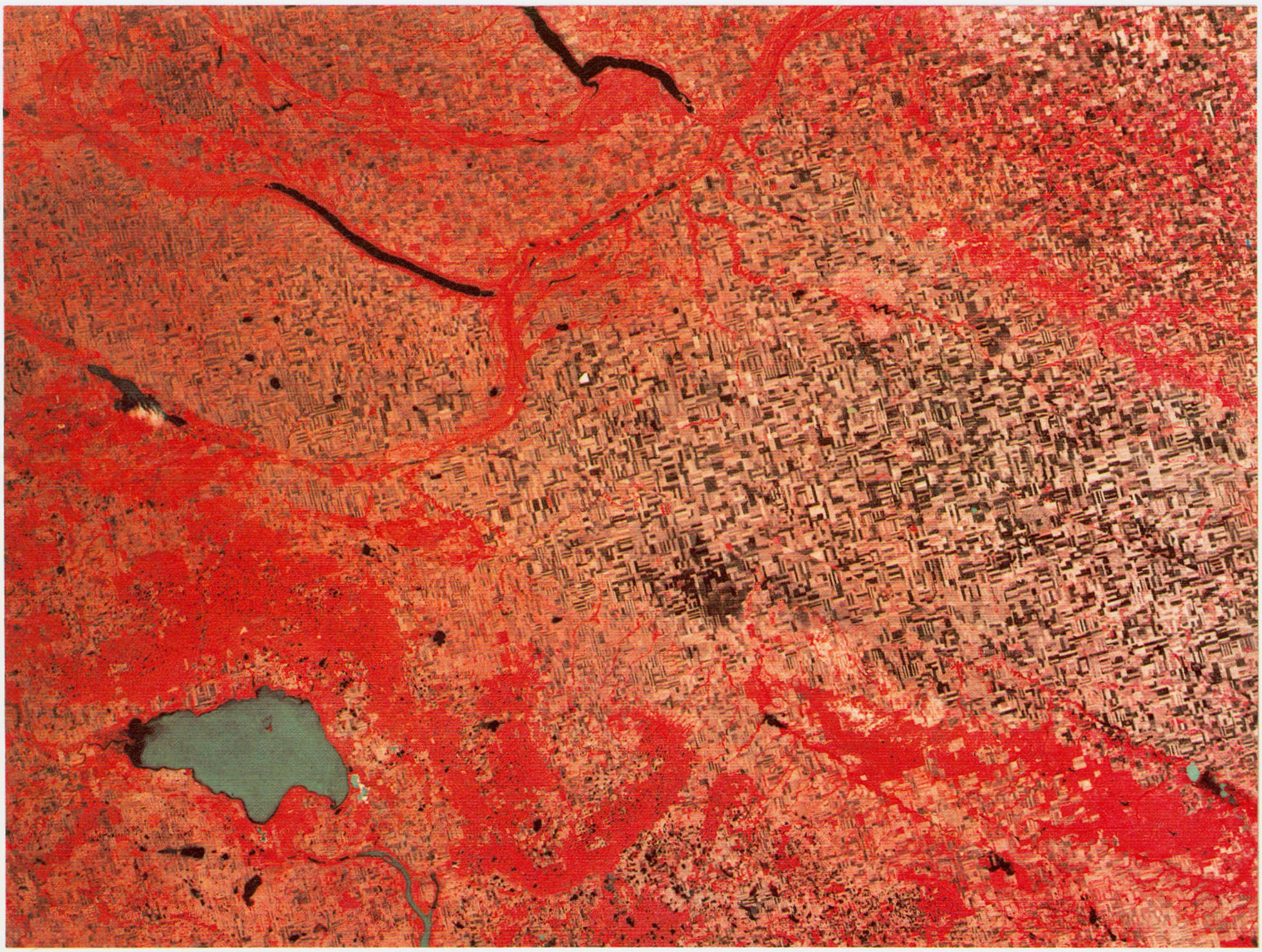
FY 1980

AgRISTARS
ANNUAL REPORT



A Joint Program for Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing

AP-JO-04111

AgRISTARS

AGRICULTURE AND RESOURCES INVENTORY SURVEYS THROUGH AEROSPACE REMOTE SENSING

ANNUAL REPORT - FISCAL YEAR 1980

Prepared by

AgRISTARS Program Support Staff

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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PREFACE

The AgRISTARS Program was initiated in Fiscal Year 1980 in response to an initiative issued by the U.S. Department of Agriculture. Led by the USDA, the program is a cooperative effort with the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the U.S. Department of Interior, and the Agency for International Development.

The program goal is to determine the usefulness, cost, and extent to which aerospace remote sensing data can be integrated into existing or future USDA systems to improve the objectivity, reliability, timeliness, and adequacy of information required to carry out USDA missions.

The program is well underway, with encouraging progress having been made in Fiscal Year 1980. The outlook is that aerospace remote sensing will contribute to USDA information needs in a significant way and, more generally, that the AgRISTARS effort will advance this technology for use in other areas of national need.

ACRONYMS

AgRISTARS	Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing
AID	Agency for International Development
C/P	Conservation and Pollution
CEAS	Center for Environmental Assessment Services
DCLC	Domestic Crops and Land Cover
EDIS	Environmental Data and Information Service
ESS	Economics and Statistics Service
EW/CCA	Early Warning/Crop Condition Assessment
FCPF	Foreign Commodity Production Forecasting
FY	fiscal year
FAS	Foreign Agriculture Service
ICC	Interagency Coordinating Committee
IPB	Interagency Policy Board
JAWF	Joint Agriculture Weather Facility
JES	June Enumerative Survey
LACIE	Large Area Crop Inventory Experiment
MAIS	Multiresource Analysis and Information System
NASA	National Aeronautics and Space Administration
NCC	National Climatic Center
NESS	National Environmental Satellite Service
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
PMT	Project Management Team
ppm	parts per million

PSS	Program Support Staff
RRI	Renewable Resources Inventory
SAR	Synthetic aperture radar
SEA/AR	Science and Education Administration/Agricultural Research
SM	Soil Moisture
SMMR	scanning multichannel microwave radiometer
SR	Supporting Research
TSS	total suspended solids
USDA	U.S. Department of Agriculture
USDC	U.S. Department of Commerce
USDI	U.S. Department of the Interior
WMO	World Meteorological Organization
YMD	Yield Model Development

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I. PURPOSE

The purpose of the Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS) Annual Report is to present the major objectives and accomplishments of the program and its eight component projects during fiscal year (FY) 1980.

The report includes an introduction to the overall AgRISTARS program, a general statement on progress, and separate summaries of the activities of each project. The primary emphasis is on the technical highlights. It is planned to issue similar annual reports around November of each year. Organizational and management information on AgRISTARS is included in the appendixes, as is a complete bibliography of publications and reports. Additional information may be obtained from:

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Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing
AgRISTARS
☆ USDA ☆ NASA ☆ USDC ☆ USDI ☆ AID ☆

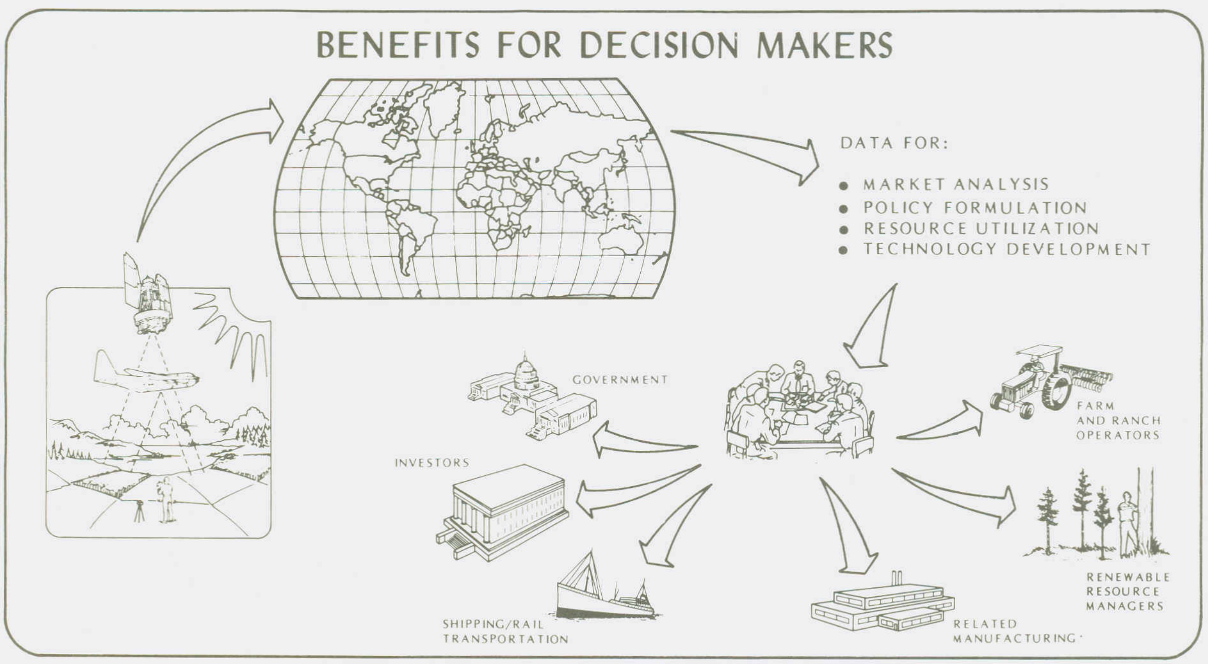
2. INTRODUCTION

AgRISTARS is a long-term program of research, development, evaluation, and application of aerospace remote sensing to meet the needs of the U.S. Department of Agriculture (USDA). The program is a cooperative effort of: the USDA; the National Aeronautics and Space Administration (NASA); the U.S. Department of Commerce (USDC) through its agency, the National Oceanic and Atmospheric Administration (NOAA); and the U.S. Department of the Interior (USDI). In addition, the Agency for International Development (AID) participates as an ex-officio observer and potential future user agency.

In 1978, the Secretary of Agriculture issued an initiative,[1] in response to which the participating agencies established the AgRISTARS program. In 1980, the program was initiated as an effort based on satisfying current and future requirements of the USDA for high-priority agricultural and other renewable resources type information. This information is important to the USDA in addressing national and international issues on supply, demand, and competition for food and fiber.

The overall goal of AgRISTARS is to determine the feasibility of integrating aerospace remote sensing technology into existing or future USDA data acquisition systems. Determining feasibility depends upon the assessment of numerous factors over an extended period of time. Determinations of the reliability, costs, timeliness, objectivity, and adequacy of information required to carry out USDA missions are planned in the program. The overall approach consists of a balanced program of remote sensing research, development, and testing which addresses a wide range of information

[1] Joint Program of Research and Development of Uses of Aerospace Technology for Agricultural Programs, February 1978.



Remote sensing technology is being developed to give timely, reliable information to those concerned with the worldwide status of renewable resources.

needs on domestic and global resources and agricultural commodities.

In this initiative, the USDA identified the following seven information requirements:

- Early warning of change affecting production and quality of commodities and renewable resources
- Commodity production forecasts
- Land use classification and measurement
- Renewable resources inventory and assessment
- Land productivity estimates
- Conservation practices assessment
- Pollution detection and impact evaluations

Based on these information requirements, as well as on a specific immediate need for better or more timely information on crop conditions and expected production, the AgRISTARS technical program was developed. It consists of eight projects which address all seven of the USDA information needs with a clear emphasis on the first two, early warning of change and commodity production forecasts. The eight projects include the following:

- Early Warning/Crop Condition Assessment (EW/CCA)
- Foreign Commodity Production Forecasting (FCPF)
- Yield Model Development (YMD)
- Supporting Research (SR)
- Soil Moisture (SM)
- Domestic Crops and Land Cover DCLC)
- Renewable Resources Inventory (RRI)
- Conservation and Pollution (C/P)

Each project has its specific set of objectives and is treated in this report as a discrete element of the AgRISTARS program. The projects are interrelated both through mutuality of information needs and through much common technology. The approach for all projects calls for exploratory experiments, pilot and/or large-scale applications tests, and USDA user evaluations.

AgRISTARS PROJECTS

3. PROGRAM SUMMARY

The AgRISTARS Program is well underway with meaningful progress having been made during FY 1980, the first year of the effort. Scientists and support personnel from the participating government agencies, from universities, and from industry are assigned to AgRISTARS research at some 35 locations in the United States. A multi-agency program management structure has been established and is functioning with planning and reporting mechanisms in place. Each of the participating agencies is supporting its effort under the program pursuant to a Memorandum of Understanding dated January 16, 1980.

The outlook for activity under the AgRISTARS program is that aerospace remote sensing technology will indeed contribute in a significant way to meeting the information needs of the USDA. Further, it is anticipated that AgRISTARS will be a major stimulus to advance remote sensing technology in general and thus will contribute to the exploitation of this technology in other areas of national need.

4. PROJECT SUMMARIES

4.1 EARLY WARNING/CROP CONDITION ASSESSMENT

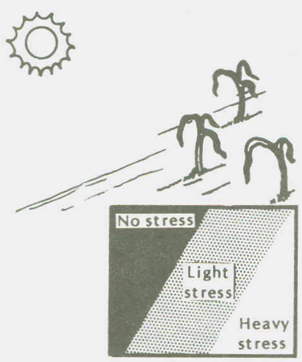
The EW/CCA research effort is designed to develop and test remote sensing techniques which will make possible or enhance operational methodologies for crop condition assessment. This technology will be used by elements of the USDA, in particular the Foreign Agriculture Service (FAS) of the USDA, which is responsible for providing early warning of changes which may affect foreign crop production and quality and for assessing crop conditions. The EW/CCA project is led by the USDA Science and Education Administration/ Agricultural Research (SEA/AR) with participation by NASA and NOAA. The project activity includes techniques for applications in the United States and several foreign countries including the U.S.S.R., Argentina, Brazil, Canada, Peoples Republic of China, Mexico, and Australia. Six major commodities of interest include wheat, barley, corn, soybeans, cotton, and rice.

Major accomplishments in FY 1980 were:

EARLY WARNING OF CONDITIONS AFFECTING CROPS

This project will assist the USDA in tracking the condition of six major crops (wheat, barley, corn, cotton, soybeans, and rice) in the United States and foreign countries.

Techniques using data from satellites to measure the effects of drought on crops are well developed, and the areas of the crops affected can be accurately measured. Other types of crop stress are also being studied.



- The improvement and testing of a soil/water budget model to assess crop stress due to lack of moisture.

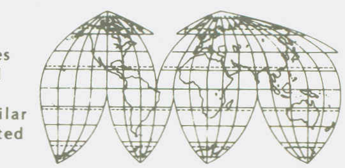
- Initial development of relationships between crop stress due to lack of moisture and information from environmental satellites.

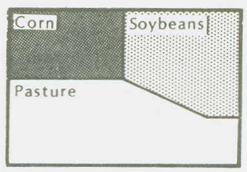
4.2 FOREIGN COMMODITY PRODUCTION FORECASTING

The objective of FCPF activity is to develop and test procedures for using aerospace remote sensing technology to provide objective, timely, and reliable forecasts of foreign crop production. The prospective users of this technology are the USDA FAS and various international organizations concerned with world food and fiber supply. The project is led by NASA with participation by USDA and NOAA. In achieving its objective, the FCPF research considers eight crop/region combinations in the United States and five foreign countries, including the U.S.S.R., Argentina, Brazil, Canada, and Australia. Small grains (wheat and barley) and corn and soybeans will be studied. FCPF research expands the remote sensing technology developed in previous experiments during the mid-1970's.

FOREIGN COMMODITY PRODUCTION FORECASTING

The FCPF project will develop techniques to monitor four commodities (wheat, barley, corn, and soybeans) in five foreign countries and in five similar growing areas in the United States.





For example, interpreting techniques for images of Brazilian crops may be aided by comparing them to images of crops grown in the State of Georgia.

Major accomplishments in FY 1980 were as follows:

- The successful adaptation of analytical techniques, initially developed for wheat, for use in identifying corn and soybeans.

- The improvement of analytical techniques for analysis of spring small grains and the testing of these techniques in Canada and the United States.

- The improvement in efficiency of these analytical methods in the sense of their becoming less labor intensive.

4.3 YIELD MODEL DEVELOPMENT (YMD)

The YMD research effort utilizes measurements of environmental and plant characteristics to project crop yield potential within a region. This effort is a key component of any commodity production forecasting methodology and, as such, contributes to both the domestic and foreign crop estimation processes. NOAA, through the Environmental Data and Information Service, Center for Environmental Assessment Services (EDIS/CEAS), leads this activity with support from USDA and NASA.

Major accomplishments in FY 1980 were:

- The selection and development of a uniform testing approach for simple predictive models for the yields of barley, soybeans, and corn in key U.S. growing regions.

- Twenty-seven crop yield models were reviewed using the criteria agreed on by USDA, NASA, and NOAA.

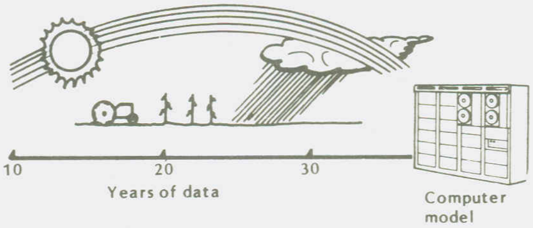
- Empirical models for corn, soybeans, wheat, and barley for specific crop reporting districts were completed.

- The selection for testing of a physiologically based wheat model which accounts explicitly for key processes taking place in the plant.

- Procedures developed and implemented to provide current worldwide quality-checked meteorological data to the Johnson Space Center through the Joint Agricultural Weather Facility (JAWF).

YIELD MODEL DEVELOPMENT

This is research to determine how various crops will respond to weather conditions, agricultural practices, and other factors. Many years of data are taken into account.



4.4 SUPPORTING RESEARCH (SR)

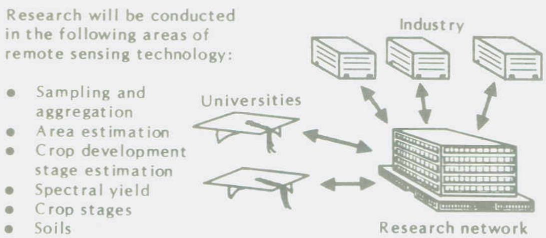
This applied research project is designed to provide technological components and procedures for testing in the other AgRISTARS projects, notably in the crop inventory activities. Research focuses on techniques to extract, from Landsat data, information on the area planted to different crops; on the stage of development of wheat, barley, corn, and soybeans; and on the crop condition determined from spectral (plant color as sensed remotely) analyses of the crops. This activity is led by NASA with support from USDA and NOAA.

The crops of concern to the EW/CCA and FCPF projects are being studied by the SR project. In addition, natural vegetation and soils are important subjects of study.

Major accomplishments in FY 1980 were as follows:

- The development of the mathematical foundation for the improved FCPF techniques described in section 4.2.
- The development of a new methodology for distinguishing among crops in the Landsat imagery on the basis of their change in appearance through the growing season.

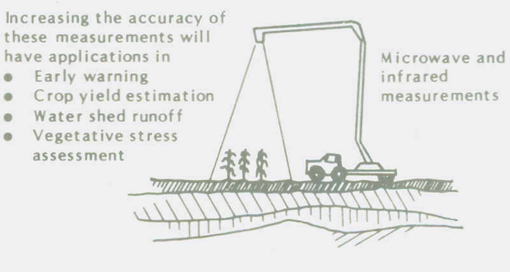
SUPPORTING RESEARCH



4.5 SOIL MOISTURE

The objective of the SM project is to develop and evaluate the technology for the remote and ground measurements of soil moisture. This technology is an intermediate step in the application of remote sensing, in that a knowledge of soil moisture is important to models which predict items such as crop yield, plant stress, and watershed runoff. This work will provide knowledge about a key variable needed in several other AgRISTARS projects. This activity is led by the USDA (Soil Conservation Service) with support from NASA. The scope of the work includes the improvement of in situ soil moisture measurement techniques and, through mathematical modeling efforts, relating these in situ measurements to remotely sensed measurements. Applications of the results will be made over broad regions to various agricultural and hydrological problems.

SOIL MOISTURE STUDIES



Major accomplishments in FY 1980 were:

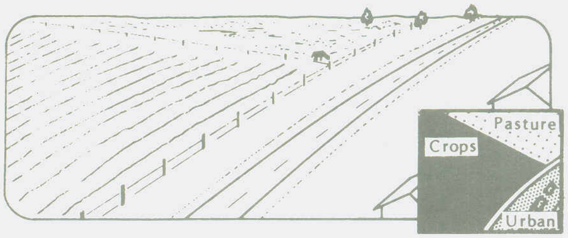
- The results of experiments in which consistent relationships over a variety of conditions were found in the way that microwave energy is reflected from soils of differing moisture content. Also, a close correlation has been found between data from ground-based systems and aircraft systems. These results show potential for eventual satellite sensing of soil moisture over a large area.
- The effects of vegetation cover on the microwave measurement of soil moisture can be accounted for by an additional factor in the model. This finding improves the basic understanding of vegetation effects and shows that soil moisture measurement through moderate vegetation canopies is possible.

4.6 DOMESTIC CROPS AND LAND COVER

The DCLC objectives are to improve state and substate crop acreage data by integrating Landsat and ground data into the existing program and evaluating the cost effectiveness of the new procedure. This technology will be used by the USDA in meeting its responsibilities to provide statistics on the commodities of U.S. agriculture. This project is led by the USDA Economics and Statistics Service (ESS) with support from NASA. The scope is to address major crops in the

DOMESTIC CROPS AND LAND COVER

Directed at automatic classification and estimation of land cover with emphasis on major crops, this project will use Landsat and advanced sensor data to improve accuracy of data classification on the local level. The first states being studied are Iowa and Kansas.



important agricultural states and apply the technology to two additional states each year.

Major accomplishments in FY 1980 were:

- Improvements in the precision of crop acreage estimates for wheat in Kansas and corn and soybeans in Iowa were made with techniques using Landsat data.

- Analytical methods were implemented at the state offices in Kansas and Iowa, and this prototype is encouraging from the point of view of adoption by actual user groups.

4.7 RENEWABLE RESOURCES INVENTORY

The objectives of the RRI project are the development and implementation, in the USDA Forest Service, of new remote sensing technology which will offer capabilities in support of the national renewable resource assessment process. The USDA Forest Service will be the user of the technologies developed under the RRI project. The Forest Service is the lead agency in this project and is supported by NASA. The scope of the effort includes: improving high-altitude aircraft sensor and pallet capability; mapping and characterizing natural and managed habitation; collecting, displaying, and using resource information to aid in forest management and planning; demonstrating advanced capabilities for monitoring, classifying, and measuring disturbances and changes in forests and rangeland; and evaluating Landsat technology as a tool for supporting multi-resource inventories and forest planning.

Major accomplishments in FY 1980 were as follows:

- The first phase of an effort to evaluate the utility of Landsat technology for meeting Forest Service needs was completed. The feasibility demonstration indicated that land cover acreages could be determined accurately using a combination of aircraft photographic and Landsat data.

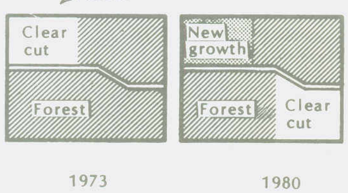
- Significant progress was made toward developing an operational change-detection algorithm, determining the effectiveness of different clustering algorithms, assessing the accuracy of existing Landsat-based forest cover type maps, and determining the objectives and issues for an operational land information support system. In addition, two new high-resolution panoramic camera systems were integrated into the NASA U-2c aircraft.

RENEWABLE RESOURCES INVENTORY

Four main categories will be addressed:

(1) National inventory
(2) Stress/damage assessment
(3) Timberland classification
(4) Environmental/land use

Use of data from the Landsat multispectral scanner and the more detailed data from the improved sensors is planned.



4.8 CONSERVATION AND POLLUTION

The conservation assessment portion of the CP project addresses applications in three areas: inventory of conservation practices, estimation of water runoff using hydrologic models, and determination of physical characteristics of snowpacks.

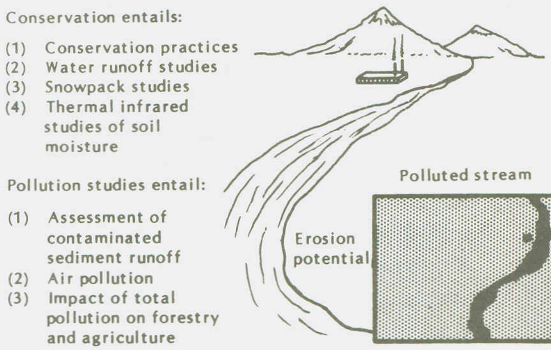
The pollution portion of the CP project will provide an assessment of conservation practices through the use of remote sensing techniques to quantitatively assess sediment runoff, to detect gaseous and particulate air pollutants, and to assess their impacts on agricultural and forestry resources.

The USDA leads this project with support from NASA and NOAA.

Major accomplishments during FY 1980 were:

- Improved accuracy in predicting runoff from a watershed was demonstrated using snow cover observations from satellites.
- A significant relationship was found between snow depth (important in assessing winterkill potential for winter wheat) and microwave data.
- Field and laboratory measurements established conditions under which suspended sediments (from agricultural runoff) could be measured in a lake.

SOIL CONSERVATION AND POLLUTION



5. PROJECT TECHNICAL HIGHLIGHTS

In each of the AgRISTARS projects, there has been good progress across a broad front, and the results have been documented in detail (see appendix B). The purpose of this section is to focus on the few most significant accomplishments in each project. If the reader desires greater detail, he should consult the key references noted below each of the highlighted efforts.

5.1 EARLY WARNING/CROP CONDITION ASSESSMENT

5.1.1 Technical Objectives

The general objective of the research and development activity is to provide a capability for the USDA to assess and respond in a timely way to factors which affect the quality and production of economically important crops. The technical objectives of this activity are:

- To develop and test methods of using meteorological information with various mathematical (simulation) alarm models and known environmental threshold measurements to provide alerts to potentially troublesome conditions.
- To develop and test methods to use Landsat and other data to assess the condition of crops and the extent of the area affected by anomalous conditions.
- To evaluate the utility of meteorological satellites in providing data useful to early warning activities.

5.1.2 Alarm Models

Models were developed, and/or existing models were improved, to provide alarms for potentially troublesome environmental conditions such as small grains winterkill and water and temperature stresses for corn, sorghum, soybeans, and small grains. A corn stress model (fig. 1) illustrates both optimum

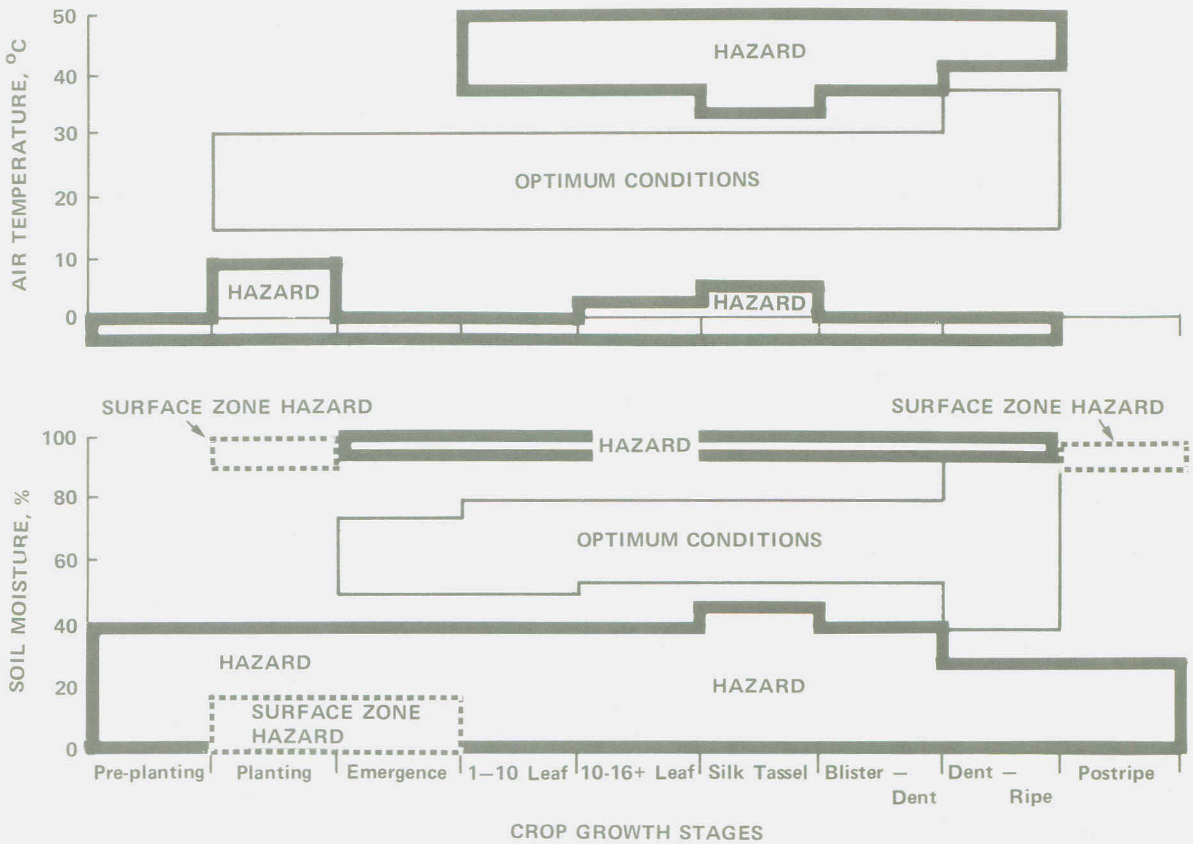


Figure 1. Corn stress model.

and hazardous moisture and temperature conditions that may occur at various plant growth stages. To support the alarm model development, an improved soil water budget model was developed and implemented in conjunction with an existing USDA data base.

(Key references: 1-06, 1-26, 1-77).

5.1.3 Condition Assessments

The assessment of the effects of abnormal conditions on the crop is important. For example, if rain occurs during harvest when wheat has been swathed, then substantial losses occur. A preliminary model has been developed to predict the portion of the crop which will be lost when such meteorological conditions occur (fig. 2). Other models have been developed to account for the effects of hot, dry winds on wheat and stripe rust on small grains. These models will be tested during the coming year.

5.1.4 Environmental Satellites

Information from the NOAA-6 environmental satellite has been analyzed for vegetation characteristics and indexes of greenness. These indexes correlate well to similar ones from Landsat data and, for large areas, will give useful insight into crop conditions; for instance, drought over county-size or larger area can be monitored using such indexes. This was the result of a joint National Environmental Satellite Service (NESS) and EDIS effort in NOAA.

(Key references: 1-03, 1-08).

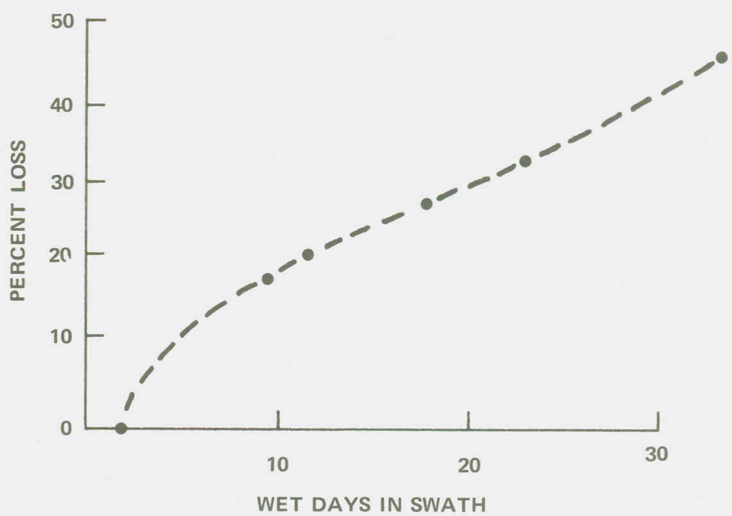


Figure 2. Water damage to swathed wheat.

5.2 FOREIGN COMMODITY PRODUCTION FORECASTING

5.2.1 Technical Objectives

The general objective of the FCPF project is to develop technology for making improved crop production forecasts in foreign areas. The focus of this work in FY 1980 has been on:

- Adapting existing technology to new crops and regions, testing the technology in limited areas, and assessing the accuracy of the results.
- Improving the efficiency with which analysis can be done; typically, by increasing the extent of automation and reducing the human analyst involvement.
- Designing experiments and acquiring and building a data base for future development and evaluation.

(Key references: 2-08, 2-19, 2-29).

5.2.2 Identification of Corn and Soybeans

Computer-aided classification of crops from Landsat measurements has been successfully accomplished for small grains, and good results were obtained in research efforts before the AgRISTARS program.[2] This technology has been extended to corn and soybeans for a U.S.-controlled Corn Belt environment with good success. Figure 3 shows the spectral characteristics of the crops in terms of greenness, a growth index, and brightness factors, as the season progresses. Clearly, there is a time at which these crops appear different to the satellite. A procedure to exploit this spectral difference was developed and tested on 58 sites in 6 states of the U.S. Corn Belt. Figure 4 shows that highly accurate identification was achieved for corn and soybeans.

(Key references: 2-08, 2-17, 2-19).

5.2.3 Identification of Spring Small Grains

Earlier work in detecting spring small grains gave relatively poor results in the U.S./Canada environment, and the procedures for estimating these crops have been greatly improved by the FCPF project. For the first time, reliable, automated, crop identification results were obtained in the U.S. Northern Great Plains and in Canada for spring small grains as a class. Figure 5 shows the accuracies achieved for these crops in comparison with pre-AgRISTARS capability.

(Key references: 2-03, 2-08, 2-19, 2-26).

5.2.4 Efficiency in Analysis

One of the major accomplishments in FCPF was the simultaneous improvement of both the accuracy and the efficiency of the process of estimating the amount of spring small grains in a test area. Prior to AgRISTARS, the technology required about 4 hours of skilled analyst time per test area (in the U.S./Canada environment) and was significantly underestimating spring small grains acreage. The current technology is now indicating a major reduction in the error (about one-half of the error on previous estimates), and a major reduction (approximately 60 to 75 percent) has been achieved in the amount of analyst time required, with potential for

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[2] The Large Area Crop Inventory Experiment (LACIE), for example, from 1974 through 1978, studied wheat in major growing areas and produced good estimates of the 1977 U.S.S.R. crop in a quasi-operational test.

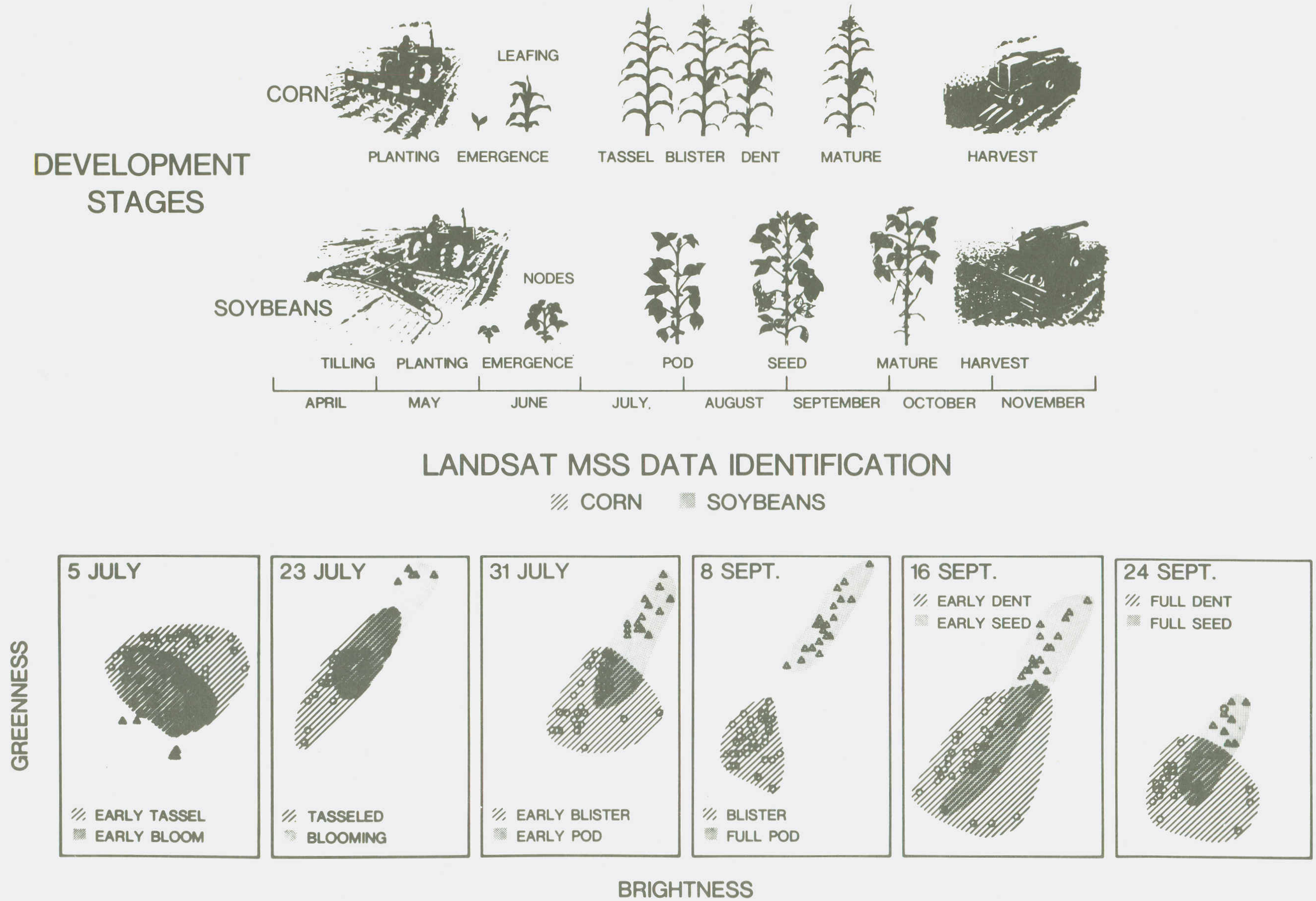


Figure 3. Spectral separability of corn and soybeans.

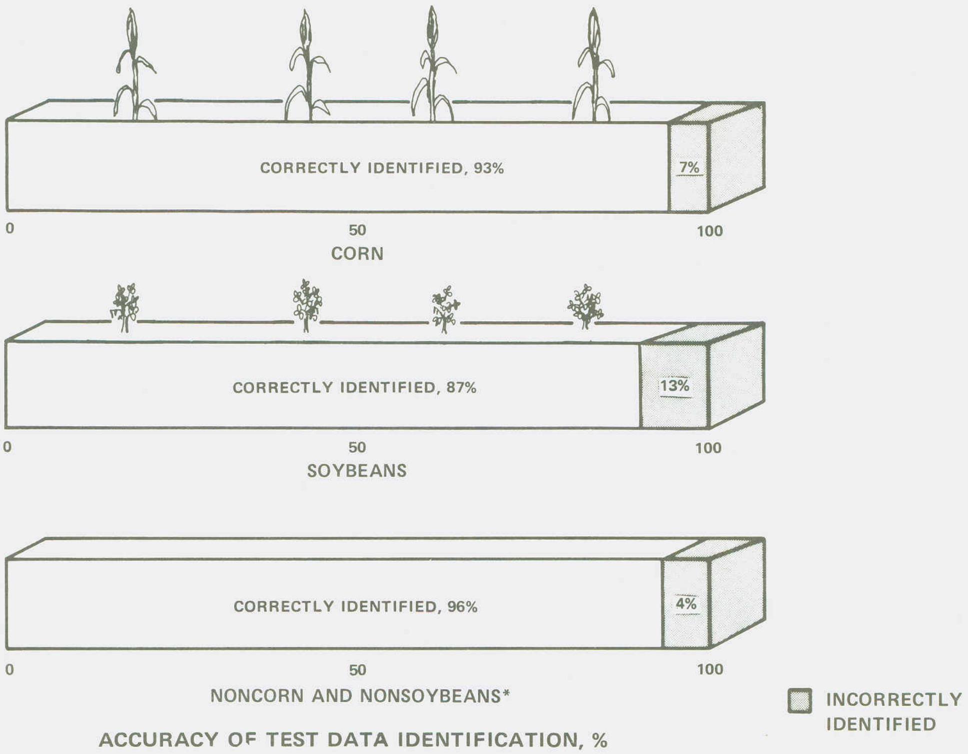


Figure 4. Results of U.S. corn and soybeans analysis.

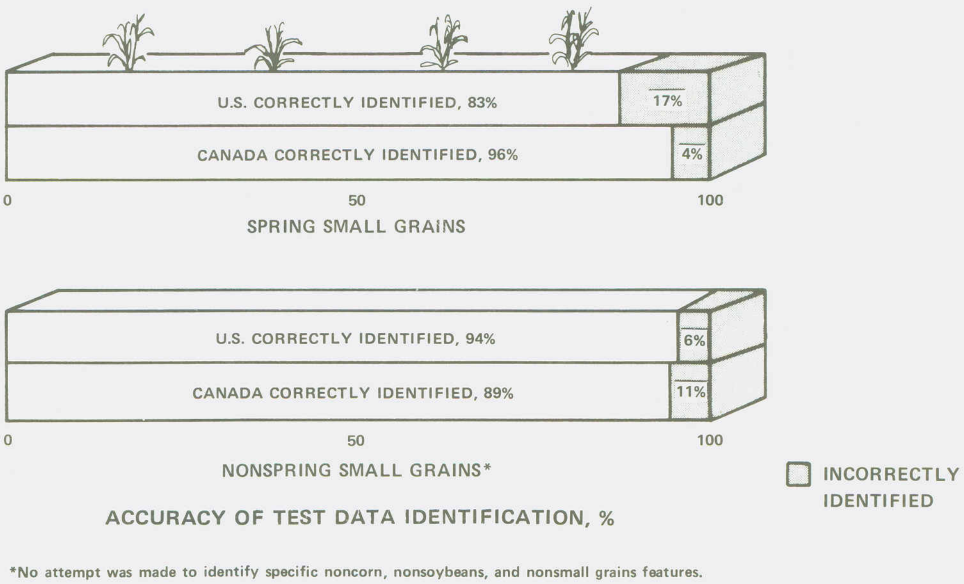


Figure 5. Results of U.S. and Canada spring small grains analysis.

additional efficiency. These results, shown in figure 6, were for tests conducted in the U.S. Northern Great Plains, where testing over a wider range of conditions will be carried out in the future.

(Key references: 2-19, 2-26).

5.2.5 Acquisitions of Research Data

During FY 1980, the most comprehensive set of correlated Landsat and ground observation data ever obtained for agricultural remote sensing research was acquired in the United States. These data were acquired over some 300 sites in various regions of the United States where the major crops are grown; i.e., winter and spring wheat, barley, corn, soybeans, sorghum, sunflower, rice, and cotton. Field enumerators of the USDA collected ground observations of crop stage and crop condition periodically throughout the growing season, consistent with the date of the Landsat overpass, for 30 randomly selected fields per site. Supportive aircraft photography was flown over the sites, and a total inventory was obtained once during the growing season for each site. Data from selected sites in Canada and Australia were obtained, also, through cooperative arrangements with the governments of these countries. The number of test areas for the crops of interest and the general locations are shown in figure 7. Additionally, Landsat data were obtained over selected regions of Argentina, Australia, Brazil, and the U.S.S.R. for future experiments.

(Key references: 2-08, 2-19, 2-37).

1980 GROUND DATA ACTIVITIES

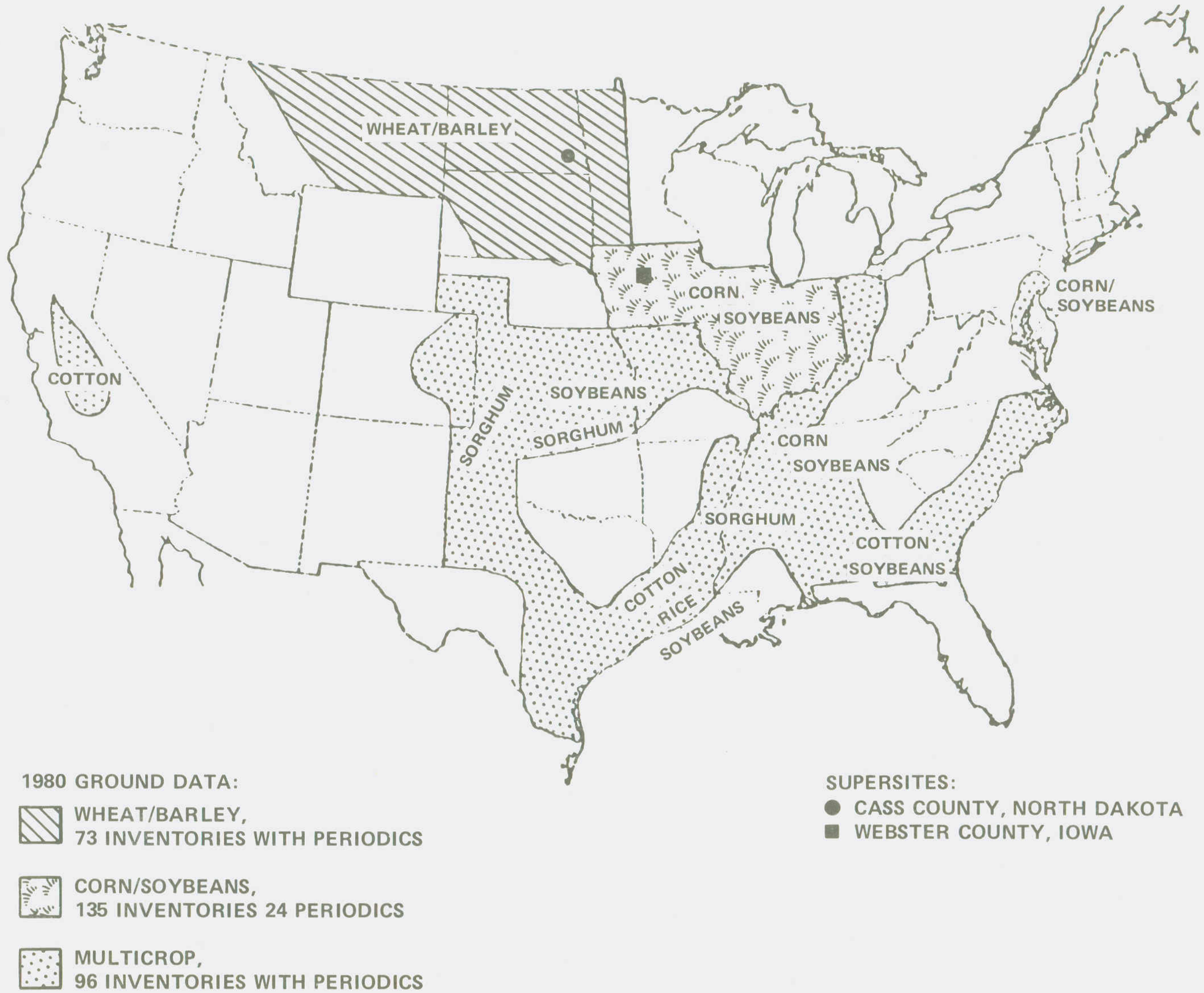


Figure 7. Map showing test areas for crops of interest.

5.3 YIELD MODEL DEVELOPMENT

5.3.1 Technical Objectives

The general objective of the YMD project is to develop improved yield estimation techniques for use in making crop production forecasts, foreign and domestic. The focus of this effort in FY 1980 was on:

- Establishing standards for selecting and testing existing yield models.
- Acquiring and testing existing yield models for crops and regions in support of the FCPF and EW/CCA projects.
- Assimilation of a meteorological and climatological data base for yield model test evaluation and development.
- Evaluation, testing, and recommendations for improvement of plant process and growth models developed by agricultural research agronomists and plant physiologists.

5.3.2 Standards for Selecting and Evaluation Models

Standards for selecting, testing, and evaluating crop yield models were established jointly by NASA, NOAA, and USDA representatives. These standards were approved by AgRISTARS management and published so that individual models could be evaluated using uniform criteria for model performance.

5.3.3 Acquisition and Testing of Yield Models

Linear regression yield models were acquired and tested in the NOAA-USDA modeling center in Columbia, Missouri. A model for each crop and area on which the FCPF project is to make a production forecast in FY 1981 was selected, documented, and prepared for operation.

(Key references: 3-03, 3-17, 3-32, 3-40, 3-51, 3-52).

Plant process and growth models for wheat are tested by agronomists, plant physiologists, and statisticians at the USDA SEA/AR facility in Fort Collins, Colorado. Requirements were documented for improving specific portions of the plant process.

(Key references: 3-16, 3-43, 3-46, 3-53, 3-75).

5.3.4 Meteorological and Climatological Data Base

A historical data base for the 12,000 U.S. cooperative stations was assembled by the NOAA/EDIS National Climatic Center (NCC), Asheville, North Carolina, and stored on the National Weather Service (NWS) computer facility at Suitland, Maryland. Current daily meteorological data are prepared by NWS and transmitted daily to the JAWF for distribution to operational units of USDA and AgRISTARS projects.

5.3.5 Improvement of Plant Process Models

Plant scientists began the incorporation of plant nutrient responses into corn and wheat growth models. The wheat model is being adapted to barley. A soybean physiological model was prepared for test and evaluation.

(Key references: 3-12, 3-62).

5.4 SUPPORTING RESEARCH PROJECT

5.4.1 Technical Objectives

The SR project, led by NASA, has the responsibility for planning, designing, conducting, and monitoring research in support of aerospace remote sensing for AgRISTARS applications. During FY 1980, the technical emphasis in SR was on the machine analysis techniques of multispectral remote sensing measurements. This research included investigations of imaging and nonimaging sensors mounted on ground, air, and space vehicles. In addition, SR efforts examined the use of automated techniques for precision combination (registering) of satellite data acquired at different times and for relating these data sets to known ground locations.

5.4.2 Machine Classification

Previous studies in agricultural remote sensing have long indicated the need to improve the efficiency of machine processing techniques and to increase the accuracy with which crops can be identified while reducing manual involvement. During FY 1980, the SR project achieved several of the needed improvements.

Earlier machine classification techniques required the user to select specific sample areas of each crop. These sample areas were used to "train" the computer for subsequent automated classifications. The approach is referred to as supervised classification. In another approach, the nonsupervised approach, crops are characterized by sets of distinguishing remotely sensed measurements and are automatically grouped according to similarities in the measurements. SR has developed a new nonsupervised classification program called CLASSY. The use of CLASSY has decreased the time it takes to discriminate crops and has reduced manual involvement.

Most current machine classification techniques in remote sensing use crop color or spectral information for discrimination purposes. Seldom, however, do analysts encounter entire fields that are spectrally pure. Typically, fields display spectrally pure areas surrounded by spectrally mixed perimeters. When a decision is made by a computer algorithm to label the field as a specific crop, it would be beneficial to isolate (spatially) the pure interiors and ignore the spectrally mixed perimeter. An alternative machine processing approach called Procedure M, which is under development in SR, uses spatial information in remotely sensed data to automatically find the spectrally pure interiors of agricultural fields. With this procedure, accuracies were substantially increased in two ways: (1) field-by-field accuracies increased, and (2) smaller samples are now required for valid statistical estimates of area. Initial tests of Procedure M over selected corn and soybeans areas demonstrated that it was effective in large fields in the U.S. Corn Belt.

(Key references: 4-95, 4-96).

5.4.3 Crop Growth Stage Research

Modeling research which utilizes the unique characteristics of crops at different growth stages is being performed in the SR project. One important use of growth stage information is to provide insight on deviations from the norm for that crop. Questions of crop vigor, plant stress, and potential yield can then be addressed.

During FY 1980, the SR project modified earlier techniques so that it is now feasible to provide accurate predictions of the crop stage of wheat to within ±5 days when an accurate starting date is known. Models to predict median planting dates to within ±6.6 days for spring small grains have also been developed. The improvement in the wheat crop-stage model is, in part, related to the development of the moisture stress index which accounts for the effects of drought on the crop development stage. Tests on the model have shown that it is consistent under wet and dry conditions.

In addition to its work with the wheat growth stage modeling, the SR project developed and tested models for determining the growth stages of corn and began research to evaluate and develop a barley model. The model for predicting crop growth stage is based on spectral or color measurements from Landsat data and agronomic farm data; and, unlike other growth stage models, it is independent of planting dates, nitrogen usage, and geographic area. Figure 8 shows the plot of a parameter called greenness, which as noted earlier is an index used to determine growth stage against time for a sample study area in Iowa. An important use of crop growth stage information is to discriminate crops which appear spectrally similar to remote sensors. For example, corn and soybeans often appear similar in color throughout their growth. These crops can be difficult to discriminate on any single image. However, SR has found that the pattern of color change throughout the growth period is different between the two crops. Thus, a log or history of the pattern of color change for specific fields would allow the analyst to discriminate the two crops as figure 9 shows.

SR project field research measured such patterns showing changes in the remotely sensed color of wheat, barley, corn, and soybeans. When such measurements for two crops are compiled on a single graph and compared, the "temporal profiles," as they are called, can be used to distinguish these crops from one another and provide a reasonably accurate basis for a highly automated crop identification procedure.

(Key references: 4-27, 4-28).

5.4.4 Crop Condition Monitoring

Remotely sensed crop color (i.e., spectral) data integrated with other agricultural and meteorological data in mathematical models have the potential to provide a significant improvement in a model's yield prediction capability. For example, leaf area index and intercepted solar radiation are values which potentially can be estimated with Landsat data and which are required for several agrometeorological yield models (fig. 10). During FY 1980, the SR project initiated efforts to integrate spectral data into yield models and anticipates further progress during FY 1981 in this research area.

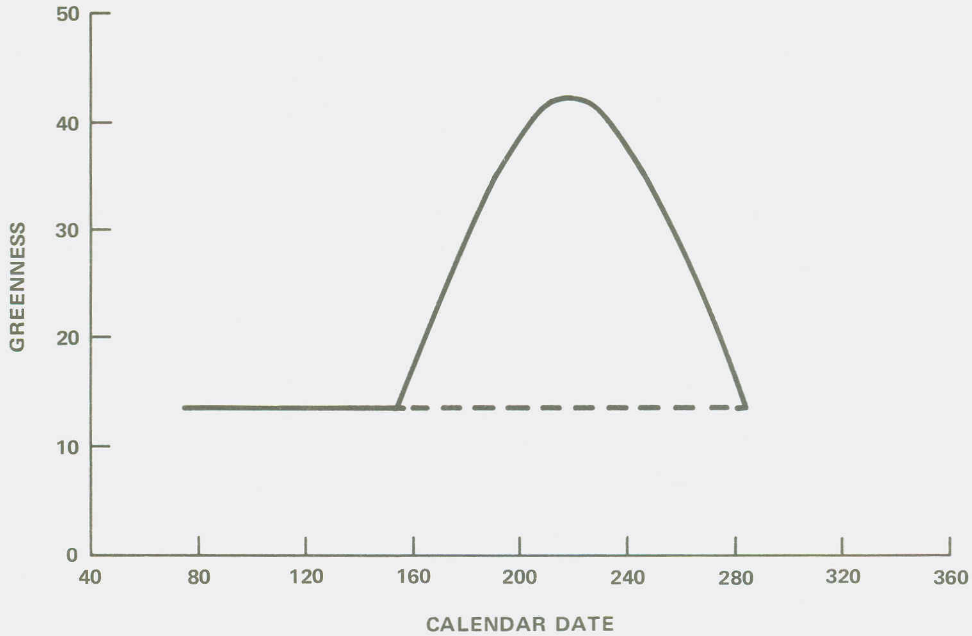


Figure 8. Seasonal change in the greenness of a cornfield.

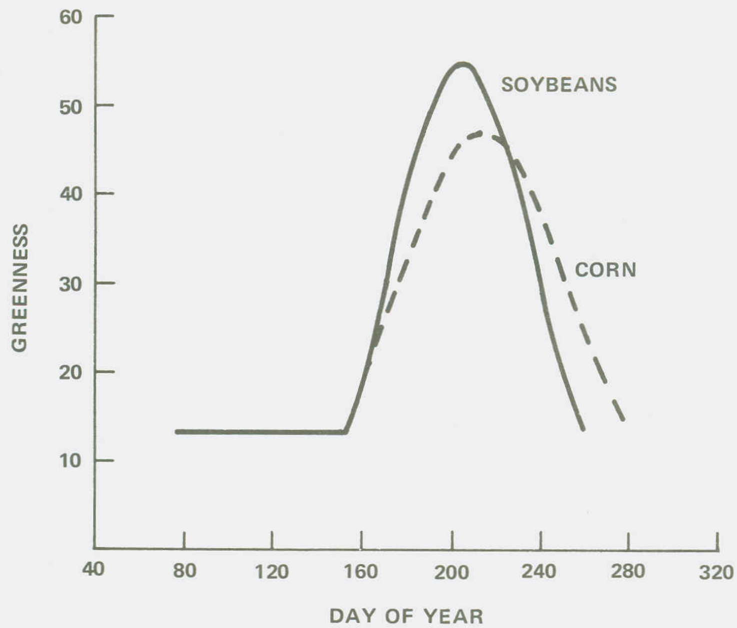


Figure 9. Comparison of crop seasonal change in greenness.

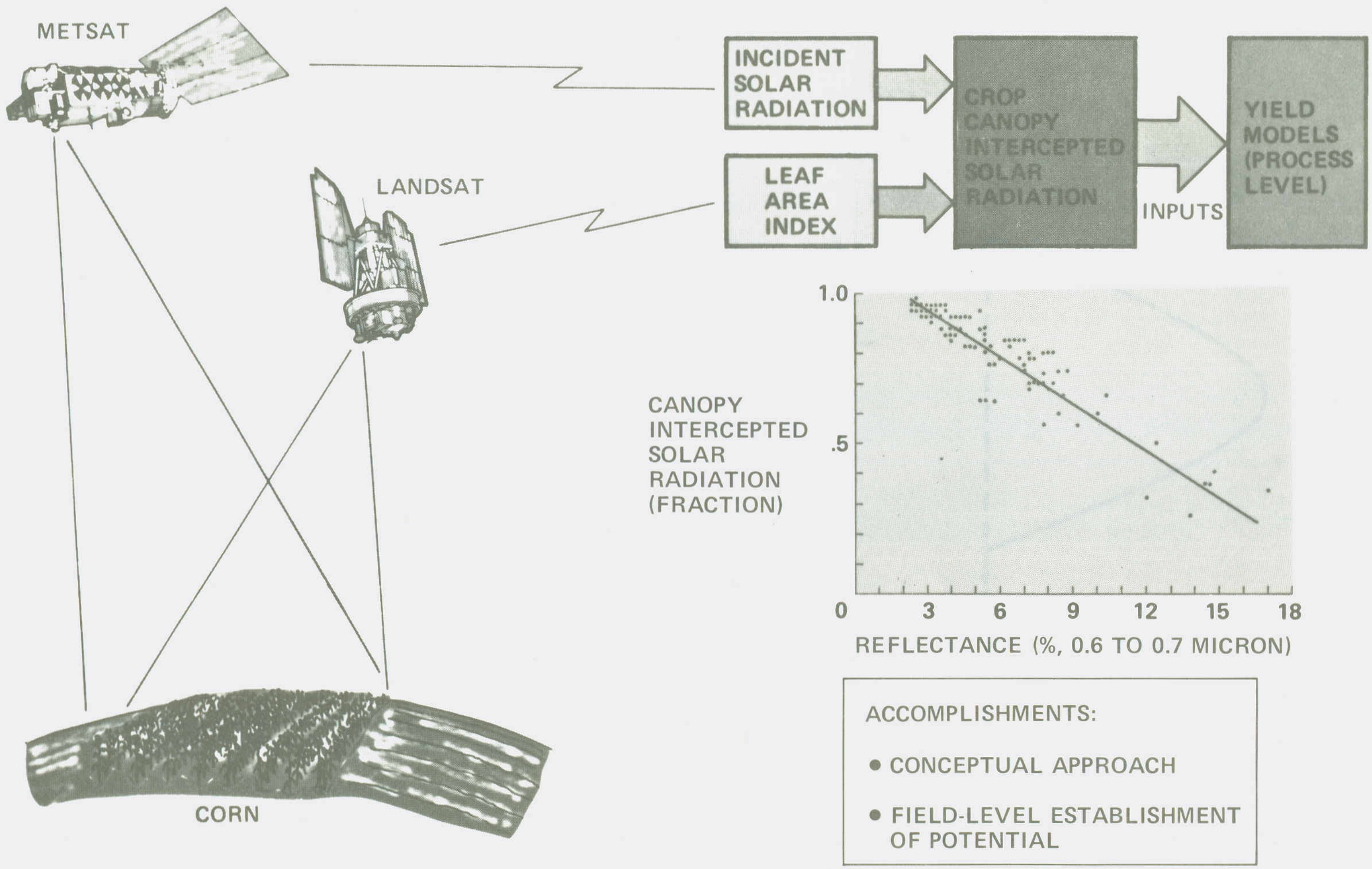


Figure 10. Remote sensing inputs to yield models.

5.5 SOIL MOISTURE PROJECT

5.5.1 Technical Objectives

The SM project will develop, test, and evaluate a capability to gather soil moisture data remotely and with in situ devices. Soil moisture data are important when used in conjunction with appropriate models to predict the behavior of crops and other ground-moisture related items, such as watershed runoff. The specific technical objectives of the SM project include:

- Sensor research.
- Field measurements, ground and airborne.
- Modeling and analysis.

(Key references: 5-05, 5-22, 5-23).

5.5.2 Microwave Sensor Research

Water has characteristics which allow it to interact very strongly with microwave radiation. Because of these unique characteristics, the capability of remote sensing at microwave frequencies (radar wavelengths) has been utilized for its potential to measure soil moisture. Moist soils are distinguished from dry soils in that the reflection from the former exceeds that of the latter. Among scientists in the field, the radar reflection is called "backscatter." Scientists also measure natural microwave emission from the Earth's surface. In general, when backscatter increases, emission decreases. Furthermore, the depth into the soil that the microwave energy penetrates varies with the wavelength of the energy. Thus, by limiting the output microwave signals to very specific wavelengths, scientists also know the approximate depth of microwave penetrations.

The maximum penetration of the sensors used in the SM project is at best a few centimeters. However, moisture at this depth is more changeable than in any other portion of the total soil column and, hence, is very important. So, with other information such as temperature, precipitation, and soil type, it is feasible to approximate soil moisture in the crop rooting zone, the total region of interest.

(Key references: 5-15, 5-16, 5-17, 5-24).

5.5.3 Analysis of Vegetation Cover

Other factors also affect microwave backscatter. In order to develop an accurate model of soil moisture, all major factors must be considered. Vegetation cover is one such factor. Two experiments were carried out to determine the effect of vegetation on microwave backscatter.

The first experiment was conducted in Georgia, Oklahoma, and South Dakota using truck-mounted microwave sensors over pasture grasses at each location. The field measurements at all three locations agreed well with laboratory measurements of soil moisture when the biomass of the pasture grasses was taken into account. Figure 11 shows the effect that different types of vegetation have on sensor performance. From this experiment, it was possible to express the amount of emission despite the vegetation and still have a reliable soil moisture measurement.

The second experiment also used truck-mounted sensors but over bare ground in California and Maryland. In California, measurements were made over dry soil and then irrigated soil as it dried out. The Maryland experiments were similar, except that the land was naturally watered with rain. The results again showed a close correlation between the remotely sensed and the laboratory-measured soil moisture (fig. 12).

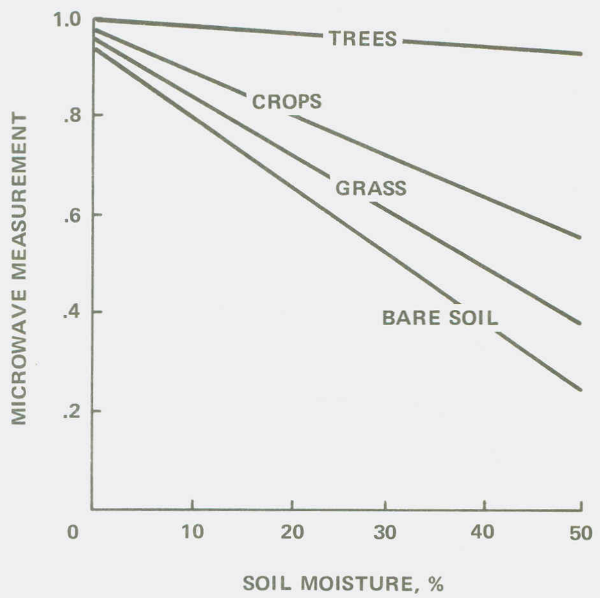


Figure 11. Microwave measurement for selected vegetative cover.

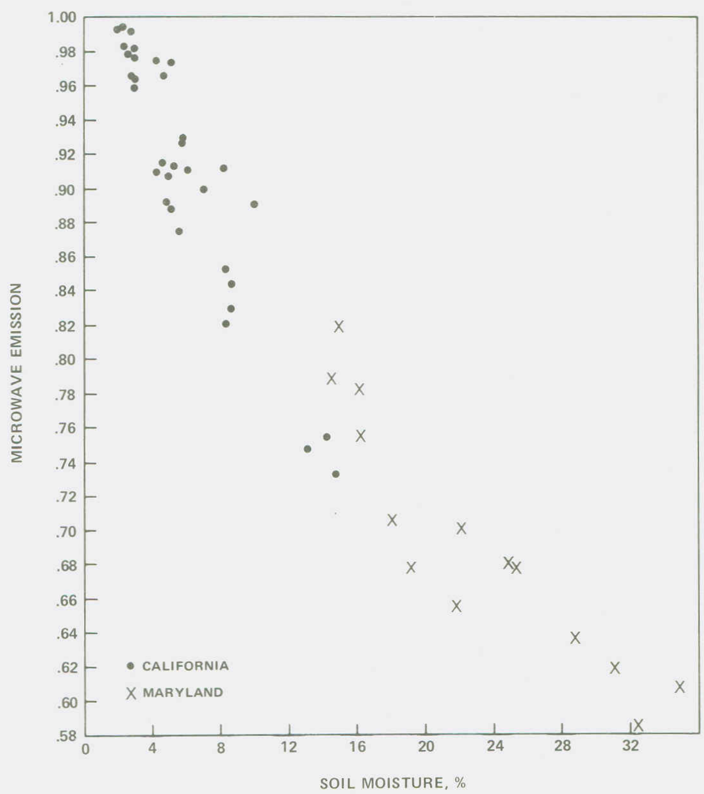


Figure 12. Microwave measurement for bare sandy loam soils in different regions.

These two experiments have indicated that soil moisture data can be obtained from remote sensors over a variety of conditions, including some with vegetative cover.

(Key references: 5-08, 5-10, 5-15, 5-16).

5.5.4 Analysis of Diverse Geographies

Another critical issue that has been addressed was whether microwave sensors would give reliable results over diverse physical geographic and climatic regions and soils. Data collected using an aircraft-mounted system over pastures in Florida, Oklahoma, and South Dakota were used to evaluate this problem. Figure 13 shows the results obtained. A very strong relationship exists between the microwave measurement and soil moisture at all sites. Many of the field variations can be attributed to variations in the amount of vegetation cover. Sites in Florida were more densely vegetated than those in Oklahoma and South Dakota. These variations, however, show the same trends observed in figure 11.

(Key reference: 5-15).

5.5.5 Analysis of Multilevel Microwave Data

During FY 1980, SM scientists continued to analyze an extensive data set collected in 1978 over Colby County, Kansas. The first analysis indicated these data to be of high quality, and initial findings were that active microwave, aircraft, and truck measurements along the same flight lines were highly correlated. If low-level sensors can be used to obtain calibrations of the upper-level sensors, then this is important for future extensions of ground data to aircraft platforms and, eventually, to space platforms.

(Key references: 5-03, 5-04, 5-06, 5-12, 5-18).

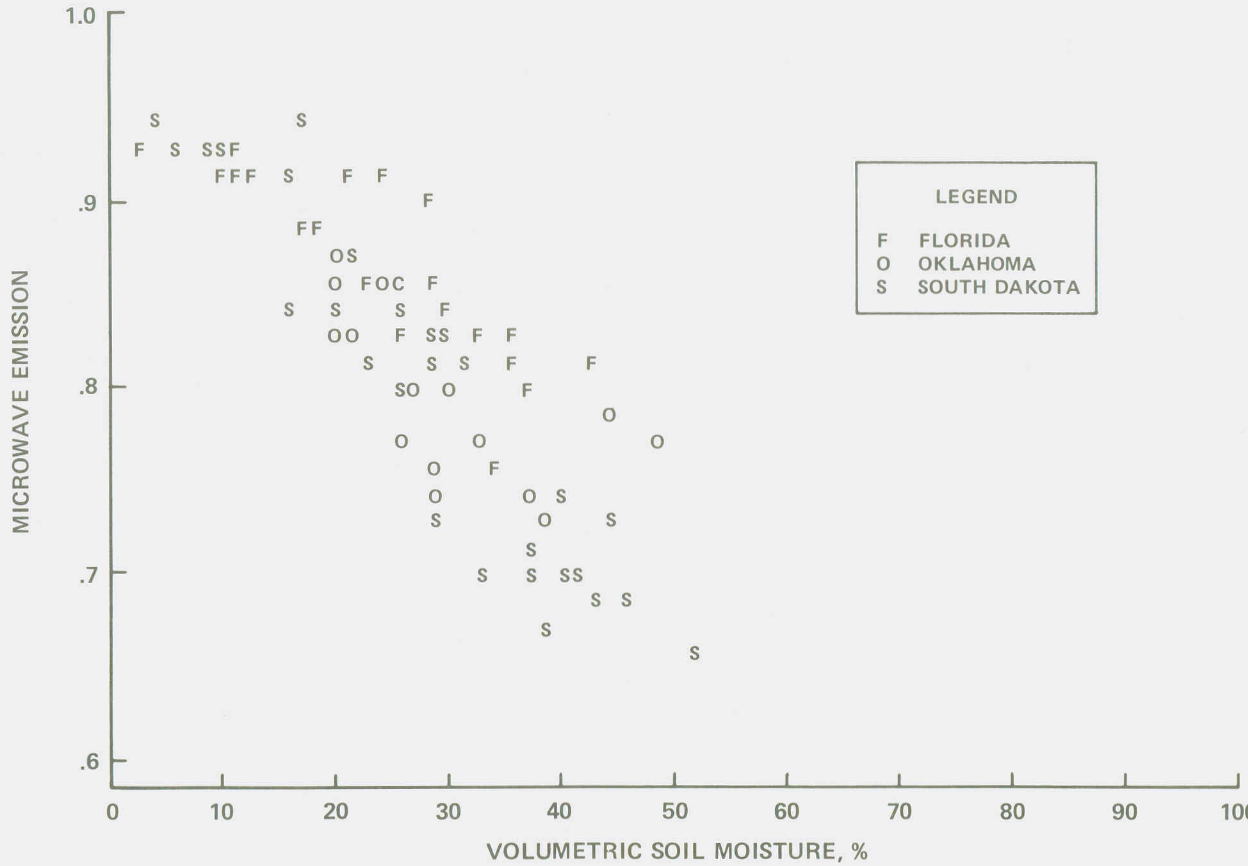


Figure 13. Graph showing relationship of microwave measurements and soil moisture.

5.6 DOMESTIC CROPS AND LAND COVER

5.6.1 Technical Objectives

Technical objectives of the DCLC project during 1980 focused on the following:

- Developing, testing, and evaluating operational procedures for estimating the acreages of major crops over large areas such as state levels.
- Assessing and improving current techniques for registration and processing of data.
- Assessing current techniques for clustering and classification and evaluating alternatives.
- Conducting experiments to determine the feasibility of integrating basic land cover classes into USDA operational surveys and measuring their acreages.
- Beginning studies of new spaceborne sensors.

5.6.2 Estimating Acreage of Major Crops

The DCLC project utilizes information on field locations, crops or land cover, and acreage from the annual ESS June Enumerative Survey (JES) as the basic data set for matching with Landsat data. Iowa and Kansas were selected as the two states for this first effort to develop operational techniques. Slight changes to the JES procedures were needed to break out continuous areas of wasteland in crop fields and to capture the reported information in a unique field-identified format.

During FY 1980, the Iowa and Kansas state offices digitized the field boundaries and performed a detailed field-by-field edit of the ground data. Current 35mm aerial color photography acquired by the USDA for other purposes was utilized for accurate editing of field boundaries.

In FY 1981, the DCLC project will calculate the estimates of Kansas 1980 harvested winter wheat acreage and Iowa 1980 planted corn and soybean acreage using available 1980 Landsat digital data combined with the ground data. The Iowa and Kansas offices will explore the feasibility of implementing some stages of the data registration and analysis processes in addition to the edit and digitization operations. Two additional states, Oklahoma (for winter wheat) and Missouri (for corn and soybeans), will be added to the project; and the operations implemented in Iowa and Kansas in 1980 will be resumed.

(Key references: 6-06, 6-07, 6-08).

5.6.3 Improving Current Techniques

USDA and NASA researchers are cooperating on developing and evaluating several possible improvements to the existing USDA acreage estimation procedures. The DCLC approach is to use ground data for training a classification procedure requiring very accurate registration (within 40 meters) of satellite data to actual ground positions. Both USDA and NASA had developed procedures for scene-to-ground registration and for the registration of images obtained at different times to one another. The effort under DCLC is to compare the various methods and implement the most automatic procedures that will provide the necessary accuracy. During FY 1980, data were registered for four agricultural sites; and 10 additional sites were selected for further testing. The accuracies for the first site were within 40.4 meters. In FY 1981, the image-to-ground registration evaluations will be completed; and evaluations of scene-to-scene techniques will be studied. An additional area of investigation will be the development of computer procedures to detect field boundaries.

Another area of improvement in current capabilities is the automating of various phases of the ground data/ satellite data analysis procedures. Changes and additions to computer software were made in FY 1980 which reduced the number of interactive steps required by data analysts and which automated most of the acreage calculations needed for each state/crop combination. Other studies begun in FY 1980 are: automating the digitization of most field boundaries and the establishment of a stand-alone capability for cases which cannot be done by the automated procedure.

(Key references: 6-09, 6-10).

5.6.4 Improving Clustering and Classification Techniques

In a specific study to assess and improve current automated data processing techniques, a comparison was made between the current classification technique and a newly developed technique called CLASSY. The purpose of the comparison was to determine which method performed the most accurate automatic classification of satellite data. Results from the statistical tests indicated that the CLASSY procedure was both more accurate and more efficient than existing methods. Subsequent analyses will increase the scope of the tests of CLASSY to larger areas and a variety of land cover classes.

(Key reference: 6-01).

5.6.5 Land Cover Studies

Under DCLC, the USDA has a requirement to develop procedures for identifying and monitoring land cover categories. During FY 1980, a land cover study was conducted in Kansas to determine the feasibility of integrating land cover categories with the operational JES of ESS. The definitions of land cover categories were successfully implemented in this special study and will be adapted to the regular JES in Kansas in 1981.

(Key reference: 6-11).

5.6.6 Studies of New Sensors

In an effort to study new sensor adaptations to crop estimation procedures, the DCLC project evaluated simulated thematic mapper data. Results from the simulation study for a small area in Missouri showed significant improvements in crop discrimination and acreage estimation over standard Landsat multispectral scanner data. In FY 1981, new sensor evaluations will extend the thematic mapper simulation study to include data from the Red River Valley of North Dakota and will study other sensor types such as synthetic aperture radar (SAR).

(Key reference: 6-10).

5.7 RENEWABLE RESOURCES INVENTORY

5.7.1 Technical Objectives

The general objectives of RRI project activity are to develop, test, and evaluate methods for applying new remote sensing techniques to the inventory, monitoring, and management of forest and rangeland renewable resources. The particular technical objectives include:

- Improving methods for the collection, display, and use of resource information for forest management and planning.
- Evaluating Landsat technology as a tool for supporting multiresource inventories and forest planning.
- Demonstrating the capability to monitor, classify, and measure disturbances and changes in forests and rangeland.
- Improving the capability to map and characterize natural and managed habitats.
- Improving the capabilities of high-altitude sensors.

5.7.2 Forest Management and Landsat Evaluation

The first phase of a Multiresource Inventory Methods Pilot Test was completed. This test is the principal vehicle for thorough evaluation of the utility of Landsat technology for meeting Forest Service needs. User-identified products resulting from the effort include:

- A comprehensive Inventory Design and Sampling Plan document.
- Development of a Multiresource Analysis and Information System (MAIS) concept.
- A feasibility demonstration of the MAIS concept through completion of the Phase IA, Kershaw County, South Carolina, MAIS component evaluation.

There is an increased need for renewable resource information in the United States. The completion of Phase I of the Multiresource Inventory Methods Pilot Test is a major step toward determining the extent to which Landsat and associated geographic information system technologies can facilitate, improve, or replace present multiresource inventory methods.

(Key references: 7-08, 7-09, 7-10, 7-11, 7-13).

5.7.3 Changes and Disturbances

New procedures for the detection, classification, and measurement of disturbances and changes in areas 3 acres or larger within national forest boundaries have been developed. Also, research has resulted in the definition of sensor parameters for detecting, classifying, and mapping forest defoliation damage.

(Key references: 7-04, 7-05, 7-16).

5.7.4 High-Altitude Sensors

Two very promising high-resolution advanced panoramic camera systems have been integrated into NASA U-2C aircraft and are being used during the FY 1981 field season to support several national-level Forest Service programs.

(Key reference: 7-06).

5.7.5 Habitat Mapping

An extensive evaluation of the use and applicability of the vegetation components of the Recommended National Site Classification System has been completed.

(Key reference: 7-01).

5.8 CONSERVATION/POLLUTION PROJECT

5.8.1 Technical Objectives, Conservation

The conservation objectives of the C/P project include extensions of remote sensing technology into conservation inventory and planning and hydrologic and watershed management. The 1980 conservation technical objectives include evaluations of:

- Aerial photography for its use in the inventory of existing, and in the planning of new, conservation practices.
- Water runoff parameters derived from Landsat data as factors for hydrologic and watershed models.
- Correlations between snowpack parameters over winter wheat and environmental satellite measurements; i.e., the Nimbus-7 Scanning Multichannel Microwave Radiometer (SMMR).

5.8.2 Inventory of Existing, and Planning of New, Conservation Practices

Aerial photography ranging in scale between 1:500 and 1:60,000 and varying in type (color, color infrared, black and white, black and white infrared, and oblique) were examined against different conservation practices used to control erosion and to improve range and forest land. The work was initiated in FY 1980 to perform a baseline inventory in the Bear Creek and Goodwin Creek watersheds in Northern Mississippi. Project scientists prepared a photointerpretation guide of 110 different conservation practices, which aided USDA personnel in determining the photographic resolution and photographic type required to identify the various specific practices. Such practices as contour farming, farmland and feedlot windbreaks, irrigation systems, reclamation of surface-mined land, and woodland improvement were included in the guide. Aerial photographic data for the test sites were acquired and the photointerpretation of the data will be completed in FY 1981.

5.8.3 Water Runoff Analysis

Runoff refers to that portion of water which is carried over land toward the lowest point in a drainage basin. The runoff waters move in constricted flow in channels or manmade conduits or unrestricted overland flow. Computation of the quantity of water (precipitation) lost is essential in USDA Soil Conservation Service hydrological investigations and is widely used by many Federal, local, and private agencies involved in agriculture, forestry, wildlife, and environmental protection. Estimation of runoff by conventional means is costly because it is labor intensive and because many types of data must be measured and integrated into a mathematical model. Preliminary studies showed that data obtained from Landsat could be substituted for land cover obtained by ground observations and would therefore provide a less costly and more effective data base for large-area investigations. Additionally, a complete computer-based procedure was developed so that engineers and technicians with only minimal training in remote sensing could integrate the Landsat data into the computer model.

A test was conducted in Colorado to see if snowmelt runoff on operational-size (100-square-kilometer) basins could be simulated successfully using a snowmelt runoff model and satellite data on a snow-covered area. Landsat was used on two tributaries to the Rio Grande River Basin to supply the critical snow-covered-area parameter. Results for 1973 through 1979 (fig. 14) suggest that

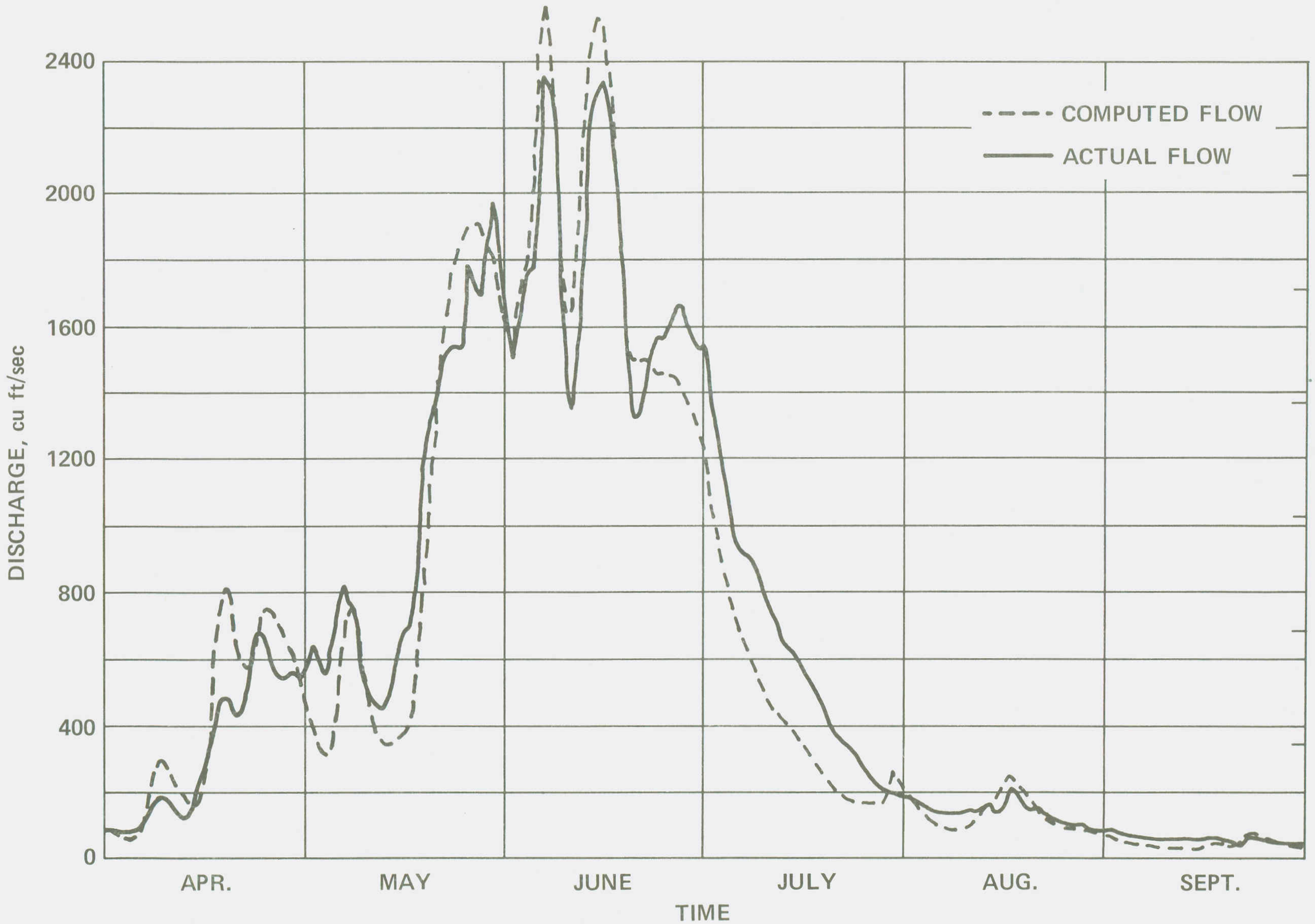


Figure 14. 1979 runoff simulation on the South Fork of the Rio Grande River using a snowmelt runoff model and Landsat snow cover data.

computed flow closely matches actual flow and that 6-month seasonal runoff was simulated with an average accuracy of 95 percent. In the short term, 85 percent of the variation in the daily flow was explained by the model. This model, when used with the input satellite data, can be used to improve snowmelt runoff forecasts and to facilitate better regulation of reservoirs for flood control, irrigation, and hydropower purposes. This work is continuing, in cooperation with the Soil Conservation Service, to implement the model operationally in the entire Rio Grande River Basin.

NOAA researchers have developed methods of making a computer analysis of snow cover as observed by the environmental satellites (fig. 15). Information of this type will be used in future models over large river basins.

(Key references: 8-47, 8-49).

5.8.4 Microwave Snowpack Studies

In order to measure remotely the snowpack properties important for agricultural water supplies and water management practices, microwave data and radiative transfer models have been used. The most significant result was obtained from using the newly available SMMR data from the Nimbus-7 envirionmental satellite. Both empirical and theoretical models were found to produce significant relationships between microwave brightness, temperature, and snow depth measurements over a winter wheat area in the U.S.S.R. The shallow snowpacks observed (less than 25 centimeters deep) are representative of the depths necessary for insulating the wheat seedlings from low winter temperatures. Early knowledge of the snow depth during the winter months is, therefore, critical in predicting the forthcoming winter wheat yield.

Figure 16 shows one result of the high degree of correlation between the predicted and the actual relationship in the snowdepth range from 0 to 25 centimeters. The model has also been used successfully to predict snow depths in deeper mountain snowpacks using truck and aircraft microwave data. Such measurements will aid in the further improvement of hydrological runoff forecasts.

(Key reference: 8-50).

5.8.5 Technical Objectives, Pollution

The pollution objectives of the C/P project include assessing the effectiveness of various conservation practices in limiting pollution and assessing the impact of pollution on the environment. Runoff from agricultural lands carries sediment into streams and lakes, and this is the primary water pollutant of initial concern. The thrust of FY 1980 work was to develop remote sensing methods of measuring such pollution.

5.8.6 Measuring and Monitoring Water Pollutants

Changes in water clarity or water turbidity occur as a result of sediment loadings. Sediment loading from agricultural runoff in lakes and reservoirs typically ranges between 50 and 500 parts per million (ppm). In estuaries and coastal waters, it commonly ranges between 1 and 50 ppm.

Because of the extremely high concentrations of agricultural runoff in lakes and reservoirs, project scientists have focused the 1980 research on the special light reflectance characteristics of these water bodies.

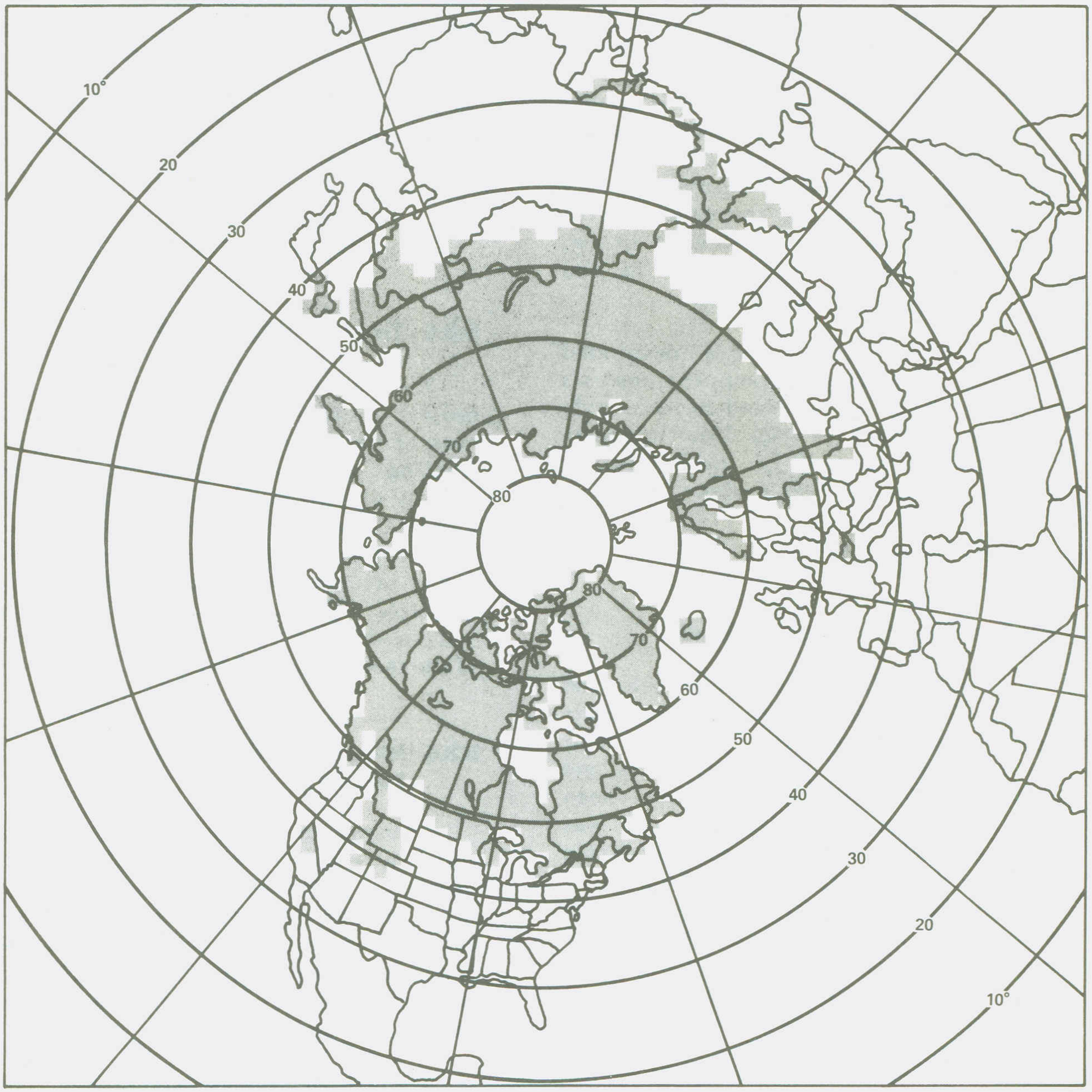


Figure 15. Polar map showing snow cover.

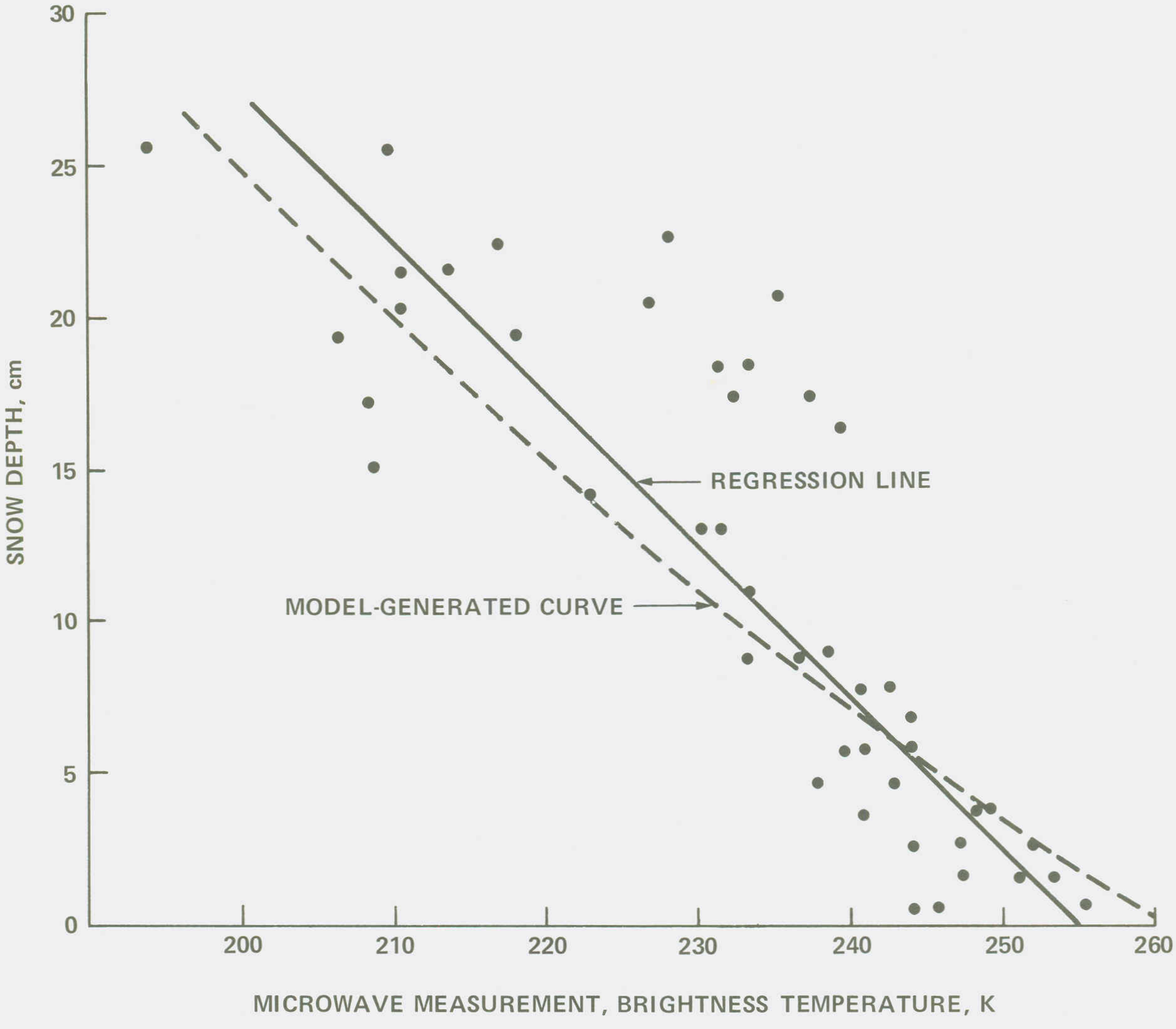
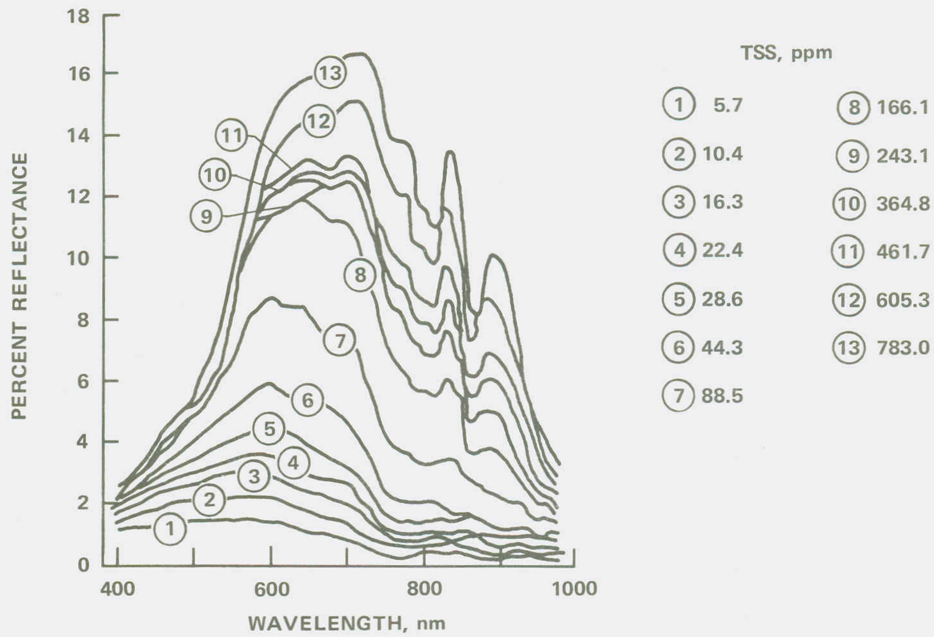


Figure 16. Nimbus-7 environmental satellite microwave measurements versus snow depth (U.S.S.R.).

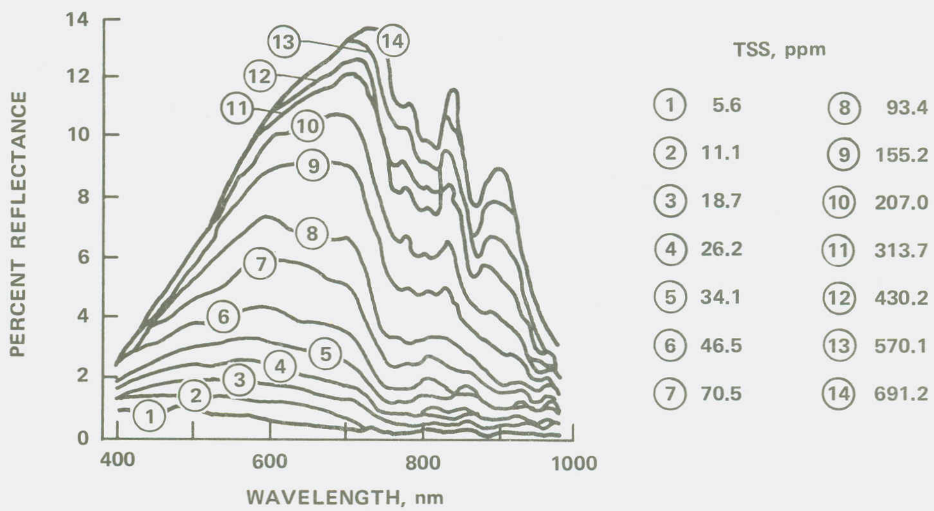
In FY 1980, laboratory measurements were made at the NASA Langley Research Center of the upwelled spectral reflectance of suspended sediments from Lake Chicot, Arkansas, and John H. Kerr Reservoir, Virginia. Figures 17(a) and (b) show the reflectance spectra obtained during these tests for various total suspended solids (TSS) concentrations. For TSS, values of 80 ppm signals tend to merge, indicating saturation, at visible wavelengths between 400 and 650 nanometers. At near-infrared wavelengths, between 700 and 960 nanometers, there is good signal discrimination for TSS concentrations up to 783 ppm. This result indicates that remote sensing measurements probably will be useful at near-infrared wavelengths.

The remote sensing saturation effect is better shown in figure 18. For both Lake Chicot and Kerr Reservoir sediments, the reflectance signal becomes flat at TSS values around 100 ppm for wavelengths equal to 450, 550, and 650 nanometers. At wavelengths equal to 750, 840, and 900 nanometers, signals have positive slopes, indicating that definitive measurements can be made at near-infrared wavelengths. Band 4 (760 to 900 nanometers) of the Landsat thematic mapper instrument appears to have good potential for monitoring high sediment loads in reservoirs and rivers.

(Key references: 8-54, 8-55).

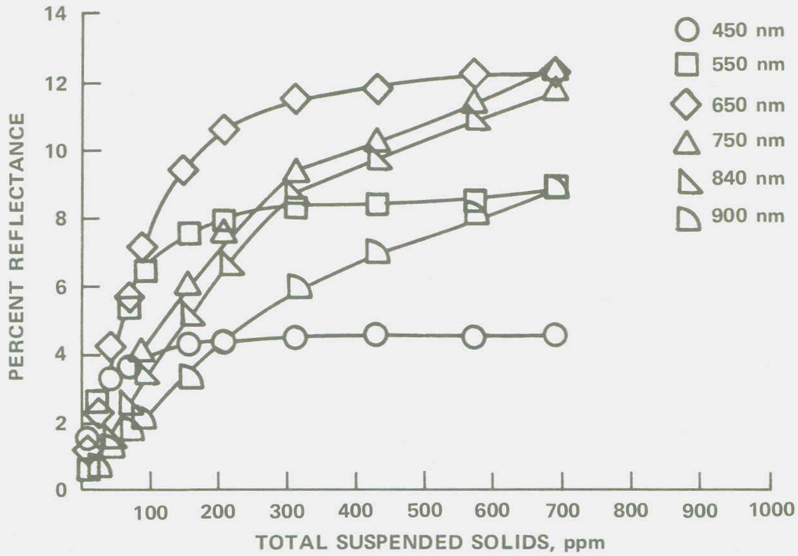


(a) Reflectance of Lake Chicot sediments in laboratory.

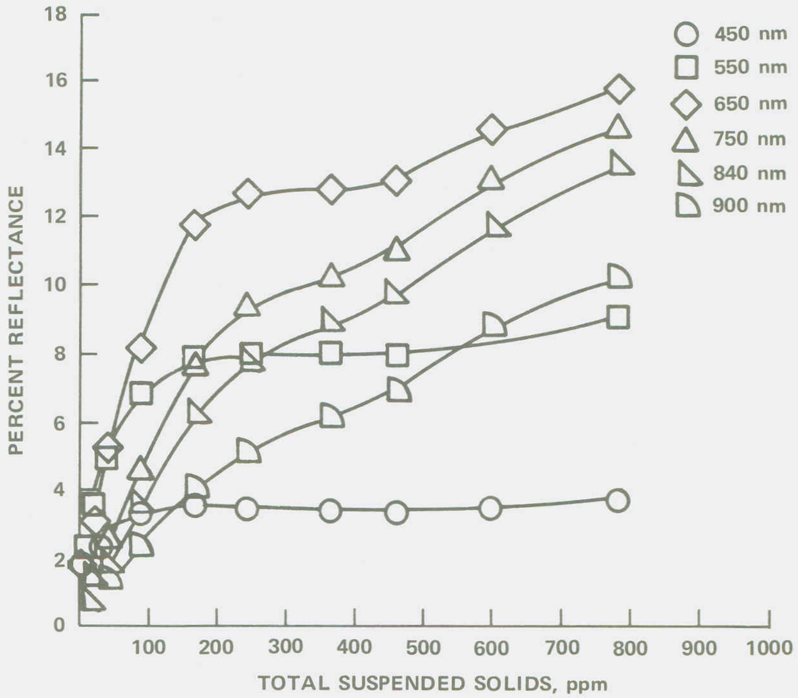


(b) Reflectance of Kerr Reservoir sediments in laboratory.

Figure 17. Spectral characteristics of waterborne sediment.



(a) Lake Chicot sediments.



(b) Kerr Reservoir sediments.

Figure 18. Reflectance of waterborne sediments at various wavelengths.

APPENDIX A

AgRISTARS MANAGEMENT AND ORGANIZATION

1. INTRODUCTION

The program scope of AgRISTARS specifically addresses the seven information requirements identified by the Secretary of Agriculture.[3] It is structured into projects designed to conduct research, develop, test, and evaluate the various applications of aerospace technology. These projects are designed to support a decision regarding the routine use of remote sensing technology by USDA.

2. RESPONSIBILITIES

The organization and management philosophy recognizes that each involved Government agency enters into an agreement to support remote sensing research which will address the information requirements defined by the USDA. Each Government agency budgets, manages, and maintains control of the resources necessary to meet its own responsibilities as jointly agreed upon (see figure A-1).

3. JOINT MANAGEMENT STRUCTURE/ORGANIZATION

The program utilizes the matrix management system. There are eight major projects, each having a number of tasks assigned to various line organizations of the participating agencies. Each of the eight projects has a project manager who reports to a Program Management Team (PMT). The PMT, in turn, takes its direction and guidance from the Interagency Coordinating Committee (ICC). As viewed in figure A-2, the functional relationships are structured into a three-level management system, each having distinct responsibilities.

3.1 INTERAGENCY POLICY BOARD

The Interagency Policy Board (IPB), chaired by USDA, is a joint agency group of policy-level officials at the Assistant Secretary or equivalent level. It is responsible for approving major interagency agreements and establishing basic policies and guidelines for the program.

3.2 INTERAGENCY COORDINATING COMMITTEE (LEVEL 1)

The ICC is comprised of membership from USDA, NASA, USDC, USDI, and AID. It is chaired by the USDA and is responsible for: approving AgRISTARS program objectives and establishing priorities; approving the AgRISTARS Program Plan; assessing progress, identifying problems, and developing corrective actions; and coordinating the use of resources assigned to the program.

3.3 PROGRAM MANAGEMENT TEAM (LEVEL 2)

The PMT represents a joint approach to management which provides participation, project integration, and needed visibility by all participants and assures full responsiveness to USDA information requirements.

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[3] Joint Program of Research and Development of Users of Aerospace Technology for Agricultural Programs, Feb. 1978.

USDA

- DEFINITION OF USDA INFORMATION REQUIREMENTS.
- YIELD MODEL RESEARCH, DEVELOPMENT, AND TESTING (RD&T) AND APPLICATIONS.
- RD&T – APPLICATIONS ANALYSIS FOR AREA, YIELD, AND PRODUCTION ESTIMATION.
- DEVELOPMENT OF AGRONOMIC/ANCILLARY DATA BASE.
- USER EVALUATION.
- GROUND DATA COLLECTION.
- RD&T AND APPLICATIONS FOR CROP/WEATHER ASSESSMENTS.[1]
- RD&T AND APPLICATIONS FOR EW/CCA ANALYSIS.
- RD&T AND APPLICATIONS FOR RRI ANALYSIS.
- RD&T AND APPLICATIONS FOR LAND USE, PRODUCTIVITY AND C/P ANALYSIS.
- RD&T FOR SOIL MOISTURE MEASURING TECHNIQUES.
- LARGE-SCALE APPLICATIONS TESTS.

NASA

- RD&T FOR FOREIGN CROP AREA ESTIMATION.
- RD&T FOR COMBINING AREA AND YEILD ESTIMATES FOR FOREIGN CROP PRODUCTION.
- FIELD RESEARCH.
- LANDSAT DATA ACQUISITION.
- RD&T – SPECTRAL INPUTS TO YIELD MODELS.
- RD&T – SPECTRAL INPUTS TO QUANTITATIVE EW/CCA.
- RD&T FOR SPECTRAL ANALYSIS RELATED TO INVENTORY AND CONDITION ASSESSMENT TECHNIQUES FOR RRI.
- RD&T INVENTORY AND MONITORING TECHNIQUES FOR LAND USE AND C/P.
- RD&T FOR REMOTELY SENSED SOIL MOISTURE MEASURING TECHNIQUES.
- DEFINITION OF REQUIREMENTS FOR FUTURE SENSORS (INCLUDING IN-SITU).

USDC

- METEOROLOGICAL DATA BASE.
- RD&T AND APPLICATIONS OF ENVIRONMENTAL SATELLITE DATA.
- RD&T METEOROLOGICAL YIELD MODELS.
- RD&T WEATHER/CROP ASSESSMENTS.[2]
- RD&T ON USE OF CONVENTIONAL AND SATELLITE-DEFINED METEOROLOGICAL DATA APPLIED TO RRI AND C/P.
- RD&T ON TECHNIQUES FOR DETERMINING SOIL MOISTURE.

USDI

- LANDSAT DATA STORAGE, RETRIEVAL, AND DISSEMINATION.

AID

- EVALUATION OF UTILITY OF RD&T RESULTS FOR APPLICATIONS IN DEVELOPING COUNTRIES.

[1]Primary emphasis is on assessment of crop conditions (e.g., yield, production) using meteorological data as an input to develop needed information.

[2]Primary emphasis is on acquisition and evaluation of meteorological data in terms of its utility for crop condition assessment.

Figure A-1. AgRISTARS responsibilities of five Government agencies.

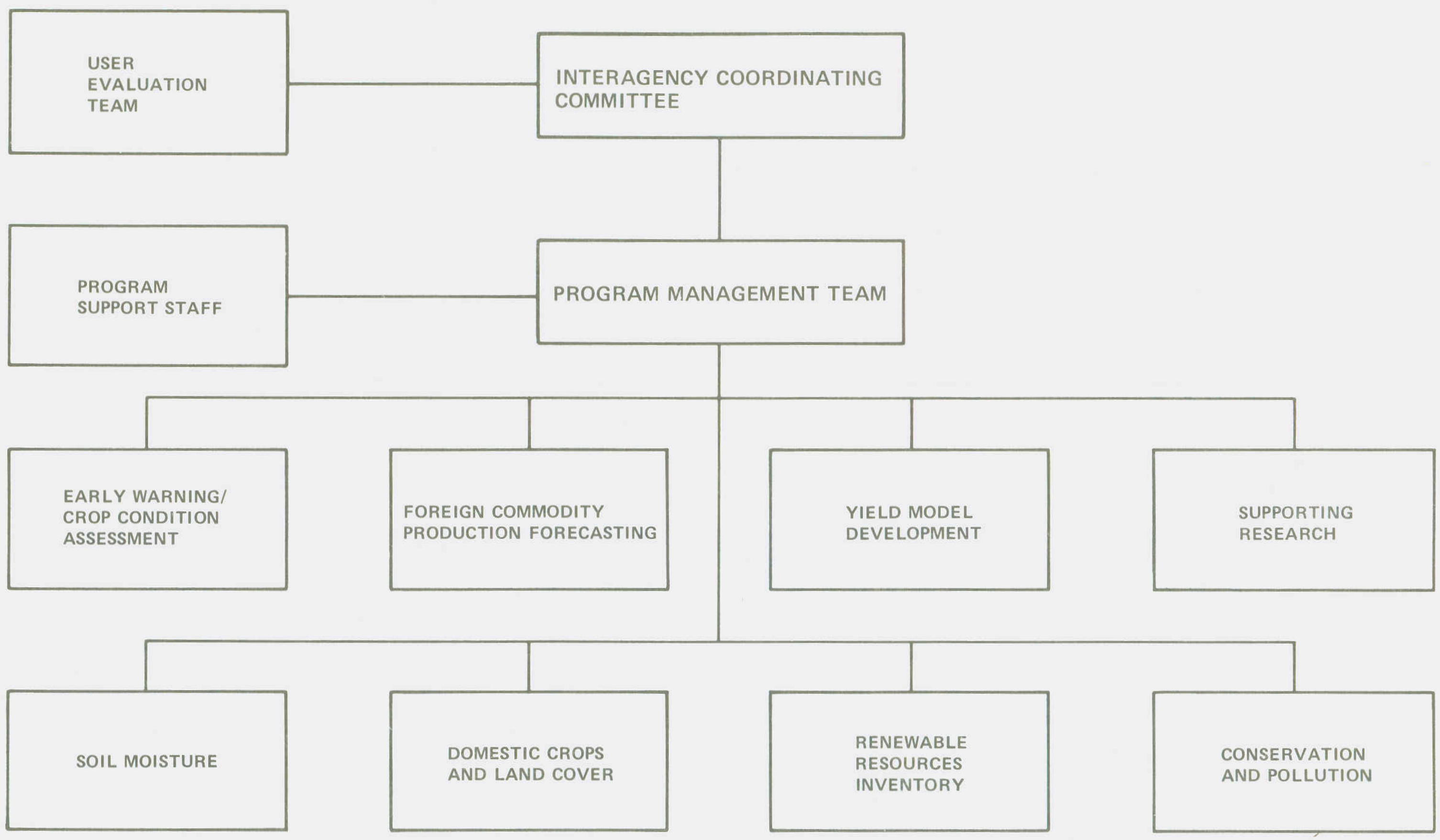

Figure A-2. Joint agency program management and functional relationships.

The PMT will act as the project change authority for all issues and significant changes affecting specified control milestones and schedules and project goals and objectives.

3.4 PROGRAM SUPPORT STAFF

The Program Support Staff (PSS) is led by USDA, has membership from all agencies, and provides staff support to the PMT.

4. PROJECT MANAGERS (LEVEL 3)

Each of these projects is headed by a project manager who is selected from a participating agency, based principally upon considerations of technical expertise and expected levels of agency involvement. The project managers are responsible to the PMT for planning and managing activities within their projects. This includes defining project content, identifying expected products and schedules, assessing status and progress, identifying problems, making change recommendations, planning and defining tasks, and participating with other project managers in the integration of the various projects.

5. REVIEW AND REPORTING

A review and reporting plan has been established to support major program planning and budgetary events.

Each year in the May-June time period, the PMT, project managers, and task managers will update each of the project implementation plans to reflect current budgets and the results and recommendations resulting from the various technical reviews.

Internal reviews will be held at the various levels of management as required.

6. DOCUMENTATION

All aspects of the program will be documented in full by: reports; technical memoranda and journal articles, as appropriate; press releases; and program progress reports.

7. PARTICIPATING ORGANIZATIONS

Many elements of Government, industry, and the university community are participants in AgRISTARS. These organizations are shown in figure A-3.

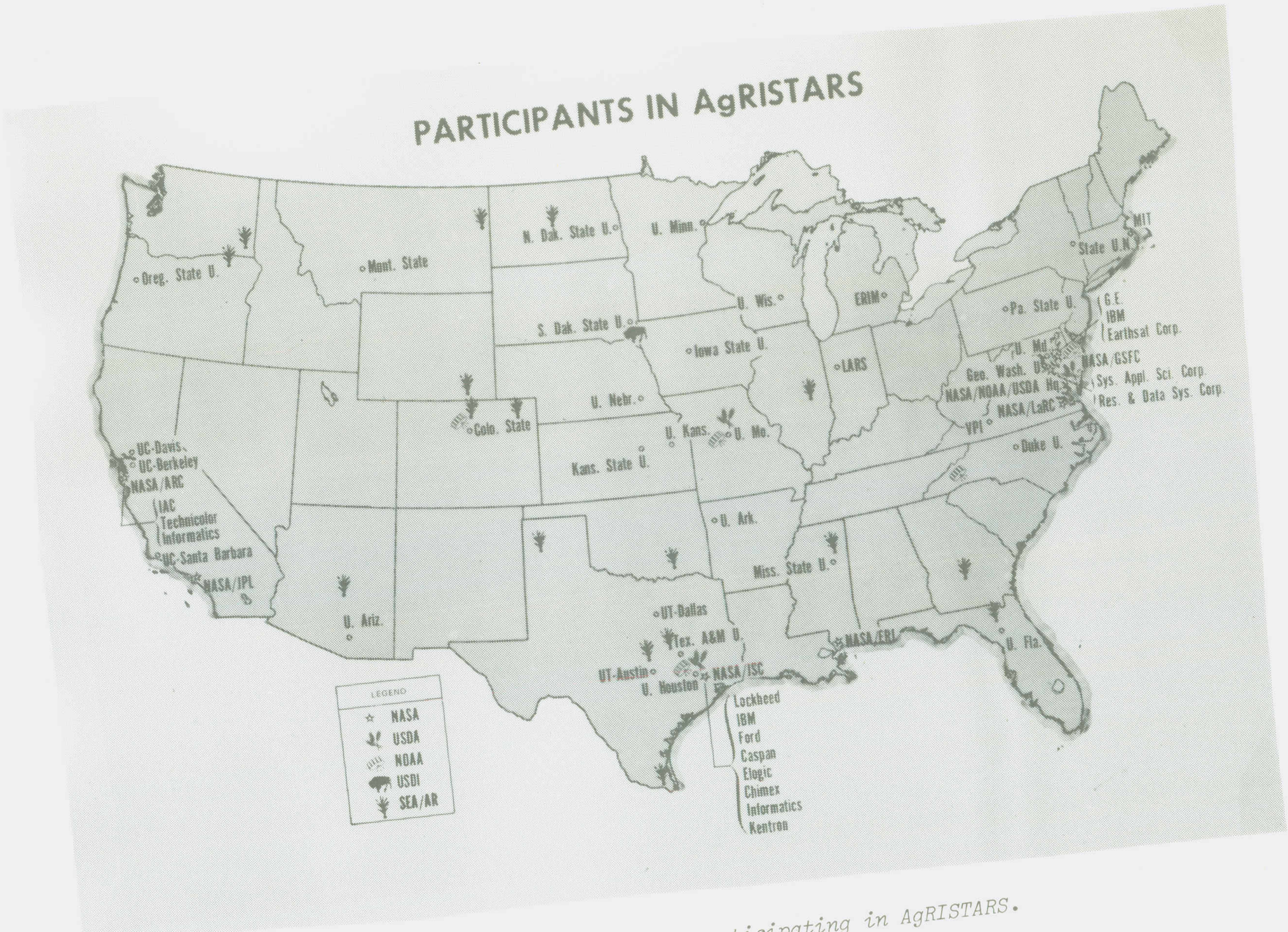

Figure A-3. *Organizations participating in AgRISTARS.*

APPENDIX B

AgRISTARS PROGRAM AND PROGRAM-RELATED DOCUMENTATION

1. GENERAL

This appendix contains a by-project listing of all AgRISTARS Program and Program-related documentation from Program inception through documentation of tasks completed in Fiscal 1980. The listing provided has been further subdivided within each project into areas of plans, reports, procedures, etc. to facilitate easy look-up of desired documentation.

2. REQUESTING DOCUMENTS

2.1 CONTROLLED DOCUMENTS

Documents which carry an AgRISTARS control number may be obtained from NASA/JSC by either telephone or mail request. Address requests to:

Lyndon B. Johnson Space Center
SK - Documentation Manager
Houston, Texas 77058
Telephone 713-483-4776

2.2 UNNUMBERED DOCUMENTS (00900 SERIES AND PRESENTATIONS)

Requests for material within this area will be honored based upon availability of data. Requests should be made to:

Lyndon B. Johnson Space Center
(Appropriate Project)
SK - Program Support Staff
Houston, Texas 77058
Telephone 713-483-2548

EW/CCA Instructions - 00100

1-01. Soil Moisture/Early Warning and Crop Condition Assessment Interface Control Document. MU-JO-0101, JSC-16842, August 1980.

1-02. Yield Model Development/Early Warning and Crop Condition Assessment Interface Control Document. MU-JO-0102, JSC-16843, August 1980.

EW/CCA Reports - 00400

1-03. Meteorological Satellite Data-A Tool to Describe the Health of the World's Agriculture. EW-N1-04042, JSC-17112, February 1981.

1-04. Hand-held Radiometry-A Set of Notes Developed for Use at the Workshop on Hand-held Radiometry. EW-U1-04052, JSC-17118, October 1980.

1-05. Soil Moisture Inferences from Thermal Infrared Measurements of Vegetation Temperatures. EW-U1-04068, JSC-17125, March 1981.

1-06. Large Area Application of a Corn Hazard Model. EW-U1-04074, JSC-17130, March 1981.

1-07. The Characteristics of TIROS, GOES, DMSP, and Landsat Systems. EW-N1-04075, JSC-17131, March 1981.

1-08. The Environmental Vegetative Index-A Tool Potentially Useful for Arid Land Management. EW-N1-04076, JSC-17132, March 1981.

1-09. Canopy Temperature as a Crop Water Stress Indicator. EW-U1-04077, JSC-17133, March 1981.

1-10. Plant Cover, Soil Temperature, Freeze, Water Stress, and Evapotranspiration Conditions. EW-U1-04103, JSC-17143, March 1981.

1-11. Utilization of Meteorological Satellite Imagery for Worldwide Environmental Monitoring: The Lower Mississippi River Flood of 1979. EW-N1-04174, JSC-17144, March 1981.

1-12. Techniques in the Use of NOAA 6-n Data for Crop Condition Evaluation. EW-N1-04105, JSC-17145, April 1981.

1-13. Two Layer Soil Water Budget Model-A Tool for Large Area Soil Moisture Estimates. EW-U1-04106, JSC-17146, April 1981.

1-14. Comparison of Landsat-2 and Field Spectrometer Reflectance Signatures of South Texas Rangeland Plant Communities. EW-U1-04107, JSC-17147, April 1981.

EW/CCA Plans - 00600

1-15. Early Warning/Crop Condition Assessment Implementation Plan. EW-J0-C0617, JSC-16852, 1980.

1-16. Early Warning/Crop Condition Assessment Implementation Plan. EW-J1-C0622, JSC-16862, 1981.

EW/CCA Procedures - 00700

1-17. Program Development and Maintenance Standards. EW-U0-00700, JSC-16367, June 1980.

1-18. Limited Area Coverage/High Resolution Picture Transmission LAC/HRPT, User's Manual Tape Conversion Processor. EW-L0-00701, JSC-16373, LEMSCO-15325, June 1980.

1-19. Limited Area Coverage/High Resolution Picture Transmission, LAC/HRPT, IJ Grid Pixel Extraction Processor User's Manual. EW-L0-00702, JSC-16374, LEMSCO-15326, June 1980.

1-20. Limited Area Coverage/High Resolution Picture Transmission, LAC/HRPT, Vegetation Index Calculation Processor User's Manual. EW-L0-00703, JSC-16375, LEMSCO-15327, June 1980.

1-21. Tape Merge/Crop Processor. EW-L0-00704, JSC-16381, LEMSCO-15356, August 1980.

1-22. EROS to Universal Tape Conversion Processor. EW-L0-00705, JSC-16382 LEMSCO-15357, August 1980.

1-23. Conversion of SPU-Universal Disk File to JSC-Universal Tape Storage CONVRT User's Guide. EW-L0-00706, JSC-16821, LEMSCO-15608, September 1980.

1-24. Patch Image Processor User's Manual. EW-L0-00707, JSC-16833, LEMSCO-15692, October 1980.

1-25. Skip Subsampling Processor User's Manual. EW-L0-00708, JSC-16854, LEMSCO-15114, November 1980.

1-26. Wheat Stress Indicator Model, Crop Condition Assessment Division (CCAD) Data Base Interface Drives, User's Manual. EW-L1-00711, JSC-17114, LEMSCO-16034, February 1981.

1-27. Winterkill Indicator Model, Crop Condition Assessment Division (CCAD) Data Base Interface Driver, User's Manual. EW-L1-00713, JSC-17117, LEMSCO-16033, March 1981.

1-28. Computer Program Documentation for the Patch Subsampling Processor. EW-L1-00709, JSC-16855, LEMSCO-15119, January 1981.

EW/CCA Unnumbered Documents - 00900

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1-39. Hatfield, J. L., J. P. Millard, R. J. Reginato, R. D. Jackson, S. B. Idso, P. J. Pinter, Jr., and R. C. Goettelman: Spatial Variability of Surface Temperature as Related to Cropping Practice with Implications for Irrigation Management. Proc. of 14th Annual Sympos. on Remote Sensing of the Environment, 1980, pp. 1311-1320.

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1-73. Wiegand, C. L., and J. A. Cuellar: Direction of Grain Filling and Kernal Weight of Wheat as Affected by Temperature. Crop Sci., vol. 21, 1981, pp. 94-101.

1-74. Wiegand, C. G., A. H. Gerbermann, and J. A. Cuellar: Development and Yield of Hard Red Winter Wheats Under Semitropical Conditions. Agron. J., vol. 73, no. 1, 1981, pp. 29-38.

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2-01. ERSYS-SPP Access Method Subsystem Design Specification. MU-I1-00300, September 1980.

FCPF Reports - 00400

2-02. Corn/Soybeans Decision Logic: Improvements and New Crops. FC-L0-00420, JSC-16301, LEMSCO-14084, January 1980.

2-03. Evaluation of Transition Year Canadian Test Sites. FC-L0-00422, JSC-16338, LEMSCO-14320, April 1980.

2-04. Evaluation of Results of U.S. Corn and Soybeans Exploratory Experiment--Classification Procedures Verification Test. FC-L0-00423, JSC-16339, LEMSCO-14386, September 1980.

2-05. Estimation of Within-Stratum Variance for Sample Allocation. FC-L0-00428, JSC-16343, LEMSCO-14067, July 1980.

2-06. Profile Similarity Feasibility Study. FC-L0-00429, JSC-16246, LEMSCO-14010, February 1980.

2-07. Statistical Outliner Detection (SOD): A Computer Program for Detecting Outliners in Data. FC-L0-00432, JSC-16346, LEMSCO-14594, June 1980.

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2-10. The Integrated Analysis Procedure for Identification of Spring Small Grains and Barley. FC-L0-00451, JSC-16360, LEMSCO-14385, May 1980.

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2-16. A Summary of Observations Concerning the Information in the Spectral Temporal-Ancillary Data Available for Estimating Ground Cover Crop Proportions. FC-L0-00486, JSC-16815.

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2-18. A Description of the Reformatted Spring Small Grains Labeling Procedure Used in Test 2, Part 2, of the U.S./Canada Wheat and Barley Exploratory Experiment. FC-L0-04000, JSC-16827, LEMSCO-15404, February 1981.

2-19. Semi-Annual Project Management Report Program Review Presentation to Level 1, Interagency Coordination Committee. FC-J0-04010, JSC-16835, November 6, 1980.

2-20. Weather Analysis and Interpretation Procedures Developed for the U.S./Canada Wheat and Barley Exploratory Experiment. FC-L0-04014, JSC-16840, LEMSCO-15612, November 1980.

2-21. Identification of U.S.S.R. Indicator Regions. FC-L0-04027, JSC-16847, LEMSCO-15118, September 1980.

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FCPF Minutes - 00500

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2-27. U.S./Canada Wheat and Barley Exploratory Labeling Experiment Implementation Plan. FC-J0-00600, JSC-16336, January 1980.

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2-35. FCPF Implementation Plan (FY81 & FY82). FC-J0-00614, JSC-16828, October 1980.

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2-36. Maximal Analysis Labeling Procedure (Preliminary). FC-L0-00700, JSC-16399, LEMSCO-14080, February 1980.

2-37. Enumerator's Manual, 1981 Ground Survey Data, NASA, USDA/ESS. JSC-16860, FC-J1-04108, Washington, D.C., January 1981.

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YMD Reports - 00400

3-03. Evaluation of "Straw Man" Model 1, The Simple Linear Model for Soybean Yields in Iowa, Illinois, and Indiana. YM-11-04095, USDA/ESS Staff, AGESS810304, March 1981.

YMD Plans - 0600

3-04. Yield Model Development Implementation Plan. YM-J0-C0616, JSC-16851, 1980.

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