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An Analysis of the Benefits and Costs of an Improved Crop Acreage Forecasting System Utilizing Earth Resources Satellite or Aircraft Information

for

United States Department of Interior
Office of Economic Analysis

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I. INTRODUCTION

This report presents the results of an analysis of the application of information produced by alternate Earth Resource Survey (ERS) systems, in the development of agricultural crop acreage estimates. It is the first in a series of case studies that form the basic building blocks of a larger study whose objective is to estimate the total costs and benefits of future ERS systems. The results of the study will assist the Department of the Interior and other interested Federal agencies in the consideration of investments in such systems.

The objective of this report is to take one case study fully through the data collection, modeling and analysis stage, in recognition of the fact that not all critical experimental data on capabilities are in hand and that definition of systems components and design must await definition of a sampling system of crop acreage estimates.

Data collected by ERTS-1 is currently being used by experimenters in universities, government agencies and industries to develop and test techniques for producing earth resource information of value for a variety of practical applications. It is the fruits of these experimental activities that provide the technical basis for this cost-benefit study.

An appreciation of the key features of the overall study design is helpful in understanding the results of the case study on crop acreage estimation which is presented in subsequent sections of this report. This first case study bears the burden of being the prototype to test and further develop program methodology. The key features of the study design include the following:

- Results from ERTS-1 experiments are reviewed and assessed as they become available. It was recognized that the first case studies would face some of the difficulties typically associated with using early results and preliminary technical data as a take off point for study development.

- Case study effort is focused on applications for which there are large potential benefits and substantial experimental results. Costs and benefits associated with each case study are extrapolated to the national level, based on similar applications of the same information.

- Estimation of costs and benefits is based on understanding and modeling the processes by which information is derived from ERS data and used in the management decision process.

- The uncertainties inherent in the estimates are assessed, testing their sensitivity to various factors indicating the range of benefits and costs, and the likelihood that they will be achieved under different conditions.

- Methodology, assumptions and data are explicitely presented so as to facilitate replication and revision of estimates in light of new data even after the study is completed.

- Costs and benefits are estimated in terms of economic efficiency, economic distribution, environmental impacts, social impacts and international impacts on the U.S.

- Benefits arising from data collected before launch of an operational system are to be identified as "one time benefits" but not estimated.

- Investment alternatives to be compared to the baseline or "without" system include a single satellite system, a multiple satellite system and a high altitude aircraft system.

This case study report is divided into the following chapters:

II. Case Study Scope and Approach

III. Analysis of the Applications System and Economic Benefits of an ERS Based Crop Acreage Reporting System.

IV. Environmental and Social Impact Analyses

II. CASE STUDY SCOPE AND APPROACH

The scope and approach for the case study in crop acreage estimation were defined following detailed review of the possibilities as they appeared during the first quarter of the cost/benefit program. This chapter sets forth the reasons why this case study was chosen. It describes the elements included within its scope and outlines the approach developed for the specific task at hand.

1. CASE STUDY SELECTION

Crop acreage estimation was selected as the first case study area for two basic reasons. First, prior cost/benefit studies estimated that application of ERS type satellite systems in this area would yield high benefits and second there were indications of reasonable success in the early ERTS-1 experimental results dealing with crop identification and acreage estimation.

The existance of substantial prior evidence that benefits existed and that current ERTS-1 experimental results seem to yield the necessary earth resources information are two key criteria for evaluating broad areas or sectors of economic activity and the different case study's possibilities within them.

Both of these critieria supported the selection of Agricultural Production as a broad area for an early case study and crop identification as the best subarea on which to focus. The key source of data with regard to potential benefits is a series of cost-benefit studies performed during the early stages of ERS satellite development. These previous studies vary widely in scope, depth, and validity. There are often instances of double counting, lumping of U.S. and world benefits together, and overlapping of benefits between differently defined sectors. The usefulness of these documents is however, greated enhanced by the fact that in 1971 the U.S. government supported a study designed to review and synthesize the results of the 10 most significant studies into a single document.1/ In doing this, an attempt was made to judge the validity of the estimates for prefeasibility studies. An attempt was made to eliminate double counting, separate U.S. from world benefits, and to organize the results into non-duplicating sector categories. This effort resulted in a useful set of internally consistant estimates. The broad area of Agricultural Production accounts for

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1/ R. Kzyczkowski et al, "Review and Appraisal: Cost-Benefit Analyses of Earth Resources Survey Satellite Systems," Interplan Corp., March 1971.

$402 million of a total of $1,310 million annual benefits considered to be valid estimates in the Interplan report. With 31 percent of the total, Agricultural Production is second only to Water Resources Management. Approximately $170 million of the annual benefits in agriculture were associated with crop identification, inventory or survey.

During the first quarter of this study only the early reports of ERTS-1 experiments were available. The need to select and begin the first case studies as early as possible was expressed. Preliminary indications of emerging ERS capabilities were the extent of experimental results available. Those were reported at the Goddard Space Flight Center Symposium in March 1973. Of the total of 327 ERTS-1 experiments, 35 are classified by NASA as pertaining to agriculture. Of these, 15 reported significant results by April. For agricultural programs early results were limited because ERTS-1 was not launched until July, 1972, and thus did not offer complete coverage of the 1972 growing season for much of the U.S. Nevertheless, the results for areas with a longer growing season and more coverage appeared to be promising.

The matrix in Table II-1 shows the ERTS-1 experiments which preliminary reviews identified as contributing to the capability to produce information of major benefit to crop production.

The early review showed substantial results in crop identification and acreage estimation but very limited progress in stress detection and vigor/yield prediction. For this reason, the decision was made to focus the first case study on crop acreage estimation. This was done with recognition of the fact that crop production forecasts are developed from two components: the estimates of crop acreage and the forecasts of yield per acre. Once a case study is completed that deals with acreage estimates, much of the methodology will have been developed for estimating the benefits from yield forecasts that are based on assessments of crop vigor and stress. As with livestock production, the possibility was reserved for conducting a later case study in crop stress and yield when the appropriate experimental results become available.

2. CASE STUDY SCOPE

The criteria of potential benefits and relative success of experimental results were also used to define the many other elements to be included within the scope of the crop acreage estimation case study. The most important of these elements were the crops to be covered, the institutions that might use the information produced, the management actions that could lead to benefits, and the geographical boundaries of the case study.

CONTRIBUTION OF ERTS-1 EXPERIMENTS TO INFORMATION
OF VALUE IN CROP PRODUCTION

EXPT. NO	NASA PRIMARY DISCIPLINE	INVESTIGATORS	GEO-GRAPHIC REGION	CROP ACREAGE ESTIMATES	CROP STRESS MONITORING	CROP YIELD PREDICTION
AG 328	1A	Von Steen	MW	X		
AG 339	1A	Weigand	SW	X	X	X
UN 664	1A	Morain	SW	X		X
UN 640	1A	Colwell Johnson Draeger	SW	X	X	X
UN 160	1A	McNair	AS	X	X	X
FO 017	1A	Mendorea	SA		X	
FO 463	1A	Sagredo Salinas	EU	X	X	
UN 652	1A	Myer, Horton Heilman	MW	X	X	X
UN 611	1A	Mahlstede Carlson	MW	X		
UN 004	1B	Sellman, Safir, Anderson, Myers	CE	X		
PR 534	1C	Poulton, Welsh, Colwell	SW	X	X	X
UN 630	1D	Baumgardner	SW	X		
UN 327	1F	Colwell	SW			
UN 609	1G	Lewis, Coleman	SW	X	X	
UN 661	1G	Kanemasu	MW	X	X	X
UN 326	1H	Colwell	SW	X		
UN 619	2A	Simonson, Poulton	NW	X		
UN 314	2A	Bowden, Johnson	FW	X		
UN 070	2A	Colwell, Estes	SW	X		
FO 367	2A	Omino	AF	X		
OT 621	2C	Thompson, Smedes	SW	X		
UN 431	7G	MacLeod	AF	X		
UN 635	7M	Polcyn	CE	X		
UN 612	8A	Malila, Nalepka	SW			
UN 636	8F	Thompson, Smedes, Canney	FW			
PR 324	9A	Danko	NW			
FO 397	10A	Fisher	AU	X	X	
FO 411	10A	Ebtehodj	AS	X	X	X
FO 515	10A	Nixon, Ntsekhe, Lane	AF	X		
ST 369	10B	Davis	SW	X	X	
UN 159	10C	Wilson, May, Anderson	NE			
NA 347	10C	Erb	SW	X		
UN 127	10C	Landgrebe Bauer	CE			

The Crop Reporting Division of the Statistical Reporting Service (SRS), U.S. Department of Agriculture annually issues 550 reports on 150 crops and livestock products with an emphasis upon commodities traded in large volumes such as corn, wheat, oats, soybeans and cotton. A preliminary list of the top fifteen crops in annual recepts was developed and compared with the crops being addressed by ERTS-1 experiments. These are shown in Tables II-2 and II-3. Based upon the coincidence between importance of crop and experimental data potential, a preliminary selection was made of nine major crops covering almost 60 percent of annual crop receipts. As the case study proceeded, oats and barley were added and oranges dropped. Other crops were treated by extrapolation which is discussed in Chapter III.

After a substantial preliminary survey of past studies, potential user institutions at the national and regional levels were identified. The major institutions involved with crop reporting are:

- the Statistical Reporting Service, U.S. Department of Agriculture,
- farmers and farm cooperatives or associations,
- state Departments of Agriculture,
- commodity traders, exporters and elevator operators,
- food processers,
- suppliers of agricultural inputs, and
- financial institutions.

An evaluation of decisions and actions taken by these institutions was included in the scope of the case study. The primary actions from which benefits from use of crop forecasts were expected to arise included inventory adjustments, adjustment of the inputs used and output level of production, and adjustment of transportation and distribution systems. Identification of these as areas for potential action based upon ERS data established the type of benefit estimation techniques needed. These techniques are discussed as part of the Approach.

The geographical scope of the study initially reflected the strength of the experimental results emerging from investigations in California. The case study was undertaken, however, in the expectation that the geographical scope would expand rapidly as experimental results became available from other parts of the country.

SUMMARY OF ERTS-1 EXPERIMENTS [a/]
RELEVANT TO TOP FIFTEEN CROPS

CROP	Percent of Crop Receipts		Number of Relevant ERTS-1 Experiments		Proposed for Inclusion in Case Study
	NATIONAL	SOUTHWEST [b/]	NATIONAL	SOUTHWEST [b/]	
Corn	15.8	1.3	5	2	X
Soybeans	15.7	c/	3	0	X
Wheat	9.2	1.2	6	3	X
Cotton	6.5	6.7	6	4	X
Tobacco	5.8	-	0	0	
Greenhouse-Nursery	4.3	8.4	0	0	
Hay	3.1	6.1	2	1	
Sorghum Grain	3.0	2.1	4	2	X
Potatoes	2.5	2.0	1	0	X
Oranges	2.2	5.8	2	1	X
Tomatoes	2.0	6.8	0	0	
Rice	1.9	3.1	4	1	X
Peanuts	1.8	0.1	0	0	
Sugar Beets	1.8	4.3	1	0	X
Grapes	1.6	9.6	0	0	

a/ These crops were taken from ERTS-1 experiment proposals. Specific crops covered subsequently will be listed as they are reported.
b/ California, Texas, & Arizona
c/ Less than 0.5%

CROPS ADDRESSED BY ERTS-1 EXPERIMENTS

Crops	Experiments
Alfalfa	AG 328 (1A), UN 640 (1A)
Barley	AG 328 (1A), UN 640 (1A)
Corn	AG 328 (1A), UN 612 (8A), UN 127 (10C), UN 640 (1A), AG 339 (1A)
Cotton	AG 328 (1A), UN 640 (1A), FO 017 (1A), UN 630 (1D), AG 339 (1A), UN 609 (1G)
Oats	AG 328 (1A), UN 640 (1A)
Pineapple	UN 160 (1A)
Potatoes	AG 328 (1A)
Rice	AG 328 (1A), FO 463 (1A), UN 160 (1A), PR 534 (1C)
Sorghum	AG 328 (1A), UN 640 (1A), UN 630 (1D), AG 339 (1A)
Soybeans	AG 328 (1A), UN 612 (8A), UN 127 (10C)
Sugar Beets	AG 328 (1A)
Sugar Cane	UN 160 (1A), FO 017 (1A)
Wheat	AG 328 (1A), UN 640 (1A), UN 619 (10B)
Winter Wheat	AG 328 (1A), UN 661 (1A), UN 664 (1A), UN 619 (10B)
Citrus Crops	FO 463 (1A), AG 339 (1A)
Coffee	FO 017 (1A)
Fruit	UN 004 (10B), UN 619 (10B), ST 369 (10B)

Other Categories*

Vegetable crops	AG 339 (1A), UN 160 (1A)
Field crops	UN 640 (1A), UN 004 (10B), UN 640 (1A), UN 636 (8F), OT 621 (2C)
Seed crops	UN 640 (1A), UN 636 (8F), OT 621 (2C)
Grains	UN 640 (1A), PR 534 (1C), UN 004 (10B), UN 619 (10B)
Grains (mixed)	AG 328 (1A)

* These categories were taken from ERTS-1 experiment proposals. Specific crops covered subsequently will be listed as they are reported.

Case study definition included recognition of the need to analyze potential benefits at local, state, national and international levels. At the international level, benefits may accrue to the U.S. from use of ERS data gathered in other parts of the world. For the purposes of analysis, benefits which derive from international applications will be handled in a separate task of the study which deals with international impacts. Many of the basic data gathering and analysis tasks as well as modeling tasks that will be needed for the international analysis have been accomplished in the domestic analysis.

3. GENERAL APPROACH TO THE CASE STUDY

The approach taken in performing the case study is shown in Figures II-1 and II-2. Figure II-1 summarizes the flow of the key analytical tasks that were performed. Tasks along the top deal with the technical aspects of the case study, namely the experimental results and the data systems needed to incorporate them into a crop survey system. Comparison is to be made between the "without" system, which is essentially the existing crop survey system, and the alternative "with" system based on ERTS-1 type data.

Tasks along the bottom deal with the analysis of the way in which the resulting information is used to yield benefits. The principal feature of the benefit estimation is that it was focused on comparing the accuracy, timeliness and costs of the alternative crop survey systems. In order to permit replication and revision of benefit estimates as new technical data or different assumptions require, the benefits have been developed parametrically and expressed as a function of the errors in the compared crop production forecasts.

The analysis of benefits available from improved yield forecasting and of the use of world crop forecasts in managing U.S. agricultural activities will be greatly facilitated because the techniques developed for domestic crop forecast benefit estimation may be applied in these case studies as well.

Figure II-2 shows the four primary elements in the application system for crop acreage estimating. The Data Interpretation Model relates the raw ERS data to the earth resource information (ERI) that can be extracted. In this case, the ERI is crop identification and acreage estimates produced for each sample unit. A statistical sampling system is needed in most applications to produce estimates of the total acreages for crops within a given geographic region. The error in the total estimate arises from both measurement and sampling errors. The management decision model then relates the crop forecast to management actions and the economic model estimates the resulting benefits. The costs of the system must also be estimated in arriving at net benefits.

Figure II-1

CASE STUDY SUMMARY - AGRICULTURE (CROP ACREAGE ESTIMATION)

- PROCEDURE

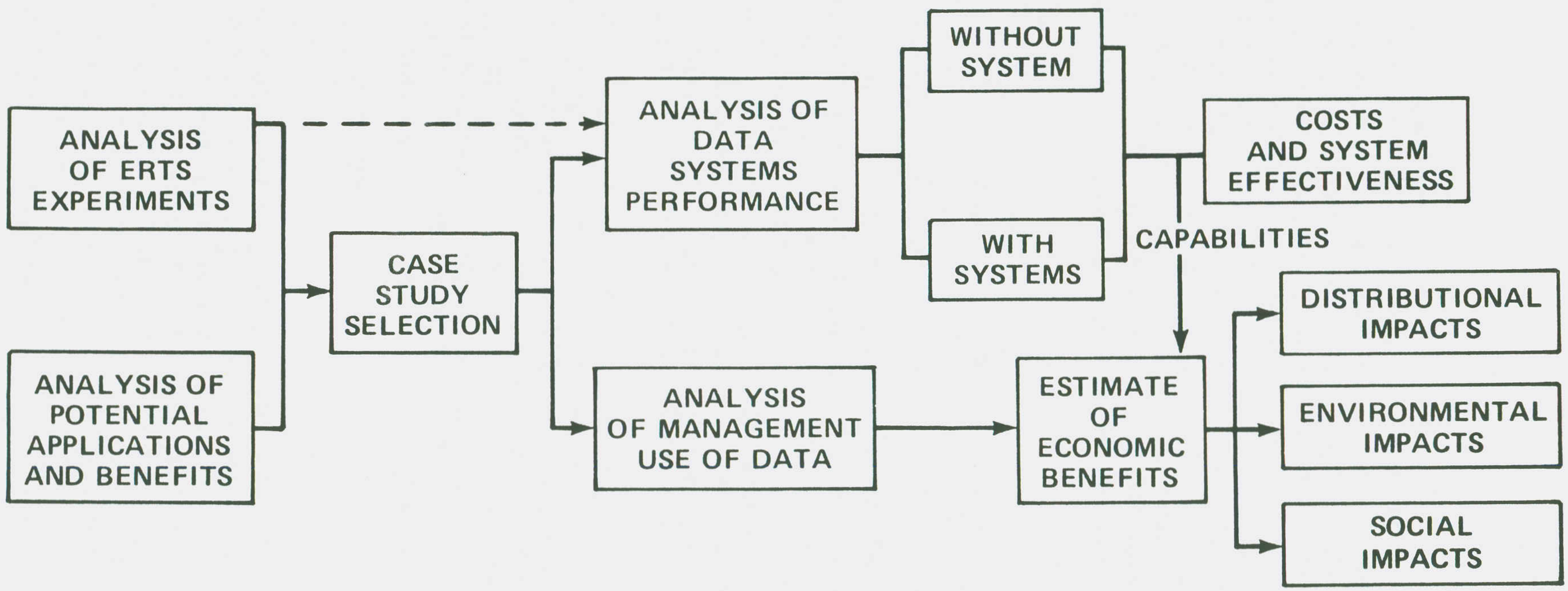
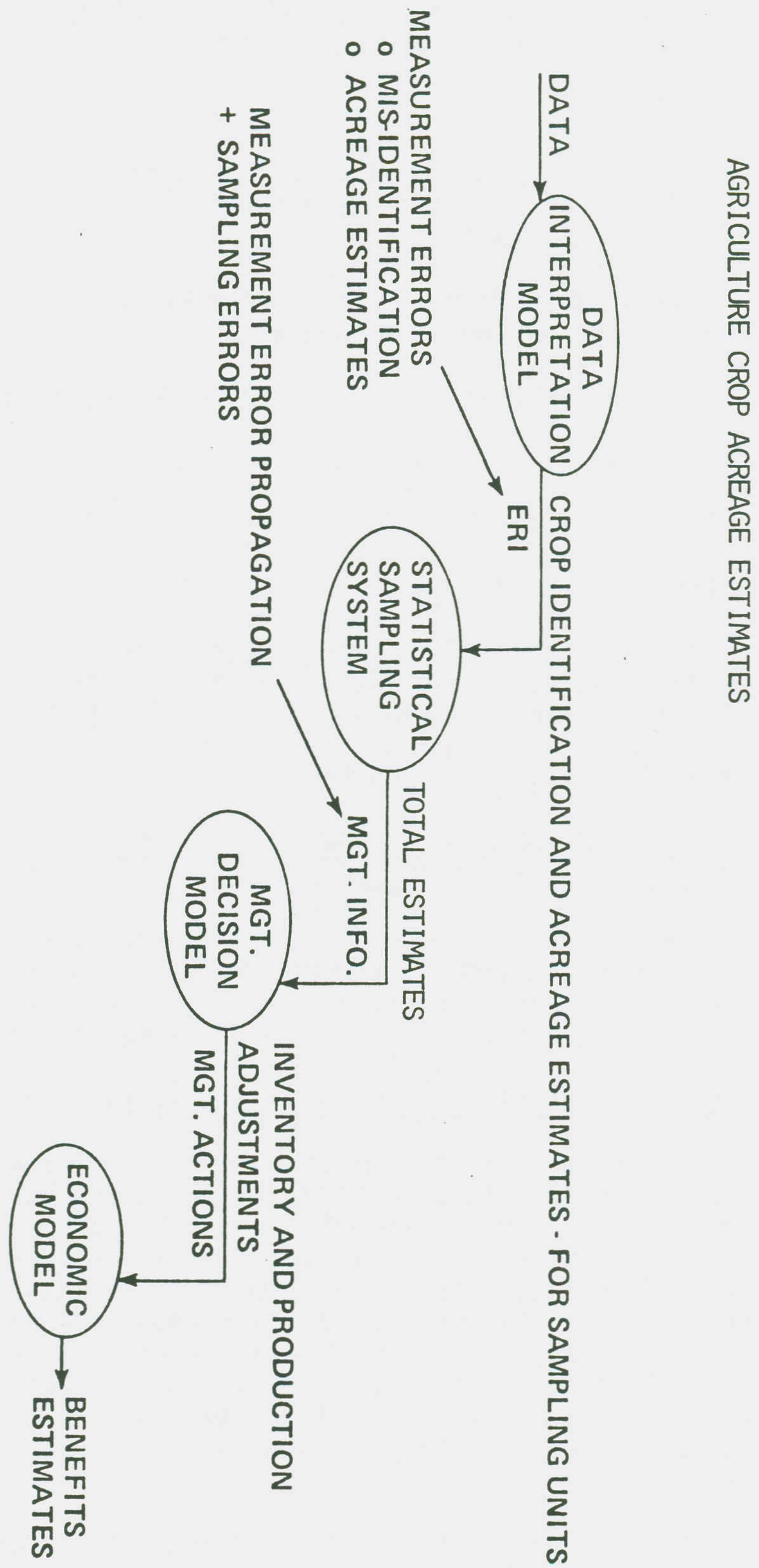


Figure II-2



AGRICULTURE CROP ACREAGE ESTIMATES
DATA
DATA INTERPRETATION MODEL
CROP IDENTIFICATION AND ACREAGE ESTIMATES - FOR SAMPLING UNITS
MEASUREMENT ERRORS
o MIS-IDENTIFICATION
o ACREAGE ESTIMATES
ERI
STATISTICAL SAMPLING SYSTEM
TOTAL ESTIMATES
MEASUREMENT ERROR PROPAGATION
+ SAMPLING ERRORS
MGT. INFO.
MGT. DECISION MODEL
INVENTORY AND PRODUCTION ADJUSTMENTS
MGT. ACTIONS
ECONOMIC MODEL
BENEFITS ESTIMATES

III. ANALYSIS OF THE APPLICATIONS SYSTEM AND ECONOMIC BENEFITS OF AN ERS BASED CROP ACREAGE REPORTING SYSTEM

The analysis of the application of satellite information for the development of agricultural crop acreage forecasts is presented in the following five sections:

- Current Methods for Crop Acreage Estimation at the National and Regional Levels
- ERS Alternatives for Crop Acreage Forecasting
- Regional vs. National Considerations
- Comparison of ERS Alternatives and the "Without" System
- Benefits Estimation

While little of the information presented in each of these sections will be new to those who are expert in each subject, it is necessary to juxtapose these various types of information in order to develop a full understanding of the nature and potential benefit of a ERS system for crop inventorying.

1. CURRENT METHODS FOR CROP ACREAGE ESTIMATION AT THE NATIONAL, REGIONAL AND INTERNATIONAL LEVELS

Current methods exist for producing estimates of crop acreage and forecasts of production to varying degrees of accuracy at the national, regional, and international level. The USDA crop forecasting system at the national level is discussed in this section.

(1) General Features of the USDA Crop Forecasting System

Periodically through the crop year, the Crop Reporting Board publishes acreage, yield per acre, and production estimates for a large number of crops. The USDA crop reporting system is geared toward producing regional and national level estimates. The estimates are most accurate at these levels. (There are nine Crop Reporting Regions in the United States). These estimates are based on a number of sources: USDA produced probability and non-probability surveys, historical data, Soil Conservation Service data, as well as data from a variety of other agricultural institutions and private sources.

Each USDA state office evaluates the above sources of information and recommends an estimate for their state to the

National Board. The Crop Reporting Board reviews each states' recommendations in light of other neighboring states' estimates and other information they may have and produces an estimate for each state. The USDA state office has a final opportunity for rebuttal prior to publication of official state estimates by the National Board.

Once estimates are published, the state offices may allocate these to the district and county levels. This is normally done for key crops such as sorghum, wheat, tobacco, oats, barley, rye, cotton, soybeans, and livestock. Allocations are based chiefly upon historical data. Some crops of importance to a state will not be estimated by USDA in sufficient detail or with sufficient accuracy for the needs of that state. In such cases, a few states make their own estimates by county.

There are two main types of acreage and yield surveys which are conducted by USDA:

- non-probability surveys

- probability surveys

USDA combines the acreage and yield (productivity per acre) estimates to produce a production estimate. In the early years of the crop reporting system, USDA relied solely on a non-probability sampling system. Crop reporters, who maintained a relationship over the years with USDA, reported the agricultural situation and outlook in their community in relation to previous years. Other surveys were conducted using lists of farmers as the sample population. Also, surveys were conducted by giving post cards to mailmen for distribution to "representative" people on the mail routes.

These non-probability survey methods are still an important input of the Crop Reporting Board's published estimate. They are the only survey methods used for the yield estimates of certain crops. They are generally considered more accurate for acreage estimation of some minor crops for which the sampling error associated with a probability survey is very high.

Regression techniques are employed using census data to remove the known persistent bias from the non-probability survey estimates. However, there have been no comprehensive studies of the validity of these survey methods.

Increasingly, USDA is relying upon a probability sampling method for the estimation of acreage for many crops and for the estimation of yield for a small number of major crops. For acreage estimates, a multiframe sampling technique which combines area sampling and list sampling is used. Sampling from an area frame produces unbiased statistics and is especially valuable for obtaining a broad range of data. In constructing the area frame, the total geographic area to be sampled is divided into a discrete number of units each of a specified size in a specified geographic location. A number of the units are sampled by enumerators who interview all farmers within the geographic unit. The estimate for the population is extrapolated from the sampled units.

A mail survey from a list frame is useful for obtaining more accurate statistics for some crops. Because of the small per-unit sampling cost, more intense sampling is possible from the list than from an area frame. This has the effect of reducing the sampling error. Few studies have been done on the non-sampling or measurement errors associated with these surveys.

(2) Timing of Crop Forecasts

The first survey of the season estimates intentions to plant. This is a non-probability survey, computed in March. The first acreage survey for most crops is the June enumerative survey, a probability survey. All later probability surveys employ subsamples of the June survey sample. Some non-probability acreage sampling is also done in June. Acreage estimates are updated periodically throughout the growing season.

The first yield forecast for most crops is computed in August. The objective yield probability survey is conducted for a limited number of crop types. Non-probability yield surveys are conducted for the many other crop types. These forecasted yields are updated periodically through the growing season. In November and December, post-harvest surveys are conducted to estimate, as closely as possible, actual production.

(3) Sampling System of USDA's Probability Surveys

The USDA employs a stratified area sampling plan. Each state is divided into strata according to intensity of agriculture. Each strata is then divided further, the smallest level of division being the sampling unit. It is from a number of selected sampling units that the forecasts and estimates are extrapolated.

A stratified sampling plan is superior to an unstratified one. Effectively done, a stratified plan can either reduce the sampling error for a given sample size, or it can produce the same sampling error as an unstratified sample of greater sample size. It also permits the use of lighter sampling in the less cultivated areas and heavier in the more intensely cultivated areas (as illustrated in Figure III-1). This adds to the reduction of the sampling error for the entire population.

Currently, USDA constructs area frames using photo-mosaics of the scale one inch to the mile. The delineation of clear boundaries which can be located by enumerators on the ground is very important for each sampling unit. Sizes of the sampling units vary from about one mile square for intensely cultivated land, to ten miles square and more for less cultivated land.

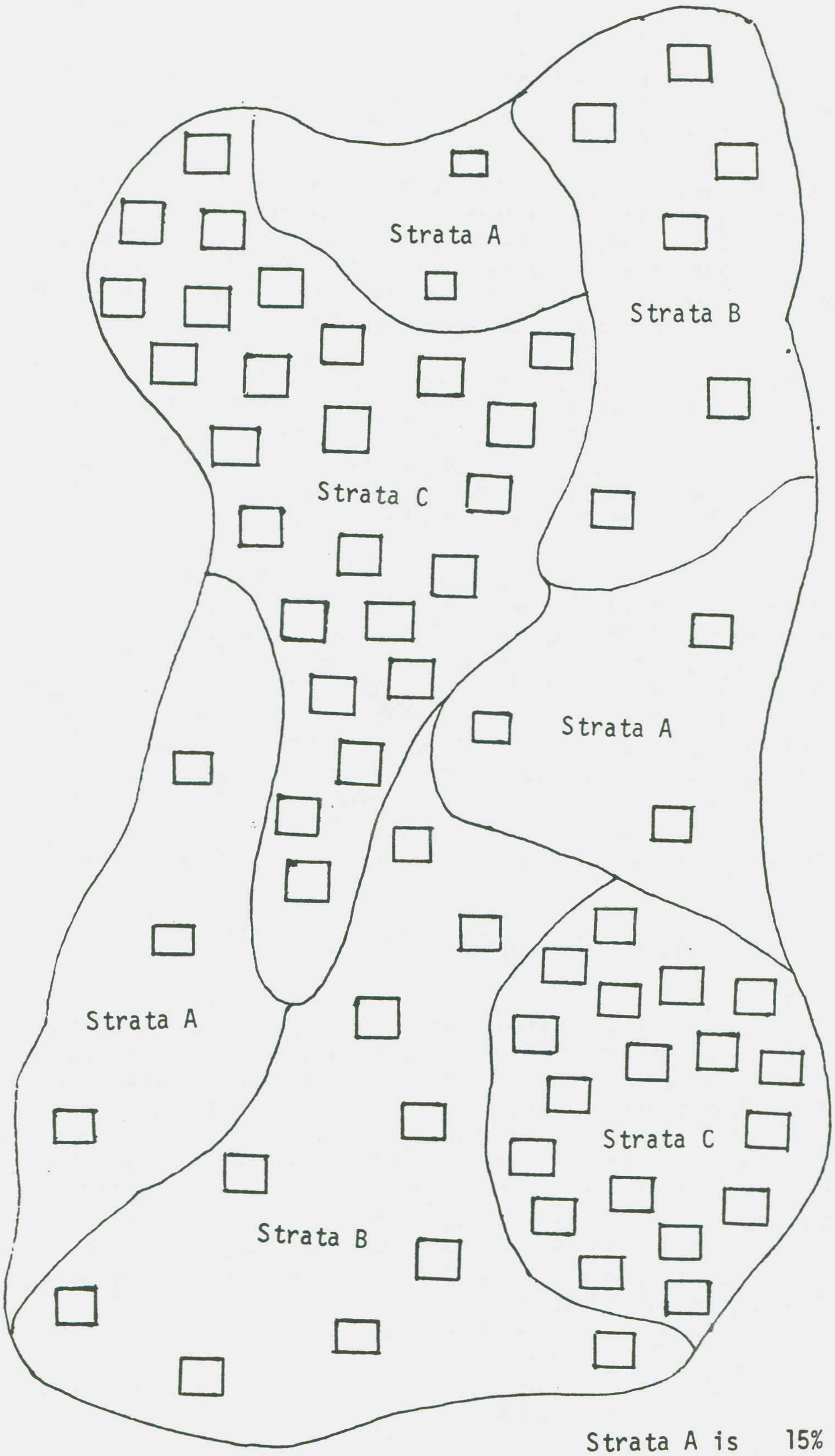
State area frames are reconstructed, on the average, every 15 to 20 years. More frequent updates are performed for states with rapidly changing land use (e.g., California). An increase in sample size over the years can compensate for what would otherwise be an increase in the sampling error. In any case, the outdating of strata does not bias the estimate.

Either a "systematic system" or an "inter-penetrating system" is presently employed in selecting the units to be sampled. Unlike random sampling systems, both systematic and inter-penetrating sample selection techniques make geographic clustering of samples impossible. They thus produce more reliable statistics than a random sampling system. However, as each unit in the systematic and inter-penetrating systems is not selected at random, independently from all the other units selected, some bias is introduced. USDA does not feel it is significant. In states where the area frame has never been completed for some strata, a point estimation system of sampling is employed.

(4) Forecasting Error of USDA's Probability Surveys

Sampling errors are the inaccuracies that occur because only part of the total population is surveyed. Non-sampling errors are the inaccuracies that occur because of imperfections in the survey methods. For instance, in estimating wheat acreage planted, USDA cannot afford to survey all wheat farmers, so a representative sample is selected. Because that sample does not perfectly mirror the population of all wheat farmers, sampling errors are introduced. Additional imperfections (non-sampling errors) can occur as a result of errors in crop identification or crop acreage estimates within each sample. These could be introduced by inaccurate reporting by farmers or enumerators, or mis-identification of crops by a satellite system. The sampling and non-sampling errors must be combined to produce an estimate of total error. The functional sources of sampling and non-sampling errors are found in Table III-1. These errors are discussed in detail below.

Area Stratification by Intensity of Agriculture



Strata A is 15% cultivated

Strata B is 15% - 50% cultivated

Strata C is 50% cultivated

☐ - A segment to be sample

Table III-1

FUNCTIONAL SOURCES OF SAMPLING AND

NON-SAMPLING ERRORS FOR USDA'S

PROBABILITY SURVEYS

SAMPLING ERROR	NON-SAMPLING ERROR
-Sample size	-Ground enumerators inadequacies in fulfilling their tasks
-Percentage of total area sampled	-Inaccuracy of farmers responses
-Overall sampling design, including stratification effectiveness	-Imperfections of the measurement procedures set up by USDA
-Geographic size of a sampling unit	

The sampling error is the absolute error expressed as a percentage of the estimate of the parameter for the total population. The parameter of present concern is the acreage of each crop. The population is the total of all the sampling units. Each sampling unit has a unique geographic location so that all the sampling units together cover all the acreage associated with the population. When a sampling unit is selected to be in the sample, it is designated as a segment.

To estimate the total acreage of one particular crop for the total population (for example, a particular state) the summation of all the acreages measured in each of the segments for that crop is multiplied by the ratio of total sampling units in the population to the number of segments in the sample. This total population acreage estimate for one particular crop for one particular state is expressed in the following equation:

$$T = \frac{1}{P} \sum_{i=1}^{n} x_i$$

where:

P = the proportion of the number of sampling units in the population

x_i = the measurement of the total acreage of the given crop for the i^{th} segment.

The sampling error, or coefficient of variation, is a function of the variance of the estimated total. The formulas for the variance of the estimated total and the coefficient of variation are as follows:

The variance of the Estimated Total:

$$V(T) = N^2 \left[\frac{\sum_{i=1}^{n} x_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} x_i\right)^2}{n(n-1)} \right] \left[\frac{N-n}{N} \right]$$

The Coefficient of Variation:

$$\epsilon_s = \frac{100\sqrt{V(T)}}{T}$$

where:

N = the total number of sampling units in the population

x_i = the measurement of the total acreage of the given crop for the i^{th} segment.

n = the sample size (i.e., the number of segments in the sample).

T = the total acreage estimate for the population for a given crop.

As the state estimates are aggregated to the regional and national level, the sampling error is generally reduced. This occurs because the square root of the sum of the state variances increases less than the total population acreage estimate. As a result, the sampling error for national crop statistics is much lower than the sampling error for the state and local statistics.

The types of <u>non-sampling errors</u> are listed in Table III-1 measurement of the non-sampling error for the total population is defined statistically as:

$$\varepsilon_m = \frac{100\, N(\bar{x} - \bar{x})}{T}$$

where:

$$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i$$

$$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i$$

x_i = the measured acreage for i^{th} segment in the sample

x_i = the actual acreage for the i^{th} segment in the sample

N = the number of sampling units in the total population

n = the sample size (i.e., the number of segments in the sample)

T = the total acreage estimate for the population for a given crop.

Though no comprehensive studies have been done, there are some studies which, though narrow in scope, give some indications of the magnitude of these errors. One such study is a quality check on a sample of the enumerators work done in each year by the survey supervisors. Although the quality check is done on too small a scale to provide meaningful state level information, they provide reliable indications for groups of states. Table III-2 illustrates representative ratios of the enumerator estimate to supervisor estimate for 1962 and 1963. USDA tries to reduce this type of error by perfecting its training system for enumerators. Presently, over 20% of the survey cost is training. A limited study has been done on the relationship between the accuracy of the farmer's response and the interviewing technique used as the measurement procedure in USDA's acreage surveys. However, this study does not quantify the relationship.

- Total error of estimation

The total error of estimation for a population can be expressed as a function of both the sampling error and the non-sampling error as follows:

$$\epsilon = \sqrt{\epsilon_s^2 + \epsilon_m^2}$$

where:

E_s = the sampling error of population

E_m = the non-sampling error of the population

In designing a probability acreage estimation survey USDA can control all the parameters associated with the total estimation error (as listed in Table III-1) except the farmer's response. In objective yield estimation surveys, even the farmer's response is controlled by eliminating it from the procedure and having the ground enumerators do the measuring.

Since USDA can control the parameters to reduce the sampling error, it is useful to express the sampling error mathematically in terms of all these parameters including the geographic size of a sampling unit. If we assume all sampling units are of equal size (and they are for each strata), then the total sampling units in the population, N, equals the total area of the population A_t, divided by the area of one sampling unit, A_s. Substituting the term for N in the equation defining V (T)

$$V(T) = \left(\frac{A_t}{A_s}\right)^2 \left[\frac{\sum_{i=1}^{n} x_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} x_i\right)^2}{n(n-1)}\right] \left[\frac{\frac{A_t}{A_s} - n}{\frac{A_t}{A_s}}\right]$$

$$\epsilon_s = \frac{100}{T}\sqrt{\left[\left(\frac{A_t}{A_s}\right)^2 - \frac{nA_t}{A_s}\right] \left[\frac{\sum_{i=1}^{n} x_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} x_i\right)^2}{n(n-1)}\right]}$$

June 1962, 1963 Enumerative Surveys -

Comparisons of Enumerator Estimate and Supervisor Estimate

ITEM	% Enumerator Estimate/Supervisor Estimate			
	North Central Region		Southern Region	
	1962	1963	1962	1963
Total Acres	107	103	106	104
Cotton	126	93	103	98
Winter Wheat	109	103	78	98
Barley	111	117	98	111
Soybeans	101	101	94	107
Tobacco		48	97	109
Corn	100	99	104	104
Rye for harvest		188		196
Sorghum	104	108	98	107
Grain Hay		61	136	227
Clover, Timonthy, & of clover for hay	76	87	104	89

From this equation, it can be shown that $\epsilon_s = k/\sqrt{n}$; that is, to halve the samping error, one must quadruple the sample size. The relationship between the sampling error and the size of the sampling unit is less simple as it is also dependent upon the value of n.

It would also be useful to express the non-sampling error in terms of the varying parameters upon which it is dependent. However, to our knowledge, a detailed error analysis has never been conducted.

USDA has a fixed budget for crop reporting. In order to design a survey which will have the lowest estimation error given their fixed budget, they must also know the costs of controlling each of the causes of errors. In reality, all the cost functions necessary to optimize the entire system are not known. Therefore, USDA analyzes each parameter separately. Historic survey designs and the resulting errors are used as an indication of how the survey design should be altered. In this manner USDA feels that it has developed an efficient survey design.

(5) Overall USDA Production Forecast Errors

The above discussion of errors relates to the statistical sampling system which provides only one input to the Crop Reporting Board forecasts. Table III-3 lists USDA average production forecast error by crop:

Table III-3
AVERAGE PRODUCTION FORECAST ERROR 1962-1971
BY CROP AND FORECAST

	FORECAST ERRORS					SAMPLE ERROR
CROP	JULY	AUGUST	SEPT	OCT	NOV	
corn	6.23	5.46	4.10	2.71	1.55	1.3
rice	4.91	3.88	2.27	2.04	1.37	10.4
sorghum grain		6.94	3.76	3.88	3.36	3.4
soybeans		4.34	2.07		1.34	2.0
cotton		6.96	5.84		2.48	3.0
potatoes - fall		4.00	4.26		1.53	9.1
oats	4.44	2.50	2.78			2.1
wheat-winter	3.04	3.26	3.80	3.35	2.02	2.2
wheat-spring[a]	6.37	6.16	2.51	2.30		4.1
barley	4.84	1.77	1.20			3.2
sugarbeets	3.57	2.94	2.72	2.41	1.84	7.3

a - winter wheat forecasts are for the months of April through August.

These errors compare the Crop Reporting Board forecasts for the months July through November with the final production forecasts made in December of the year following the forecast growing year. Note that the sample error of the statistical sampling system (last row) in Table III-3 is greater, in some cases, than the forecast errors, indicating that the forecast is based in part on other information. Use of these errors as a goal for improvement for a satellite system is discussed further in Section 4 of this chapter, and in Appendix C.

2. ERS ALTERNATIVES FOR CROP ACREAGE FORECASTING

ERS information could potentially be used as an additional input for the USDA crop reporting system, or an ERS system could be considered as an alternative to the current system. In either case consideration will have to be given to factors affecting identification accuracy of an ERS system, sample design or re-design issues, and design considerations for satellite and aircraft systems. These issues are discussed in this section under the following headings:

- Factors Affecting Crop Identification Accuracy
- Use of ERS Data in USDA's Crop Reporting System
- Design Considerations for Satellite and Aircraft Systems

(1) Factors Affecting Crop Identification Accuracy

Present results of experiments in crop identification are limited because 1972 data was only available for part of the growing season and results of analyses of 1973 data have not been fully reported at this writing. Results thus far, based on limited data, do allude to several parameters affecting crop identification accuracy. Figure III-2 illustrates the type of variation which may be expected in accuracy of crop identification, with respect to the timing of data acquisition, number of multi-data images available, and experience of working with orbital imagery. These factors are discussed below.

- Identification accuracy varies with time during the growing season. The lack of data for a complete growing season has prevented definitive experimental results on this relationship. Since investigators have limited data and few repetitive images over a given area, there is insufficient information available to develop such a curve for any crop.

Figure III-2

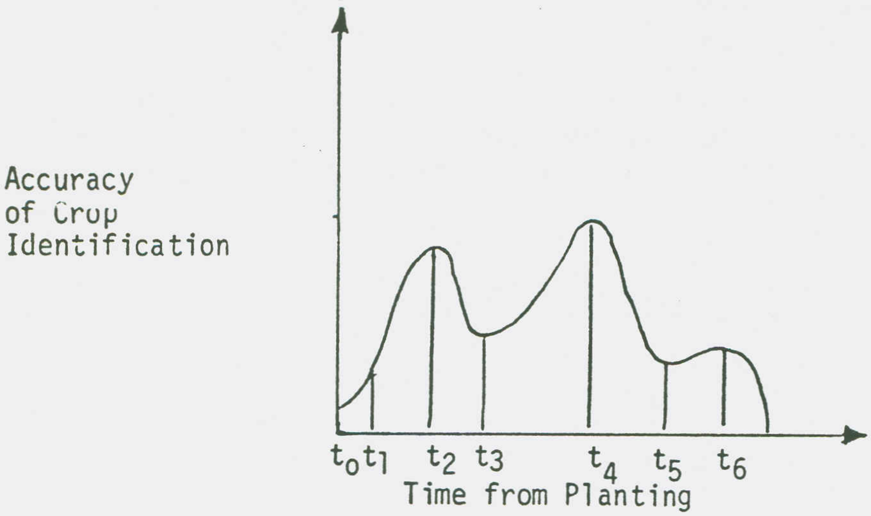


Figure 1a
Variation in Accuracy with Time of Data Acquisition

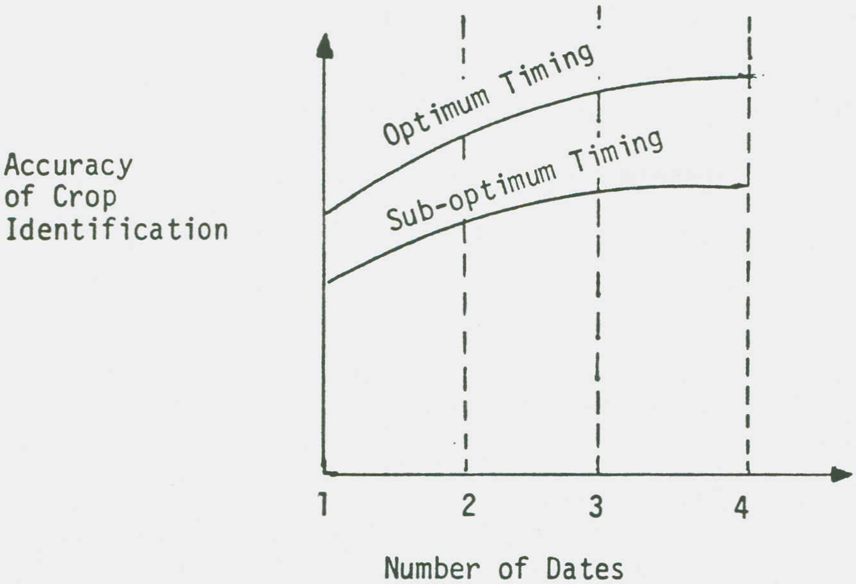


Figure 1b in
Variation Accuracy with Data Acquired on Multiple Dates

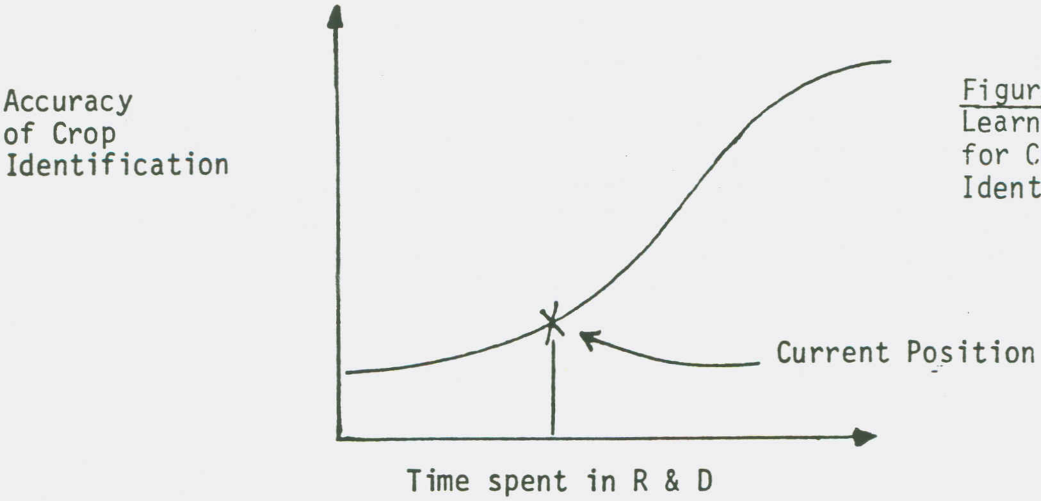


Figure 1c
Learning Curve for Crop Identification

- The number of repetitive images used to perform the identification influences the resulting accuracy. Several experimenters have indicated that multiple images of a single crop help to eliminate uncertainties in the interpretation process, and reduce estimating errors. Note in Figure III-2b that this characteristic will vary depending upon the time in the growing cycle of the first image and the time interval between successive images.

- It is likely that accuracies will improve because of learning curve effects as investigators gain experience and improve interpretation technology.

- Accuracy of crop identification appears also to be a function of other variables including: the number and size of training sets, spectral variance between crops and within each crop, identification algorithm, and the number of crops and cropping practices.

To assess the benefits of a crop reporting system incorporating ERS data, it is necessary to estimate the measurement errors introduced by the satellite which differ from those found in the current crop reporting system. These errors include those resulting from mis-identification of crops as well as errors in estimating the acreage of given fields, expecially when fields are not uniform in size. In light of the ERTS-1 experimental results to date, it appears that considerable additional research is required to demonstrate crop identification and acreage estimation accuracies high enough to be useful for an improved crop reporting system. Data being collected during the current growing season, when analyzed by experimenters, should permit substantial additional analysis with regard to the above issues. Whether or not this experimentation will, in fact, result in significant improvements in our knowledge of crop identification accuracy remains to be seen. Errors in current and proposed systems are discussed further in the subsequent section entitled "Comparison of ERS Alternatives and the Without System."

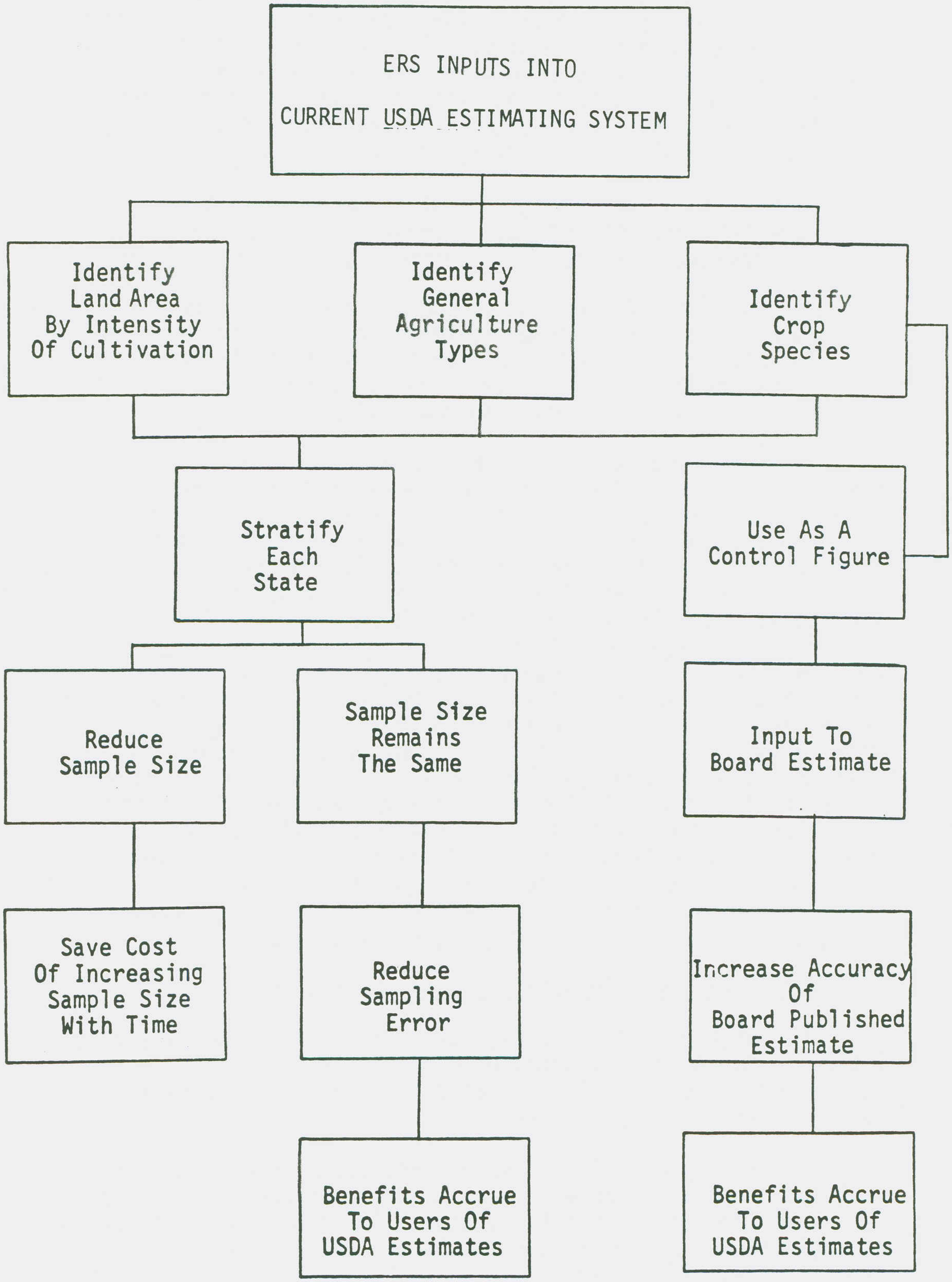
(2) Use of ERS Data in USDA's Crop Reporting System

ERS imagery could be integrated into USDA's Crop Reporting System in two ways. It could be used as one of many inputs to the current crop reporting system or it could be used as the basis for an entirely new system.

The various ways in which ERS data could be incorporated into the current system are shown in Figure III-3. These possibilities are described in this section. The potential cost savings that would result are evaluated in Chapter III. As an input to the current system, ERS imagery could be the basis for a better stratication plan. That is, the strafication could

Figure III-3

POTENTIAL ERS SYSTEM RELATIONSHIPS TO
THE CURRENT USDA CROP REPORTING SYSTEM



be updated more frequently as dictated by the rate of change of agricultural land use. More accurate delineation and area determination of various strata could improve sampling efficiency. Presently the stratification is by intensity of agriculture. Another useful level may be the distinction between general types of crops such as row crops and orchards or irrigated and non-irrigated land. To a limited extent, this distinction is made now. A third level may be the distinction between crop types. Information derived from ERS imagery on crop types by location, which may not be suitable for final estimates of acreage because of a large measurement error, may be suitable for stratification purposes.

To achieve sampling errors comparable to the present system, more effective stratification could allow USDA to reduce the sample size and thus reduce costs. However, given the current magnitude of the sampling system budget, the possibilities for cost savings do not appear significant. (See Appendix E)

With the current sample size, more effective stratification may reduce the sampling error. To determine the potential gains from a better stratification system, the expected data variability between strata and within strata would have to be determined for each postulated stratification system. If the data variability between strata is large and accounts for most of the total variability in the characteristic being measured, then there could be a considerable gain from stratification.

To determine the optimal level of stratification, the incremental change in variability between and within strata, respectively, must be compared with the incremental cost for each stratification level being considered. Also, loss of degrees of freedom with increased stratification must be evaluated. Knowledge of the variabilities within and between strata is dependent upon measurements of their characteristics. These could be taken by a pre-sampling survey or could be drawn from previous years' data. The most detailed levels of stratification, i.e., by crop type, are likely to need updating more frequently than more general agricultural levels. The expected rate of land use change at each of the levels of stratification would need to be determined and related to cost.

Crop acreage estimates from ERS data could also be used as a means of calibrating acreage estimates produced by ground enumeration. These "calibration" figures could be used to modify the conventionally produced estimates either by the Crop Estimating Branch of USDA before the estimates were submitted to the Crop Reporting Board, or by the Crop Reporting Board in light of the many other inputs they consider.

Potential ERS system linkages with the USDA crop reporting system are outlined in Figure III-3.

It must be recognized that the crop acreage estimate is only one of many inputs to the Crop Reporting Board's published production estimate. The upper limit of the resulting benefits is a function of the weight the Board would put on the ERS-produced inputs in making their decision. It is assumed, however, that the more accurate the statistical sampling system the more reliance the Board will place on its results.

(3) Design Considerations for Satellite and Aircraft Systems

In order to estimate the benefits of a system using ERS data, it would be necessary to design a statistical sampling system using satellite imagery as a primary input. Such a system might involve the following characteristics:

- Increased number of segments in the sample.
- A floating sample, rather than fixed, to allow for the fact that cloud cover may sometimes prevent the satellite from obtaining imagery of fixed locations.
- Continuous operation of a statistical model that is updated with each pass of a satellite over the U.S., and provides continuous estimates of acreage and the associated sampling error.

The design of such a system is an appreciable task which is beyond the scope of ERTS-1 experiments and this study.

However, for an aircraft or satellite system to become operational, the required statistical sampling plan must be developed and evaluated. Key elements of this plan include the requirements for multi-date imagery to facilitate crop identification, and plans to circumvent the cloud cover problem through redundant sampling frames. It can then be determined whether a single satellite with an 18 day period is sufficient to meet the data requirements of such a plan. Until this analysis is done it is not possible to specify the satellite requirements.

It is significant to note, however, that it may be desirable to increase the swath width of an ERS satellite, if this were possible without losing spacial resolution capability, in order to reduce the coverage period. Such an improvement in coverage might then obviate the need for additional satellites.

The design of a high altitude aircraft system to collect the same information as would be collected by a satelite system, requires aircraft system design information which has not yet been furnished to the contractors. In addition, the characteristics of the statistical sampling system must be known in order that aircraft flight patterns might be analyzed. An aircraft system provides somewhat more scheduling flexibility than a satellite in taking advantage of weather forecast information to avoid cloud problems. These trade-offs can only be made when detailed information becomes available on the sampling system requirements and the aircraft system characteristics.

3. REGIONAL VS NATIONAL CONSIDERATIONS

There are at least two distinct issues to be evaluated when considering regional and national effects of better forecast information. The first of these issues is the definition of the "without" system at the regional level, and the second is determination of the extent to which actions are taken on a local or regional basis vs a national basis. Each is discussed below.

Defining the "without" system for the local and regional level is complex task because local systems differ significantly by region and by crop. For some major crops (such as ones included in this study), there exists alternative or supplemental information systems. The local and regional USDA forecasts may not be the "most likely alternative" system. For example, major grain companies and co-ops use regional USDA forecasts as an input to their information system, but this input is supplemented by other sources. One reason this occurs is that USDA local and regional forecasts are formed by allocating the national produciton based on *a priori* information such as historical trends. Whereas the USDA national forecasts are quite accurate, the local and regional forecasts derived from them have characteristically higher error rates, as would be expected. While it is quite reasonable to define the USDA national forecasting system as the "without" system for national forecasts, it is not as reasonable to define the USDA regional and local forecasting system as the "without" system for regional and local estimates. Furthermore, to use the USDA local/regional system as the without system would result in an overstatement of benefits. To correctly define a local/regional "without" system would require extensive interview and survey work with grain companies, co-ops, farmers and millers who are major inventory holders and users of forecast information. Some regional information has been gathered in California from a major bank and a fruit growers association, but quantitative error estimates were not available. Further survey work in this area might reveal additional information. Because of the problem of double counting and because the benefit overlap is probably substantial it was decided to take a conservative approach and only include benefits from inventory adjustment derived from national forecast information.

Beyond the issue of defining the without system is the issue of determining the extent to which actions are taken on the basis of local/regional information vs national information. Prices in major regional grain markets do vary from one region to another, but the differences are constrained to costs of transport from one market to another. In a sense, there is local and regional variation in price levels and price expectations, and hence in inventory depletion rates, but these variations are constrained by national market characteristics and transportation costs among regions. Therefore, to include fully both regional inventory adjustment benefits and national inventory adjustment benefits would be double counting some of the benefits. It would be ideal to devise a method of separating the inventory adjustment effects of local/regional and national information and to individually estimate the benefits of better forecasts at each level. Unfortunately, there appears to be no way of separating the effects of regional vs. national information.

While national forecasts are more important in crop inventory decisions, local/regional forecasts may be significant for inventory decisions in agribusinesses, such as fertilizer, harvesting equipment, and rail equipment. In the case of fertilizer, most of the annual application occurs during pre-planting preparation, planting, and in early growing stages. Most of the fertilizer is produced and distributed before the growing season begins; hence, there could be no significant benefits from inventory adjustments in the fertilizer industry due to improved domestic forecasts.

Hypothetically, railroad companies could improve the distribution of rail cars based on better regional and local production forecasts. More efficient use of transport equipment would result in cost savings to the rail industry. A survey of some major rail companies has shown that better production forecasts would probably not affect the use of rail equipment. Railway cars are historically in short supply to meet peak needs of the post harvest season. Rail car inventories are maintained to meet adjusted average annual needs, not peak needs. Given no idle resources during peak periods, there is little potential for achieving cost savings from improved allocation. No change in efficiency can be foreseen even with better information inputs. Therefore, potential benefits from cost savings in rail transport appear unrealistic.

With better local forecasts, a more optimal allocation of harvest machinery could potentially be achieved. More accurate knowledge of where and when particular crops will be ready for harvest should enable better scheduling of harvesting machinery and manpower. However, the extent to which harvest schedules are flexible is uncertain. In the case of wheat it is generally the case that harvesting machinery and manpower move across the midwest from south to north. In this harvest cycle there is little room for harvest optimization by each individual farmer. Weather throughout the harvest season plays an important role in determing when any given farmer's fields will be harvested. It appears therefore, that cost saving in harvesting due to better crop information would be minimal.

In summary, there is little doubt that there would be both regional and national benefits from better forecast information. However, the regional and national benefits in commodity inventory adjustment significantly overlap and including both would result in double counting. It is also probable that some agricultural industries would benefit from better forecast information. But it appears the magnitude of these benefits is quite small. In both cases, this analysis will err on the conservative side, and only national commodity inventory adjustment benefits will be included.

4. COMPARISON OF ERS ALTERNATIVES AND THE WITHOUT SYSTEM

(1) Definition of the Without System

The "without" system is defined as "The alternative information gathering system thought to be most likely in the absense of the assumed ERTS-type system." It is further stated that "The current proportion of funds provided by the Federal Government for non-satellite imagery acquisition will be maintained." 1/ From these guidelines it appears that the "without" system for estimating crop acreage should be defined as the current level of operation of the USDA crop reporting system.

In this analysis, the ERS systems have been compared to a "without" system, which is the survey procedure used by USDA. This case study has been concerned only with the acreage estimation component of crop production forecasts. In this analysis the yield estimation and forecast procedure currently in use for yield will be assumed to be the same for both the "without" system and ERS systems.

The total production forecast is derived from the acreage forecast and the yield forecast:

$$P = AY$$

P = production forecast
A = acreage forecast
Y = yield forecast

Taking the total derivative of this equation and dividing by P yields the following relationship:

$$\frac{\Delta P}{P} = \frac{\Delta A}{A} + \frac{\Delta Y}{Y}$$

$\frac{\Delta P}{P}$ = error in total production forecast

$\frac{\Delta A}{A}$ = error in acreage forecast

$\frac{\Delta Y}{Y}$ = error in yield forecast

1/ Dept. of Interior, Request for Proposal No. 5166.

Assuming the yield forecast remains the same, the improvement required in acreage projection to achieve a given level of improvement for the production forecast may be calculated as follows:

$$(1-I_p)\ \frac{\Delta P}{p} = \frac{\Delta A}{A} - I_p \frac{\Delta P}{p} + \frac{\Delta Y}{Y}$$

$$I_A = I_p \frac{\Delta P}{p} \Big/ \frac{\Delta A}{A}$$

I_p = error improvement for production forecast

I_a = error improvement required for the acreage projection to achieve a given I_p

For example, if production forecast error is 4%, acreage and yield forecast errors are both 2%, and the production forecast improvement is .1, the acreage forecast error must be improved 20% to 1.6% to achieve the 10% improvement in production forecast (to 3.6%). Table III-4 provides a range of error rate proportions and required improvements in acreage forecasts to achieve improvements in production forecasts:

Table III-4

TOTAL ERROR = 4%		IMPROVEMENT REQUIRED FOR ACREAGE FORECAST TO ACHIEVE STATED PRODUCTION FORECAST IMPROVEMENTS		
ACREAGE ERROR	YIELD ERROR	10% IMPROVEMENT IN PROD. FORECAST ERROR	20% IMPROVEMENT IN PROD. FORECAST ERROR	30% IMPROVEMENT IN PROD. FORECAST ERROR
0.5%	3.5%	80%	160%	240%
1.0%	3.0%	40%	80%	120%
2.0%	2.0%	20%	40%	60%
3.0%	1.0%	13%	27%	40%
4.0%	0.0%	10%	20%	30%

Unfortunately, no breakdown is available as to the proportion of total error which is attributable to the two components. It is likely that the proportion changes through the growing season, and it is also likely that the two components cannot be completely separated. For example, if there is a major crop disease late in the growing season, the production forecast (or estimate) can be adjusted either by reducing acreage to account for acres lost, or by reducing yield. The final and revised final estimates concentrate more on the accuracy of the production forecast and less on the accuracy of the component acreage and yield forecasts.

It should be emphasized that these required improvements in acreage forecast represent the upper bound. In other words, with acreage error of 2% improved by 20% to 1.6%, at least a 10% improvement in production forecast would result. If this acreage forecast improvement allowed for better use of some a priori information, greater than a 10% improvement in production forecast could occur.

Adjustments of the statistical analyses by the Crop Reporting Board based on a priori information are assumed to be the same for all alternative systems. Any assumed reductions in total forecast error from an alternative ERS system are assumed to be derived from reduction of acreage estimation error. Therefore, only the cost of the acreage estimation and analysis is considered to be the "without" system cost.

(2) Error Rates for the "Without" System

In previous analysis, the sample error for each crop was used as a measure of total error. However, total error is a function of both sampling error and measurement (or non-sampling) error. Also, adjustments in the statistical results are made by the Crop Reporting Board based on a priori information, which could change the total forecast accuracy. Originally, it was proposed to estimate total error indirectly by combining sampling error with an estimate of measurement error based on enumerator error. However, because of the possibility of offsetting errors and because of the possibility of Crop Reporting Board adjustments in the statistical results in producing the forecast, an alternative procedure was adopted to determine total error. Based on work by Gunnelson, Dobson, & Pamperin1/ production forecast error was calculated by crop and forecast for the years 1962-1971. The procedure used was to subtract the revised estimate of actual production from the forecast and then divide this difference by the actual production to obtain the percent error in each forecast. An average error for each forecast for each crop was calculated for the ten year period. Table III-5 summarizes the results of this analysis:

1/ Gunnelson, G., W.D. Dobson, & D. Pamperin. "Analysis of the Accuracy of USDA Crop Forecasts." Journal of Agricultural Economics, Nov., 1972, pp. 639-645.

Table III-5

AVERAGE PRODUCTION FORECAST ERROR 1962-1971 BY CROP AND FORECAST

CROP	JULY	AUGUST	SEPT	OCT	NOV	SAMPLE ERROR
corn	6.23	5.46	4.10	2.71	1.55	1.3
rice	4.91	3.88	2.27	2.04	1.37	10.4
sorghum grain		6.94	3.76	3.88	3.36	3.4
soybeans		4.34	2.07		1.34	2.0
cotton		6.96	5.84		2.48	3.0
potatoes - fall		4.00	4.26		1.53	9.1
oats	4.44	2.50	2.78			2.1
wheat- winter[a]	3.04	3.26	3.80	3.35	2.02	2.2
wheat- spring	6.37	6.16	2.51	2.30		4.1
barley	4.84	1.77	1.20			3.2
sugarbeets	3.57	2.94	2.72	2.41	1.84	7.3

a = winter wheat forecasts are for the months of April through August

The last column of the table is the sample error for each crop. The above procedure implicitly assumes that the revised estimate of actual crop production is 100% correct. All indications are that the revised estimates are accurate, and certainly there are no better estimates of total production. Hence, for purposes of this study, the errors inherent in the without system will be those found in the previous table. (See Appendix C for further discussion)

(3) <u>Error for the ERS Alternative</u>

As stated above, total error for a sampling system is a function of both sampling error and measurement error. Experimental results to date have not specified or projected consistent measurement errors for an ERTS type system. Neither has sample error for an ERTS based system been estimated. However, some progress has been achieved in analyzing sources of error in an ERTS based system.

Sampling error is a function of sample size and sample design. Design of an ERTS based sampling system is beyond the scope of this case study. However, it appears that sampling error in an ERTS based operational system could be quite low, perhaps very near zero. The reason for this is that once a national ERTS based sampling system is designed and once the processing and interpretation algorithms are developed, the marginal cost of increasing the sample size is quite low. If the current sampling error is an average of 2%, increasing the sample size by a factor of 4 reduces the sampling error to 1% and increasing the sample size by a factor of 16 reduces the sampling error to .5% <u>all other things being equal</u>. Once an ERTS based sampling system is designed and operational, it appears from the projected cost information that sample size could economically be quite large relative to the current sample size. (See cost data in Section 6.) This is not to deny that there would exist a cost/sample size tradeoff. This tradeoff would in fact be quite important in the range if a second satellite were required to increase sample size (because of cloud cover and other problems discussed above). The argument is that within certain ranges the marginal cost curve would be quite flat and therefore the total sampling cost would be relatively insensitive to sample size within these ranges.

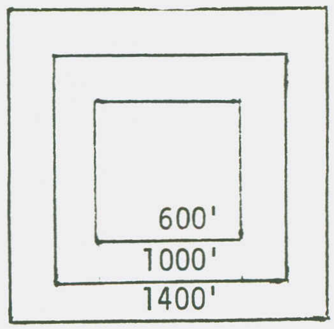
Measurement error is a combination of acreage estimation error (ϵ_{AE}) and crop identification error (ϵ_{CID}). Acreage estimation error is a function of field size, system resolution, and crop identification error:

$$\epsilon_{AE} = f(F, R, \epsilon_{CID})$$

F = field size
R = resolution

The relationship between field size and ϵ_{AE} may be plotted holding resolution constant.

R = 200 feet



Actual field size: 1000 feet

Figure III-4

This analysis assumes that either field size for all crops is equal or that crop identification error is zero.

If the average field size of each crop is known, acreage estimation error for each crop may be determined from the above graph. As of this writing, most investigators have found that acreage estimation error for fields below twenty acres in size is substantial. The mean error curve would be an appropriately conservative measure of acreage estimation error given the stated assumptions.

This relationship assumes either that field sizes are identical for all crops or that crop identification error is zero or has a consistent bias. If average field sizes differ among crops, as they usually do, acreage estimation error would also depend on crop identification error. If the ϵ_{CID} is biased such that two (or more) crops are confused more than others; i.e., if the commission error is lumped into one or two crops, then acreage estimation can be adjusted according to the difference in average field size between the crop being identified and the other crop (assuming the bias is known). The bias in identification error must be consistent over time and have a known value. If the commission error is random, the adjustment would be according to the difference in average field size of the crop being identified and a weighted average of other crops. These adjustments are important only when average field sizes are significantly different and crop identification error is high.

Crop identification error is a function of the number of training sets or resolution elements per crop, spectral variance between crops and within each crop, identification algorithm, number of crops, and other variables, and may be expressed as:

$$\epsilon_{CID} = f\,(T, S_W, S_B, I, N, Z, \ldots. Z_n)$$

T = number of training sets or resolution elements (no. size, and distribution of training sets)
S_W= spectral variance within the crop

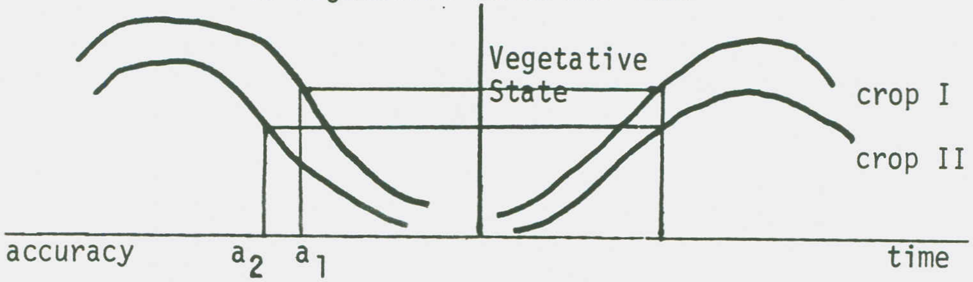
S_B= spectral variance between the crop and other crops

I = identification algorithm
N = number of crops being identified
$Z, \ldots. Z_n$ = other unspecified variables

Spectral variance both within and between crops is a function of vigor and vegetation growth stage. Crop development is a function of time in the growing season, weather, geographic area and other variables. Because vegetative development and crop spectral signatures are variable over time new training sets must be obtained each crop year for each specific region. Holding other variables constant, a plot of vegetative development over time may permit estimates of accuracy of identification if the degree of separability between crops can be related to spectral variances at particular growth stages.

Figure III-5

Hypothetical Curves Relating Identfication Accuracy To Vegetative State and Time



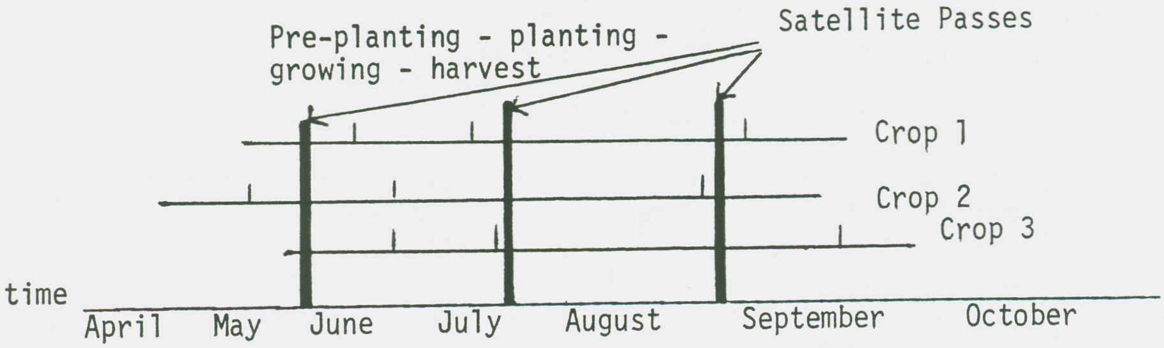
One set of curves would be required for each change in other variables (assumed constant) affecting identification accuracy for each crop. For example, increasing the number or size of training sets would cause the accuracy curves to shift upward. Accordingly, changes in other variables would also cause the curves to shift.

It was hoped that general information available in the agronomy literature, experimental results to date, and in-house first hand information, would permit approximations or ranges for these curves to be developed which would provide a basis for "if-then" assumptions to be used in benefit estimation. Unfortunately, the paucity of information on ERTS capabilities from the investigators prohibited the study team from accomplishing this analysis at this time. A summary of experimental results supporting this conclusion is provided above.

There is, however, substantial evidence to indicate that accuracy of an ERTS based system would be considerably enhanced by using a priori information to improve estimates. Von Steen has shown that knowledge of historical cropping patterns provided improved accuracies of crop identification.

S. Morain has used knowledge that field sizes in Kansas are usually 40, 80, 160, 320, or 640 acres to improve his acreage estimation accuracy. Field sizes are assigned on the basis of "best fit" using this a priori information. For example, if the image analysis procedure esimates a field size of 35 acres, the field is more likely to actually be forty acres and is recorded as such. Using this procedure total acreage estimation accuracy is improved. In one study Morain produced an estimate of wheat acreage that differed from the USDA estimate by only one percent. Other investigators are using knowlege of regional crop calendars and multiple satellite passes to aid in crop identification.

Figure III-6
Hypothetical Crop Calendars



The use of information from multiple satellite passes coupled with crop calendar data and knowledge of farm practices can also significantly improve forecast accuracy. In the above illustration, multiple passes will show the time sequence of pre-planting preparation, growing fields, and mature crops which can be related to individual crop calendars to improve accuracy.

(4) Range of Error for an ERTS Based System

Generally, it has been shown that the factors described above are important in determining measurement accuracy for an ERTS based system. However, despite the fact that the causal factors are generally know, it would be premature at this time to project the range of error levels that might exist for an ERTS based operational system.

Given the early stages in which experiments exist, the fact that accuracy levels currently being achieved by investigators for the most part do not as yet compare favorably with accuracy levels achieved with the current USDA system comes as no surprise. (See Section II.) There is not enough full year crop data on hand to draw firm conclusions about ERTS capability. In this context, it has been concluded that ERTS accuracy levels should not be projected for an operational system.

In the absence of conclusive results on ERTS capabilities, benefits have been estimated that would be achieved *if* an ERTS based system could produce more accurate estimates than the "without" system. In keeping with the basic design objectives for this study, as data on achievable accuracy levels become available and more certain, these levels may be "pluged" into the benefit estimation model.

5. BENEFIT ESTIMATION

(1) The Hayami-Peterson Model

Crop and livestock estimates were started more than one hundred years ago to help farmers determine the value of their production.1/ Today, farmers and other inventory holders continue to use crop forecasts to judge the value of farm output. Inventory holders match demand expectations with supply forecasts to develop their price expectation for the near future.

Benefit estimation in this case study is primarily concerned with determining the value of better supply (crop) information. Since Dupuit's famous work in 1844, economists have believed that the social value of a commodity is determined by what consumers are willing to pay for the good rather than what they actually pay.2/ The difference between what consumers are willing to pay and what they actually pay is called consumer's surplus. Using partial equilibrium assumptions, the "willingness to pay" for a good is measured by the area under the demand curve for the good, and changes in the willingness-to-pay (or social value) are measured by changes in the area under the demand curve.

Expanding on this theoretical background, Hayami and Peterson developed the basic framework for estimating benefits of improved supply forecasts.3/ Social benefits from more accurate forecasts arise by reducing the losses incurred through erroneous inventory decisions. It is assumed that inventory holders form price expectations from the crop production forecasts as if they knew the demand curve.

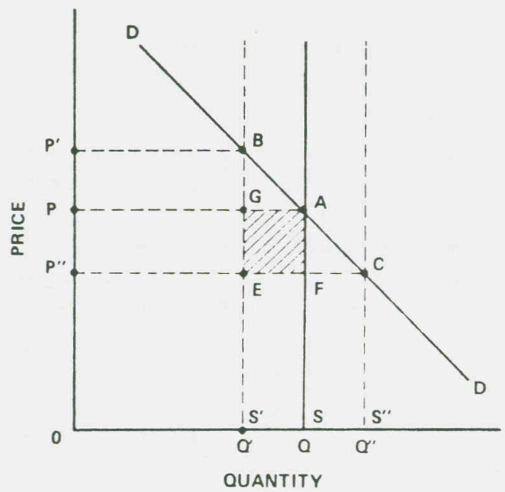
1/ United States Department of Agriculture - Statistical Reporting Service. "Crop and Livestock Estimates." May, 1967. 12p.

2/ Dupuit, Jules. "On the Measurement of the Utility of Public Works." Reprinted in A.E.A. Readings in Welfare Economics edited by Arrow and Scitovsky.

3/ Hayami, Yujiro and Willis Peterson. "Social Returns to Public Information Services: Statistical Reporting of U.S. Farm Commodities." American Economic Review. March, 1972. pp. 119-130.

In Figure III-7, the supply curve S depicts the true output for the current period as OQ. This supply is assumed to be perfectly inelastic, reflecting the fact that increases in price cannot alter production during the current period. Suppose that the forecast output is OQ'. Inventory holders would then expect the price for this period to be OP'. In

FIGURE III-7
INVENTORY ADJUSTMENT MODEL



SOURCE: HAYAMI, Y. AND PETERSON, W., "SOCIAL RETURNS TO PUBLIC INFORMATION SERVICES: STATISTICAL REPORTING OF U.S. FARM COMMODITIES," AMERICAN ECONOMIC REVIEW, MARCH 1972, P. 120.

other words, they expect the price to be higher by PP' than they would have expected with no forecast error. Because of this higher price expectation, inventory holders reduce their rate of inventory depletion until the price rises to P'. This erroneous reduction in consumption during the current period reduces consumer welfare, as measured by changes in "willingness-to-pay" (or consumer surplus), by the area ABQ'Q. In the period following production, supply is equal to the true production OQ plus the inventory carry-over Q'Q=QQ". This increased supply causes price to fall to OP' and results in an increase in consumption to OQ'. Consumer welfare is increased in this period by the area ACQ"Q. The net result of the crop forecast error in this instance is a reduction in current consumption and an increase in future consumption with a net loss in consumer welfare equal to the rectangle AGEF (ABQ'Q - ACQ"Q). The same net loss would have resulted from an overestimate of crop production.

Assuming a linear demand curve, the area AGEF = $\Delta Q \cdot \Delta P$ can be calculated from data on forecast error (E) crop production (PQ), and price elasticity of demand (λ):

$$AGEF = \Delta P \cdot \Delta Q = E^2 \, PQ/\lambda$$

$$E = \frac{\Delta Q}{Q} \qquad \lambda = \left| \frac{\Delta Q}{\Delta P} \cdot \frac{P}{Q} \right|$$

The benefit from more accurate crop forecasts is the reduction in loss of consumer welfare that follows from reduction in inventory adjustment errors. This welfare loss is a direct function of the forecast error and the value of production and is inversely related to elasticity of demand. In other words the welfare loss increases with increasing forecast error and crop production and decreases with increasing elasticity. An improved crop forecast with its lower forecast error would result in social benefits amounting to the reduction in loss of consumer welfare.

The model described above is essentially that developed and used by Hayami and Peterson to estimate benefits from more accurate crop forecasts. In their analysis, Hayami and Peterson made assumptions, both explicit and implicit, that bear on the use made of the model in this case study:

- Perfect competition is assumed in the crop markets with no single inventory holder nor purchaser large enough to influence price. Implicit in this assumption is that there is no government intervention in the market. Individual inventory holders do not consider the actions of other inventory holders in making their marketing decisions.

- Adjustments in inventory depletion rates are assumed to occur instantaneously at the time the forecast is received and at the time true production is known.

- It is assumed that inventory holders completely believe in and act upon the forecast. There is no risk aversion caused by potential forecast error.

- Inventory holders expect total production to be consumed in the market each production period. In other words, there are no changes in carry-over stock.

- There is no information on production of future periods (beyond the current season) that could influence current inventory depletion levels.

- Price is assumed to be the only variable influencing quantity demanded. All factors which determine demand (the demand structure) are assumed constant. These factors include income, population, tastes, and prices of substitute and complementary goods.

- Hayami and Peterson use total production figures and make no distinction between domestic consumption and exports. They use domestic price elasticities of demand for total production thereby implicitly assuming that international elasticities are equal to domestic elasticities and that benefits to the world (not only the U.S.) are being estimated.

The implications of these assumptions for this analysis will be discussed in detail below.

(2) Dynamic Inventory Adjustment Model

A study effort was initiated to develop a dynamic inventory adjustment model. This dynamic model was of primary importance in showing how inventory actions would actually be taken. The model calculates the social welfare increase from inventory adjustment behavior. Assuming a low forecast, the social welfare increase is the social gain in the period after the harvest minus the social loss in the period before the harvest: $SW = SG_b - SL_f$. If the forecast is low, consumption would decrease in the period before the harvest and increase in the period after the harvest. There would be an inventory withheld unnecessarily because of the low forecast. This withheld inventory is assumed to be depleted in the period following harvest. Inventory withheld (IW) depends on the difference between the old consumption rate (q_0) and the consumption rate with the forecast (q_f):

$$IW = f(q_0 - q_f) = K(q_b - q')$$

f = no. of months between forecast and harvest

k = no. of months between harvests

q_b = consumption rate after the harvest with the forecast (corresponding to q_f)

q' = consumption rate after the harvest with no forecast (corresponding to q_o)

Substituting in the equation for social welfare (SW), which was derived by integrating the two areas under the demand curve, yields the following equation for social welfare increase:

$$SW = \frac{IW}{2} (P_b + P' - P_o - P_f).$$

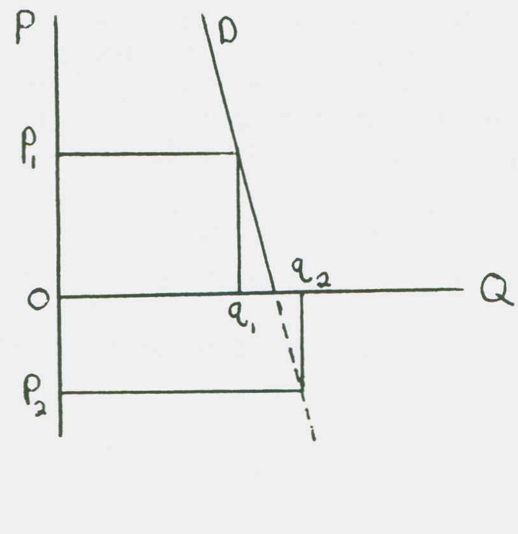
Given demand elasticities these prices can be calculated. For example, P_f is calculated as follows:

$$P_f = \frac{P_b(\alpha q_b + \alpha q_f - q_f + q_b)}{(\alpha q_b + \alpha q_f + q_f - q_b)}$$

Input to the original version of the model included assumed forecast errors, projected production figures, elasticities of demand, and initial consumption rates and prices. When the model was operated with only these inputs, the model exploded and price became negative or very large even with low forecast errors.

The reason this occurred in the unconstrained model is because of the inelastic demand of major food crops. Thus, a small change in quantity caused a large change in price. When the forecast error is positive (forecast too high), the increase in consumption was sometines sufficient to drive prices below zero. This result is illustrated in Figure III-8.

FIGURE III-8
DYNAMIC INVENTORY ADJUSTMENT MODEL



A small increase in consumption could cause negative prices because there were no constraints in the model to prevent this from happening as exist in actual markets.

In an attempt to make the model more closely correspond to actual markets, it was decided to alter the model structure by incorporating additional variables and including price and quantity constraints designed to reflect actual government policies and actions. In addition to production, projected domestic consumption, exports, and stock changes were included in the model. A minimum price constraint (and maximum consumption) was added which was designed to reflect government price support programs. If the model calculates a price lower than the minimum price, the support level price is substituted, the consumption level changed, and adjustments are made in stock input. This is comparable to the CCC support program. A minimum consumption constraint was also added to prevent exceptionally high prices or significantly curtailed consumption. This constraint operates as an export control would operate in actual markets. If consumption in the model is below the minimum level, the level is raised to the minimum level and exports reduced. With these added inputs and constraints, the model worked and calculated changes in social welfare. However, for many of the years, constraints controlled the operation of the model and benefits were quite small.

After reflecting on these results and assumptions, it was decided that the constrained model results are appropriate. Since the markets under investigation are controlled markets and they are controlled for the purposes of reducing price instability and maintaining farm income the results of the dynamic analysis appear to be reasonable. Through developing this dynamic model, the relationship between low elasticities, government control policies and benefit estimates from better forecasts became obvious. The tighter the constraints the lower the benefits and vice versa. No realistic "without" system or ERS system could be envisioned that ignored the effects of government control policy. The importance of government control policy is discussed in more detail in a subsequent section.

(3) Factors Affecting Benefit Estimation

Through the conduct of the case study, it became clear that several factors are particularly important in determining the magnitude of potential benefits. The following factors are discussed in this section:

- Demand elasticity
- Production, domestic consumption, and export data
- Government policy
- Information timeliness
- Length of the benefit period

1. Demand Elasticity

The magnitude of benefit estimates is very sensitive to the size of price elasticity of demand used for each crop. Although there has been extensive research in the area, demand elasticity estimates are still considered to be subject to a large margin of error. Many researchers have looked at one or two crops rather than at a broader group of agricultural commodities. Some researchers have estimated demand elasticity at the farm level, others at the retail level. Elasticity estimates also vary with the period and time frame of analysis. A literature search has been conducted on demand for agricultural commodities, and the subject has been discussed with a number of experts in the field.

Selection of estimates followed lenghty discussions with scholars who are currently working on demand and price analysis and trade projections with USDA.1/ Attempts were made to combine the estimates from the literature with the estimates in use (or considered appropriate) at USDA to produce elasticities that represent as closely as possible the current "state of the art". Table III-6 summarizes the results of the investigation.

Two considerations were especially important in selecting domestic elasticities. Retail elasticities are higher than farm elasticities. Since inventory behavior occurs at all levels from farm to retail, an attempt was made to adjust farm price elasticities upward. Also, elasticities for feed (and other non-food)

1/ Team members interviewed Jim Matthews and Tony Rojko at USDA.

TABLE III-6
ESTIMATES OF PRICE ELASTICITY OF DEMAND

Investigator	Corn	Soybeans	Wheat	Cotton	Sorghum Grain	Potatoes	Rice	Sugar Beets	Oats	Barley
Domestic Elasticities										
• G.E. Brandow	.03		.02	.40		. 2a .11b	.04	.17c	.01	.07
• Henry Schultz	.77		.03	.51		.69			.54	
• Jim Matthews	.3	.5	.15		.3		.1			
• R.J. Foote	.6									
• F. Lowenstein & M. Simon				.20					.5	.4
• J.R. Donald, F. Lowenstein, & M.S. Simon				.14						
• P.S. George & G.A. King						.31a .15b	.32	.24c		
• J.P. Houck & J.S. Mann		.35								
• Grant & Moore							.16			
• K.W. Meinker	.63								.49	.41
Export Elasticities										
• G.E. Brandow	1.4			3.7	1.4				1.4	1.4
• Jim Matthews	.9	1.2	.35		.8				.8	.8
• Grant & Moore							1.5			
• Tony Rojko			.6			.4				
• J.P. Houck & J.S. Mann		.46								
• Paul R. Johnson			1.77							
Elasticities Used by Hayami-Peterson (domestic only)	.03	.3	.02	.1		.1	.04		.01	.01
Elasticities Selected for This Study:										
Domestic	.35	.42	.10	.30	.30	.20	.16	.08	.33	.29
Export	1.25	1.05	.5	3.7	1.1	.40	1.5	.30	1.1	1.1

a - retail   b - farm level   c - processed sugar uses are generally higher than elasticities for food use. Many of the crops selected for this study are consumed mostly in non-food uses. For these two reasons, it was felt that the estimates used in earlier work were too low. The selected estimates take into consideration that much of the grain output is used for feed and that inventory adjustments occur at all levels in the economy from farm to retail. The selected elasticities are considered best for this study but would not necessarily serve equally well for other purposes.

Early analysts have used total production as the benefit base and domestic elasticities in the calculations for benefit estimates. For many crops selected in this case study, production for export is quite significant. Export demand elasticities are considerably higher than domestic demand elasticities. Thus, the use of total production figures and domestic elasticities results in an overstatement of benefits. For this study, projected exports and projected domestic consumption were analyzed separately using the appropriate export and domestic elasticities. Only benefits from domestic consumption are included in the study results for national benefits, and the positive effects on consumers in importing countries are ignored.

2. Production, Domestic Consumption, and Export Data

A number of sources were considered for data on value of domestic production of the crops in this study:

- OBERS Projections of Economic Activity in the U.S.
- Dave Culver - "Possible Directions for Farm Production, Prices, and Income", February, 1973. USDA.
- FAO - "Agricultural Commodity Projections, 1970-1980.
- Estimates based on Series E population growth estimates for the U.S. and current export projections

Although the OBERS projections are commonly used in economic and statistical work, they are based on Series C population growth estimates which are considered to be quite high given current expectations on population growth. OBERS projections of food demand are generally too high, and projections of feed demand too low because of recent changes in meat demand. OBERS data incorporated export projections made around 1970 before the recent changes in agricultural export patterns and outlook. Therefore, for some crops the OBERS estimates are too high for the domestic food consumption component and too low for export and feed consumption components (only total production is presented).

Recent USDA projections (Culver) used Series D population projections (about 1.2% per year) and 1973 export projections. These projections provide an improvement over the older OBERS data. However, because coarse grains and other crop groups are not disaggregated, the data was of limited use for this study. Similarly, the FAO projections are too aggregated for use in this study. Instead, it was decided to use projections based on Series E population growth projections (about .9% per year) with approximately the same export demand projections used by Culver. The lower population growth projection is more in line with recent trends and current thinking on population growth. These projections also incorporate recent trends in meat (and feed) demand. It should be emphasized that these projections and all other available projections are demand constrained (not supply constrained) projections and assume that some sort of government support or control program will be in existence. Although these projections specify no particular support program, some form of control is projected because supply capacity will exceed demand through (at least) the benefit period.1/

1/ Although most experts believe agricultural production will be demand constrained from 1975-1985, there are some who believe no support program will be necessary and agricultural production will be supply constrained.

Table III-7 compares OBERS projections for 1980 with those selected for the study:

TABLE III-7
AGRICULTURAL PRODUCTION PROJECTIONS FOR 1980
(millions of dollars)

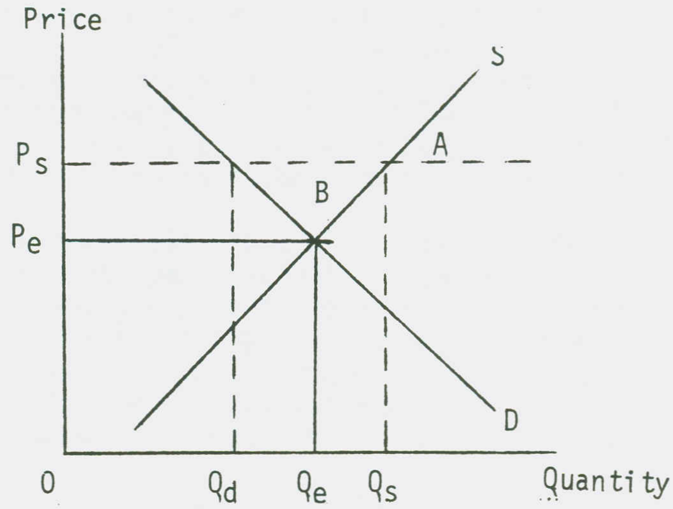
CROP	OBERS	STUDY PROJECTIONS	
		TOTAL PRODUCTION	DOMESTIC CONSUMPTION
wheat	$2,108	$2,723	$1,502
rice	488	714	295
corn	6,491	9,099	7,614
grain sorghum	1,141	1,214	1,052
oats	564	601	593
barley	492	587	546
soybeans	3,748	6,675	3,863
cotton	1,508	1,574	1,054
sugarbeets	321	453	448
potatoes	662	784	771

The domestic consumption projections above were used in this study to compute benefit estimates. Figures for annual prices, quantities, and values for each crop are included in Appendix C . It is important to note that benefits are directly proportional to the consumption values chosen. Therefore, benefits may be easily adjusted for alternative values. For example, if prices are expected to rise by 10% and quantities remain constant (unlikely for domestic consumption), benefits would rise by a factor of 1.1. Changes in consumption values result in proportional changes in benefits. Alternatively, different consumption values may be easily entered the benefit calculation program.

3. Government Policy

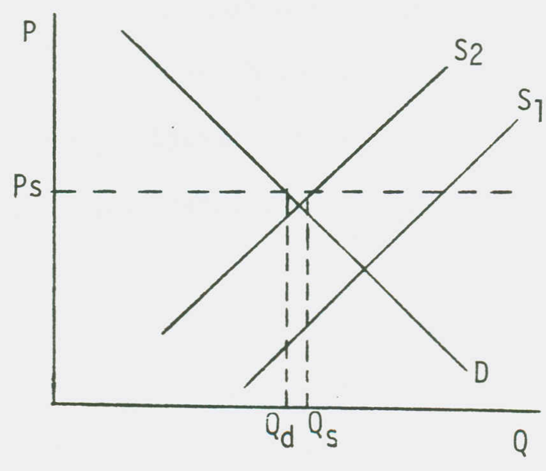
The nature of government policy in the agricultural sector has an important bearing on the magnitude of benefits from better forecast information. Government farm programs aimed at improving or maintaining farm income generally provide a price support, a subsidy, an acreage or output restriction, or some combination of these. If the farm program is in the form of a price support, it may be represented diagrammatically in Figure III-9.

FIGURE III-9
OPERATION OF GOVERNMENT PRICE SUPPORTS



The objective of government policy is to maintain farm income at levels higher than those which would obtain in a freely competitive market. This is achieved by instituting a price support (P_s) to insure this higher income level. Farm income is OP_sAQ_s instead of the competitive level of OP_eBQ_e. With a price of P_s, farmers supply Q_s and the market demands Q_d. The difference, Qs - Qd, must be purchased by the government to maintain the support price. To prevent the government from having to purchase and inventory huge stocks of commodities, the government often institutes supply limitations to reduce or eliminate required government purchases. This case is shown in Figure III-10.

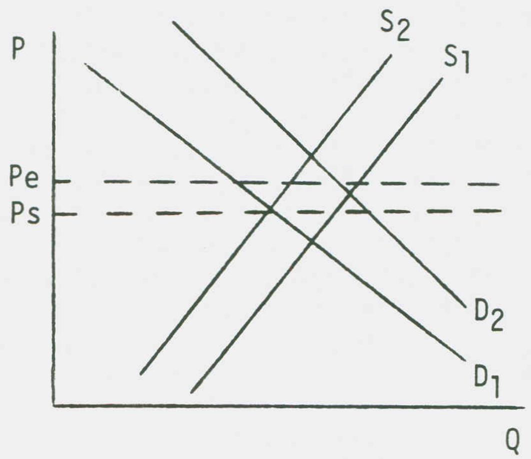
FIGURE III-10
OPERATION OF GOVERNMENT SUPPLY CONSTRAINTS



Here, S_1 is the market supply with no supply restrictions by the government and S_2 is the government constrained supply curve. By combining supply restrictions with a price support the government can influence the amount of stocks it is required to acquire. During the 1960's the government used this type of combined control program, but for the immediate future it appears that price supports will provide the primary means of government control.

Supply limitations are not as necessary now as they have been in the past because demand has shifted out to such an extent that the government does not expect to accumulate high inventories. The primary reason for this shift is the increase in export demand stimulated by the devaluation of the dollar, foreign crop failures, and rising world income.

FIGURE III-11
INCREASED DEMAND AND GOVERNMENT SUPPORT PROGRAMS



D_1 - old demand

D_2 - new demand

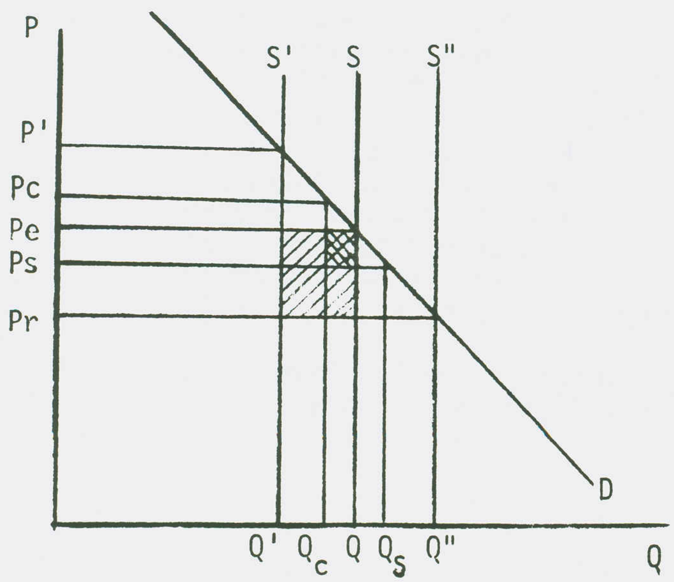
S_1 - free market supply

S_2 - restricted supply

In Figure III-11 the intersection of S_1 and D_2 curves is the competitive equilibrium with the assumed increased demand and market supply curves. So long as this intersection lies above the price support, the government program would not accumulate stocks or directly supplement farm incomes. Instead, it would eliminate or reduce the risk inherent in unstable agricultural commodity markets by establishing a price floor. So long as farm prices remain higher than government support prices, the competitive market assumption is valid and the resulting benefit measure is appropriate (excluding other limitations discussed elsewhere). However, to the extent that farm prices are influenced by government support levels, the estimates assuming competitive equilibrium would be an overstatement of actual benefits.

Benefits arise from a reduction in social welfare loss which is caused by price instability due to forecast errors. Lower forecast error leads to less price and consumption instability, and therefore to higher welfare levels. If, however, there is a government price support program which prevents prices from falling below a certain level (P_S) (and therefore limits price instability), the price and consumption stabilization benefits of better forecasts do not occur in full because stabilization is achieved in part by the government support program. Similarly, if the government is expected to impose price ceilings (P_C) or export controls (resulting in Q_C) to limit price rises, a degree of stabilization is achieved by this control which further reduces the range of benefits from better forecast information. This situation is depicted in Figure III-12:

FIGURE III-12
EFFECT OF GOVERNMENT PRICE CONTROLS



S = true production

S' = forecast production (consumption in period before harvest)

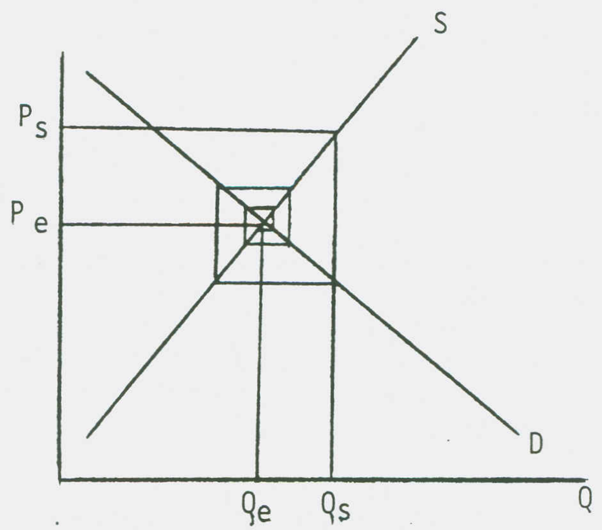
S" = consumption in period after harvest

Pc = price ceiling   Ps = price support

Instead of fluctuating between P'Q' and P"Q" as in the competitive model, consumption could only range from PcQc to PsQs. The large shaded rectangle depicts benefits estimated from the competitive model and the smaller shaded rectangle represents benefits that could arise with government control programs in operation.

If an agricultural commodity market free of government intervention is assumed, the projections to be used for future value of agricultural output must be reconsidered. If the price support level is higher than the equilibrium price, price would fall in the absence of the support and production adjustments would occur in future periods. This situation is depicted in Figure III-13.

FIGURE III-13
COBWEB PRODUCTION ADJUSTMENTS



Following the production adjustments, equilibrium price and quantity are lower than the support price and quantity (assuming the stability conditions for convergence hold). In other words, the value of agricultural output is lower in the absence of government controls. If no government controls and demand-constrained market conditions are assumed, the projected values of crop production should be reduced by some factor. Brandow has estimated the implications of removal of government supports.1/

1/ Brandow, G.E.: Farm Products and Market Supply, Pennsylvania Agricultural Experiment Station Bulletin 680. 1961.

From this study based on 1956 production the reduction in output that is likely to result from removal of government supports can be calculated as shown in Table III-8.

TABLE III-8
EFFECTS OF REMOVAL OF GOVERNMENT SUPPORT PROGRAMS

CROP	PQ ACTUAL	Q ACTUAL P REDUCED	% REDUCTION	BOTH P&Q REDUCED	% REDUCTION
Corn	4060	2956	27.2	2755	32.1
Oats	897	652	27.3	643	28.3
Barley	367	282	23.2	236	35.7
Sorghum	440	326	25.9	299	32.0
Wheat	1938	1120	42.2	686	64.6
Soybeans	889	718	19.2	-	-
Cotton	2115	1775	16.1	1468	30.6
Other	-	-	10.0	-	-
Total	10,706	7829	26.9	6805[a]	36.4

a - using 718 for soybeans

These figures indicate that the production value of major crops may be reduced up to one third in the absence of controls because of the production adjustments that would take place. On the other hand, this may be too high because the demand elasticities used in Brandow's work were generally in the low end of the range.

Whether a competitive market free of controls or a government regulated market is assumed, the competitive market assumption results in an overstatement of benefits if price controls would be operative. This can be seen by examining the benefits:

$$B = \epsilon^2 \; PQ/\eta$$

which may be written

$$B = \left(\frac{\Delta Q}{Q}\right)^2 PQ\left(\frac{\Delta P}{\Delta Q} \cdot \frac{Q}{P}\right) = \Delta P \, \Delta Q$$

With government controls ΔP and ΔQ are directly reduced, thus lowering benefits. Under a free market assumption P and Q are reduced by production adjustments. For the estimation of benefits, the problem is to determine the appropriate reduction in competitive equilibrium benefits. If there was some certainty of the appropriate magnitude for these changes, government control constraints could be incorporated in the first case and the value of production estimate reduced in the second case, both on a crop by crop basis. But given the uncertainty of the appropriate magnitudes of these changes for each crop,it appears better to simply reduce the total benefits by factors ranging from zero to one third. No reduction is appropriate if price supports are expected to be lower than competitive equilibrium prices; otherwise, the magnitude of the reduction depends on the extent government control policies are expected to influence prices and production. In this way the probable effects of government control can be accounted for without performing the highly speculative detailed projections of these differential effects. Obviously, future demand and supply conditions and government control policies will significantly affect the magnitude of realized benefits from better forecast information.

4. Information Timeliness

Benefits from better information on crop production can result from more accurate information or more timely information or both. Currently, the Crop Reporting Board issues crop forecasts monthly for most crops beginning in July or August and continuing through December.

If an ERTS based system could produce an earlier forecast of comparable accuracy, this could provide for more optimal inventory management and additional benefits. At this writing there is not sufficient experimental evidence on hand to address this issue with certainty. Based upon the work of the next several months we anticipate having an answer in hand.

5. Length of the Benefit Period

The appropriate length of the benefit period is primarily dependent on two factors. These are physical and technical obsolesence of the ERS system. A relatively short benefit period of ten years is used in this analysis because both these lifetimes are relatively short. There is little doubt that satellite and ERS technology will be considerably more advanced in 1986 than at present. Satellite systems also have a relatively short physical lifespan. Even is some components of the ground system would be operative by 1986, it is likely they would be technically obsolete. Consistent with study guidelines, a conservative ten year benefit period is used.

(4) Gross Benefits

Benefit estimation for more accurate crop forecasts has been performed to show the benefits that could be achieved as a function of forecast errors. This parametric or "what-if" type of benefit estimation will permit easy determination of benefits from any level of ERS system performance indicated by future technical data.

1. Assumptions and Procedures

A summary of the assumptions and procedures used to calculate benefits is given below:

- Production, export, and domestic consumption projections were based on Series E U.S. population growth projections incorporating recent demand trends and current USDA export projections.

- Estimates of demand elasticity have been developed based on a survey of the literature and modified based upon conversations with experts in the field. Sensitivity tests on the values of these elasticity estimates are included in the Appendix. Separate domestic and export elasticities have been developed.

- Since benefits in inventory adjustment accrue to the consumers of the commodities, benefits in stabilization of export price and quantity would accrue to export recipients and hence, by the ground rules of the study are not included in U.S. benefits. These benefits have been tabulated separately.

- Within the context of this study, only benefits from better forecasts of domestic production have been calculated. However, it is expected there will be benefits to the U.S., that could be produced by an ERS system, from better forecasts of world production. These benefits will be calculated in the International Analysis and integreated with this report at a later date.

- Government intervention in the agricultural commodity markets at the beginning of the benefit period requires adjustment of the computed benefits regardless of whether the government intervention continues.

- If government support and control programs continue, the range of consumption instability (ΔP and ΔQ) will be narrowed by the government and thus benefits will be reduced. It is impossible at this point to determine the appropriate magnitude of this reduction.

- If government support programs are dropped and support prices were higher than equilibrium prices, production adjustments would occur and the value (PQ) of agricultural production would fall below projected levels thus necessitating adjustments of benefit estimates. From work done elsewhere, indications are that value of production and of benefits should be reduced up to one-third to reflect the assumed production adjustment that would follow removal of government controls.

- Obviously, both of these conditions could not exist simultaneously. Indications for the appropriate magnitude of benefit adjustment are sparse, but the best guide available places the appropriate reduction between zero and one-third. Three benefit estimates will be presented: no reduction, reduction by one-sixth, and reduction by one-third. If government control programs are not expected to affect prices or production, no adjustment is required, and the magnitude of the actual reduction depends upon the strength of government controls in determining prices and production. On balance, reduction of calculated benefits by one-sixth is considered to be the best estimate at this time. Again, as price or policy changes, a simple calculation may readjust benefit estimates.

• Using the "without" system error for the September forecast as a base, benefits are calculated for assumed reductions in the forecast error by crop. The September forecast was chosen for two reasons:

  - It is the last forecast before harvest for which USDA data are available for most crops. Since the forecast is late in the growing season, accuracy levels are quite high. Using these "without" system error rates produces a conservative measure of benefits which is consistent with the general study posture.

- The forecast is late enough in the growing season for data to have been collected and analyzed for several satellite passes. A September forecast could incorporate all data received through August. It has been demonstrated that ERS system accuracy improves with multiple imagery. Thus, the later in the growing season, the more likely it is that an ERS system could provide an improved forecast.

2. Benefit Estimates

Table III-9 lists benefits by crop for an assumed 10%, 20%, and 30% reduction in forecast error as compared to the "without" system and tables III-10 and III-11 list the annual benefits. These tables include benefits from better forecasts of the ten selected crops which account for about 60% of the total value of farm production annually in the U.S. plus extrapolated benefits. Figure III-14 is a benefit curve for corn relating the without system error (4.1%) to any level of improved error.

- Benefit Extrapolation

  Benefits estimates were extrapolated from the ten crops representing 60% of the value of farm production to 80% of the value of farm production. The ten crops selected include the major grain crops which constitute a substantial portion of the farm production and also are the crops which are expected to have the largest field size and hence greater ERS system measurement accuracy. Moreover, many of the additional crops in the other forty percent of farm production would be expected to have complex crop mixtures and average field sizes too small for best identification and measurement using an ERS based system. USDA forecast errors could be expected to be large for these crops, but ERS system errors could also be high. However, a small improvement in high error rates can be significant because benefits are proportional to the difference of the squares of the "without" and ERS system errors. An improvement in error from 9% to 8% provides more than three times the benefits of an improvement from 3% to 2%.1/

1/ $(.09)^2 - (.08)^2 = (.0081 - .0064) = .0017$

$(.03)^2 - (.02)^2 = (.0009 - .0004) = .0005$

Benefit ratio = 17/5 = 3.4

PRESENT VALUE BENEFIT ESTIMATES FOR IMPROVEMENT IN DOMESTIC FORECAST ACCURACY

CROP	USDA SEPT. FORECAST ERROR	ERROR WITH ASSUMED 10% IMPROVEMENT	ESTIMATED UPPER BOUND FOR INVENTORY ADJUSTMENT BENEFITS	ESTIMATED REDUCED BENEFITS FROM GOV'T CONTROL PROGRAM 1/6	ESTIMATED REDUCED BENEFITS FROM GOV'T CONTROL PROGRAMS 1/3 red.	ERROR WITH ASSUMED 20% IMPROVEMENT	ESTIMATED UPPER BOUND FOR INVENTORY ADJUSTMENT BENEFITS	ESTIMATED REDUCED BENEFITS FROM GOV'T CONTROL PROGRAMS 1/6 red.	ESTIMATED REDUCED BENEFITS FROM GOV'T CONTROL PROGRAMS 1/3 red.	ERROR WITH ASSUMED 30% IMPROVEMENT	ESTIMATED UPPER BOUND FOR INVENTORY ADJUSTMENT BENEFITS	ESTIMATED REDUCED BENEFITS FROM GOV'T. CONTROL PROGRAMS 1/6 red.	ESTIMATED REDUCED BENEFITS FROM GOV'T CONTROL PROGRAMS 1/3 red.
CORN	4.1	3.7	41.8	34.8	27.9	3.3	79.3	66.1	52.9	2.9	112.5	93.8	75.0
RICE	2.3	2.1	1.0	.9	.7	1.8	2.4	2.0	1.6	1.6	3.2	2.62	2.1
SORGHUM GRAIN	3.8	3.4	6.7	5.5	4.4	3.0	12.6	10.5	8.4	2.7	16.5	13.8	11.0
SOYBEANS	2.0	1.8	4.5	3.8	3.0	1.6	8.6	7.1	5.7	1.4	12.1	10.1	8.1
COTTON	5.8	5.2	14.3	11.9	9.5	4.6	26.9	22.5	18.0	4.1	36.3	30.3	24.2
POTATOES-FALL	4.3	3.9	7.8	6.5	5.2	3.4	16.5	13.7	11.0	3.0	22.6	18.8	15.0
OATS	2.8	2.5	1.8	1.5	1.2	2.2	3.4	2.8	2.3	2.0	4.4	3.6	2.9
WHEAT	2.5a 3.3b	2.[illegible] 3.0	1.9 13.5	1.6 11.2	1.3 9.0	2.0 2.6	4.5 29.4	3.8 24.5	3.0 19.6	1.8 2.3	6.1 39.9	5.0 33.2	4.0 26.6
BARLEY	1.2	1.1	.3	.2	.2	1.0	.5	.4	.4	.8	.9	.8	.6
SUGAR BEETS	2.7	2.4	5.5	4.6	3.7	2.2	8.8	7.32	5.9	1.9	13.2	11.0	9.8
TOTAL	3.0c		99.0	82.5	66.0		192.8	160.7	128.6		267.6	223.0	178.4
APOLATED TO OF FARM VALUE			115.5	96.2	77.0		225.0	187.5	150.0		312.2	260.2	208.2
RAPOLATED TO OF FARM VALUE			132.0	110.0	88.0		257.1	214.3	171.4		356.8	297.3	237.9

Discounted Total Farm Value = 111,005.81

a - spring wheat, September forecast
b - winter wheat, May forecast
c - unweighted average

TABLE III-10

AVERAGE ANNUAL BENEFITS AND CONSUMPTION

CROP	AVG. ANNUAL CONS.	AVG. ANNUAL BENEFITS[1]	BENEFITS AS A % OF CONSUMPTION
Wheat	1,486	4.70	.316
Rice	300	.32	.108
Corn	7,629	10.89	.143
Soybeans	4,064	1.19	.029
Cotton	1,054	3.66	.347
Sugarbeets	467	1.20	.257
Potatoes	774	2.24	.290
Sorghum Grain	1,128	1.75	.155
Oats	610	.47	.076
Barley	555	.07	.014
TOTAL	18,066	26.49	.147
EXTRAP. TOTAL[2]	21,077	30.90	.147

[1]Using a 20% improvement in error rate, a 1/6 reduction for government control.

[2]Extrapolated to 70%

Table III-11

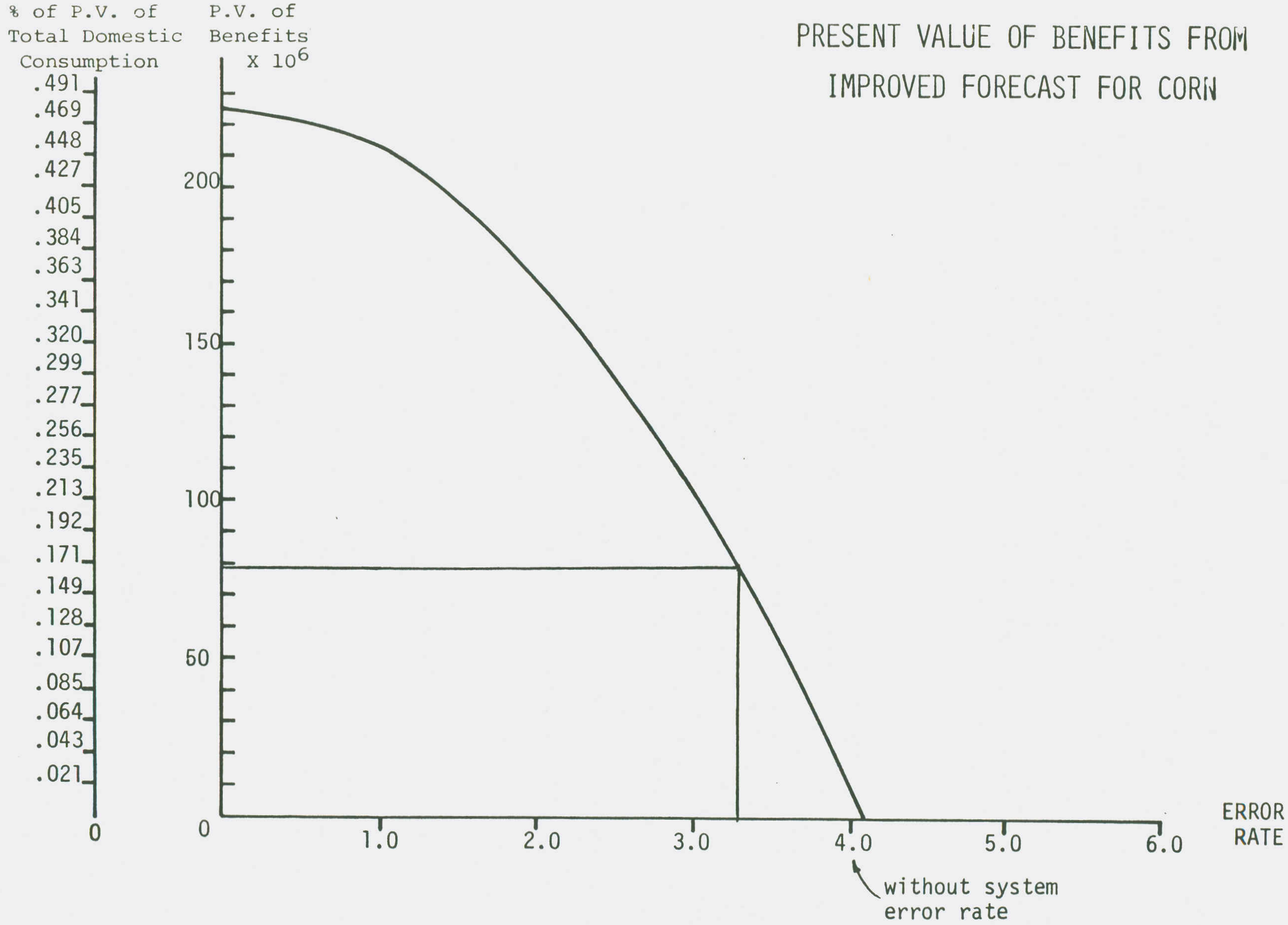
YEARLY BENEFITS BY CROP ASSUMING A 20% IMPROVEMENT IN ERROR RATE

YEAR	WHEAT	RICE	CORN	SOYBEANS	COTTON	SUGARBEETS	POTOTOES	SORGHUM GRAIN	OATS	BARLEY	TOTAL
1977	4.82	.34	12.01	1.25	4.33	1.43	2.63	1.87	.54	.07	29.29
1978	4.99	.35	12.24	1.28	4.33	1.40	2.61	1.89	.53	.08	29.70
1979	5.26	.36	12.56	1.30	4.39	1.39	2.65	1.89	.54	.09	30.43
1980	5.58	.37	12.88	1.33	4.39	1.37	2.67	1.90	.54	.08	31.11
1981	5.69	.39	13.05	1.38	4.39	1.40	2.68	2.00	.55	.09	31.62
1982	5.80	.40	13.23	1.43	4.39	1.43	2.70	2.09	.56	.08	32.11
1983	5.91	.41	13.41	1.49	4.43	1.46	2.72	2.19	.57	.09	32.68
1984	6.02	.42	13.59	1.55	4.43	1.48	2.74	2.29	.57	.09	33.18
1985	6.13	.43	13.77	1.61	4.43	1.52	2.76	2.38	.59	.09	33.71
1986	6.24	.45	13.94	1.66	4.43	1.55	2.78	2.48	.60	.10	34.23
TOTAL	56.44	3.92	130.68	14.28	43.94	14.43	26.94	20.98	5.59	.86	318.06
AVERAGE ANNUAL	5.64	.39	13.07	1.43	4.39	1.44	2.69	2.10	.56	.09	31.81

Average annual benefits with 1/6 reduction for government controls = 26.51
Average annual benefits with 1/3 reduction for government controls   21.21

Figure III-14

PRESENT VALUE OF BENEFITS FROM IMPROVED FORECAST FOR CORN



PRESENT VALUE OF TOTAL DOMESTIC CONSUMPTION = 46,874.47

AVERAGE ANNUAL DOMESTIC CONSUMPTION = 7,628.60

Nothing definitive can be said about elasticities for these crops as a whole. Many are used only in food consumption (as opposed to feed), and elasticities could be expected to be generally lower. However, some of the food crops are "luxury" foods and hence would be expected to have higher elasticities. No general trend is evident for elasticities for this group of crops.

In the absence of more definitive information on elasticities, expected error rates, and considering accuracies on small field sizes, it is deemed appropriate to extrapolate benefits to the seventy and eighty percent levels. At this writing, it is not probable that an ERS based system could accurately forecast crops accounting for more than 80% of the farm production. Using the benefit figure of $160.7 million for the ten crops studied, the extrapolated national benefit estimates would be $187.5 and $214.3 million using seventy and eighty percent bases respectively.

- Benefit calculations

It is useful to note that the benefit table and the calculation algorithm behind it provide substantial information beyond the total benefit estimates listed. Using the adopted procedure, benefits may be found for any initial and final error rates and error rates may be varied by crop. Additional sensitivity tests may be conducted on elasticity estimates as a group or individual crop estimates may be varied. Different government policy effects may be assumed and calculated with ease. Also, alternate projections of production and consumption may be used. The program used for benefit calculation is included in Appendix B. The program is quite flexible and adaptable to suit special requirements.

(5) Distribution of Benefits

Benefits derived from better crop forecasts are distributed vis. a vis. the pattern of consumption of the commodities. The benefits arise from increases in consumer's surplus due to reduced price instability. Total food consumption is used as the measure for distribution. Since the commodities being studied were all crops, separating meat consumption from total consumption was considered. This procedure was rejected because much of the crop output is used for animal feed to produce meat and poultry products. Therefore, much of the benefit is channeled through meat production. Using total food consumption as the distributional measure assumes that feed price stability and the benefits thereof are shifted to consumers of meat and poultry products.

Several data sources were considered for information on income distribution, regional distribution of families, and food consumption expenditures by income class and region:

- BLS 1960 survey - Since the 1972-73 BLS survey data will not be available in time for this study, the 1960 BLS data is the most comprehensive data source available.

- Market Profiles of Consumer Products - prepared by the National Industrial Conference Board. This source used 1960 BLS data, displayed consumption patterns in more detail, and updated the data to a 1966 basis.

- "A Cross-Sectional View of U.S. Food Consumption," by Helen M. Eklund, USDA, 1969. This source calculated food consumption by region and income class in index form for the year 1965.

- Profiles of Consumer Markets - Life study of consumer expenditure. This source used data from an independent survey of more than 10,000 households for the years 1955-56.

The National Industrial Conference Board data was selected for use in the analysis. The data is adjusted to 1966, so it is relatively recent. It is based on 1960 BLS data and therefore should be quite reliable. This source was chosen over 1960 BLS data because it is equally reliable and more current. The Life survey was rejected because of the age of the data, and the USDA source was not selected because it offered no advantages over the other sources and was presented in index rather than money form.

The team also considered adjusting 1960 BLS consumption data to 1970 income levels and using 1970 Census income. This idea was rejected, after consultation with BLS economists, for the following reasons:

- Prices and purchasing power change over time making the direct comparison not valid.

- Income distribution from Census decennial figures is lower than the BLS distribution because all income is not reported. A better census source is the annual income survey which is a part of the current population survey.

The distribution analysis has been performed by sector, region, and by income class. All of the benefits occur in the agricultural sector but accrue to consumers of agricultural commodities. These consumers are distributed by region and by income class. Table III-12 summarizes the results of the regional distribution of benefits using a benefit figure of $160.7 million.

Table III-12

REGION	% of FAMILIES	% of BENEFITS	AMOUNT OF BENEFITS
Northeast	26.5	30.5	49.0
North Central	27.0	26.0	41.8
South	29.0	25.0	40.2
West	17.5	18.5	29.7
TOTAL			160.7

As might be expected, those regions with the higher per capita income levels (Northeast and West) consume more food and thus receive a greater proportional share of the benefits than the poorer regions. The contrast is most marked comparing the South and the Northeast. The distribution of actual benefits can be calculated using any benefit figure by multiplying the benefit by the proportion for each region.

Benefit distribution by income class also follows the pattern that would be expected with the poor spending a larger proportion of their income on food than the rich. Upper income families spend more on food in total, but poor families spend more as a percent of their income. Table III-13 summarizes the results of the income class distribution analysis:

Table III-13

CLASS	% OF FAMILIES	% OF INCOME	% OF BENEFITS	AMOUNTS OF BENEFITS
under $3000	16.0	4.0	6.5	25.7
$3000 - $5000	15.0	7.0	10.5	24.1
$5000 - $7500	21.0	17.0	19.0	33.7
$7500 - $10,000	19.0	19.0	21.5	30.5
$10,000 & over	29.0	53.0	42.5	46.6
TOTAL				160.7

Gini coefficient for income distribution = .320 [1/]
Gini coefficient for benefit distribution= .209

G_B/G_Y= .65

In Figure III-15, the distribution of income and benefits is shown graphically. The diagonal OA represents complete equality in income distribution. The closer the distribution curves are to the diagonal, the more equal is the distribution. As can be seen from the diagram, the distribution of benefits is more eqal than the distribution of income.

It is generally agreed that the best single measure of income inequality is the Gini index of concentration. 2/ The Gini index is the ratio of the area between the diagonal and the distribution curve to the total area under the diagonal. The smaller the ratio, the smaller the degree of inequality. To calculate the index, the curves between points are assumed to approximate straight lines and the area under the trapezoidal sections is then summed:

$$\text{Index} = \frac{.5 - \sum (1/2)(b)(h_1+h_2)}{.5} = 1 - \sum (b)(h_1+h_2)$$

b = % of families between points
h_1= cumulative distribution of income for left side of trapezoid
h_2= cumulative distribution of income for right side of trapezoid

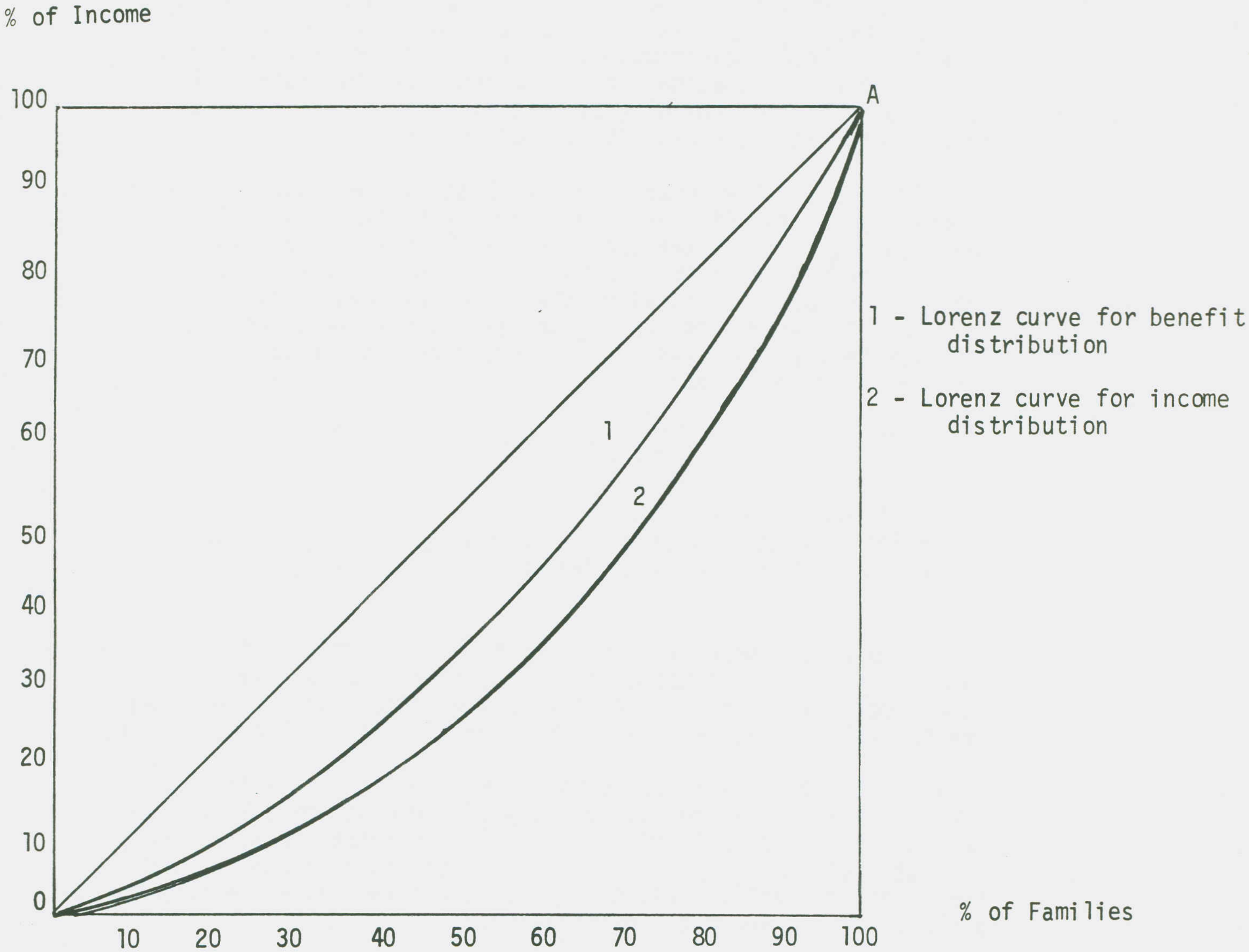
The ratio of the benefit Gini index to the income distribution index is a measure of the difference between the two distributions. 3/ If the ratio is equal to one, the equity effects of the investment are neutral. If it is greater than one, the distributional effects

1/ This coefficient may not be comparable with other coefficients found in the literature because only five classes have been used and the linear approximations may be less precise. However, only the ratio of the income and benefit coefficients is useful, and the ratio is a valid measure so long as the same data and computation process is used for both coefficients.

2/ Morgan, James. "The Anatomy of Income Distribution" Review of Economics and Statistics. (44) August, 1962 pp. 270-283.

3/ Kalter, Robert J. and Thomas H. Stevens. "Evaluation of Public Investments: Distributional Impacts of Water Resource Projects" Search Agriculture. Vol. 2, No. 12 Cornell University Agricultural Experiment Station.

FIGURE III-15
LORENZ CURVES FOR INCOME
AND BENEFIT DISTRIBUTIONS



of the investment tend to more inequality, and if it is less than one the distribution of benefits is more equal than the distribution of income. In this case the ratio is less than one confirming the equalizing distributional effects of the benefits for this case study.

The preceding analysis is clearly only a distribution of the gross benefits in inventory adjustment and does not consider the distribution of costs. The distribution of costs will be done for the entire satellite system after the individual case studies are complete. At that point distribution of gross benefits for each case study will be summed and combined with the cost distribution to obtain a distributional analysis of net benefits for the entire system including all anticipated benefits and costs.

(6) Cost Estimates for Alternative Systems

This section discusses the estimation of the costs of the data processing and analysis needed for an ERS based crop reporting system. Cost estimates for this case study have not been prepared at this time for two reasons:

- Substantial uncertainties exist regarding the design of the statistical sampling plan and data analysis system and their associated costs.

- Data processing facilities for producing crop acreage forecasts would likely be used for other purposes as well, including the processing of data on crop yield and stress and possibly forestry and range.

The factors involved in the design of satellite and aircraft ERS systems for crop surveying have been discussed in detail above. Such systems must include a means of assembling, for each survey, a set of sample units for which ERS imagery would be interpreted. This involves consideration of the relationships between the distributions in space and time of the relevant crop characteristics (spectral reflectance, growth stage, field size, homogeniety) and the system characteristics (cloud cover, resolution, spectral coverage, swath width, and flight path).

The statistical sampling design must resolve these issues. For a satellite system, this would determine the number, area, location and timing of the sample units that need to be interpreted, and the associated ground truth. The requirements and costs for a high altitude aircraft fleet also cannot be established without a statistical sampling plan design. Given such a design, it would be necessary to analyze alternate flight path patterns which would provide mission flexibility in the event of inclement weather in one region. Specific timeliness and repetition rate requirements need to be established to provide a baseline for the aircraft fleet sizing.

Since there is not sufficient technical information in currently available experiment reports, the task of relating these various factors to the costs of the system will be deferred until later in the study. In addition, the completion of other case studies in Agricultural Production and Forestry will make possible, at that time, the treatment of the sharing of the overhead costs of an agricultural survey system.

(7) International Benefits from Improved Crop Forecasting

1. The "Without" System

The basic data needed for the international impact analysis was also sought in the course of conducting the case study. Current estimates of foreign production lack both accuracy, timeliness and comparability. Foreign estimates are reported to USDA by that department's network of agricultural attachés abroad. The attache' in turn depends on his own subjective analysis, the official estimates of foreign governments, estimates made by large trade companies (e.g., Cargill's estimate on Brazilian corn) which may be available to him through unofficial contacts. Data by USDA published on foreign production is limited to very general gross forecasts and historical data on actual production with reporting delays of months, often years.

The problem of studying the accuracy of foreign data is complicated by the many nations and the political issues involved. Some assumptions will have to be made about the current system based on the obvious gaps and delays. Benefits of better foreign crop reporting from an ERS system will depend upon the crop concerned, the current system of national statistics in the nations concerned and the role of that country in the U.S. export market. The types of roles include:

- a country that usually produces a competing export
- a country that always produces a competing export
- a country that usually is self-sufficient in food and fiber
- a country that occasionally requires imports
- a country that always requires imports

2. Potential Benefit Areas

Improved global forecasts (of crop production) would benefit the U.S. in at least three different ways through:

- A more efficient inventory policy and more optimal private inventory management
- Improved production decisions; and
- Larger (or higher valued) exports which would contribute to strengthening the balance-of-payments of the U.S.

Each of these potential benefit areas will be addressed below, but before doing so, a certain number of clarifying points should be made.

First, the total demand for U.S. commodities (D_t) can be divided into three fairly distinctive parts: domestic demand (D_d), commercial export demand (D_f), and concessionary (PL 480) exports (D_a)

$$(1) \quad D_t = D_d + D_f + D_a \text{ 1/}$$

Until recently these three types of demand were relatively compartmentalized. Domestic demand was a function of income in the U.S. and relative prices of these commodities which in turn were substantially influenced by the various price support programmes such as acreage controls and soil bank. Commerical exports depended on income abroad (in the major importing nations), export prices (including subsidies), and levels of protectionism in importing countries such as the variable-levy system of the Common Agricultural Policy in the EEC. Finally, concessionary exports were either extended purely on humanitarian or relief grounds or on the basis of relatively long term dollar loans at subsidized interest rates and conditional upon recipient countries undertaking self-help policies to improve their capacity to feed themselves directly or indirectly. By Congressional intent, food aid (D_a) was not to compete with commerical foreign demand (D_f).

1/ At this stage, we abstract from changes in stocks, i.e., net addition to inventory or net depletions from inventory.

Likewise, domestic demand (D_d) did not really compete with foreign demand (D_f) since because of the subsidy element the U.S., in fact, was using a two-price policy for a number of commodities.

Very recently, because of a combination of reasons such as simultaneous crop failures in many producing countries, purchases at favourable prices by the USSR and, in general, high population growth trends, commodity prices have risen dramatically and D_f may become - or has become - competitive with D_d. At the same time the real cost of D_a has increased drastically since for the same level of Congressional appropriations the actual volume of food which can be purchased is greatly reduced. The days of surplus-disposal programs where the opportunity - cost of food tended towards zero may be over and D_a may become competitive with D_f and D_c. Thus, it appears that in the present market the degree of competition between these three types of demand is increasing. The best guess is that the events of 1972-73 are unlikely to repeat themselves soon so that there will again exist a certain degree of compartmentalization between these three types of demand in the future - but much less than prior to 1972. In any case, this question has to be analyzed at the commodity level to make sense.

Now, the effects of improved global forecasts on U.S. welfare can be examined: (a) inventory policy; (b) production decisions; and (c) exports.

- <u>Inventory Policy and Inventory Adjustment Benefits</u>

  Clearly, improved global forecasts should be an essential element in judging total world production over a given future time period - say over the next 6 months. With estimates of world demand for any given crop it is then possible to estimate the effects of predicted output on world prices. (For major countries, estimates of import demand might also be useful). Forecasts which imply price rises - as would have been the case in 1972-73 - have important implications for inventory depletion policy. Depending on the level of stocks - a slowdown in the depletion rate would make prices rise more gradually and provide a signal to the producers - and vice-versa. If stocks were very large and the goal was price stability and it was clear that the events leading to shortfalls were temporary, the depletion rate could be accelerated and the stock reserve used as a true buffer. It is important to specify the policy objectives which may be different for the public and private spheres.

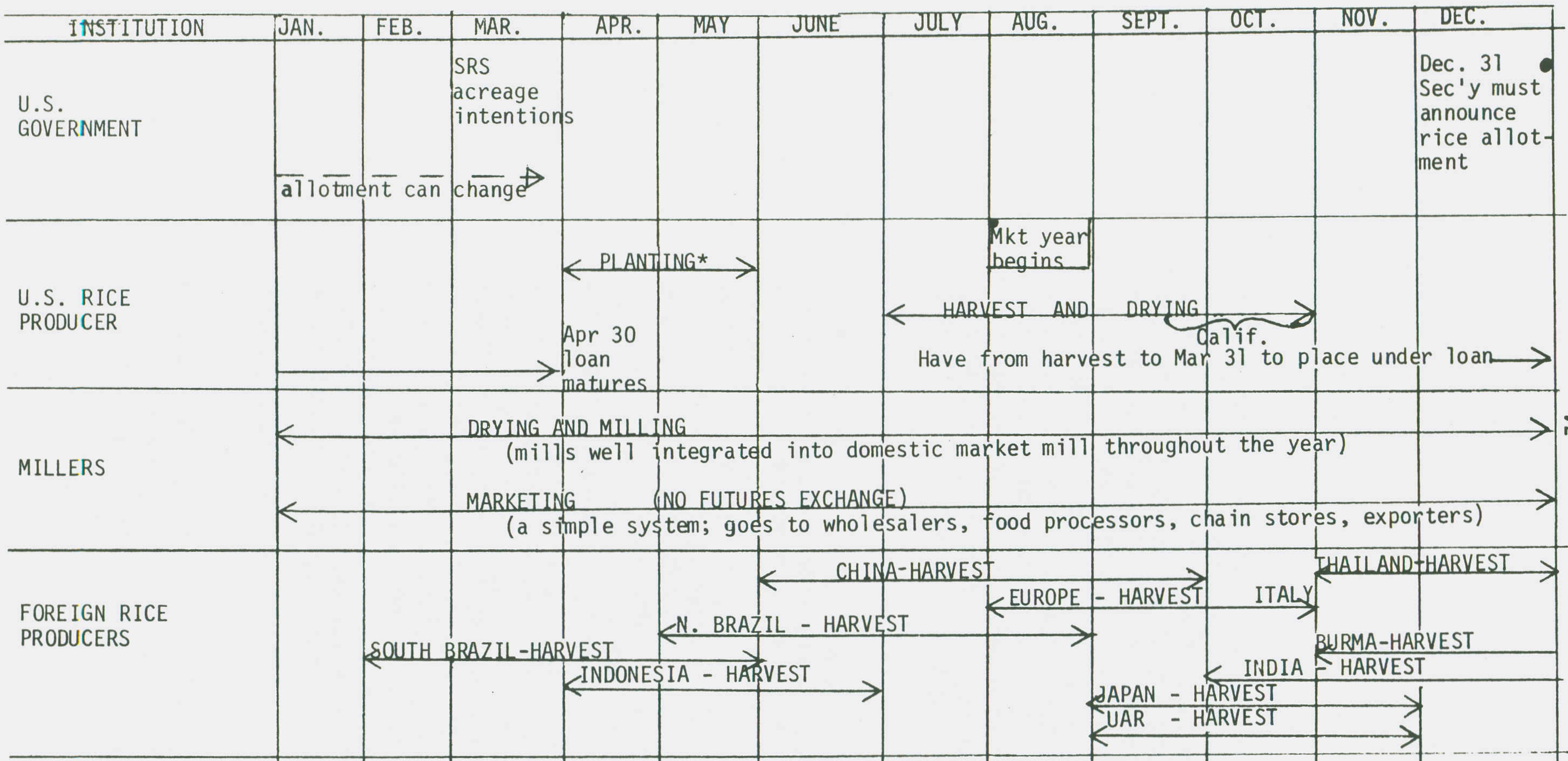
- Production Adjustments

In the previous example, global forecasts which would tend to indicate a drop in world supply and consequent price rises should be of great importance to policy-makers (USDA) in altering their supply controls (e.g., acreage limitations) and price policies to encourage greater domestic supply in the short-run. As an example, Figure III-16 illustrates the sequence of actions undertaken in the world production and distribution of rice. Producers (farmers) could benefit - if decisions were rationally taken - in the light of short-run and long-run estimates of supply and demand elasticities. The impact of improved forecasts on U.S. production is becoming much more important because of the greater degree of competition between the three types of demand discussed previously - as the U.S. is moving, at least temporarily, from a position of producing large surpluses to one of possible shortages.

- Exports

Clearly, any contribution which improved global forecasts can lead to production decisions which would be reflected in larger exports (in value terms) and would benefit the U.S. balance-of-payments. This is a crucial contribution at this time - given: (a) the historical balance-of-payments deficits which led to the *de facto* dollar devaluations and the breakdown of the international monetary system - based on fixed exchange rates; and (b) the large present and future potential contributions of agricultural exports to the improvement in the balance-of-payments.

INSTITUTIONS, ACTIONS, & INTERRELATIONSHIPS: RICE



* rotated on most U.S. rice farms on a 3-year cycle. In years rice is not grown, fields may be used for soybeans, cattle grazing or fish breeding.

3. Effects on World Food Policy

One additional point relates to FAO's plans to set up a World Food Research Scheme to which all producing countries would contribute. The World Bank has indicated a strong interest in such a program. The potential for better global forecasts as a "management tool" in running such a scheme would be potentially great. Indirectly, it could also benefit the U.S. by permitting it to run a more efficient food aid policy. Even in the absence of a World Food Reserve Scheme, a case can be made that better global forecasts would improve the efficiency of U.S. food aid policy.

IV. ENVIRONMENTAL AND SOCIAL IMPACT ANALYSES

This chapter summarizes the approach used and the results of the evaluation of environmental and social costs and benefits. These analyses follow completion of the case study economic efficiency and distribution evaluation. The results presented follow from an analysis of the environmental and social impacts that parallel the economic impacts. They do not, at this point in the study, represent an evaluation of the total environmental and social impacts from all uses of ERS data in the broad area of Agricultural Production. Other case studies and reviews remain to be performed before this can be accomplished.

The presentation is presented in the following parts:

- Environmental impact analysis
- Social impact analysis

1. ENVIRONMENTAL IMPACT ANALYSIS

The purpose of the environmental analysis is to evaluate the impacts of ERS data utilization on the quality of the human environment. Performance of the environmental analysis yields four products.

- Identification of potential ERS data impacts on management, conservation, preservation or improvement of the quality of natural resources and ecological systems
- Estimation of the benefits to environmental quality that will result from these impacts
- Estimation of the costs to environmental quality that will result
- Development of information required for CEQ environmental impact statements.

Section 102(2) (C) of the National Environmental Policy Act requires preparation of impact statements on proposals for "major Federal actions significantly affecting the quality of the human environment." The Council of Environmental Quality (CEQ) guidelines for impact statements call for agencies to "assess in detail the potential environmental impact," consturing "major" and "significantly" with a view "to the overall, cumulative impact of the actions proposed." 1/

1/ Preparation of Environmental Impact Statements: Guidelines, Fed. Register, Vol. 38, 20550-20562, August 1, 1973.

In a memorandum expanding upon its impact statement guidelines, the CEQ recommended that agencies develop "lists of the full range of impacts" that are likely to result from the actions typical of their programs.2/ Several such lists have been published, by the U.S. Geological Survey 3/, by the Water Resources Council4/, and by the U.S. Forest Service5/. The Water Resources Council, for example, suggests consideration and quantification of impacts on the elements listed in Table V-1. Because of the broad range of ERS data applications, these lists and those prepared by other agencies for impact statement preparation have been reviewed and a comprehensive list developed. A summary of this list, shown in Table V-2, is used to identify the potential environment impacts of ERS data use.

It is important to recognize that the environmental impact analysis must ultimately deal with ecological systems that comprise the biosphere. Impact lists are limited in their ability to reflect the continuous interaction of the primary energy and chemical cycles that sustain life. Nevertheless, they represent a simplification of complex ecological relationships, highlighting areas of potential impact which more detailed analyses in the past have indicated to be potentially significant.

It is expected that the environmental impacts of ERS data will arise from two types of applications:

- Those environmental management applications in which the decision-makers' primary objectives are to conserve, preserve, or enhance environmental quality

- Those applications in which the decision-makers' primary objectives are to maximize the net benefits from resource extraction, production or consumption. The environmental impacts in these applications will be secondary effects resulting from meeting the primary objective.

2/ Council on Environmental Quality Memorandum to Federal Agencies on Procedures for Improving Environmental Impact Statements, Environmental Reporter, Vol. 3, No. 3 - p. 82, 19 May 1972.

3/ Leopold, Luna B. et. al., A Procedures for Evaluating Environmental Impact, Geological Survey Circular 645.

4/ Water Resources Council, Proposed Principles and Standards for Planning Water and Related Land Resources, Fed. Register 234, Vol. 36, p. 24159-62, 21 December 1971.

5/ U.S. Forest Service Procedures for NEPA, Fed. Register, Vol. 36, p. 23670, 1971.

Table IV-1

Classes of Environmental Effects
Suggested by the Water Resources Council

Open and Green Space
Wild and Scenic Rivers
Lakes
Beaches and Shores
Mountains and Wilderness Areas
Estuaries
Other Areas of Natural Beauty
Archeological Resources
Historical Resources
Biological Resources
Geological Resources
Ecological Systems
Water Quality
Air Quality
Land Quality

Table IV-2

Summary of
Potential Environmental Impacts

Primary Environmental Element	Important Components	Aspects of Quality
Earth's Crust	Land form Soils Subsurface Resources Unique or Critical areas	Land use Resource reserves Open space Historic or Archeological Value
Water Bodies	Rivers and streams Lakes and other fresh water impoundments Estuaries Oceans	Concentration of pollutants Acidity Temperature Turbidity Dissolved Oxygen Odor
Atmosphere	Oxygen Carbon Dioxide Nitrogen Water Vapor Particulates	Concentration of pollutants Humidity Temperature Odor Noise Radiation
Fauna	Domesticated species Wild species Endangered species Pests	Vigor Population Size Population Distribution
Flora	Agricultural species Lumber & Pulp species Wildlife Habitat	Vigor Population size Population Distribution
Human Culture	Human Population	Population size Population Distribution

The direct environmental management applications will be treated by case studies defined in that broad area. The evaluation of the significant environmental costs and benefits that arise from use of ERS data in extraction, production, and consumption activities follows the performance of the economic efficiency analysis. In most of these activities environmental impacts are expected to arise from changes in the magnitude and location of the use of resources. Estimates of these changes will be based both on ERS data and on the economics of the actions taken. ERS data may also aid these decision-makers' in achieving required environmental quality standards at minimum cost. In these situations the economic efficiency analysis and the environmental analysis are performed together. Because of the large number of potential indirect impacts, this analysis is limited to significant impacts which can be predicted with reasonable accuracy and which can be directly attributed to ERS data utilization.

The environmental analysis for the case study on crop acreage estimation focused primarily upon inventory adjustments because the case study concluded that they were the most significant actions taken on the basis of crop reports. A review of the list of potential environmental impacts resulted in the conclusion that no significant environmental impacts would be expected to arise from the use of ERS data in crop acreage estimation.

2. SOCIAL IMPACT ANALYSIS

The discussion of the impacts from use of ERS data has focused thus far on economic and environmental aspects. For most applications, there will be impacts on the quality of life in our society which are not adequately reflected in measures of their economic and environmental aspects. The purpose of the social impact analysis is to evaluate this residual category, the social aspects of impacts from ERS data use. Some potential applications have as their primary objective the provision of public goods or services or the enhancement of social well-being in ways not measurable using economic and environmental criteria. In others, the social impacts arise primarily as side-effects of actions taken with economic or environmental objectives. The provision of crop forecasts is primarily a case of the second type. This section discusses the general approach for identifying and evaluating social impacts and gives the results of the analysis for the crop estimation case study.

The development of indices for measuring overall social well-being, or Quality of Life (QOL) as it has come to te called, has been the subject of recent efforts by a variety of social scientists.1/ While these

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1/ The Quality of Life Concept: A Potential New Tool for Decision Makers, Environmental Protection Agency, 1973.

efforts have not yet produced a set of measurement techniques that are useful for the purposes of this study, they have provided insight into the factors which are considered important to social well-being. One list of such factors is presented in Table IV- 3. The natural environment factors included in this list are to be analyzed in this study as part of the environmental analysis. In addition to the factors in the man-made environment, social and political categories, a list was developed to include effects that would not be quantified in the other analyses performed in the study. These are shown in Table IV- 4.

The social analysis identified two impacts that could significantly influence the value of ERS data for crop acreage estimation:

- changes in competitive structure of the commodity markets;
- changes in employment and job skills related to crop surveys;

Those impacts are discussed below.

Economic theory recognizes the importance of information to the competitive operation of markets. An improvement in the accuracy, timeliness or availability of information can, in general, be expected to improve competition. An important social impact may arise from improved crop forecasts through changes in the availability of accurate crop information to the different types of inventory holders.

Inventories of major crops are held by farmers, farm cooperatives, and small and large commodity trading firms. The commodity market tends to be dominated by a small number of large firms, especially in internationally traded grains. Three firms handle about 70 percent of world grain shipments.1/

Crop information is gathered by both private and public means. Farmers and small firms can be expected to depend more on public sources of crop information while large firms devote their own resources to gathering additional data. A major objective of the USDA crop reports is to provide the farmer knowledge of the value of his crops. This Congressionally stated intent may be furthered and the ability of the small inventory holders to compete with the large may be improved by improving the accuracy of crop forecasts.

1/ Business Week (March 11, 1972), P. 84.

Table IV-3

Quality of Life Factors

Natural Environment

- Air Pollution
- Water Pollution
- Noise Pollution
- Aesthetics
- Land-Use Planning
- Ecosystem Balance
- Radiation Hazards
- Pesticide/Chemical Contamination
- Soil Quality
- Solid Waste

Man-Made Environment

- Leisure Facilities
- Work Environment
- Housing
- Technology
- Aesthetics
- Transportation
- Material Quality
- Utilities
- Physical Structures

Social

- Education
- Family Structure
- Status
- Culture
- Privacy
- Safety
- Social Stability
- Personal Skills
- Equality
- Choices in Life
- Community
- Wealth

Political

- Opportunity Structure
- Information Media
- Democratic Process
- Civil Liberties
- Justice

Source: The Quality of Life Concept, Environmental Protection Agency, 1973; pp. I-63 through I-69.

Table IV-4

Additional Factors For
Social Impact Analysis

INSTITUTIONAL STRUCTURE
- Government vs. Private
- Federal vs. State vs. Local

POPULATION
- Distribution
- Size
- Density

EMPLOYMENT OPPORTUNITIES
- Employment Structure
- Satisfaction

QUALITY OF BASIC GOODS
- Nutrition
- Clothing
- Shelter

HEALTH
- Morbidity
  - Disease
  - Injury
- Mortality
  - Infant
  - Child
  - Adult

SAFETY (INCLUDING CRIME CONTROL)
- Personal Injury
- Property Damage or Loss

INSTITUTIONAL COMPOSITION
- Economic Concentration
- Information Media Concentration
- Governmental Centralization

RECREATION ACTIVITIES
- Quality of Experience
- Diversity of Opportunity
- Geographic Distribution

ECONOMIC MOBILITY

EQUALITY

MOOD/ATMOSPHERE
- Awe-Inspiration
- Isolation-Solitude
- Mystery
- Oneness with Nature
- Privacy
- Challenge- Excitement

ENVIRONMENTAL QUALITY, N.E.C.*

JUSTICE

EDUCATIONAL
- Disciplines
- Levels

SCIENTIFIC RESEARCH

HISTORIC RESEARCH
- Anthropological
- Archeological

CULTURAL HERITAGE

* N.E.C. - Not elsewhere cited

This social impact can be expected to vary substantially with the type of information. Information on world crop production collected by large commodity firms is currently more accurate than that publically available. A widely disseminated world crop report based on ERS data could be expected to be of major value to farmers and small traders who currently have limited access to such information. National crop data is currently available to small and large firms alike. Because private information is relatively less important at the national level, increases in the accuracy of public crop reports will have less impact on competitiveness of small firms.

At the regional level, the information available varies substantially from crop to crop and region to region. Much information flows through informal channels among county extension agents, farmers, farm cooperatives, food processors and financial institutions. As noted in the economic benefit analysis, it is difficult to separate actions based on local information from those based on national information. It is also difficult to assess the balance between public and private information. It is likely, however, that the competition is more even at the local level than in the large national and international markets despite recent trends toward concentration in farm ownership and operation. This would tend to limit the impact on competitiveness of improved local crop information.

The shift from ground enumeration to ERS data would result in some changes in employment structure and skills within the crop survey institutions. Retraining in use of ERS data would be required and some new staff with skills in interpretation of ERS data would be needed to operate an ERS crop forecasting system. Some of the currently employed ground enumerators would probably be no longer needed. Many are employed part time in crop enumeration and would lose a supplement to their other sources of income. Ground truth collection, however, would continue to require some enumerators. While these changes would be significant within the USDA, their impact on total national employment patterns would not be substantial.

APPENDIX A

SENSITIVITY TESTS ON ELASTICITY ESTIMATES

This appendix contains results of the benefits using increased and decreased demand elasticities. According to the formulae used to calculate benefits, the larger the elasticity the smaller the benefit:

$$B = E^2 PQ/\alpha$$

Tables A-2 and A-3 display benefits using one half of the selected elasticities and 1.5 times the selected elasticities. It is quite simple to calculate benefits for any range of elasticities. Benefits are multiplied by the reciporocal of the elasticity adjustment. Table A-1 lists benefit multipliers for a range of elasticity values:

Table A-1

Multipliers for A Range of Elasticities Values

Elasticity	Benefit Multiplier
.1E	10.000
.2E	5.000
.3E	3.333
.4E	2.500
.5E	2.000
.6E	1.667
.7E	1.429
.8E	1.250
.9E	1.111
1.1E	.909
1.2E	.833
1.3E	.769
1.4E	.714
1.5E	.667
1.6E	.625
1.7E	.588
1.8E	.556
1.9E	.526
2.0E	.500
2.5E	.400
3.0E	.333

E = selected elasticities

Table A-2

BENEFITS USING ELASTICITIES INCREASED BY 50%

	USDA SEPTEMBER FORECAST ERROR	ERROR WITH ASSUMED 10% IMPROVEMENT	ESTIMATED UPPER BOUND FOR INVENTORY ADJUSTMENT BENEFITS	ESTIMATED REDUCED BENEFITS FROM GOV'T CONTROL PROGRAMS 1/6 red.	ESTIMATED REDUCED BENEFITS FROM GOV'T CONTROL PROGRAMS 1/3 red.	ERROR WITH ASSUMED 20% IMPROVEMENT	ESTIMATED UPPER BOUND FOR INVENTORY ADJUSTMENT BENEFITS	ESTIMATED REDUCED BENEFITS FROM GOV'T CONTROL PROGRAM 1/6 red.	ESTIMATED REDUCED BENEFITS FROM GOV'T CONTROL PROGRAMS 1/3 red.	ERROR WITH ASSUMED 30% IMPROVEMENT	ESTIMATED UPPER BOUND FOR INVENTORY ADJUSTMENT BENEFITS	ESTIMATED REDUCED BENEFITS FROM GOV'T CONTROL PROGRAMS 1/6 red.	ESTIMATED REDUCED BENEFITS FROM GOV'T CONTROL PROGRAMS 1/3 red.
CORN	4.1	3.7	27.9	23.2	18.6	3.3	52.9	44.1	35.2	2.9	75.0	62.5	50.0
RICE	2.3	2.1	.7	.6	.5	1.8	1.6	1.3	1.1	1.6	2.1	1.8	1.4
SORGHUM GRAIN	3.8	3.4	4.4	3.7	3.0	3.0	8.4	7.0	5.6	2.7	11.0	9.2	7.3
SOYBEANS	2.0	1.8	3.0	2.5	2.0	1.6	5.7	4.8	3.8	1.4	8.1	6.7	5.4
COTTON	5.8	5.2	9.5	7.9	6.3	4.6	18.0	15.0	12.0	4.1	24.2	20.2	16.2
POTOTOES -	4.3	3.9	5.2	4.3	3.5	3.4	11.0	9.2	7.3	3.0	15.0	12.5	10.0
OATS	2.8	2.5	1.20	1.00	.80	2.2	2.3	1.9	1.5	2.0	2.9	2.4	1.9
WHEAT	2.5a 3.3b	2.3 3.0	1.3 9.0	1.1 7.5	.9 6.0	2.0 2.6	3.0 19.6	2.5 16.3	2.0 13.1	1.8 2.3	4.0 26.6	3.3 22.2	2.7 17.7
BARLEY	1.2	1.1	.2	.2	.1	1.0	.3	.3	.2	.8	.6	.5	.4
SUGAR BEETS	2.7	2.4	.7	3.1	2.4	2.2	5.9	4.9	3.9	1.9	8.8	7.3	5.9
TOTAL	3.0c		66.1	55.1	44.1		128.7	107.3	85.7		178.3	148.6	118.9
EXTRAPLOATED TO 70% OF FARM VALUE			77.1	64.3	51.5		150.2	125.2	100.0		208.0	173.4	138.7
EXTRAPOLATED TO 80% OF FARM VALUE			88.1	73.5	58.8		171.6	143.1	114.3		237.7	198.1	158.5

a - spring wheat, September forecast
b - winter wheat, May forecast
c - unweighted average

BENEFITS USING ELASTICITIES REDUCED BY 50%

Table A-3

CROP	USDA SEPTEMBER FORECAST ERROR	ERROR WITH ASSUMED 10% IMPROVEMENT	ESTIMATED UPPER BOUND FOR INVENTORY ADJUSTMENT BENEFITS	ESTIMATED REDUCED BENEFITS FROM GOV'T CONTROL PROGRAMS 1/6 red.	ESTIMATED REDUCED BENEFITS FROM GOV'T CONTROL PROGRAMS 1/3 red.	ERROR WITH ASSUMED 20% IMPROVEMENT	ESTIMATED UPPER BOUND FOR INVENTORY ADJUSTMENT BENEFITS	ESTIMATED REDUCED BENEFITS FROM GOV'T CONTROL PROGRAMS 1/6 red.	ESTIMATED REDUCED BENEFITS FROM GOV'T CONTROL PROGRAMS 1/3 red.	ERROR WITH ASSUMED 30% IMPROVEMENT	ESTIMATED UPPER BOUND FOR INVENTORY ADJUSTMENT BENEFITS	ESTIMATED REDUCED BENEFITS FROM GOV'T CONTROL PROGRAMS 1/6 red.	ESTIMATED REDUCED BENEFITS FROM GOV'T CONTROL PROGRAMS 1/3 red.
CORN	4.1	3.7	83.6	69.6	55.7	3.3	158.6	132.1	105.7	2.9	225.0	187.5	150.0
RICE	2.3	2.1	2.0	1.7	1.4	1.8	4.7	3.9	3.2	1.6	6.3	5.3	4.2
SORGHUM GRAIN	3.8	3.4	13.3	11.1	8.9	3.0	25.1	20.9	16.8	2.7	33.0	27.5	22.0
SOYBEANS	2.0	1.8	9.0	7.5	6.0	1.6	17.1	14.3	11.4	1.4	24.3	20.2	16.2
COTTON	5.8	5.2	28.5	23.7	19.00	4.6	53.9	44.9	35.9	4.1	72.7	60.5	48.4
POTATOES - FALL	4.3	3.9	15.6	13.0	10.4	3.4	33.0	27.5	22.0	3.0	45.1	37.6	30.
OATS	2.8	2.5	3.6	3.0	2.4	2.2	6.8	5.7	4.6	2.0	8.7	7.3	5.8
WHEAT	2.5a 3.3a	2.3 3.0	3.9 26.9	3.2 22.4	2.6 17.9	2.0 2.6	9.0 58.8	7.5 49.0	6.0 39.2	1.8 2.3	12.1 79.7	10.1 66.4	8.1 53.1
BARLEY	1.2	1.1	.5	.5	.4	1.0	1.0	.9	.7	.8	1.9	1.6	1.3
SUGAR BEETS	2.7	2.4	11.0	.2	7.3	2.2	17.6	14.7	11.7	1.9	26.4	22.0	17.6
TOTAL	3.0a		197.9	164.9	132.0		385.6	321.4	257.2		535.2	446.0	356.8
EXTRAPOLATED TO 70% OF FARM VALUE			230.9	192.4	154.0		300.1	624.4	520.3		449.9	375.0	416.3
EXTRAPOLATED TO 80% OF FARM VALUE			263.9	219.9	175.0		342.9	713.6	594.7		514.1	428.5	475.7

a - spring wheat, September forecast
b - winter wheat, May forecast
c - unweighted average

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APPENDIX B

COMPUTER PROGRAM

A copy of the program used to compute benefits is included in this appendix. The first card is the control card and specifies the options to be used and the size of various parameters: The card should be completed as follows:

COLUMNS	FORMAT	DESCRIPTION
1-2	I 2	Number of crops - right justified - maximum of 20.
3-4	I 2	Number of years - right justified - maximum of 30.
5	I 1	If blank - print annual benefits by crop for each error rate. If 1 - do not print annual benefits.
6-10	F5.3	Highest error value to be included. If blank, .060 is used.
11-15	F5.3	Error decrement. If blank, .001 is used.
16-20	F5.3	Lowest error value to be included. If blank, .000 is used.
21-25	F5.3	Elasticity sensitivity factor. If blank, no adjustment is used.

Program arrays are set up for a maximum of one hundred error values. For example, if a decrement of .001 is used, the highest permitted error value is .099, and if a decrement of .002 is used, the limit is .198.

The follow crop data cards are included after the program deck:

Card 1	Col. 1-12	3A4	Crop name - right justified
Card 2	Col. 1-5	F5.3	Crop elasticity
Card 3	Col. 1-72	9F8.0	Crop production (or consumption) data. Up to 9 years of data per card, in fields of 8. The first card field contains data for the first year, etc. Up to 4 cards may be used to supply data for the number of years specified on the control card.

This set of crop data cards is repeated for each crop, and the number of sets must correspond to the number of crops specified on the control card.

- Program output

  1) If specified, annual benefits by crop for each error rate.*

  2) Present value of benefits by crop and by error rate. Also, present value of total benefits for each error rate.

  3) Present value of annual crop values, individual and total.

  4) Difference matrix for each crop and for total crops. The matrix displays benefits for any initial and improved error rate. Initial error rates are at the top heading for each column and improved error rates are on the left for each row. For example, if the initial error rate is .058 and the improved error rate is .043, the benefit from that improvement is the number in the .043 row and the .058 column. Using this procedure, benefits may be determined for any crop (or total crops) for any initial error rate and any improved error rate.

* To determine annual benefits from an improvement in forecast error, the improved error benefit should be subtracted from the initial error benefit for each year desired.

BENEFIT CALCULATION PROGRAM

```
      DIMENSICN BEN(20),ER(100),PQ(20,30),
     D  TOTAL(100),ELAS(20),PQSUM(100),DIFF(100,100)
       REAL I
       INTEGER T,BENIND
      REAL*4 CRNAME(3,20),TOTNAM(3)/'    ','    T','OTAL'/,
     R  BENTOT(100,30)/3000*0.0/,PVBEN(20,100)/2000*0.0/
      EQUIVALENCE (BENTCT(1,1),DIFF(1,1))
       I=0.1
      READ (5,20) NCROP,T,BENIND,A,B,C,D
   20 FORMAT (2I2,I1,4F5.3)
C NERR = NUMBER OF ERROR VALUES
C ERINIT = INITIAL EFROR VALUE
C ERLAST = FINAL ERROR VALUE
C ERDECR = ERRCR VALUE CECREMENT
      NERR = 0
      ERINIT =C.060
      ERDECR =C.001
      ERLAST =0.000
      IF (A.GT.0.0) ERINIT = A
      IF (B.GT.0.0) ERDECR = B
      IF (C.GT.0.0) ERLAST = C
      DO 50 K = 1,100
      ER(K) = ERINIT
      NERR = NERR + 1
      ERINIT = ERINIT - ERDECR
      IF ((ERINIT.LT.0.000).AND.(ERINIT.GT.-ERDECR))ERINIT = +0.000
      IF (ERINIT .LT. ERLAST) GO TO 100
   50 CONTINUE
  100  DO 200 N=1,NCROP
      READ (5,21) (CRNAME(K,N),K=1,3)
   21 FORMAT (3A4)
       READ (5,110) ELAS(N)
  110  FORMAT (F5.3)
      IF (D.GT.0.0) ELAS(N) = ELAS(N) * D
       READ(5,120) (PQ(N,IT),IT=1,T)
  120  FORMAT (9F8.0)
  200 CONTINUE
      NBR = NCROP / 5
      IF (NBR*5.LT.NCROP) NBR = NBR + 1
      IA = 1
      IB = 5
      IF (IB.GT.NCROP) IB = NCROP
      IF (BENIND.GT.0) GO TO 500
      WRITE (6,1)
    1 FORMAT(//,38X,'BENEFITS BY CROP BY ERROR BY YEAR')
      IF (IB.EC.NCROP) GC TO 90
   80 WRITE (6,2)((CRNAME(J,K),J=1,3),K=IA,IB)
    2 FORMAT (//,24X,6(2X,3A4))
```

```
      GO TO 500
   90 WRITE(6,2) ((CRNAME(J,K),J=1,3),K=IA,IB),(TOTNAM(L),L=1,3)
  500 DO 160 J=1,NERR
       DO 150 K=1,T
       DO 140 N=IA,IB
      BEN(N)      =  ER(J)**2*PQ(N,K)/ELAS(N)
      BENTOT(J,K) = BENTOT(J,K) + BEN(N)
       PVBEN(N,J)=BEN(N)     /(1.0+I)**K+PVBEN(N,J)
  140 CONTINUE
      IF (BENIND.GT.0) GO TO 150
      IF (IB.LT.NCROP.AND.K.EQ.1)
     1WRITE (6,3) ER(J),(BEN(N),N=IA,IB)
    3 FORMAT (' ERROR =',F6.3,' YEAR =  1',6F14.2)
      IF (IB.LT.NCROP.AND.K.GT.1)
     1WRITE (6,4) K,(BEN(N),N=IA,IB)
    4 FORMAT (22X,I2,6F14.2)
      IF (IB.EQ.NCROP.AND.K.EQ.1)
     1WRITE (6,3) ER(J),(BEN(N),N=IA,IB),     BENTOT(J,1)
      IF (IB.EQ.NCROP.AND.K.GT.1)
     1WRITE (6,4) K,(BEN(N),N=IA,IB),     BENTOT(J,K)
  150 CONTINUE
  160  CONTINUE
      IF (IB.EQ.NCROP) GO TO 162
      IA = IA + 5
      IB = IB + 5
      IF (IB.LT.NCROP) GO TO 80
      IB = NCROP
      GO TO 90
  162  DO 161 J=1,NERR
       TOTAL(J)=0.0
       DO 161 N=1,NCROP
  161   TOTAL(J)= PVBEN(N,J)+ TOTAL(J)
       WRITE (6,170)T
  170  FORMAT (/,23X,'PRESENT VALUE BENEFITS USING',I3,' YEARS - X10**6'
     X)
      IA = 1
      IB = 5
      IF (IB.GT.NCROP) IB = NCROP
      DO 340II=1,NBR
      IF(II.EQ.NBR) GO TO 330
      WRITE (6,5)((CRNAME(J,K),J=1,3),K=IA,IB)
    5 FORMAT (//,10X,'ERROR',6(2X,3A4),/)
      DO 325 J=1,NERR
      WRITE (6,6)  ER(J),(PVBEN(N,J),N=IA,IB)
    6 FORMAT (F15.3,6F14.2)
  325 CONTINUE
      IA = IA + 5
      IB = IB + 5
```

```
      IF (IB.GT.NCROP) IB = NCROP
      GO TO 340
  330 WRITE(6,5) ((CRNAME(J,K),J=1,3),K=IA,IB),(TOTNAM(L),L=1,3)
      DO 335 J=1,NERR
      WRITE (6,6) ER(J),(PVBEN(N,J),N=IA,IB),TOTAL(J)
  335 CONTINUE
  340 CONTINUE
      PQTOT=0.0
      DO 156 N=1,NCROP
      PQSUM(N)=0
      DO 155 K = 1,T
  155 PQSUM(N)=PQ(N,K)/(1.0 +I)**K + PQSUM(N)
  156 PQTOT = PQTOT + PQSUM(N)
      WRITE(6,300)PQTOT
  300 FORMAT (//' PQ TOTAL = ',F15.2,//,' CROP NO.    INDIVIDUAL PQ')
      WRITE (6,310) (N,PQSUM(N),N=1,NCROP)
  310 FORMAT (I5,10X,F15.2)
      NE=NERR+1
      NERR1 = NERR / 9
      IF ((NERR1* 9) .NE. NERR) NERR1 = NERR1 + 1
      DO 450 N=1,NCROP
      DO 410 J=1,NERR
      DO 400 K=1,J
400   DIFF(J,K)=PVBEN(N,K) -PVBEN(N,J)
410   CONTINUE
      WRITE(6,420)(CRNAME(J,N),J=1,3)
  420 FORMAT(//,10X,'DIFFERENCE MATRIX FOR   ',3A4)
      I1 = 1
      I2 = 9
      IF (I2 .GT. NERR) I2 = NERR
      DO 600 II = 1,NERR1
  650 WRITE(6,430)(ER(J),J=I1,I2)
430   FORMAT(//////6X,9F14.3,//)
      DO 660 J=I1,NERR
      J1 = J
      IF (J1 .GT. I2) J1 = I2
      WRITE(6,445) (ER(J),  (DIFF(J,K),K=I1,J1))
  445 FORMAT (F6.3,9F14.2)
  660 CONTINUE
  690 I1 = I1 + 9
      I2 = I2 + 9
      IF (I2 .GT. NERR) I2 = NERR
  600 CONTINUE
450   CONTINUE
      DO 810 J=1,NERR
      DO 800 K=1,J
  800 DIFF(J,K) = TOTAL(K) - TOTAL(J)
  810 CONTINUE
```

```
      WRITE (6,820)
  820 FORMAT (//,10X,'DIFFERENCE MATRIX FOR TOTAL CROPS')
      I1 = 1
      I2 = 9
      IF (I2.GT.NERR) I2=NERR
      DO 830 II = 1,NERR1
      WRITE (6,430) (ER(J),J=I1,I2)
      DO 860 J=I1,NERR
      J1 = J
      IF (J1.GT.I2) J1 = I2
      WRITE (6,445) (ER(J),(DIFF(J,K),K=I1,J1))
  860 CONTINUE
      I1 = I1 + 9
      I2 = I2 + 9
      IF (I2.GT.NERR) I2 = NERR
  830 CONTINUE
  700  STOP
       END
```

APPENDIX C

This appendix contains projection data on crop production, prices, and value for the period 1977-1986. (Table C-1) The background for this data is contained in section III of the report. Table C-2 contains annual and average forecast errors by crop for the USDA system for the period 1962-1971. The following section discusses the relationships between annual and average error rates and the benefit estimation procedure.

In this study, the average error rate by crop for the years 1962-71 was used as the "without" system error rate. This assumption has important implications for the magnitude of potential benefits in acreage estimation. The assumption is grounded in the concept that the acreage estimation case is only one component of the agriculture broad area. Further case studies in yield estimation and stress monitoring would complement the acreage estimation study in that an alternative view of the "without" system forecast error could be incorporated in the combined package.

The approach to benefit estimation in this study as described in the text incorporates the following formulae:

$$B_t = \left(\epsilon_e^2 - \epsilon_w^2\right)\left(P_t Q_t\right) / \alpha$$

where

B_t = benefits in period t

ϵ_e = error rate for ERS system in period t

ϵ_w = error rate for "without" system in period t

$P_t Q_t$ = value of production in period t

α = crop elasticity

(one such calculation is made for each crop)

In present value terms, benefits are:

$$PVB = \sum_{t=1}^{T} B_t / (1+i)^t$$

PVB = present value of benefits

T = number of years in the benefit period
(For this study the number of years is ten.)

i = discount rate = .10 for this study

The average error by crop is the simple sum divided by the number of years:

$$\epsilon_A = \sum_{t=1}^{T} \epsilon_t / T$$

$$\epsilon_A^2 = \left(\sum \epsilon_t\right)^2 / T^2$$

ϵ_t = annual error rate (by crop)

ϵ_A = average error rate (by crop)

Combining these equations yields the following formulation for benefit calculation:

$$PVB = \sum_{t=1}^{T} \left[\left(\sum \epsilon_{t_e}\right)^2 - \left(\sum \epsilon_{t_w}\right)^2\right] \left(P_t Q_t\right) / T^2 \alpha (1+i)^t$$

This formulation uses anticipated average error for the ERS system and average error for the "without" system as the basis for benefit calculation.

An alternative procedure is to use anticipated errors on an annual basis rather than an average:

$$PVB = \sum_{t=1}^{T} \left(\epsilon_{t_e}^2 - \epsilon_{t_w}^2\right) \left(P_t Q_t\right) / \alpha (1+i)^t$$

To use this procedure, error rates for both the ERS and without systems would have to be generated for each year of the benefit period.

It is probable that using this formulation the total benefits would be higher than using the formulation selected for the case study. Using a simplied calcuation that approximates this approach, the present value of benefits for corn increased from $41.8 to $54.5 million and for winter wheat from $13.5 to $31.3 million. However, this formulation actually includes more than acreage estimation benefits.

The high error values which account for most of the benefits in this formulation are not normally caused by acreage estimation errors. The high error rates are usually caused by errors in yield forecast brought about by a crop disease such as wheat rust or corn blight.

When the yield estimation study is combined with the acreage estimation results, this formulation will be considered for measuring benefits of better production forecasts including both yield and acreage.

Table C-1

PROJECTIONS OF PRODUCTION, PRICES, AND VALUE BY CROP
1977-1986

YEAR	CORN P	CORN Q	CORN PQ	OATS P	OATS Q	OATS PQ	SORGHUM - GRAIN P	SORGHUM - GRAIN Q	SORGHUM - GRAIN PQ
1977	1.35	5260	7101	.74	803	594	1.31	789	1034
1978	1.35	5360	7236	.74	797	590	1.31	794	1040
1979	1.35	5500	7425	.75	794	596	1.30	802	1043
1980	1.35	5640	7614	.75	791	593	1.30	809	1052
1981	1.35	5718	7719	.76	795	604	1.30	849	1104
1982	1.35	5796	7825	.77	799	615	1.30	889	1156
1983	1.35	5874	7929	.78	803	626	1.30	930	1209
1984	1.35	5952	8035	.79	807	638	1.30	970	1261
1985	1.35	6030	8141	.80	811	649	1.30	1010	1313
1986	1.35	6108	8246	.81	815	660	1.30	1050	1365

YEAR	BARLEY P	BARLEY Q	BARLEY PQ	WHEAT P	WHEAT Q	WHEAT PQ	SOYBEANS P	SOYBEANS Q	SOYBEANS PQ
1977	1.15	443	509	1.60	810	1296	3.75	975	3656
1978	1.15	456	524	1.62	830	1345	3.75	1000	3750
1979	1.15	466	536	1.63	870	1418	3.75	1015	3806
1980	1.15	475	546	1.65	901	1502	3.75	1030	3863
1981	1.15	485	558	1.66	922	1531	3.80	1058	4020
1982	1.15	495	569	1.67	934	1560	3.85	1086	4181
1983	1.15	505	581	1.68	946	1589	3.90	1114	4345
1984	1.15	515	592	1.69	958	1619	3.95	1142	4511
1985	1.15	525	604	1.70	970	1649	4.00	1170	4680
1986	1.15	535	615	1.71	982	1679	4.05	1198	4852

PROJECTIONS OF PRODUCTION, PRICES, AND VALUE BY CROP
1977-1986

Table C-1
cont'd

	RICE			COTTON			POTATOES		
YEAR	P	Q	PQ	P	Q	PQ	P	Q	PQ
1977	6.35	42	267	133.375	7.8	1040	2.25	337	758
1978	6.42	43	276	133.375	7.8	1040	2.25	334	753
1979	6.48	44	285	133.375	7.9	1054	2.25	338.7	762
1980	6.55	45	295	133.375	7.9	1054	2.25	342.6	771
1981	6.58	46.1	303	133.375	7.9	1054	2.25	344.9	776
1982	6.61	47.2	312	133.375	7.9	1054	2.25	347.3	781
1983	6.64	48.3	321	133.375	8.0	1067	2.25	349.6	787
1984	6.67	49.4	329	133.375	8.0	1067	2.25	353.0	792
1985	6.70	50.5	338	133.375	8.0	1067	2.25	354.3	797
1986	6.73	51.6	347	133.375	8.0	1067	2.25	356.6	802

	SUGAR BEETS		
YEAR	P	Q	PQ
1977	14.32	3248	465
1978	14.32	3205	459
1979	14.32	3169	454
1980	14.32	3125	448
1981	14.32	3194	457
1982	14.32	3258	467
1983	14.32	3336	476
1984	14.32	3389	485
1985	14.32	3460	495
1986	14.32	3525	505

Table C-2

ANNUAL AND AVERAGE SEPTEMBER FORECAST ERRORS BY CROP

YEAR	CORN	OATS	SORGHUM GRAIN	BARLEY	WINTER WHEAT[a]	SPRING WHEAT	SOYBEANS	RICE	COTTON	POTATOES - FALL	SUGAR BEETS
1962	-3.36	1.58	-4.62	0.72	8.26	4.39	0.0	-5.14	-0.84	-1.79	1.07
1963	-1.99	.93	-11.53	0.70	-3.17	2.25	4.15	-5.00	-6.41	-3.98	-6.43
1964	-4.48	-4.81	1.57	0.63	-0.78	3.49	0.43	-1.29	-1.35	3.73	6.18
1965	1.00	6.88	-1.86	3.72	-3.83	2.16	2.48	0.68	1.14	-3.37	4.48
1966	-1.87	4.11	0.20	0.45	3.22	2.64	-0.22	-0.95	15.07	-11.13	-0.20
1967	-3.42	1.51	4.68	-0.08	0.08	-1.30	2.77	0.84	10.02	-3.51	-2.14
1968	4.18	-1.79	8.15	-0.37	-1.97	2.03	-2.44	5.55	2.50	-5.11	-1.06
1969	-8.00	-2.90	3.83	-2.61	-0.35	-1.28	-6.88	0.01	10.95	-3.16	-0.21
1970	6.05	-2.84	0.59	-1.41	0.18	-3.32	0.53	0.96	5.55	-4.13	-2.75
1971	6.65	.45	0.58	1.35	-10.75	-2.28	0.85	-2.33	4.53	-2.73	-
AVG.	4.10	2.78	3.76	1.20	3.80	2.51	2.07	2.27	5.84	4.26	2.72

a - May forecast

APPENDIX D

PRELIMINARY ERTS-1 EXPERIMENT RESULTS

This appendix contains a summary of the significant results as of July, 1973, of the ERTS-1 experiments pertaining to the crop acreage estimation case study. Because the experiments are still in progress, new information and results will be forthcoming during the coming months. At an appropriate time, the appendix will be updated with substantive changes in results.

ERTS-1 Experiments:

UN 640 (1A): To determine the feasibility of making regional agricultural surveys using ERTS-A and aircraft data (Thorley, Draeger, Benson).

Objectives: Major emphasis is to evaluate the feasibility of using satellite data to provide regional agricultural information on an operational basis. This experiment is being performed in San Joaquin County, California and Maricopa County, Arizona. The investigators are working in cooperation with several user agencies listed in Table I-1. Objectives include:

- Assessment of the usefulness of ERTS-1 data in agricultural resource evaluation and inventories.
- Development of human and automated interpretation and data handling techniques amenable to ERTS-1 data.
- Quantitative evaluation of the degree to which information required by agricultural managers and land use planners can be extracted from the data.
- Assess the extent to which successful survey methods can be applied to dissimilar regions.

Three major tasks are being performed to meet the above objectives. These include:

- Delineation of agriculture land - this task is to evaluate the accuracy by which agricultural areas can be differentiated from other land use categories on a periodic basis.
- Classification of agriculture land - a feasibility assessment of performing periodic tabulations of predominate agricultural use of each square mile of land within each agricultural area delineated in Task 1.
- Crop inventory - determination of accuracy of selected crop acreage estimates.

USER AGENCY COOPERATION AGRICULTURAL APPLICATIONS PROJECTS

USER GROUP AGENCY	REMOTE SENSING APPLICATION
USDA, Statistical Reporting Service California Crop and Livestock Reporting Service	Classification of Agricultural Land (Stratification); Crop Acreage Inventories
USDA, Agricultural Stabilization and Conservation Service, Butte County, California	Subsidy and Allotment Program Compliance Monitoring
California Department of Water Resources, Planning Staff	Water Consumptive Use Require-Ment Monitoring in Agricultural Areas
Department of Water Resources, Central District	Detection of Land Use Change and Agricultural Yield Reduction Due to Hydrologic Projects
University of California Extension Service	General Agricultural Evaluation and Land Management Planning

(FROM THORLEY AND DRAEGER'S TYPE II REPORT, JANUARY 1973)

(1) Agricultural Land Use Stratification:

Stratification, often the first step in the allocation of ground enumeration samples, is currently done by the SRS for California on uncontrolled aerial photo mosaics. The existing agriculture land use stratification map for California was prepared approximately eight years ago and shows the following land use strata within San Joaquin County:

- Urban areas
- Non-agricultural areas
- Irrigated agricultural areas
- Dry land agricultural areas
- Rangeland areas

These investigators have shown that initial stratification of agricultural land use categories is easily done on ERTS-1 imagery and that stratification of San Joaquin County, California can be completed in about thirty minutes of interpreter time. Six categories of agricultural land discernible from ERTS-1 data over San Joaquin County are:

- Orchards
- Vineyards
- Continuous cover crops
- Row crops
- Irrigated pasture crops
- Fallow ground

Results suggest the feasibility of further defining these six broad categories into categories shown in Table I-2, providing a more detailed and current stratification than that currently used by USDA's Statistical Reporting Service (SRS). Also, since the six categories have varying water requirements, acreage estimates for these categories would provide water resource planners with more useful information than does the stratification map currently in use.

DESCRIPTION OF STRATE CLASSIFICATIONS

Stratum #	Major Land Use	Major Crops	Secondary Crops
1	Urban and non-agriculture	none	some orchards and pastures
2	range	native grassland	none
3	range	native and improved grassland	some irrigated pasture and dry land grains
4	urban and non-agriculture	water storage	recreation
5	pasture and grains	range and irrigated & non-irrigated improved pastures and dry land grains	vineyards and orchards
6	pasture and grains	irrigated pasture	fruit orchards and vineyards, field crops
7	orchards and vineyards	vineyards	fruit and nut orchards, minor field crops and irrigated pasture
8	orchards and vineyards	fruit and nut orchards	field crops
9	pasture and grains	grains and field crops	irrigated pasture
10	pasture and grains	irrigated pasture	field crops, fruit and nut orchards
11	orchards and vineyards	nut and fruit orchards	vineyards, irrigated pasture
12	orchards and vineyards	vineyards, orchards	irrigated pasture
13	field crops	asparagus, sugar beets, alfalfa, beans, grains, safflower	tomatoes
14	field crops	grains, alfalfa, sugar beets	other field crops
15	field crops	grains, alfalfa, sugar beets, tomatoes	other field crops
16	field crops	asparagus, corn, alfalfa, sugar beets	other field crops
17	pasture and grains	irrigated pasture alfalfa, grains	sugar beets, vineyards

(FROM THORLEY AND DRAEGER'S TYPE II REPORT, JAN. 1973)

Accurate delineation and area determination of agriculture land use strata seemingly could improve sampling efficiency by decreasing the variance within strata to permit more precise estimates to be made and to avoid possible bias in subsequent sampling designs.

(2) Crop Identification and Inventory

- Manual Interpretation:

  The objective of this task is to develop techniques and procedures for interpretation and analysis of ERTS-1 data to provide regional crop statistics.

  An initial test of manual interpretation of crop type was performed by conducting a survey of safflower fields. Sixty fields were selected for this test of which thirty were actually safflower. The interpreters were asked to identify which of the sixty fields were safflower and, in addition, the interpreters were asked to delineate all safflower fields within another portion of the test area. In the first case 83% of the safflower fields were correctly identified. In the second test 79% of the fields were correctly identified as safflower with a 4.6% commission error (i.e., 4.6% of fields were incorrently delineated as safflower).

- Automated Interpretation

  The first analysis of this type was performed using B&W MSS bulk transparencies of the San Joaquin test site acquired on July 26, 1972. Eleven four square-mile ground cells in the field crop strata were selected for intensive analysis.

  Twenty-seven training sets were selected for training and classification algorithm on the ten categories:

  - Sunflower
  - Asparagus
  - Corn
  - Sorghum

- Potatoes
- Safflower
- Sugar beets
- Water
- Non-vegetated
- Plowed

After classifying all data points, each field was assigned to the class with the maximum point count. A total of 201 fields were classified with an overall accuracy of 84% correct identification. This figure is somewhat misleading in that all it really says is that 84% of the 201 fields were correctly identified. Results by class are shown in Figure I-3. At first glance, these results do not appear encouraging except for asparagus and corn; however, several factors must be considered in evaluating these results. The low accuracy figures for correct identification are a function of small field size in relation to resolution and possibly poor selection of training points. Also, the imagery was acquired on a single, less than optimum date and only a very small area was analyzed. Commission errors of 100% are also misleading, in that there were no actual fields in those classes and any fields incorrectly identified as belonging to those classes would result in 100% commission errors.

A second test, conducted to show the capability of an automated approach over a large area, was accomplished by training on 1,340 acres, testing on 11,000 acres, and inventorying 219,872 acres. This test was performed using the following classes:

- Asparagus
- Corn
- Potatoes
- Safflower

RESULTS OF CALSCAN CLASSIFICATION OF ERTS-1 DATA
SAN JOAQUIN COUNTY TEST AREA, CALIFORNIA

CLASSIFICATION RESULTS	GROUND DATA: SUNF	ASPA	CORN	SORG	WATR	N.VEG	POTA	PLOW	SAFF	SUG.B	TOTAL	COMMISSION ERROR
SUNF	4		1								5	20
ASPA	4	96	5				3	4	4	5	115	17
CORN	1	3	48				1				53	11
SORG										1	1	100
WATR		1			4						5	20
N.VEG	1	1						1			3	100
POTA							2				2	0
PLOW		1					1	8			10	20
SAFF									5		5	0
SUG.B										2	2	0
TOTAL	10	102	51	0	4	0	7	13	9	5		
% CORRECT	40	94	94	-	100	-	29	62	56	40		

TOTAL PERCENT CORRECT 84.3

Class	% Correct Identification	% Commission Error	No. of Fields in Class
Sunflower	40	20	10
Asparagus	94	17	102
Corn	94	11	51
Sorghum	--	100	0
Potatoes	29	0	7
Safflower	56	0	9
Sugar Beets	40	0	5
Water	100	20	4
Non-Vegetated	--	100	0
Plow	62	20	13

(FROM THORLEY AND DRAEGER'S TYPE II REPORT, JANUARY 1973)

- Sugar beets
- Alfalfa
- Tomatoes
- Harvested
- Bare soil
- Flooded irrigation

An evaluation of point-by-point classification indicates an overall accuracy of 96.1% correct identification, and field-by-field results yielded an overall accuracy of 88.3% correct identification. These overall accuracy figures, again, are somewhat misleading, and individual crop accuracies are shown in Figure I-4. Commission errors, in a sense, reflect the degree to which other crops "resemble" the target crop and, similarly, ommission errors reflect the degree to which the target crop "resembles" other crops. Both types of errors can be expected to decrease with multi-date data analyses or analysis of single date data required at a more optimum time during the growing season. Results of crop identification studies completed thus far, although seemingly discouraging for some crops over some areas, indicate that regional crop statistics can be generated over large regions from ERTS-type data. Work by these investigators is to continue to develop techniques for conducting crop inventories and to complete a crop inventory for the entire San Joaquin County test area. Regional accuracy figures will not be available until estimates are available from the investigators, as well as from the SRS.

UN 314 (2A): Use of ERTS-1 Data to Assess and Monitor Change in the Southern California Environment (Bowden, Johnson). This investigation is one of several submitted by the University of California. The experiment is a multidisciplinary experiment with one part addressing the problem of monitoring crop changes in the Imperial Valley from ERTS-1 imagery.

Objective: The primary objective is to develop a semi-automated system for identification of specific crops in each field and produce thematic computer maps for the Imperial Valley.

Figure I-4

FIELD BY FIELD RESULTS OF CLASSIFICATION OF TEST AREAS FROM ERTS-1 TAPE DATA

CLASSIFICATION	GROUND DATA											
	ASPA	CORN	HARV	BARE SOIL	POTA	SAFF	SUG BEET	FL. IRR.	ALFA	TOMA	TOTAL	COMMISSION % ERROR
ASPA	126			4	3						133	5
CORN	7	59									66	11
HARV			19								19	0
BARE SOIL	5			5							10	50
POTA	2				4						6	33
SAFF	1	1				6					8	25
SUG BEET		1			2		5				8	37
FL. IRR.								3			3	0
ALFA											0	-
TOMA		3				1					4	100
TOTAL	141	64	19	9	9	7	5	3	0	0	257	
% CORRECT	89	92	100	56	44	86	100	100	-	-		227/257

TOTAL PERCENT CORRECT - 88.3

Class	% Correct Identification	%Commission Error	No. of Fields in Class
Asparagus	89	5	141
Corn	92	11	64
Potatoes	44	33	9
Safflower	86	25	7
Sugar Beets	100	37	5
Alfalfa	--	--	0
Tomatoes	--	100	0
Harvested	100	0	19
Bare Soil	56	50	9
Flooded Irrigation	100	0	3

(FROM THORLEY & DRAEGER'S TYPE II REPORT, January, 1973)

The approach taken in this investigation differs from Thorley and Draeger's work in that image interpretation is performed manually and a computer is used only to reduce and analyze the interpreted data. Also, emphasis is placed heavily on crop calendars and sequences of changing field conditions. Crop regionalization and field sizes are two other variables being programmed into the automated identification system.

The investigator has divided the entire Imperial Valley into seven regions:

- Region 1 - vegetable crops, primarily asparagus
- Region 2 - vegetable crops, primarily carrots
- Region 3 - transition from vegetable crops to field crops
- Region 4 - transition from vegetable crops to field crops
- Region 5 - large acreages of field crops
- Region 6 - large acreages of field crops
- Region 7 - large acreages of field crops

In essence, the success of this experiment depends on (1) the ability to detect individual field conditions, and (2) the ability to relate sequential field conditions to a regional crop calendar.

Four distinct colors have been identified on a single band of imagery acquired on August 26, 1972, and relate to field conditions as follows:

- Red - vegetated, growing crops that have good ground cover
- White - bare (fallow) fields or fields abandoned because of uneconomical production due to salinity
- Deep purple - irrigated fields or recently seeded, wet, bare fields
- Light lavendar - freshly plowed fields

Table I-3

FIELD CONDITION STATISTICS FOR IMPERIAL VALLEY

Field Conditiors 26 August 1972

REGION	TOTAL ACRES	NO DATA	GROWING CROPS	WET BARE FIELDS	PLOWED BARE FIELDS	DRY BARE FIELDS	HARVESTED CROPS	PERM CROP	FEED LOTS	AGRICUL OFFSITE	URBAN
1	58,255	2,047	23,211	4,846	11,371	9,180	342	27	243	5,698	1,290
2	54,455	968	19,014	4,361	8,327	13,367	1,300	324	720	5,379	695
3	111,771	2,380	33,087	1,728	28,233	26,876		288	562	10,352	8,265
4	119,629	1,390	37,603	3,510	37,048	22,461	220		301	11,396	5,700
5	74,203	689	22,599	805	17,415	24,627			287	7,381	400
6	78,131	594	15,503	1,075	28,364	23,877			309	7,749	660
7	38,047	1,189	3,412	99	5,089	23,228				3,670	1,360
TOTAL	534,491	9,257	154,429	16,424	135,847	143,616	1,862	639	2,422	51,625	18,370
Less URBAN	18,370										3.45%
	516,121										
Less OFFSITE	51,625									10%	
Total AGRI ACREAGE	464,496	2.0%	33.3%	3.5%	29.2%	30.9%	0.4%	0.14%	0.5%		

(FROM BOWDEN, JOHNSON TYPE II REPORT, JANUARY 1973)

Initial efforts were to attempt delineation of agricultural vs. non-agricultural (idle land) in a portion of Kern County in San Joaquin Valley, California. An agriculture land use map, depicting the two categories mentioned above, was prepared from ERTS-1 data and compared to statistics from the Kern County Water Agency (KCWA). The estimate of agricultural acreage from ERTS-1 data agreed to within 6% of the estimate reported by KCWA in 1971.

A manual interpretation test, performed to evaluate the feasibility of crop identification on ERTS-1 data, was conducted over a 56 square-mile agricultural area located west of Mendota, California in the San Joaquin Valley. Interpreters were asked to identify and classify each field in the test area as one of the following classes:

- Alfalfa
- Bare soil
- Cotton
- Melons
- Sugar beets
- Tomatoes

Results of this test are shown in Table I-4 and are seemingly low; however, the interpretation was performed on a single image acquired in July, 1972 when color or tonal contrasts were quite similar. As multi-data imagery becomes available, the ability to discriminate crops will improve. Preliminary "looks" at October, 1972 imagery by the investigators reveals considerable tonal differences between categories of alfalfa and cotton and they feel that October imagery will improve the identification accuracy of these two crops by 50%.

Work is continuing in this experiment to monitor and record changing field conditions over time as identified on ERTS-1 imagery. A crop calendar based on tonal changes is being constructed and will be evaluated as a technique for conducting crop surveys via satellite data.

<u>AG 339(1A)</u>: Reflectance of Vegetation, Soil, and Water (Wiegand, Allen, Gausman)

<u>Objectives</u>: The specific objective of this experiment is to develop an operational system of ERTS data analysis which will

Table I-4

ACCURACY OF IDENTIFICATION OF SELECTED CROP
AND FIELD CONDITIONS OF ERTS-L MSS COLOR COMPOSITE IMAGERY

Ground Truth Categorization of fields	Photo Interpreter Identification of Fields						actual number of fields in category	% correct identification	% commission error
	Alfalfa	Bare Soil	Cotton	Melons	Sugar Beets	Tomatoes			
Alfalfa	12.5	2	24.5	3	10	0.5	52.5	24	25
Bare Soil	0	26	0	1	0	0	27	97	.006
Cotton	6	0.5	32	5.5	3.5	1	48.5	66	11
Malons	0	0	5	2	0	0	7	28	.03
Sugar Beets	0	0	1	0	4	2	7	57	.02
Tomatoes	3	0	2	4	3.5	2.5	15	16	8

Total Number of Fields Interpreted 157 .

FROM ESTES TYPE II REPORT, JANUARY, 1973 be responsive to the U. S. Department of Agriculture's informational needs. Three specific objectives which will help them meet their primary objective have been proposed. These are:

- Compare experimental results using ERTS data with predictions of analytical models for interaction of light with vegetation for leaf-area index determinations.

- Detect differences in chlorophyll concentrations of plants from an orbiting satellite.

- Determine seasonal changes of various crops and soils in Hidalgo County, Texas, discriminate among them and estimate acreages.

This investigation should provide significant results with respect to soil discrimination, crop discrimination, and crop vigor and yield. The investigators have reported that all software necessary for data processing has been developed. An elaborate statistical ground truth data base has been established in cooperation with SRS personnel to provide data for approximately 1,300 fields. Ground truth data include: % crop cover, % weed cover, crop maturity, plant height, plant condition, soil surface condition, and nutrient deficiency.

Their ground truth sampling design was planned with Mr. Harold Huddleston at SRS and is quite an intensive sampling scheme. It consists of eight interpenetrating samples each with 43 sample segments distributed over Hidalgo County, Texas. The sample frame results in a 4% sample of the area. Each field in each segment will be ground truthed and fields will be selected for training signatures for pattern recognition studies. The experimental design is quite good in that the interpenetrating samples essentially become repetitious in a randomized block design experiment and may permit assessment of the variation from one repetition to another. Since these samples are the basis of the pattern recognition studies, an assessment of the consistency of accurate crop identification and acreage estimation can also be made.

The experiment has been delayed due to the lack of good quality data. The first acceptable ERTS-1 frame was not acquired until December, 1972 and detailed analyses of these data have not been completed.

UN 652 (1A): Effective Use of ERTS Multisensor Data in Northern Great Plains (Myers)

Objectives:

- Determine crop "signatures" for crops common to the Northern Great Plains, e.g., wheat, sorghum, corn, alfalfa.
- Determine parameters obtainable by ERTS suitable for inputs to a model predicting a really integrated radiance from a cropped field.
- Determine degree of ERTS applicability to detection of vegetation stress in crops and forests.
- Determine species identification capabilities of ERTS data with emphasis on temporal data analyses.

This experiment proposes to conduct studies in crop identification, acreage and yield estimation, stress evaluation, soil association mapping, and rangeland resource assessment. Results in crop identification studies are very preliminary in that only one image has been analyzed with 90%+ accuracy in nonparametric K-classification of fallow, corn, and soybeans.

The investigator has identified "informational requirements" of rangeland managers which include information requirements related to the following:

- land forms, drainage patterns, soil water regime, stored water, erosion patterns, range sites, and range condition classes, degree, and patterns of use.
- herbage residue - stage of maturity, nutritional value, rainfall patterns, range fires, snow cover, animal or human disturbance.

Thematic maps or tabular data of the above would permit measurement of change in these parameters and allow prediction of herbage production, stocking rates, needed range improvements, livestock marketing patterns, etc. The rangeland study is designed as a six-stage, multi-stage study employing:

- ERTS-1 satellite data
- NASA U-2 and RB-57 aircraft data
- SDSU aircraft data
- ERIM aircraft data
- Ground camera data
- Clipped ground plot data

AG 328 (1A): To Investigate and Evaluate Techniques of Using Space Imagery to Identify Crop Species (Von Steen)

Objectives:

- Develop methods of crop species identification from space imagery by photo interpretation and discrimination techniques within the context of multiple frame sampling. An alternative approach employing double sampling techniques would study interpretation accuracy from ERTS imagery compared with interpretations from low flying aircraft imagery when both are combined with ground data.

- Develop methods for estimating crop acreages by extracting information from space imagery.

ERTS-1 imagery will be evaluated for the purpose of providing current county crop estimates at an earlier date, or for alternative times, based on crop conditions and market needs. This experiment is being conducted in the States of Missouri, Kansas, South Dakota, and Idaho. Major crops being studied in these states are:

- Kansas - wheat, barley, sugar beets, alfalfa, corn, grain, sorghum

- Idaho - mixed grain, sugar beets, field beans, potatoes, alfalfa

- Missouri - cotton, wheat, corn, soybeans

- South Dakota - corn, spring wheat, soybeans, oats

The investigator suggests that since the SRS currently uses ground observations of land area segments 1/ in its agricultural statistics program, these area segments could be used as training sets for ADP of ERTS-1 imagery.

No significant results have been generated as of April, 1973. The final report is to present detailed comparison of accuracies of crop surveys from satellite, aircraft, and ground procedures. A comparison is also to be made of the turn-around time for data from ERTS-1 and from ground enumeration surveys.

1/ "Area segments" are defined in Section 3 of this chapter, "ERS AND THE CURRENT CROP REPORTING SYSTEM."

This investigator has demonstrated the capability to delineate six agricultural land use categories on ERTS-1 imagery. These are:

- Large field irrigated areas - fields are 160 acres or larger, irrigated by flooding and center pivot systems; primary crop is corn and grain sorghum.

- Small field irrigated areas - more intensive agricultural than the above, irrigation exclusively by flooding. Primary crops are sugar beets, and alfalfa; other crops include corn, grain sorghum, and winter wheat.

- Dryland cultivation - extensive cropping and summer fallowing. Fields are generally large, but strip cropped to prevent wind erosion; primary crops are wheat and grain sorghum, some pasture land.

- Rangeland

- Cultural features

- Riverine features

Only preliminary results are available on crop identification. Initial results indicated 78% correct classification of wheat and non-wheat and 58% correct estimate of the number of wheat fields. This is quite discouraging; however, the interpretation was done on December 1972 imagery which is not necessarily an optimum date. Another interpretation based on multi-date imagery acquired on 16 August, 21 September, and 2 December, 1972 resulted in 93% correct classification of wheat and non-wheat and 98% correct estimate of the number of wheat fields in the training area. Although interpretation over the entire sample area yielded only 86% correct classification of wheat and non-wheat, the estimated number of wheat fields equaled the actual number.

The above results would suggest a marked improvement in accuracy with temporal data; however, recent results suggest this may not be necessary in all cases. Analyses of data subsequent to the above tests revealed that the 21 September image provided the best single date discrimination capability; however, on that date, much of the sample area was cloud covered. Imagery acquired on 22 September was cloud free and provided coverage for a portion of the area imaged on 21 September. Analysis of the 22 September imagery of 54,612 acres indicated 89% of the acreage was correctly classified as wheat or non-wheat and the estimated wheat acreage was 99% of the actual amount.

The investigators indicate that with appropriate ground truth, knowledge of local environment, knowledge of crop phenology, and a modest amount of equipment and training, a wheat inventory method could be implemented at the local or county level.

APPENDIX E

COST ESTIMATES FOR THE WITHOUT SYSTEM

As discussed Section III of the case study report, it appears that cost savings from using ERS system inputs to the current system would be minimal. As shown in Table E-3, total annual cost for the acreage estimation component of the current probability survey is only $2.7 million. The data collection costs of the current system currently amount to $1.0 million annually (Table E-4). With data collection and processing costs of this order of magnitude, even if costs savings could be achieved, the annual benefit would be quite small.

Table E-1 lists the regional and national component costs of the total probability survey. Table E-2 provide the same information for crop items in the probability survey. Acreage estimation costs by region and cost category are included in Table E-3. Table E-4 provides costs of data collection for the acreage probability survey by region and by crop. The above cost information will be integrated into the detailed cost analysis of alternative systems to be accomplished at a future date.

It should be emphasized that these cost figures are unofficial and that the component, regional, and crop breakdowns are approximate. The figures are, however, sufficiently accurate for purposes of this analysis.1/

1/ The study is deeply indebted to Dr. William E. Kibler, Director of the Survey Division of the Statistical Reporting Service, USDA, for this cost information and other data on sampling and forecast accuracies.

Table E-1

Total Probability Survey Costs all Items, 1973

Category	N.E.	N. Cent.	South	West	Total
	($000)	($000)	($000)	($000)	($000)
Permanent Staff.....	100	1,250	1,450	600	3,400
Data Collection.....	120	1,050	1,130	700	3,000
Data Processing.....	5	45	65	35	150
Other 1/...........	20	80	90	60	250
Total.........	245	2,425	2,735	1,395	6,800

1/ Photography, supplies, printing, etc.

Table E-2

Total Probability Survey Costs Crop Items, 1973
(Acreage and Yield)

Category	N.E.	N. Cent.	South	West	Total
	($000)	($000)	($000)	($000)	($000)
Permanent Staff.....	60	790	1,010	340	2,200
Data Collection.....	70	710	850	370	2,000
Data Processing.....	-	30	40	15	85
Other 1/...........	10	50	50	40	150
Total.........	140	1,580	1,950	765	4,435

1/ Photography, supplies, printing, etc.

Table E-3

Total Probability Survey Costs Crop Acreages Only, 1973

Category	N.E.	N. Cent.	South	West	Total
	($000)	($000)	($000)	($000)	($000)
Permanent Staff.....	60	540	700	300	1,600
Data Collection.....	60	300	430	220	1,010
Data Processing.....	-	10	20	10	40
Other 1/............	10	30	30	20	90
Total..........	130	880	1,180	550	2,740

1/ Photography, supplies, printing, etc.

Table E-4

Data Collection Costs, Crop Acreages Probability Survey, 1973

Crop	N.E.	N. Cent.	South	West	Total
	($000)	($000)	($000)	($000)	($000)
Corn................	10	100	50	20	180
Soybeans............	-	70	65	15	150
Wheat...............	-	30	20	70	120
Cotton..............	-	-	75	30	105
Sorghum.............	-	20	30	20	70
Other...............	50	80	190	65	385
Total..........	60	300	430	220	1,010

APPENDIX F

GOVERNMENT SUPPORT PROGRAMS AND PRIVATE INVENTORY DECISIONS

This appendix describes government support program operation as of July, 1973. Private inventory decisions at the national and local level are also discussed using the California situation as an example.

Management decisions on production and inventory adjustments are made at both national and local levels. They are closely tied to the governmental policies which have applied in the past. Crop forecasts may be used by producers operating within the framework of such a set of policies or by the policy makers themselves. Therefore, it is important to understand the current situation in order to be able to construct the scenario of action for the study period. A discussion of these decisions, the institutions making them and the crop estimates influencing them is presented below. While the discussion is not comprehensive, it reflects our research to date and is representative of the most significant institutions involved at each level.

(1) Federal Government Decisions on Production Adjustment

The U.S. Department of Agriculture, Agriculture Stabilization and Conservation Service (ASCS) administers the federal commodity price-support programs. There are three types of programs:

- Those in which allotments (i.e., producer's share of total national acreage to be planted in that crop) actually restrict production and cover both export and domestic markets. Producer participation is compulsory. Among the crops covered are rice and peanuts.

- Those in which allotments are merely the basis of government payments to producers but production is not limited to those acres. Programs of this type cover cotton, wheat and feed grains. The national allotment is equal to the estimated domestic market needs without regard to export demand. Producer participation is voluntary and varies with market conditions, but in a typical year, a majority of producers sign up.

- Those in which quotas (i.e., tons marketed), not acreage allotments, are the means of restriction. Participation is compulsory. Crops covered include sugar and tobacco.

A representative crop is used to describe the significant features of each type of program: rice for the first type, cotton for the second and sugar for the third.

1. The Rice Program

By December 31st of each year the Secretary of Agriculture must announce three decisions affecting rice production during the following year:

- Acreage allotment for the nation and for each state.

- "Set-aside" requirement, if any. "Set-aside" is the current term for soil bank. It is a percentage of a producer's allotment that must not be planted to rice nor to any other cash crop. It can be left fallow, planted to a soil enriching crop, or used as pasture during the period between harvest and planting. The set-aside is a prerequisite to participation in the government price support program. (In some years the Secretary gives producers an option of retiring acres in addition to the required set-aside, and for those additional acres, the producer receives a government payment).

- The level of price support as a percentage of parity. (Parity is an index of the prices farmers receive over the prices farmers pay based on the years 1910 to 1914 with some adjustment to reflect the changes in technology since then). The range of support possible under current legislation is 65 to 90 percent; typically it is around 65 percent.

Allotment decisions are based upon:

- estimated domestic demand

- national inventory needs expressed as a percentage of domestic demand; 10 percent is a rule of thumb for rice

- current stock levels

- estimated exports

- states' historical shares of domestic production.

Each state's allotment is distributed to counties and producers within counties according to 1951-53 patterns. Distribution is made by elected local and county committees representing producers. USDA employees of the local ASCS who administer the price support program, however, influence the current committee's decisions. Legislation provides for a percentage of a state's allotment (up to 5 percent) to be distributed to new producers, but as this would diminish established grower's allotments, few or no new producer allotments ever are made.

Producers then sign up for the government program at their county ASCS office. That office makes spot checks of compliance throughout the year. Producers who exceed their allotment must pay penalties equal to the market price of their production on the excess acreage. Producers who plant too few acres "lose history," i.e., their allotment for subsequent years is reduced.

The Secretary of Agriculture can adjust the acreage allotment if the situation changes. USDA is reluctant to change the allotment after planting has started because, however, it would be unfair to farmers who have already planted. In the spring of 1973 for instance, rice acreage allotments were increased 10 percent because Thai and Phillippine crop failures increased prospects for US rice exports and for higher world rive prices. (A national increase of 10 percent means each producer's allotment increases about 10 percent.) The allotment increase will allow the United States to maximize rice exports without limiting domestic consumption. Only rarely are allotment adjustments made in response to changes in domestic market consumption.

Producers participating in the government program are eligible for both the loan program and direct payments.

At harvest, prices typically are at the season's low. Any time after harvest until March 30, a producer can decide to put any portion of his rice crop under loan. When he does so, he receives a guaranteed loan by the government based on the value of his crop valued at the prevailing support price level. His crop is collateral for this loan, and must be placed in approved storage facilities. During the term of the loan, the farmer pays the storage costs. The loan period is 8 to 10 months; typically loans are due April 30. At any time during the period, the producer can redeem his crop by repaying the loan plus the interest (usually 3-1/2 percent) and sell his crop on the open market. He will do so if the post-harvest market price has risen enough to cover his costs. If he does not redeem the crop by April 30, it becomes the property of the Commodity

Credit Corporation (CCC) and the interest is considered paid. At this point the CCC takes over the storage costs.

Participating producers receive direct payments whether or not they place their crop under loan. A producer's payment is based on the average yield on his acreage allotment, multiplied by government price per pound which is to bridge the gap between the market price and the parity price. The first payment is made soon after July 1. A subsequent "adjusted payment" is made if the market price falls during the first five months (August-December) of the marketing year. The direct payment that each producer may receive is currently limited to $55,000 per crop.

2. The Cotton Program

The program for cotton is similar in many ways to that for rice described above. Therefore only the exceptions to the rice program will be noted;

- The allotment must be announced by November 15th. Since it covers only domestic market needs, export demand is not considered in setting the national allotment. Domestic inventory needs for cotton are usually 25 percent of estimated domestic needs. Producers are not limited by their allotment; they can plant as many acres as they wish.

- Any portion of the participating producer's crop may be placed under government loan; loans are not limited to cotton grown on allotments.

- A producer's direct payment is based upon his allotment. The direct payment in 1973 will be 15¢ per pound for a typical grade of cotton. If a participating producer is alloted 100 acres and has produced an average of 500 pounds per acre, his total direct payment will be $7500. (100x500x$0.15) regardless of how many acres he plants or harvests. If the market price for cotton falls between August and December he will receive a supplemental payment.

3. The Sugar Program

US sugar quotas are announced by October 15th of each year based upon:

- the amount of sugar distributed in the United States for the 12 month period ending August 31.
- surpluses or deficits in the national sugar inventories.
- changes in population and demand
- the raw price for sugar and its relation to the "price objective," i.e., support price.

The sugar program differs from the commodity program described above, not merely because production is limited by quotas (expressed in short tons, raw value) rather than acreage allotments, but also because quotas are assigned to foreign importing countries as well as domestic producers. The distribution of quotas among the states and among producers is similar to the distribution of rice or cotton allotments described above; distribution among the importing countries is established by the U.S. Congress. If a foreign country cannot meet its import quota, the deficit is shared among the importing countries; domestic quota deficits are made up by increasing domestic producers' quotas. Within limits, quotas for Hawaii and Puerto Rico can be adjusted upward when their production exceeds their basic quota. The increase is offset by reducing the quotas of foreign countries other than Philippines and Ireland.

In years of excess supply, quotas are also assigned to processors to assure "orderly marketing" and to maintain the "price objective." In a typical year growers also receive prices above the world levels for their sugar as well as incentive payments on their marketed cane or beets. The basic rate for incentive payments is $16 per ton but declines as the volume marketed by a single producer increases.

(2) Federal Government Decisions On Inventory Adjustment

Inventory adjustment decisions are made by two divisions of USDA, the Commodity Credit Corporation (CCC) and the Export Marketing Service.

1. The Commodity Credit Corporation

The federal government becomes an inventory holder through the acquisition of CCC stocks. In addition to acquiring commodities through foreclosures on producers, the CCC can also purchase commodities on the open market in order to bolster prices. In the fifties and early sixties, CCC surplus stocks were huge. But agricultural policies world and domestic market conditions since then have reduced CCC inventories to a minimum. For instance, CCC cotton stores fell from averages of about 16 million bales in the early 1960's to the current low of 4000 bales. Savings in CCC storage cost were projected as a benefit in the earlier cost-benefit studies of a satellite system (e.g., PRC estimated wheat storage savings at $85.7 million per year), but these savings have been achieved without the assistance of an ERS system. In years of shortages, CCC stocks may be released onto the open market in order to stabilize rising prices but releasing them in years of surplus would depress farm prices. In the latter case, CCC commodities may be exported abroad under PL480 "Food for Peace" program or another - usually subsidized - export program.

2. The Export Marketing Service

U.S. Department of Agriculture, Export Marketing Service administers four programs under which U.S. agricultural commodities are exported: the Public Law 480 (PL 480) or Food for Peace Program, CCC Export Credit Sales, the Barter Program and the Commercial Sales Program.

- In 1972 two-thirds of U.S. rice exports and about 20 percent of all U.S. agricultural exports took place under Public Law 480 or "Food for Peace." These exports of government and private stocks help developing countries to meet their food and fiber needs and at the same time create export markets for U.S. goods. At one time payment for PL 480 exports was usually made in foreign currency. This option was discontinued in 1972 and now payment is to be made in dollars under credit terms up to 40 years.

- The CCC Export Credit Sales program provides for the financing of export sales of U.S. agricultural commodities for one to three years. For the past four years only privately owned stocks have used this program, though CCC stocks are eligible. Exports are limited to a list of commodities prepared by the CCC but at present this list covers the major U.S. agricultural exports.

- The Barter program allows U.S. firms to export selected U.S. commodities from both private and CCC stocks; their destinations are limited to protect existing dollar markets. This program helps the U.S. balance of payments by providing funds for goods and services needed abroad by U.S. agencies, primarily by Defense and AID. In 1972 30 percent of U.S. cotton exports were under the barter program.

- Most commercial export sales are from stocks owned by U.S. firms but when private stocks are inadequate, CCC stocks can become commercial exports. U.S. commercial exporters commonly receive an export subsidy (i.e., the difference between the world price and the U.S. support price) so that U.S. products can compete in world markets. Currently most export subsidies have been discontinued because of the unusual shortage and subsequent high world prices. (e.g. the rice export subsidy amounted to $2.75 per hundred weight until it was discontinued in December 1972).

The decisions involved in the export marketing program include:

- establishing allotments for commodities like rice in which both export and domestic markets are controlled by the U.S. price support program, (a decision made by the Secretary of Agriculture and ASCS).

- deciding which commodities are eligible for export under the programs of PL 480, CCC Export Credit Sales, and Barter. (The Office of Management and Budget and the

Department of State as well as USDA's Export Marketing Service are involved in this decision.)

- determining the level of export subsidies for U.S. agricultural commodities, and adjusting the level of those subsidies as conditions change.

- determining if export controls are needed to conserve domestic supplies and, if so, what type of control used to be used.

(3) <u>Private Industry's Inventory Adjustment Decisions at the National Level</u>

The decisions made by the U.S. grain dealers exemplifies private industry's inventory adjustment at the national level. Inventory decisions in agriculture are made at all stages from production to final consumption. In the case of wheat, once the grain is harvested it is often stored in country elevators which are relatively small and geographically dispersed. These elevators provide interim storage before the wheat is shipped to a central market. In some cases the farmer rents space in these elevators and in some cases he sells his crop to the elevator operator. Elevator operators may be small middlemen or large grain companies or co-ops. Some large millers own a significant amount of storage capacity, but this is not the usual case. From the country elevators (and sometimes directly from the farm) grain moves to terminal elevators which are large elevators located at central marketing points. Here grain is officially graded. From the terminal elevators grain is sold to millers and other purchasers.

One link in the grain marketing process discussed only briefly above is the Commodity Credit Corporation. When a farmer stores his wheat, he gets a certificate from the grain elevator which he may use to obtain a loan through the CCC. With the grain as collateral, the CCC authorizes a bank to loan the farmer an amount up to the value of the grain less prepaid storage costs.

Inventory decisions are made by farmers, elevator operators, co-ops, millers (to some extent), and the CCC. Millers, large co-ops, and large grain companies operate extensively in the futures market. Millers are able to avoid extensive inventories and maintain assured supply with certain costs through the futures market. Data on stocks of grains in all positions is available on a quarterly basis from USDA.

(4) Local Decisions: The California Story

The discussion of local management decisions for adjusting both production and inventory is essentially a summary of a field trip to northern California. Figure F-1 shows the relationship of:

- the institutions
- the decisions
- crop information
- benefits of better information
- the crop year

The "generic crop" discussed is vegetable crop produced for processing. No crop precisely fits the description; canned green peas was the model; marketing orders, however, do not apply to that crop.

In the example presented in Figure F-1production decisions are made in the fall preceding spring planting. At that time the producer must get his ground ready and more importantly - make a commitment on his planting intentions as he contracts with the bank for credit. (In this case, the bank is the Bank of America which provides 35% of all California agricultural credit financing and keeps track of its producers through a very sophisticated data system). The processor (Del Monte is the model) also makes his plans for the coming year and contracts for cans and labels needed to fulfill 85 percent of the plan. By December the processor has begun to make contracts with producers for their production. Typically they contract by acreage and pay for production by the pound.

About the time the producer begins spring planting, the commodity advisory board meets to establish the price the producer will receive that year. A commodity advisory board, a quasi-governmental institution, is created by a marketing order. The marketing order is authorized by the state or federal 1/ government allowing the marketing of a specific commodity to be controlled. A marketing order is issued at the request of over half of the producers concerned. Once in effect, all producers of the

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1/Federal marketing orders on crops generally do not involve controls on quantity and quality marketed. For instance, the order on cotton provides for promotion and research only. State orders are more comprehensive.

LOCAL DECISIONS

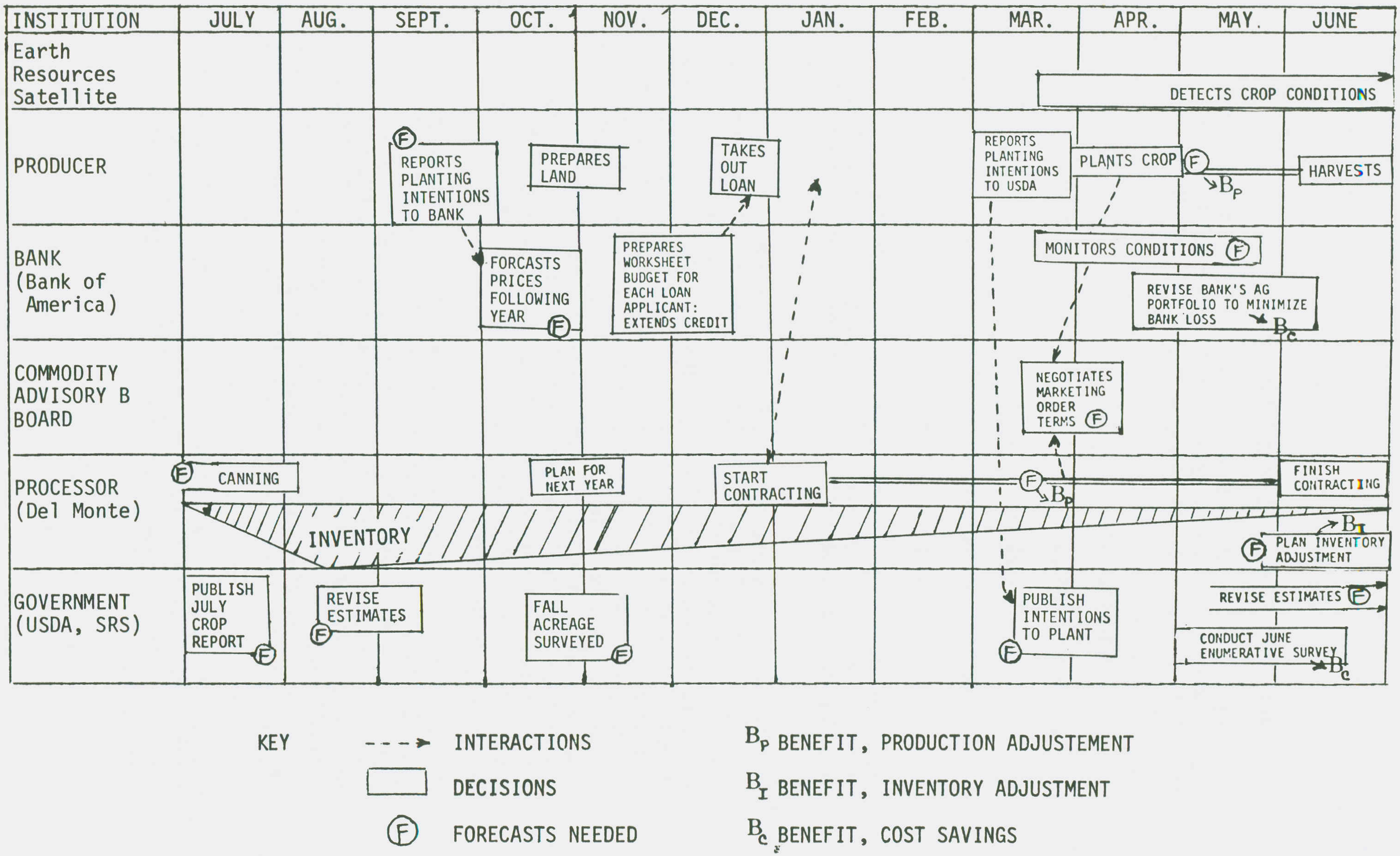


FIGURE F-1

commodity must comply. Costs of administrating the order is paid for by an assessment on producers based on the volume of their crop. The order may allow control of quality, quantity and timing for marketing of the crop concerned; it also may provide funds for market promotion and research on diseases affecting that crop. Each spring following planting, processors, producers' representatives, and government observers attend a commodity advisory board meeting to set up specific terms for the year on price, quality standards and quantity to be marketed. Producers typically estimate a small crop, hoping for a high price; processors predict a large crop, hoping to establish a low price. Some production adjustment may result from this meeting; e.g., if there is an overabundance, green peaches are deliberately shaken down from the trees of, say, every third row in the orchard; a portion of each producer's tomato plants may be pulled up or plums below a certain size may be culled. Better forecasts of production would assist in setting the marketing orders' yearly terms.

All during the spring, right up until harvest, the processor may contract with producers. Contracts are made on the basis of acreage; payment is made on the basis of volume produced. If a processor over-contracts, he may destroy some of the crop (a form of production adjustment) even though he has reimbursed the producer at the agreed terms. Thus, better forecasts would aid in the contracting decisions of processors. Forecasts can also assist in planning processing operations. For instance, with data on tomato acreage by variety and a knowledge of the ripening sequence of the varieties, a tomato canning plant would be better able to maximize plant capacity and avoid bottlenecks.

Typically, a processed vegetable crop is inventoried by the processor. His stocks peak soon after harvest and are depleted throughout the year. A processor may make a significant inventory adjustment in the spring and early summer of a year in which a small harvest is predicted. The small harvest will mean higher prices for the processed product on the grocery shelves. In anticipation of this price increase, the processor may discontinue distribution of his inventory about a month before the new crop is processed. The storage costs and the market loss resulting from this decision may be offset by charging prices a few cents per can higher when the withheld inventory is released with the new crop. Accurate crop estimates would, of course, reduce the risk involved in this decision.

II. CHARACTERISTICS OF CURRENT AND PROJECTED CROP FORECASTING SYSTEMS

1. THE U.S. DEPARTMENT OF AGRICULTURE'S CROP REPORTING SERVICE USES A NATIONAL STATISTICAL SAMPLING PLAN FOR THE DEVELOPMENT OF CROP PRODUCTION ESTIMATES WHICH THEN SERVE AS ONE INPUT TO CROP PRODUCTION FORECASTS MADE BY THE CROP REPORTING BOARD

The statistical sampling plan incorporates a broad land use stratification which governs sampling density and includes approximately 17,000 sample units used in the development of crop acreage and yield estimates. Typical sampling errors and overall production forecast errors for this system for several major crops are as follows:

	Sampling Error (%)	Average September Forecast Error
Corn	1.3	4.1
Wheat - winter	4.1	2.5
Rice	10.4	2.3

2. A STATISTICAL SAMPLING SYSTEM BASED ON SATELLITE (OR HIGH ALTITUDE AIRCRAFT IMAGERY IS ENVISIONED WITH THE FOLLOWING CHARACTERISTICS:

- substantially larger number of sample units to reduce sampling error
- a "floating" sample to permit substitution of fields which are cloud free for those which may be cloud covered
- a continuous computer-based estimation program which would permit daily updates of forecasts as additional imagery is collected, and as identification accuracy is improved through multiple imagery of the same sample unit.

The design for such a system would be required to permit the detailed analysis of satellite and data system requirements, and system performance. The design of a statistical sampling plan with the characteristics described above was beyond the scope of this study. Therefore, it has not been possible to establish the specific requirements for the capabilities of such a system.

3. <u>IN ADDITION TO THE SAMPLING ERRORS ASSOCIATED WITH THE STATISTICAL SAMPLING PLAN, MEASUREMENT ERRORS RELATED TO CROP IDENTIFICATION ACREAGE ESTIMATION MUST BE CONSIDERED.</u>

The measurement accuracy levels demonstrated to date by ERTS-1 experiments do not at this early stage, permit design of a crop survey with accuracies significantly better than current systems. It appears likely that continued research will show improved accuracies through improved digital processing techniques and better use of multiple imagery and *a priori* information.

4. <u>THE BENEFITS TO BE DERIVED FROM MORE TIMELY INFORMATION, AT A GIVEN LEVEL OF ACCURACY, HAVE NOT, AT THIS TIME, BEEN ASSESSED. AS THE PROGRESS OF INVESTIGATIONS CONTINUE THESE FACTORS WILL BE INTEGRATED INTO THE STUDY RESULTS.</u>

5. <u>THE BENEFITS TO BE ACHIEVED FROM A WORLD CROP FORECASTING SYSTEM WILL BE HANDLED AS PART OF THE INTERNATIONAL IMPACT ANALYSIS. THE DOMESTIC CROP FORECAST ANALYSIS ESTABLISHES MUCH OF THE GROUNDWORK AND METHODOLOGY NEEDED IN THE INTERNATIONAL ANALYSIS.</u>

III. ANALYSIS OF BENEFITS

1. <u>IN THE ABSENCE OF ESTIMATES OF THE OVERALL ACCURACY OF ERS CROP ACREAGE ESTIMATES, BENEFITS WERE ESTIMATED AS A FUNCTION OF ERROR OVER A RANGE OF IMPROVEMENTS.</u>

Benefits from improved crop forecasting can accrue in one or more of the following ways:

- <u>Production Adjustments</u>:

  Production adjustments based on national domestic crop forecasts are expected to a relatively minor factor within the United States, since information is not generally available soon enough to permit such adjustments.

- <u>Production or Inventory Adjustments Based on Local Crop Forecasts</u>:

  Local and regional crop forecasts are of value to many growers and suppliers in various parts of the country. An analysis of California agriculture indicates that most users develop their own crop forecasts based on local, often informal, data collection. This data is generally more accurate than the local and regional projections developed from the USDA national forecast. Benefits from local and regional forecasts depend upon the extent to which local decisions depend on local as opposed to national information and on the accuracy of local crop forecasts produced by different systems.

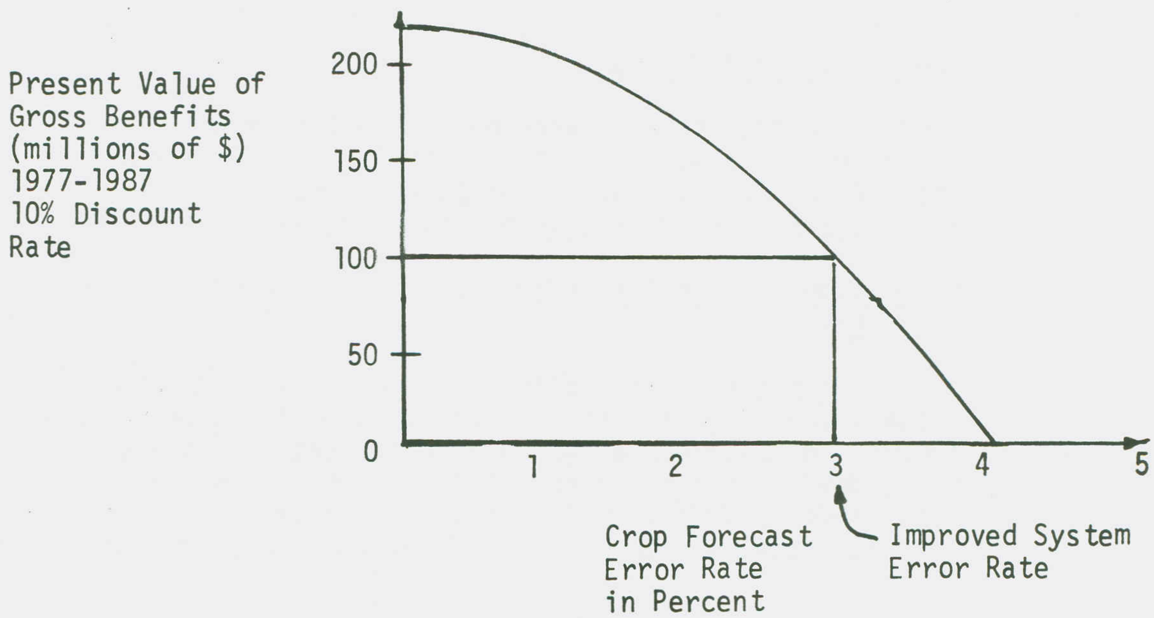
- Inventory Adjustments

  Inventory adjustment of stored commodities and some processed foods are made as a function of price expections based on anticipated crop production. Benefit estimation within this case study have been focused on improvements in such adjustments that relate to improvements in the accuracies of crop forecasts.

2. INVENTORY ADJUSTMENT BENEFIT ESTIMATES HAVE BEEN MADE USING A PREVIOUSLY DEVELOPED MODEL WHICH PROVIDES A THERETICAL FRAMEWORK FOR MEASURING REDUCTIONS IN SOCIAL LOSS BROUGHT ABOUT BY MORE ACCURATE CROP FORECASTS.

A paper entitled "Social Returns to Public Information Services" (American Economic Review, March 1972) served as the basis for benefits estimates. Adjustments were made to the model to incorporate the best current data on demand elasticities, crop production and price forecasts, and market conditions for the time period 1977-87.

3. AN EXAMPLE OF POTENTIAL INVENTORY ADJUSTMENT BENEFITS FOR CORN IS SHOWN IN THE FOLLOWING FIGURE



This indicates that an improvement from 4.1% error rate to 3.0% would yield a $100 million benefit for the 10 year period. Gross benefit estimates for 10% reduction in forecast errors for all crops range from $88 million to $132 million.

4. THE ESTIMATED BENEFITS ARE EXPECTED TO BE MORE EQUALLY DISTRIBUTED ACROSS DIFFERENT REGIONS AND INCOME CLASSES THAN IS CURRENT INCOME

This results from the assumption that benefits accrue ultimately to the consumers of food and the fact that low income families spend a higher proportion of their income on food than do higher income families.

5. MIMIMAL SOCIAL AND ENVIRONMENTAL IMPACTS WERE IDENTIFIED

Inventory adjustments have little impact on the environment. Social impacts may arise, however, if the improvement in crop forecasts makes publically available crop information more competitive to that collected privately by the larger commodity firms. More even competition could result, especially if world crop forecasts are made available from an ERS system.

6. THE POTENTIAL BENEFITS FROM USE OF AN ERS SYSTEM TO PROVIDE IMPROVED INTERNATIONAL CROP FORECASTS ARE LARGE AND WILL BE THE SUBJECT OF FURTHER ANALYSIS AS A PART OF A SEPARATE STUDY TASK TO CONDUCT AN INTERNATIONAL ANALYSIS