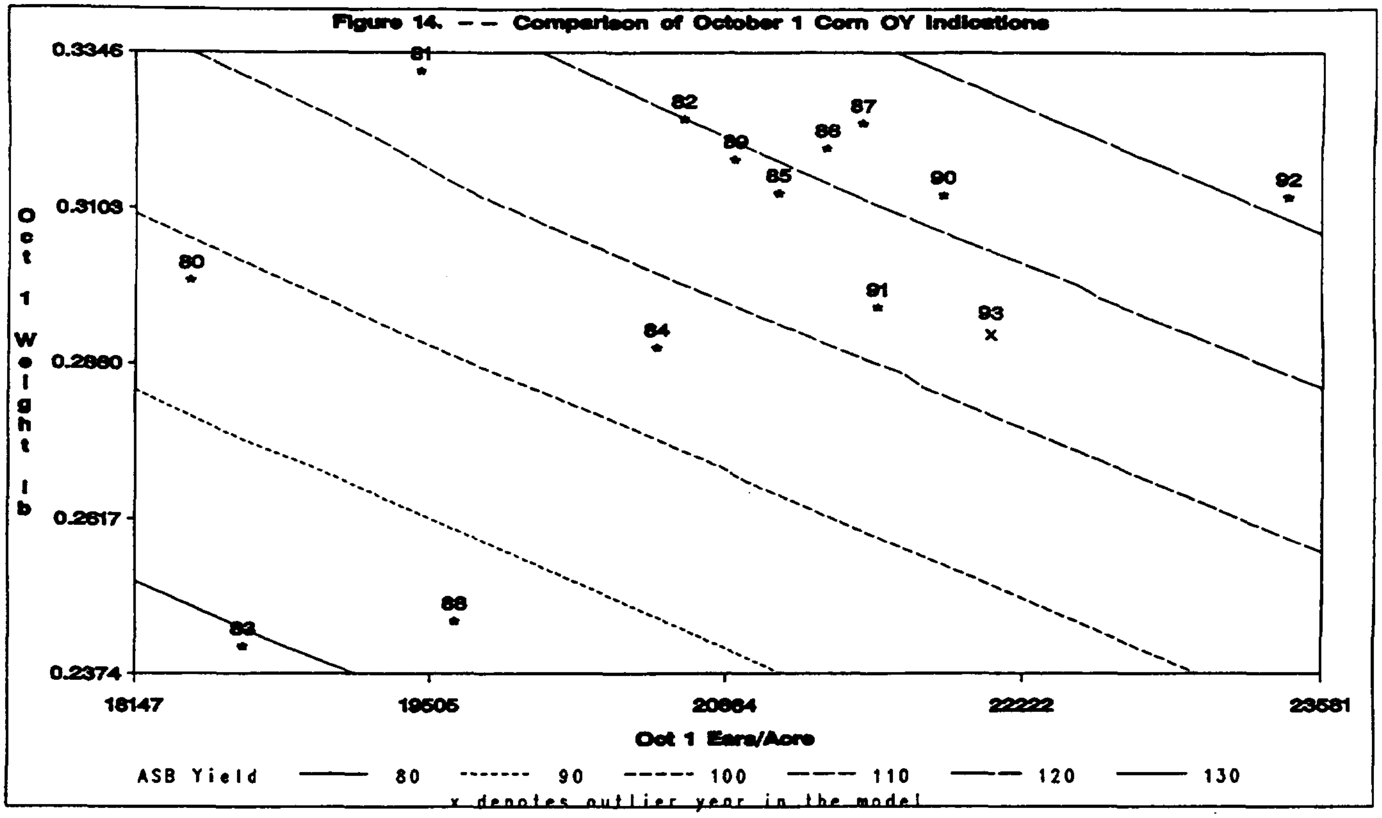


Figure 14. -- Comparison of October 1 Corn OY Indications
0.3346
0.3103
0.2860
0.2617
0.2374
Oct 1 Weight lb
18147
19505
20864
22222
23581
Oct 1 Ears/Acre
81
82
87
86
89
85
90
92
80
91
93
84
88
83
ASB Yield 80 90 100 110 120 130
x denotes outlier year in the model

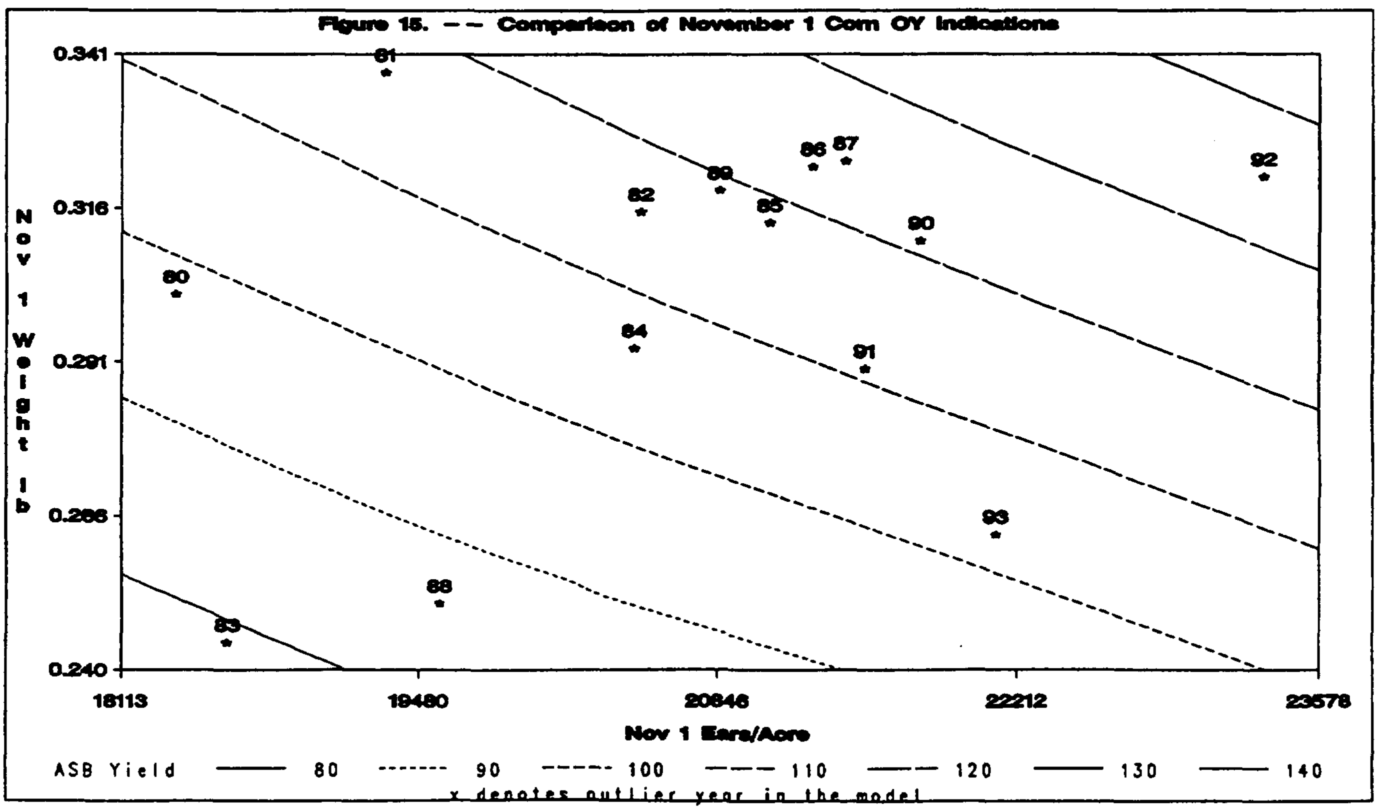


Figure 15. -- Comparison of November 1 Corn OY Indications
0.341
0.316
0.291
0.266
0.240
Nov 1 Weight lb
18113
19480
20846
22212
23578
Nov 1 Ears/Acre
81
86
87
92
89
82
85
90
80
84
91
93
88
83
ASB Yield 80 90 100 110 120 130 140
x denotes outlier year in the model

Figure 16. -- Comparison of September 1 Corn OY Indications to Final Yield -- Iowa

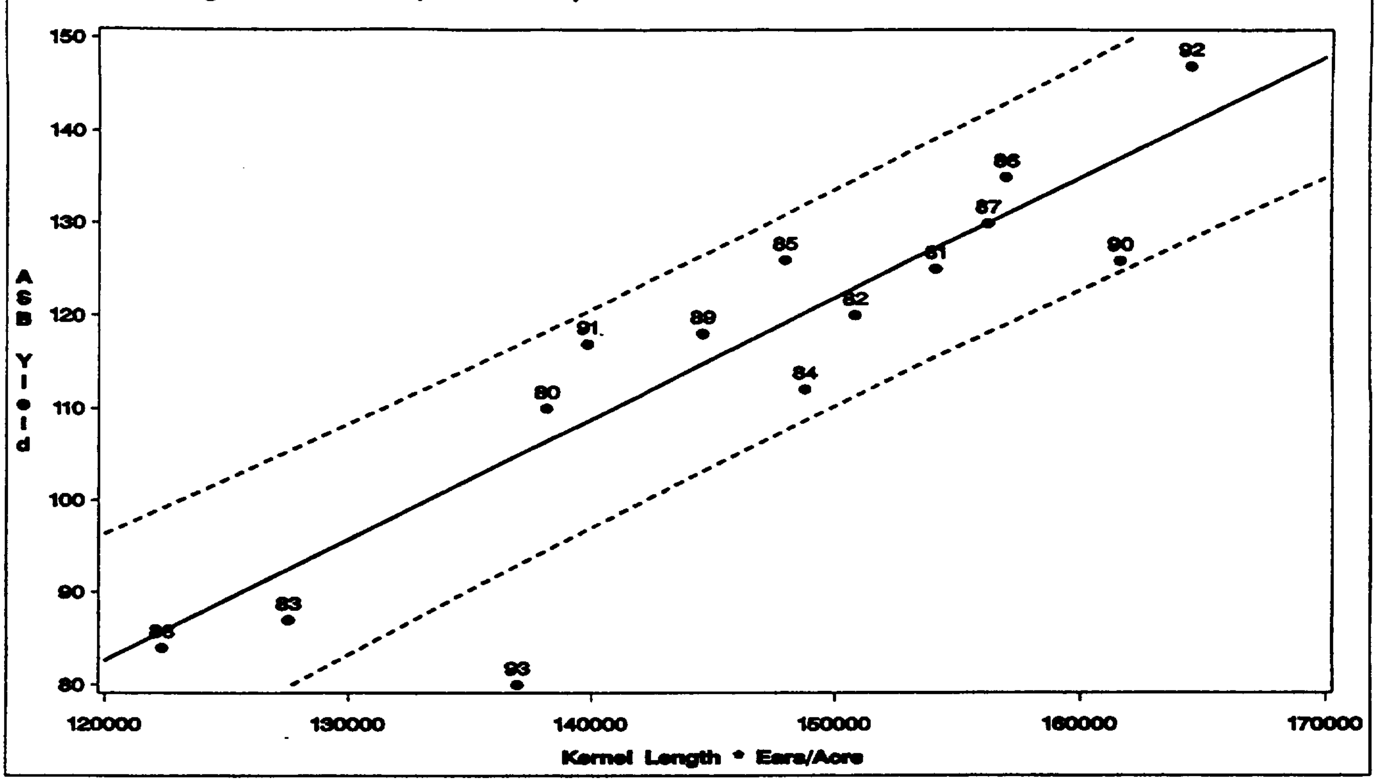
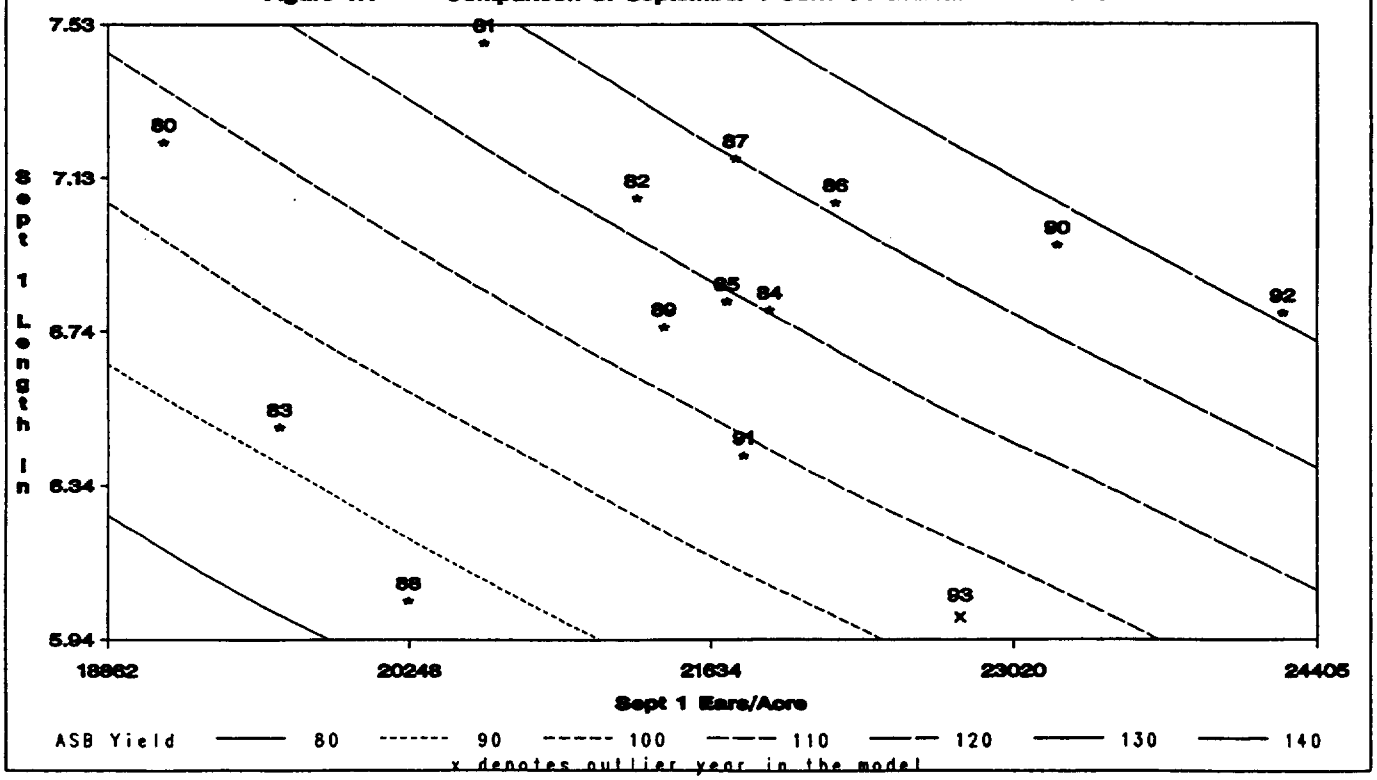


Figure 17. -- Comparison of September 1 Corn OY Indications -- Iowa



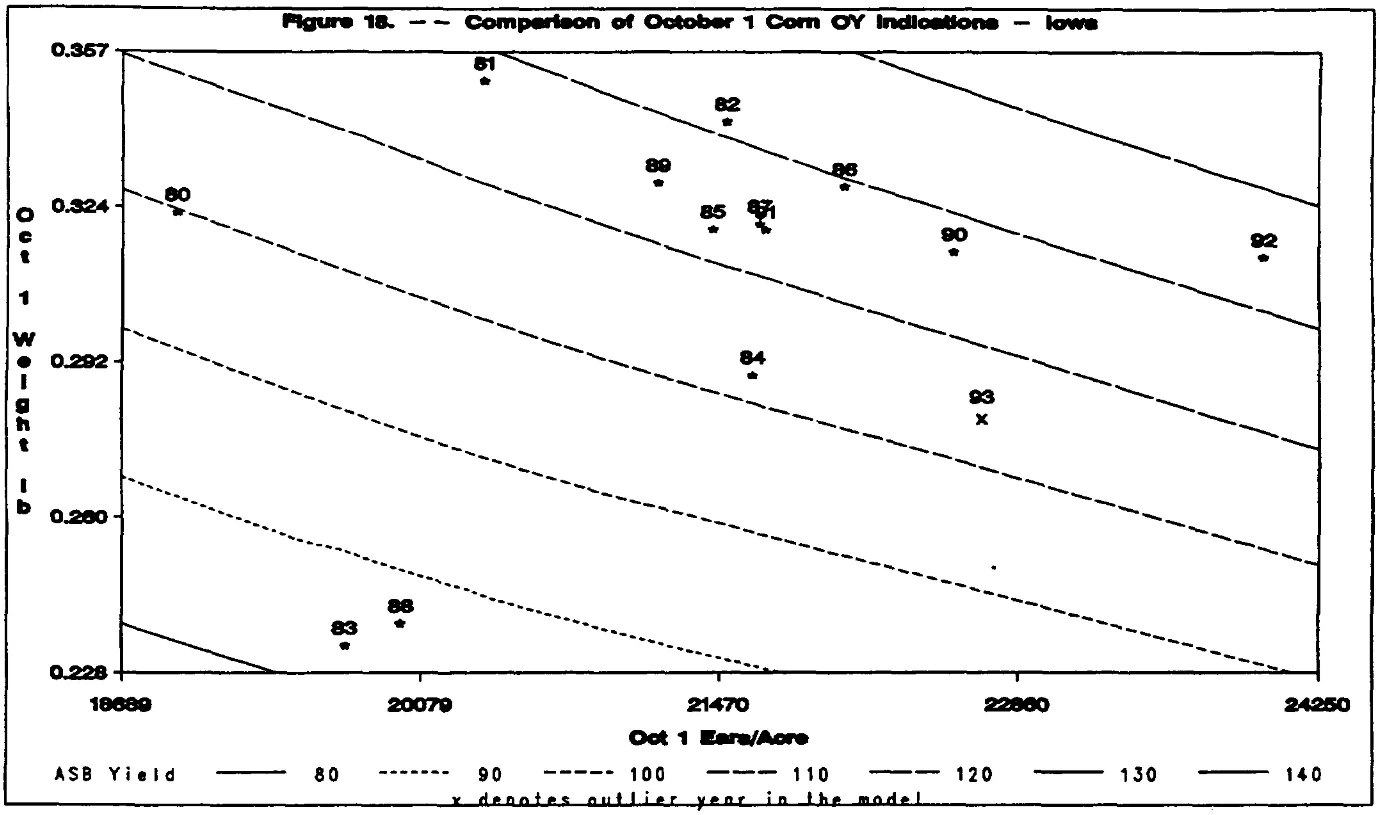


Figure 18. -- Comparison of October 1 Corn OY Indications - Iowa
Oct 1 Weight lb
0.357
0.324
0.292
0.260
0.228
18689
20079
21470
22860
24250
Oct 1 Ears/Acre
81
82
89
86
80
85
87
91
90
92
84
93
83
88
ASB Yield 80 90 100 110 120 130 140
x denotes outlier year in the model

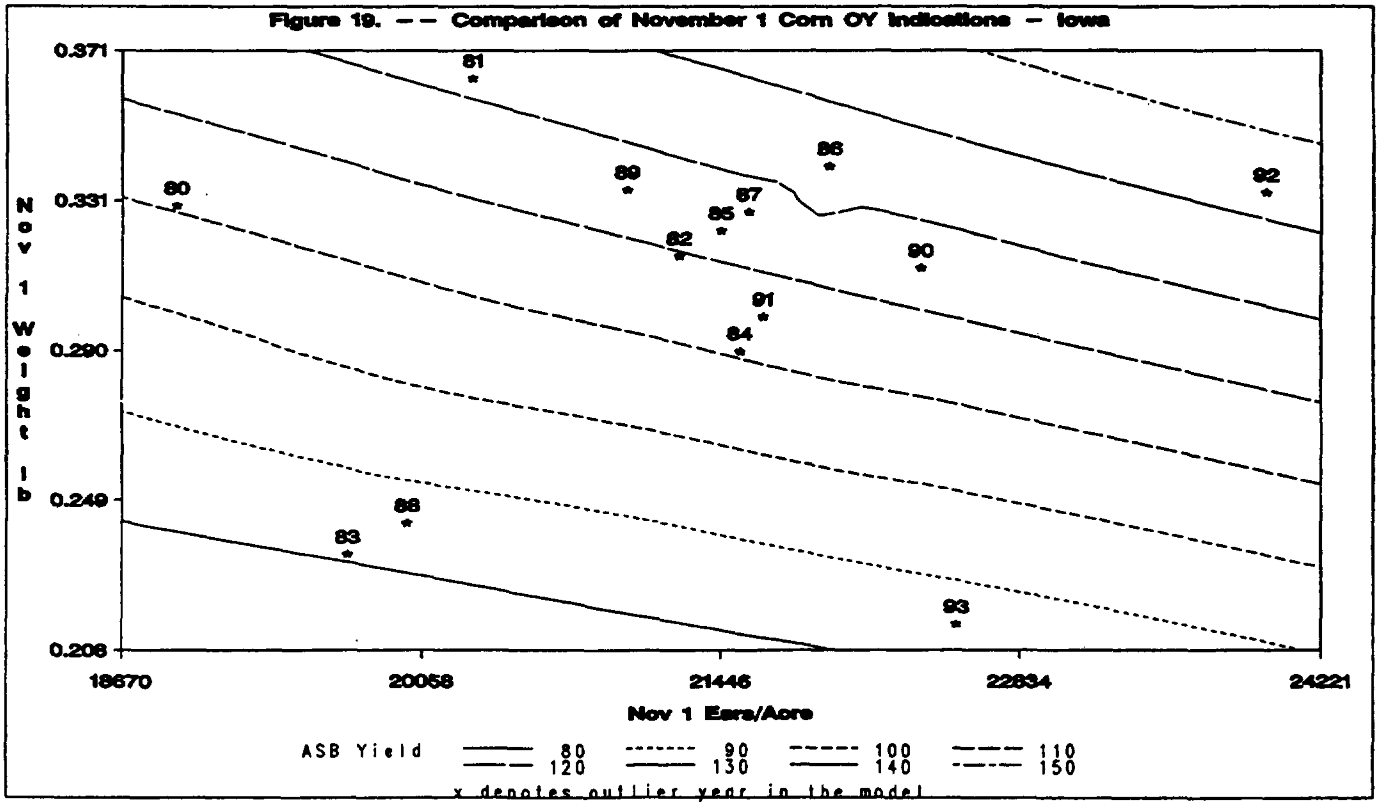


Figure 19. -- Comparison of November 1 Corn OY Indications - Iowa
Nov 1 Weight lb
0.371
0.331
0.290
0.249
0.208
18670
20058
21446
22834
24221
Nov 1 Ears/Acre
81
86
92
89
80
87
85
82
90
91
84
88
83
93
ASB Yield 80 90 100 110 120 130 140 150
x denotes outlier year in the model

For the U.S. as a whole, the decrease in corn yield potential from October 1 to November 1 was larger than any experienced in the past 20 years. Table 9 presents the October to November comparison for both corn and soybeans. The 20 bushel per acre drop in Iowa was close to the absolute record for that State in any month.

Table 9.--Comparison of 1992 and 1993 U.S. Production Forecast Changes from October 1 to November 1 with Recent History

Crop and Comparison	Change in	
	Yield Per Acre	Production
	Bushels	Mil. Bu.
	Corn	
Largest change 1972-1991	+2.8	+198
Change in 1992	+5.5	+391
Change in 1993	-7.2	-459
	Soybeans	
Largest change 1972-1991	+1.4	+81
Change in 1992	+1.0	+59
Change in 1993	-1.0	-57

END OF SEASON YIELD ESTIMATES

As farmers completed their harvest, many found final yield turned out to be even lower than experienced with their early harvest. For example, the end-of-season corn yield estimate for Iowa, based on the December Agricultural Survey, was another 5 bushels lower than November. The corn yields in Iowa and Minnesota ended up lower than during the 1983 and 1988 drought years.

Soybean yields were not as adversely affected as for corn and Illinois and Indiana did realize the high potential which had been present all season. Table 10 presents the 1993 changes for each month to the final compared with other years.

Table 10.--Comparison of Changes in U.S. Production Forecast to the End of the Season, 1992, 1993, and Historic Maximums

Month	RMSE 1/	Maximum Change 1972 - 1991	Change in 1992	Change in 1993
	- - - - - - Million Bushels - - - - - -			
		Corn		
August	1,192	-1,063	+720	-1,079
September	719	+660	+712	-885
October	563	+538	+544	-618
November	401	+378	+153	-159
		Soybeans		
August	212	-207	+109	-93
September	186	-124	+103	-101
October	143	+120	+80	-82
November	119	-109	+21	-25

1/ 90 percent confidence interval for root mean square error calculation based on 1972-1991 results.

WHY WEREN'T EARLY FORECASTS CLOSER TO FINAL YIELD? Looking back at the NASS historic performance record, it is easy to assume that forecasts should have been closer to final estimates. Prices rose significantly after the November forecasts but some people had already sold much of their crop on contract before the price rise. There was surprisingly little reaction from farmers at the time of the November forecasts since they hadn't been able to determine their own low yields until harvest.

There were at least four theories expressed for the drastically low yields in States like Iowa, Minnesota, and South Dakota. Those are: (1) excess moisture caused significant leaching out of nitrogen, (2) there were not enough growing degree days in 1993, (3) timing of frost prevented final accumulation of dry matter in corn kernels, and (4) "the crop just quit" even before frost.

Concern about nitrogen leaching was mentioned throughout the season, once soil conditions became so saturated. Corn depends on extracting nitrogen from the soil; soybean plants actually return nitrogen to the soil so they would not be affected. No definitive studies on 1993 effects of nitrogen leaching are known but corn farmers are being encouraged to apply additional nitrogen in 1994 since soil levels are believed to be lower than normal. Individual farmers can run soil tests to determine their 1994 needs.

The 1993 season was cool and people might conclude that growing degree days could be a significant factor in lowering corn yields. (Growing degree days accumulate the daily maximum temperatures above 50°F, with an upper cutoff of 85°F, if the daily minimum is 50°F or higher.) Soybean plants react more to length of day for triggering of growth stages so they would be less affected by growing degree days. Figure 20 shows the growing degrees days for Iowa in the past three seasons, with accumulation starting at April 1. This does indicate that 1993 was considerably lower than 1991 for total growing degree days <u>but</u> was higher than 1992 which was the record producing year. Thus, lower growing degree days is not the single contributing factor.

The greatest contributor to the lower yields in Iowa, Minnesota, and South Dakota was corn crop maturity at the time of the killing frost. Figure 21 expresses several comparisons of the 1992 and 1993 Iowa seasons. In this graph, growing degree days have been accumulated from the date that 50 percent of the corn crop was planted. This illustrates that the 1993 growing degree days did trail 1992 until mid-August. Thus, corn was affected both by later plantings and cooler temperatures. One commonly accepted "rule" for corn production is that it takes 60 days from pollination to maturity. Figure 21 indicates that the 1992 corn crop in Iowa had 87 days from the 50 percent silking date to first frost. However, in 1993, there were 60 days from the 50 percent silking date to first frost so only about 50 percent of the crop would have reached biological maturity. Frost was not early but the crop was not ready for this nearly normal frost date.

Figures 22 to 25 illustrate the effects of the lower than expected ear weights. Figure 22, based on data from all objective yield States, shows that the regional average was about 5 percent lower than would be expected from previous years. Figure 24 shows that the average weight in Iowa was more than 10 percent lower. The same type of discrepancy would be true also in Minnesota, South Dakota, and Wisconsin. Figures 23 and 25 indicate that average ear weights in Indiana and Ohio were about 10 percent higher than expected based on the shorter than average ears.

Lack of time from silking to frost is surely the largest explanation and is likely what people mean when they feel the "crop quit." However, higher moisture conditions and early cool weather probably did lead to some additional disease problems and to plants and fields which did not look healthy and normal. Thus, some people concluded that the plants just wore out by October 1.

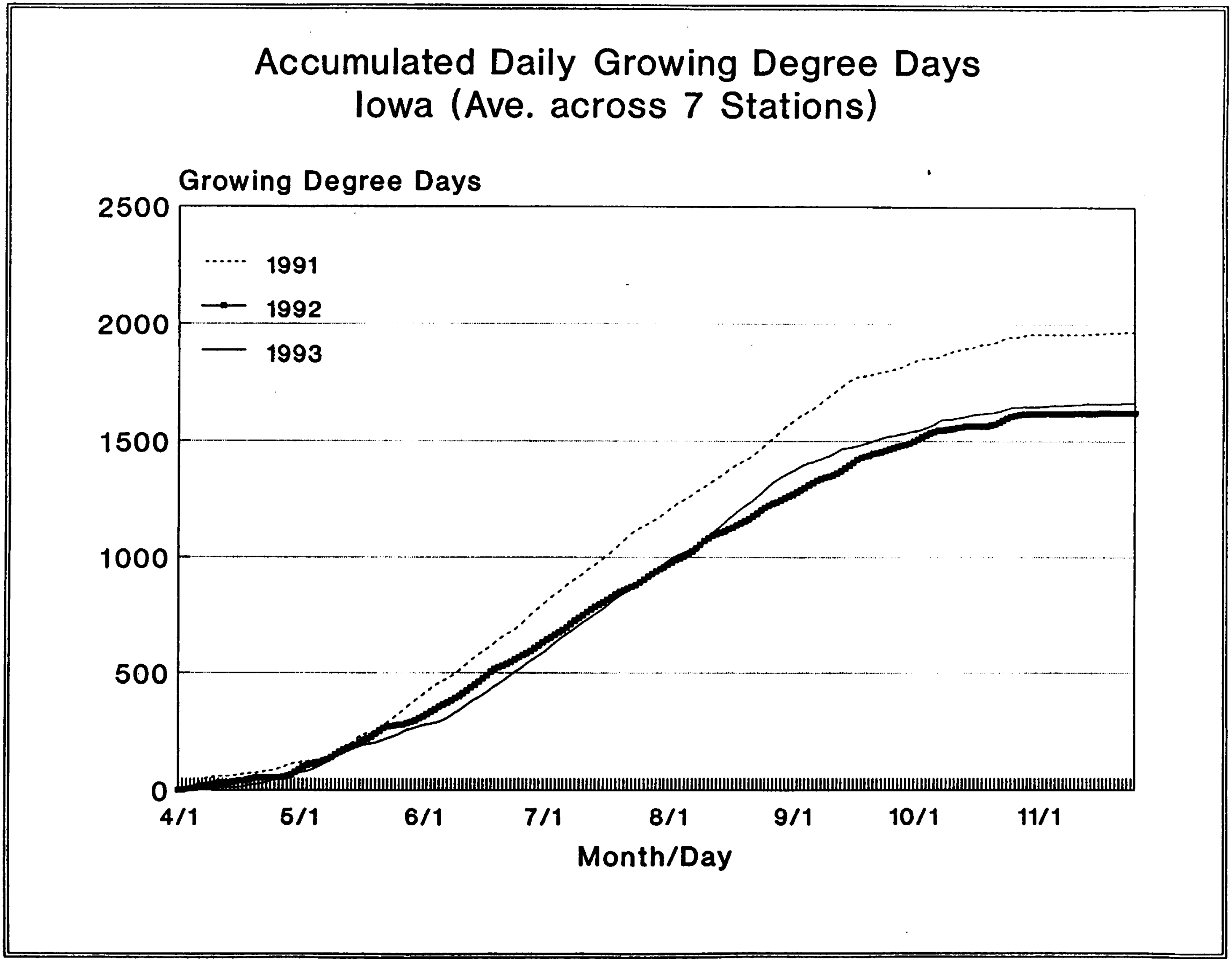


FIGURE 20 GROWING DEGREE DAYS IN IOWA, 1991-1993

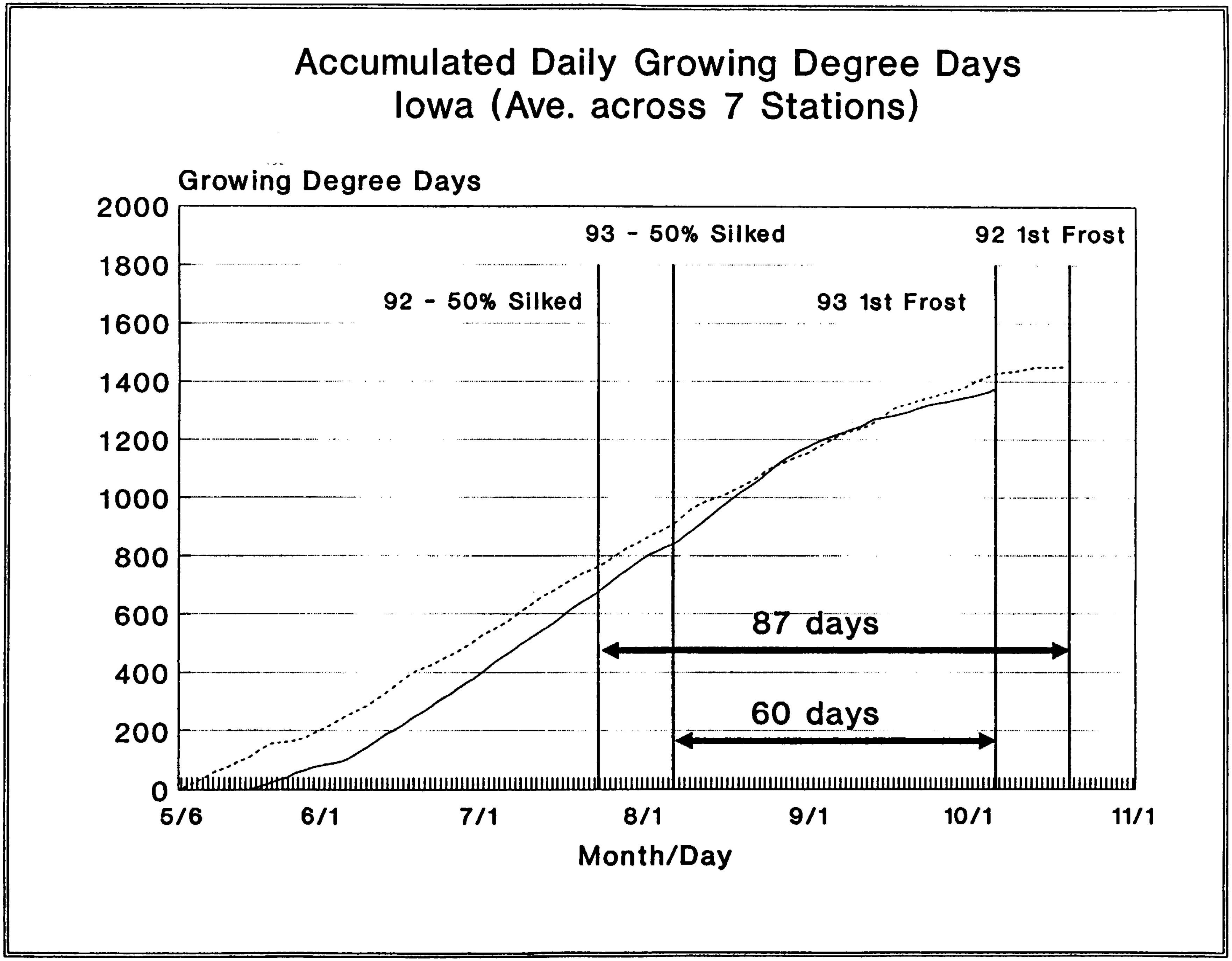


FIGURE 21 GROWING DEGREE DAYS AND FROST DATES, IOWA, 1992 AND 1993

Figure 22. -- Regression of Weight per Ear on Kernel Row Length, Speculative Region

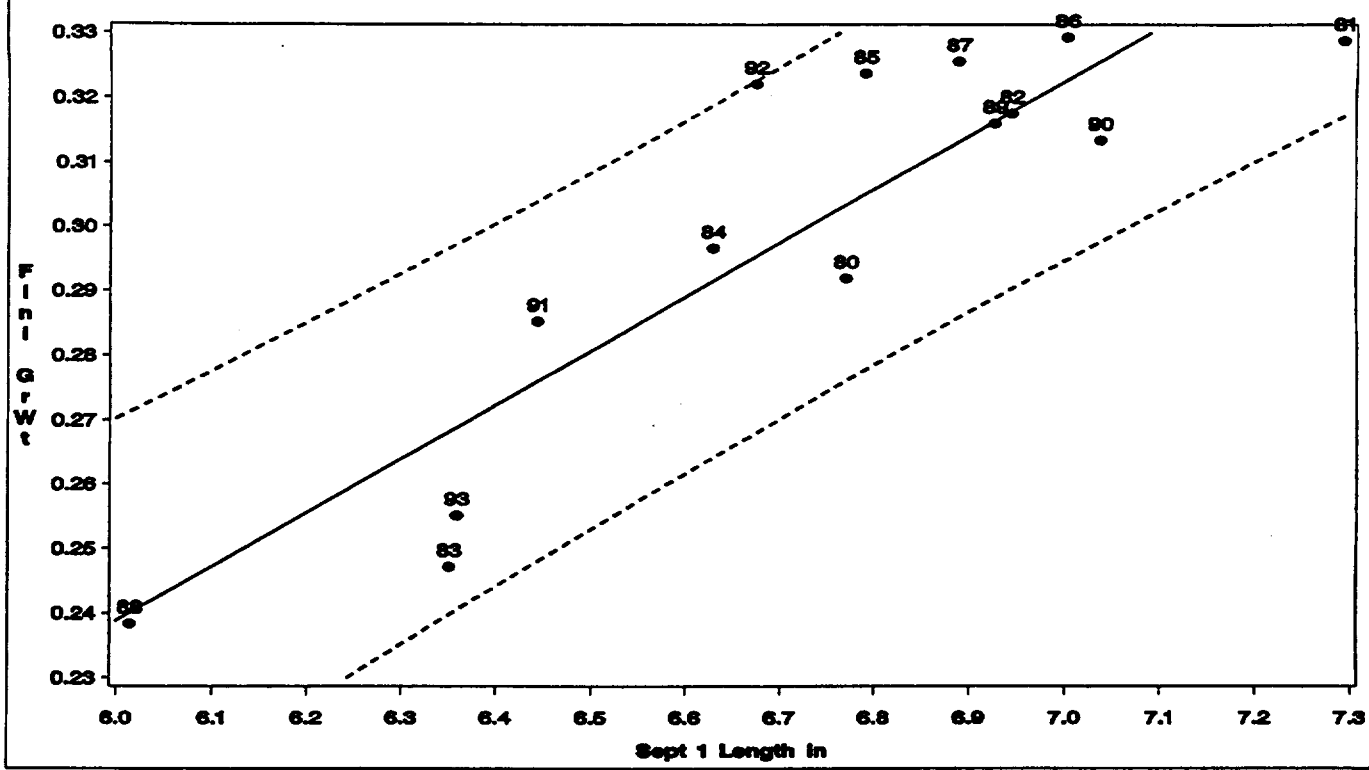


Figure 23. -- Regression of Weight per Ear on Kernel Row Length, Indiana

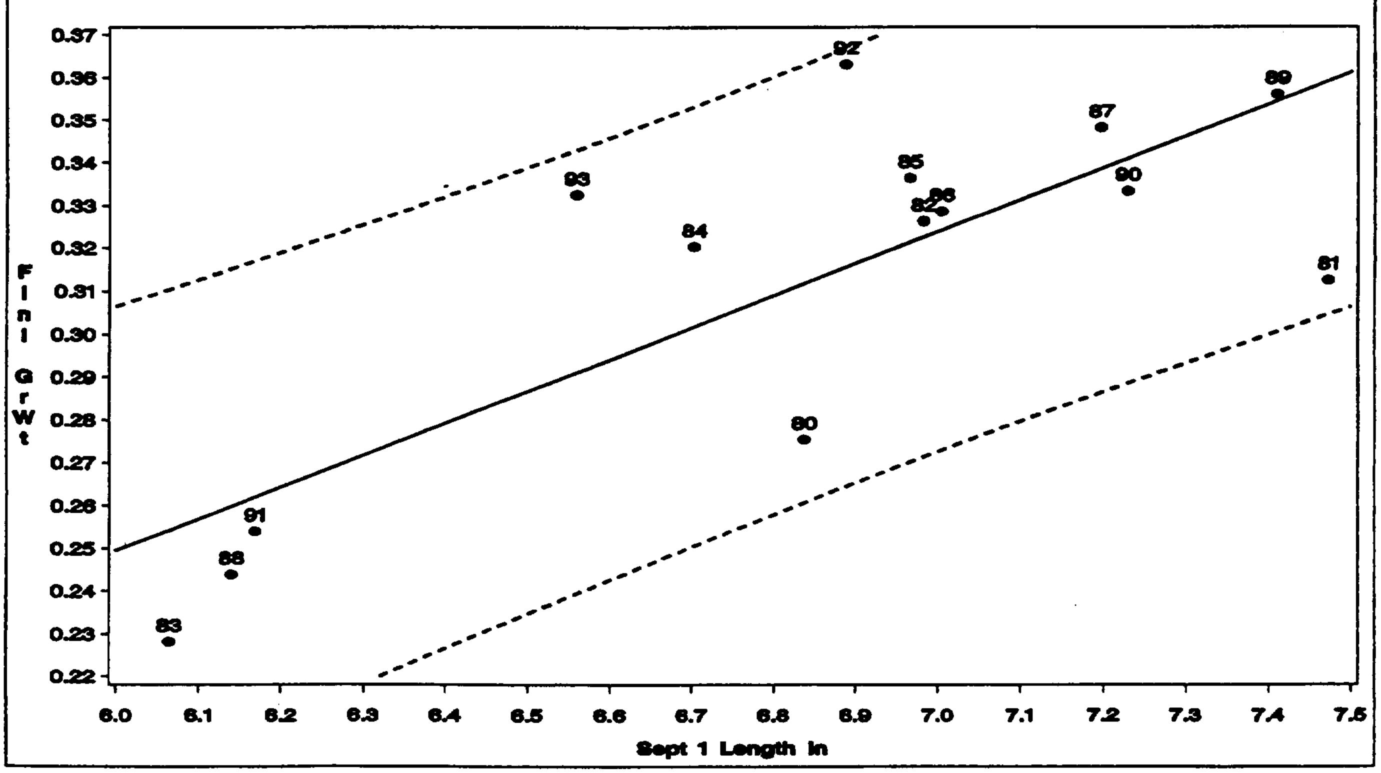


Figure 24. -- Regression of Weight per Ear on Kernel Row Length, Iowa

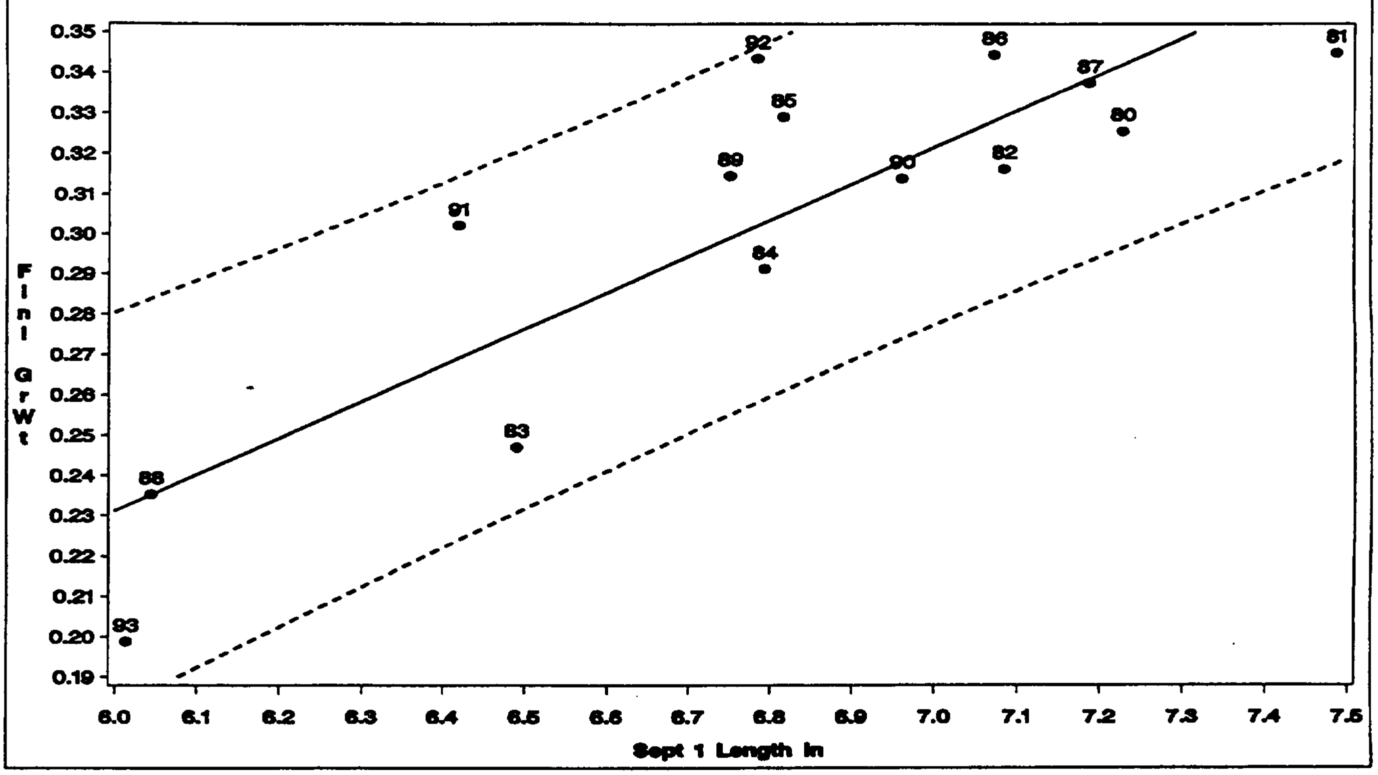
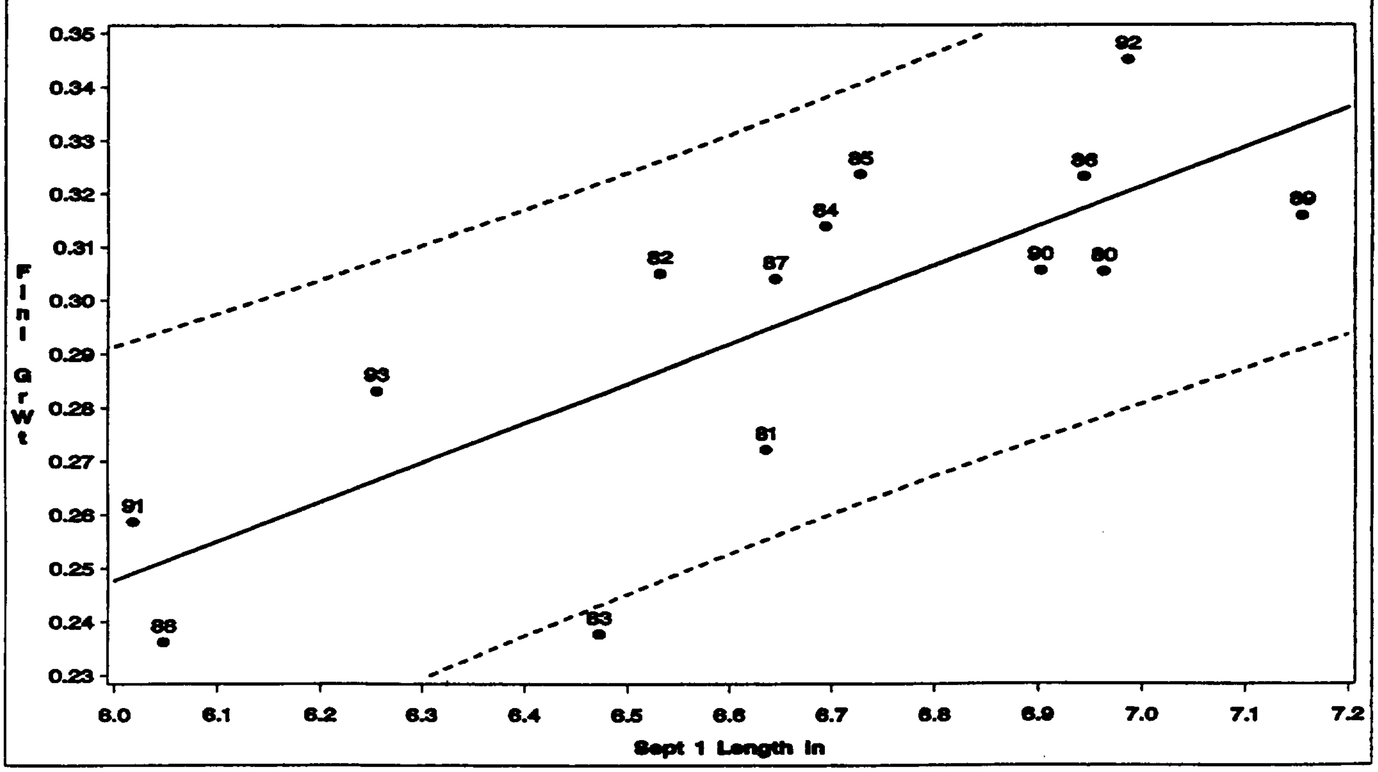


Figure 25. -- Regression of Weight per Ear on Kernel Row Length, Ohio



IMPACT OF 1993 FLOODS ON PRODUCTION AND VALUE

This report has looked at the effects of flooding and other weather conditions on almost a month by month by month basis. Some people might still want to know "what was the bottom line?" What was the loss of production potential in 1993 and what adjustments were made in agriculture because of the lower potential?

NASS normally does not deal in "what could have been." It does maintain track records of all acreage, yield, and production forecasts. Thus, normal NASS comparisons for production would only start with the August 1 forecast. However, since the audience for this paper might be interested in a more comprehensive figure, WAOB production projections from May will be used as a base.

In May, the WAOB starts with the NASS Prospective Plantings planted figures and adjusts them for normal abandonment and other uses acres. In May 1993, WAOB projected 69.3 million corn acres for harvest for grain based on 76.5 million acres to be planted. Their soybean acres harvested projection was 58.2 million based on 59.3 million to be planted. Trend yields were used to project production and the WAOB projected other information such as categories of use and ending supplies. For 1993, the WAOB projected total U.S. production levels of 8.500 billion bushels of corn and 2.045 billion bushels of soybeans. That would have been the third largest crop ever for corn and the fifth largest soybean crop but those levels seemed reasonable based on 1992 production and weather conditions when the growing season started.

The end-of-season production U.S. estimates were 6.344 billion bushels of corn and 1.809 billion bushels of soybeans. The 25.4 percent decline in corn potential production was composed of a 9.1 percent decrease in acres harvested and a 17.9 percent lower yield per acre. The 11.9 percent decline in soybeans consisted of a 3.1 percent acreage decrease and a 8.9 percent lower yield.

The lower corn production is largely reflected in projected lower stocks on hand at the end of the 1993 crop marketing year on September 1, 1994. Comparing the March 10, 1994 World Agricultural Supply and Demand Estimates projections to those of May 11, 1993, 61.4 percent of the drop in potential corn production was accounted for in lower stocks, 12.8 percent in lower exports, and 27.8 percent in the "feed and residual" category. Those numbers add to more than 100 percent since there has been a projected increase in the use of corn for food, seed, and industrial purposes which includes corn sweetener and ethanol production and a 15 million bushel increase in corn imports. If these projections hold, the U.S. corn supply would be the lowest since 1976.

One other aspect of the monthly WAOB report is projection of average farm price. Between May 1993 and March 1994, the projection has changed from $2.05 per bushel to $2.60. As a result, the projected value of the crop has declined only 5.3 percent in spite of the 25.4 percent decline in production. Thus, the decline in value to the corn producing sector was small but the effect was very severe for producers who had small crops.

PROCEDURES FOR THE FUTURE

All in all, NASS was pleased with the efforts undertaken in 1993. The Agency was able to gear up on short notice to add questions, edits, and summary routines in time for the August 1 and later surveys. Some lessons were learned which would make those processes even smoother if such an emergency resurfaces.

The procedures for evaluating acreage not planted and acres remaining to be harvested by August 1 worked very well. The end-of-season adjustments of planted acreage after the December Agricultural Survey were only 0.5 percent for corn and 0.2 percent for soybeans. Similarly, the end-of-season harvested acreage for soybeans ended up only 0.2 percent higher than forecast in August. The corn acreage actually harvested for grain was down 1.5 percent from August, largely accounted for by October 1 when the 0-92 signup had been completed.

The yield forecasting approach of focusing on individual components instead of just the composite yields was very helpful in 1993. It allowed NASS staff members to reference the high plant and ear counts for corn and the record high pod counts in some States in answering questions during the season. NASS publishes selected objective yield survey counts each year in the November Crop Production report. Some data users have now requested that the Agency publish monthly its assumed fruit counts and weights for corn and soybeans. That request will be considered.

The graph of days from silking to frost for Iowa illustrated the biggest shortcoming in 1993 forecasts. No weather models are available which absolutely predict the date and severity of first frost.

One change that NASS is making for 1994 is to select samples of ears which have reached the dent stage in the September 1 and October 1 Objective Yield Surveys for laboratory analysis. (Normally ears are not sent in until the mature stage unless the farm operator is going to harvest at a high moisture level.) One agronomy theory is that 90 percent of the kernel weight has formed by the dent stage although there is some disagreement from other corn researchers. Sampling the dent stage ears will allow the Agency to determine if final weight per ear can be predicted earlier.