ERIM

ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN
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PROGRESS REPORT
FOR
NASA CONTRACT NAS9-15476

ANALYSIS OF SCANNER DATA FOR CROP INVENTORIES

PROGRAM MANAGER

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PERIOD COVERED

16 FEBRUARY 1980 - 15 MAY 1980

ERIM REPORT NUMBER 132400-40-P

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
132400-40-P		

4. Title and Subtitle	5. Report Date
Progress Report for 16 February 1980 - 15 May 1980	May 1980
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
R. Horvath, R. Cicone, E. Crist, R. Kauth, W. Pont	132400-40-P

9. Performing Organization Name and Address	10. Work Unit No.
Environmental Research Institute of Michigan P.O. Box 8618 Ann Arbor, Michigan 48107	11. Contract or Grant No. NAS9-15476
	13. Type of Report and Period Covered Progress Report 16 February 1980 - 15 May 1980
12. Sponsoring Agency Name and Address National Aeronautics & Space Administration Johnson Space Center Houston, Texas 77058 Mr. I. Dale Browne/SF3	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report summarizes the progress on subject contract during the second quarter of the 1980 contract year. It is comprised of the presentations supporting quarterly project management reviews and a quarterly technical interchange meeting.

17. Key Words	18. Distribution Statement
Crop Inventory, Landsat, Sampling, Temporal Profile Fitting, Machine Labeling, Area Estimation, Software Implementation, Multiyear Estimation	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

PREFACE

The following report serves as the Quarterly Report for Contract NAS9-15476 which is entitled "Analysis of Scanner Data for Crop Inventories". This report describes the work carried out under that contract for the period 16 February 1980 through 15 May 1980.

Work on this contract is performed in the Infrared and Optics Division directed by Mr. Richard R. Legault. Mr. Robert Horvath is the Program Manager for this contract.

This contract, performed by the Environmental Research Institute of Michigan (ERIM) for the Earth Observations Division of the NASA/Johnson Space Center, is part of the multi-agency AgRISTARS Program and supports both the Supporting Research (SR) and Foreign Commodity Production Forecasting (FCPF) Projects within AgRISTARS. The overall goal of AgRISTARS is to determine the usefulness, cost and extent to which aerospace remote sensing data can be integrated into existing or future U.S. Department of Agriculture (USDA) systems to improve the objectivity, reliability, timeliness and adequacy of information required to carry out USDA missions.

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CORN AND SOYBEAN CLASSIFICATION TECHNOLOGY DEVELOPMENT FOR AREA ESTIMATION

FOR

FOREIGN COMMODITY PRODUCTION FORECASTING

ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN
UNIVERSITY OF CALIFORNIA AT BERKELEY
NASA, JOHNSON SPACE CENTER, SF4

14 MAY 1980 FCPF PROJECT REVIEW

FCPF C/S CLASSIFICATION TECHNOLOGY DEVELOPMENT FOR AREA ESTIMATION

OBJECTIVES

- Conduct Foreign Exploratory Experiments in Area Estimation Technology for Corn and Soybeans in Support of Pilot Experiments.
- Deliver Pilot-Compatible C/S Area Estimation Procedures.
- Support Pilot

SCOPE OF FCPF RELATED PROGRAM

- IDENTIFY COMPONENT TECHNOLOGIES FOR CORN AND SOYBEAN AREA ESTIMATION.
- ADAPT TECHNOLOGY TO FOREIGN APPLICATION.
- DEVELOP END-TO-END PROCEDURES FOR EXPLORATORY EXPERIMENT TESTING.
- IMPLEMENT PILOT-COMPATIBLE PROCEDURES FOR TEST AND EVALUATION.
- COMPARATIVELY TEST AND EVALUATE TECHNOLOGIES.
- SUPPORT SUBSEQUENT MODIFICATION AND PILOT TESTING.

C/S CLASSIFICATION TECHNOLOGY DEVELOPMENT
TECHNOLOGY PHASES

EVENT	U.S. Pilot FY 81	Brazil Expl. Exp. FY 82	Argentina Expl. Exp. FY 83	U.S. P2 Expl. Exp. FY 83	U.S. TM Expl. Exp. FY 84	Brazil/Argentina P2 Expl. Exp. FY 85
TECHNICAL THRUST	End of Season	Throughout Season Foreign Understanding	Objective Labeling Throughout Season Small Fields Foreign Understanding	Multisegment Full-Frame	Advanced Labeling Small Fields	Self Assessment Foreign Understanding
FUNDAMENTAL EMPHASIS	Baseline	Accuracy Timeliness	Accuracy Timeliness	Efficiency	Accuracy	Objectivity Efficiency

FY81 U.S. C/S PILOT IMPLEMENTATION APPROACH

- Overall Implementation Managed by ERIM
- Labeling Procedure Delivery by UCB
- Software Development on LARS Computer Pending Availability of ERSYS at JSC
- Existing Technology Modified and Implemented
  - Procedure M tuned for Corn/Soybeans
  - LEC Labeling Procedure adapted to field-like targets rather than dots

FCPF C/S CLASSIFICATION TECHNOLOGY DEVELOPMENT FOR AREA ESTIMATION*
PROJECT ELEMENT TASKS

	TASK	FISCAL YEAR	PERFORMING INSTITUTE
1.	US C/S AREA ESTIMATION PROCEDURE DESIGN	80	ERIM/UCB
2.	US C/S LABELING LOGIC DEVELOPMENT	80	UCB
3.	US C/S PROCEDURES IMPLEMENTATION	80/81	ERIM/UCB
4.	US C/S EXPLORATORY TEST AND EVALUATION	80	JSC/SF4
5.	US C/S CLASSIFICATION IN SUPPORT OF PILOT EXPERIMENT	81	JSC/SF4
6.	BRAZIL C/S AREA ESTIMATION PROCEDURE DESIGN	81	ERIM/UCB
7.	BRAZIL C/S LABELING LOGIC DEVELOPMENT	81	UCB
8.	BRAZIL C/S PROCEDURES IMPLEMENTATION	81	ERIM/UCB
9.	BRAZIL EXPLORATORY TEST AND EVALUATION	81	ERIM
10.	BRAZIL C/S CLASSIFICATION IN SUPPORT OF PILOT EXPERIMENT	82	JSC
11.	ARGENTINA C/S AREA ESTIMATION PROCEDURE DESIGN	81/82	ERIM/UCB
12.	ARGENTINA C/S LABELING LOGIC DEVELOPMENT	82	UCB/ERIM
13.	ARGENTINA C/S PROCEDURES IMPLEMENTATION	82	ERIM
14.	ARGENTINA C/S EXPLORATORY TEST AND EVALUATION	82	ERIM
15.	ARGENTINA C/S CLASSIFICATION IN SUPPORT OF PILOT EXPERIMENT	83	JSC

*Management Responsibility at ERIM

ACTIVITIES AND ACCOMPLISHMENTS

(14 FEB '80 - 14 MAY '80)

GENERAL

- FY80-85 INTEGRATED EXPERIMENT IMPLEMENTATION PLAN
- INITIATED RECONSIDERATION OF ORDER FOR FOREIGN APPLICATIONS (POSSIBLE SWITCH OF BRAZIL AND ARGENTINA)
- INITIATED DEVELOPMENT OF ALTERNATIVE FOREIGN AGRONOMIC DATA SOURCES

ACTIVITIES AND ACCOMPLISHMENTS (CONTINUED)

(14 FEB '80 - 14 MAY '80)

TASK 1: U.S. C/S AREA ESTIMATION PROCEDURE DESIGN

- FINALIZED OVERALL BASELINE PROCEDURE DESIGN
- SPECIFIED COMPUTER REQUIREMENTS FOR IMPLEMENTATION
- INITIATED DEVELOPMENTAL COMPONENT EVALUATION/SELECTION

ACTIVITIES AND ACCOMPLISHMENTS (CONTINUED)

(14 FEB '80 - 14 MAY '80)

TASK 2: U.S. C/S LABELING LOGIC DEVELOPMENT

- IDENTIFIED CANDIDATE PROCEDURES/COMPONENTS
- IDENTIFIED AREAS OF AI INTERACTION IN BASELINE PROCEDURE FLOW
- SPECIFIED PRELIMINARY MACHINE-GENERATED AI AIDS
- IDENTIFIED CONTENTS (SUBSTANCE) OF AI PACKET
- SPECIFIED DETAILED CROP CALENDAR/WEATHER INTERPRETATION REQUIREMENTS
- DEFINED INITIAL CRITERIA FOR AI ACQUISITION SELECTION
- INITIATED PROCDURALIZATION OF DFS (CROP GROUP STRATIFICATION)
- DESIGNED GENERAL FLOW OF LABELING LOGIC

ACTIVITIES AND ACCOMPLISHMENTS (CONTINUED)

(14 FEB '80 - 14 MAY '80)

TASK 3: U.S. C/S PROCEDURES IMPLEMENTATION

- ESTABLISHED GENERAL DESIGN APPROACH (ERSYS-INDEPENDENT)
- COMPLETED DESIGN OF APPLICATION MODULE INTERFACE
- SELECTED PREFOR/FORTRAN AS PRINCIPLE IMPLEMENTATION LANGUAGE
- INITIATED DESIGN AND CODING OF SYSTEM SERVICES
- INITIATED CODING OF APPLICATIONS MODULES
- COMPLETED STAFFING AND INITIATED TRAINING FOR IMPLEMENTATION TEAM

ACTIVITIES AND ACCOMPLISHMENTS (CONTINUED

(14 FEB '80 - 14 MAY '80)

TASK 4: U.S. C/S EXPLORATORY TEST AND EVALUATION

- SCHEDULED AI C/S BLOB LABELING EXPERIMENT

TASK 5: U.S. C/S CLASSIFICATION IN SUPPORT OF PILOT EXPERIMENT

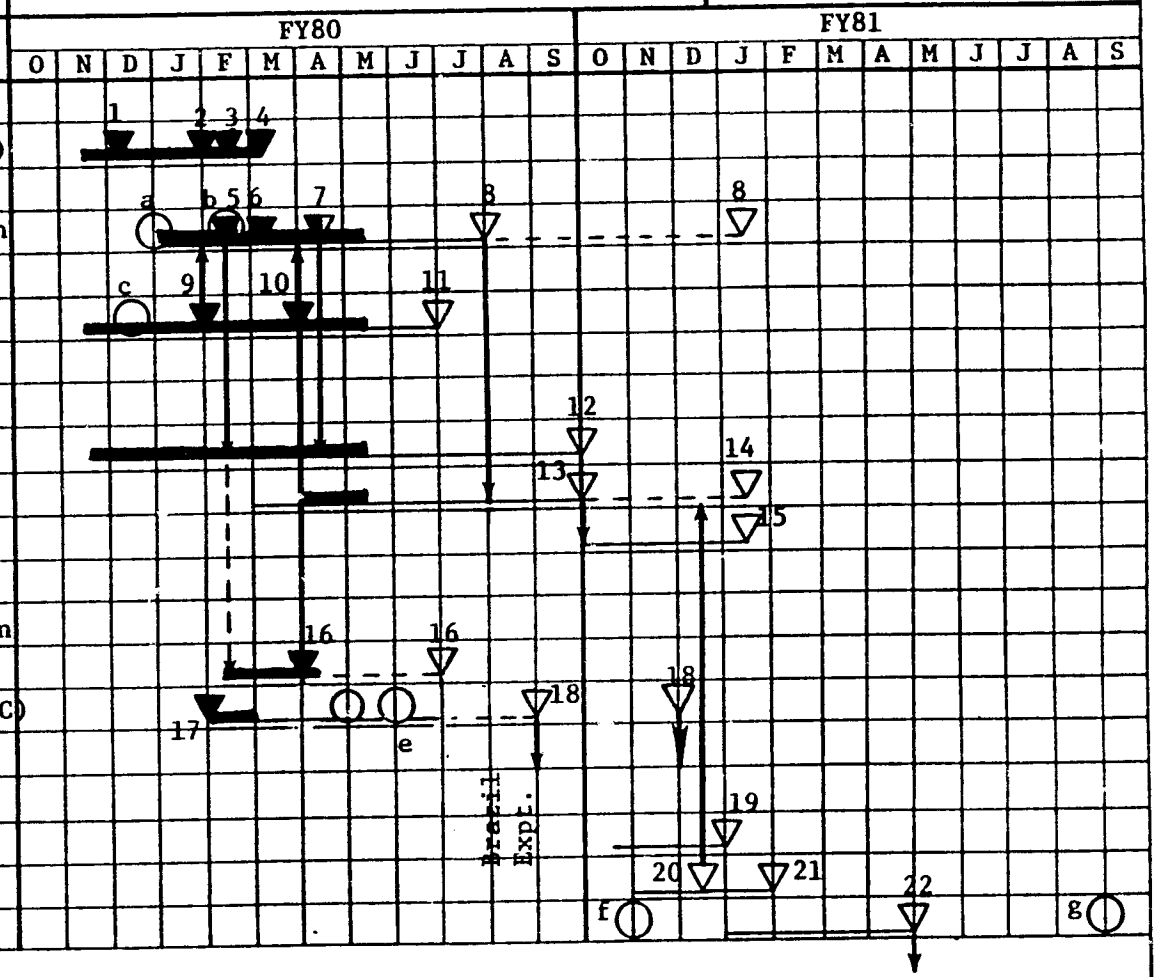
- IDENTIFIED CANDIDATE PILOT EVALUATION FACTORS TO EXPERIMENT DESIGN
- IDENTIFIED CANDIDATE PILOT PRODUCTS TO ACCURACY ASSESSMENT
- IDENTIFIED NATURE OF SEGMENT ESTIMATES TO SAMPLING AND AGGREGATION

Fiscal Years 1980-1981

Integrated Schedule

Foreign Commodity Production Forecasting

U.S. Technology Phase 1

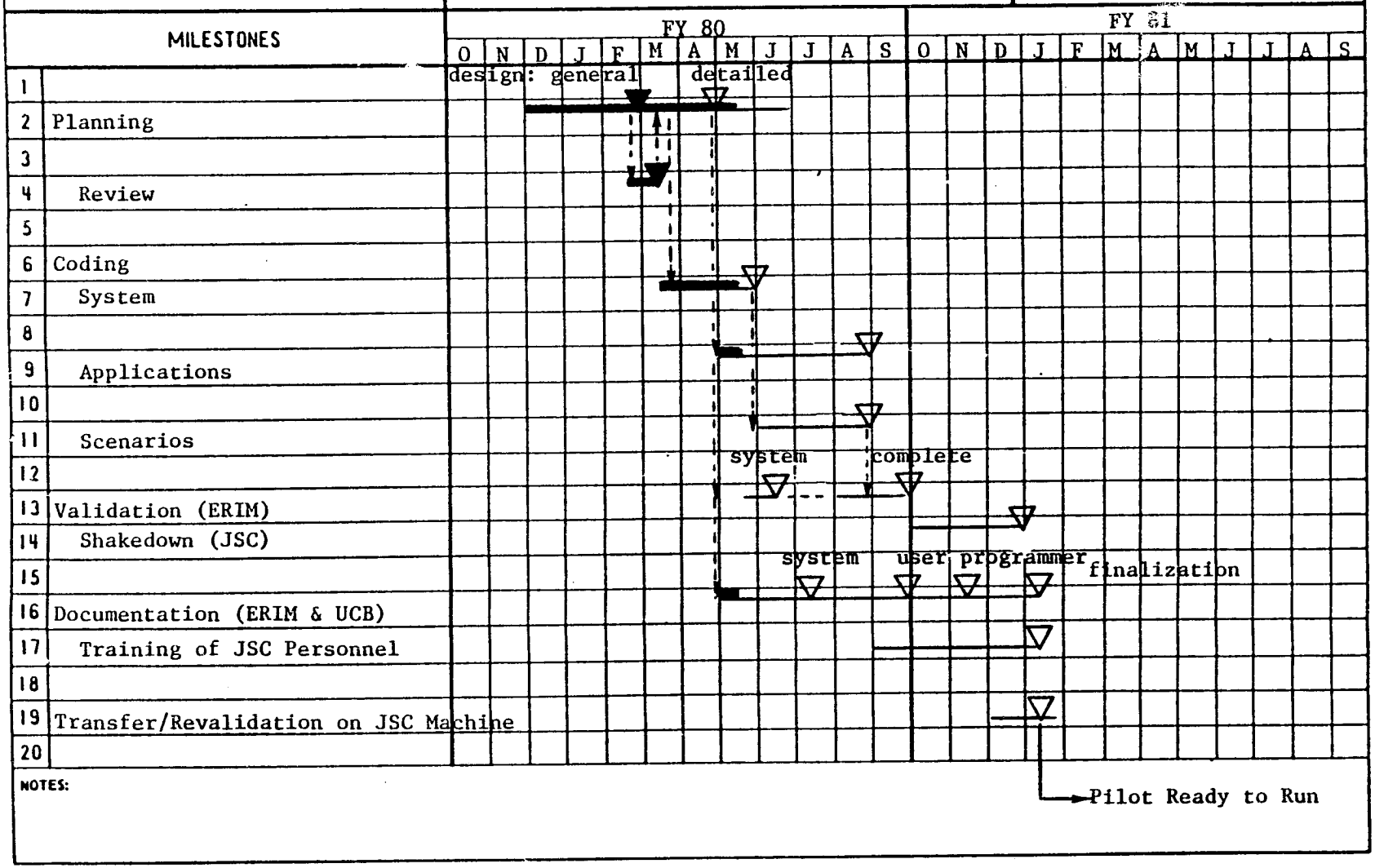


NOTES:

▽ Products, Deliverables

◯ Receivables

IMPLEMENTATION SCHEDULE OF U.S. CORN/SOYBEAN PILOT SOFTWARE ON ERSYS BY ERIM



NEAR TERM PLANS
(15 MAY 80 - 14 AUG 80)

GENERAL

- FINALIZE ORDER FOR FOREIGN APPLICATIONS (ARGENTINA/BRAZIL)
- PURSUE ALTERNATIVE FOREIGN AGRONOMIC DATA SOURCES WITHIN CONSTRAINTS OF AgRISTARS POLICY GUIDELINES
- INITIATE TASK 6: BRAZIL C/S AREA ESTIMATION PROCEDURE DESIGN

TASK 1: U.S. C/S AREA ESTIMATION PROCEDURE DESIGN

- COMPLETE DETAILED BASELINE PROCEDURE DESIGN
- COMPLETE COMPONENT EVALUATION/SELECTION
- COMPLETE COMPONENT PARAMETER SPECIFICATION
- IDENTIFY NEEDS FOR DEVELOPMENTAL DATA PRODUCTS FROM ACCURACY ASSESSMENT OF U.S. PILOT

NEAR TERM PLANS (CONTINUED)
(15 MAY 80 - 14 AUG 80)

TASK 2: U.S. C/S LABELING LOGIC DEVELOPMENT

- COMPLETE FORMAT DEFINITION FOR AI PACKET
- COMPLETE DEFINITION OF COMPONENT PROCEDURES
  - ACQUISITION SELECTION
  - CROP GROUP STRATIFICATION (DFS)
  - LABELING LOGIC
- COMPLETE STRUCTURING OF OVERALL MANUAL PROCEDURE

NEAR TERM PLANS (CONTINUED)
(15 MAY 80 - 14 AUG 80)

TASK 3: U.S. C/S PROCEDURES IMPLEMENTATION

- COMPLETE CODING, VALIDATION AND DOCUMENTATION OF SYSTEM SERVICES
- CONTINUE CODING AND INITIATE DOCUMENTATION OF APPLICATIONS MODULES AND SCENARIOS
- DESIGN PILOT USERS MANUAL AND INITIATE PREPARATION (MACHINE AND MANUAL PROCEDURES)
- INITIATE DEVELOPMENT OF AI TRAINING METHODOLOGY

NEAR TERM PLANS (CONTINUED)
(15 MAY 80 - 14 AUG 80)

TASK 4: U.S. C/S EXPLORATORY TEST AND EVALUATION

- INITIATE C/S BLOB LABELING EXPERIMENT

TASK 5: U.S. C/S CLASSIFICATION IN SUPPORT OF PILOT EXPERIMENT

- CONTINUE TO SUPPORT EXPERIMENT DESIGN, ACCURACY ASSESSMENT AND SAMPLING & AGGREGATION ELEMENTS

FCPF C/S CLASSIFICATION TECHNOLOGY DEVELOPMENT FOR AREA ESTIMATION

ISSUES

- NONE

CORN AND SOYBEAN CLASSIFICATION TECHNOLOGY DEVELOPMENT FOR AREA ESTIMATION FOR SUPPORTING RESEARCH

ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN
UNIVERSITY OF CALIFORNIA AT BERKELEY

15 MAY 1980 SR PROJECT REVIEW

OBJECTIVES

- RESEARCH AND DEVELOP C/S AREA ESTIMATION TECHNOLOGIES ADAPTABLE BY FCPF FOR EVALUATION IN FOREIGN EXPLORATORY EXPERIMENTS.

- CONDUCT U.S. EXPLORATORY EXPERIMENTS IN ADVANCED AREA ESTIMATION TECHNOLOGY FOR CORN AND SOYBEANS IN SUPPORT OF PILOT EXPERIMENTS.

- DELIVER PILOT-COMPATIBLE ADVANCED AREA ESTIMATION PROCEDURES IN THE PROCESS OF CONDUCTING U.S. EXPLORATORY EXPERIMENTS.

SCOPE OF SR RELATED PROGRAM

- IDENTIFY REQUIREMENTS FOR CORN AND SOYBEAN AREA ESTIMATION TECHNOLOGY BASED ON CURRENT TECHNOLOGY.
- RESEARCH AND DEVELOP COMPONENTS FOR AN END-TO-END SEGMENT-BASED AREA ESTIMATION TECHNOLOGY.
- DELIVER COMPONENTS TO FCPF FOR FOREIGN ADAPTATION, TEST AND EVALUATION.
- RESEARCH, DEVELOP, TEST AND EVALUATE ADVANCED AREA ESTIMATION TECHNOLOGIES FOR CORN AND SOYBEAN THAT ARE NOT NECESSARILY SEGMENT BASED.
- RESEARCH, DEVELOP, TEST AND EVALUATE METHODOLOGIES USING THEMATIC MAPPER FOR CORN AND SOYBEAN AREA ESTIMATION.
- IMPLEMENT PILOT-COMPATIBLE PROCEDURES FOR ADVANCED TECHNOLOGIES.

C/S CLASSIFICATION TECHNOLOGY DEVELOPMENT

TECHNOLOGY PHASES

EVENT	U.S. Pilot FY 81	Brazil Expl. Exp. FY 82	Argentina Expl. Exp. FY 83	U.S. P2 Expl. Exp. FY 83	U.S. TM Expl. Exp. FY 84	Brazil/Argentina P2 Expl. Exp. FY 85
TECHNICAL THRUST	End of Season	Throughout Season Foreign Understanding	Objective Labeling Throughout Season Small Fields Foreign Understanding	Multisegment Full-Frame	Advanced Labeling Small Fields	Self Assessment Foreign Understanding
FUNDAMENTAL EMPHASIS	Baseline	Accuracy Timeliness	Accuracy Timeliness	Efficiency	Accuracy	Objectivity Efficiency

C/S CLASSIFICATION TECHNOLOGY DEVELOPMENT FOR AREA ESTIMATION

SUPPORTING RESEARCH TASKS

	FISCAL YEAR	PERFORMING INSTITUTE
1. CURRENT AREA ESTIMATION TECHNOLOGY DEVELOPMENT		
1.1 Improve at harvest area estimation technology	80-81	ERIM
1.2 Midseason labeling and area estimation	80-81	UCB/ERIM
1.3 Early season labeling and area estimation	80-81	UCB/ERIM
1.4 Multiyear (preseason) area estimation	81-82	ERIM
1.5 Error model development	81	ERIM
1.6 Corn and soybean feature definition	80-81	UCB
1.7 Contextual information extraction	81	UCB
2. ADVANCED AREA ESTIMATION TECHNOLOGY DEVELOPMENT		
2.1 Advanced design	80-82	ERIM/UCB
2.2 Advanced technology development	81-83	ERIM/UCB
2.3 Implementation	81-83	ERIM
2.4 Exploratory testing	82-84	ERIM
3. AREA ESTIMATION TECHNOLOGY DEVELOPMENT WITH THEMATIC MAPPER	82-84	ERIM/UCB

ACTIVITIES AND ACCOMPLISHMENTS

(14 Feb '80 - 15 May '80)

General

- FY80-85 Integrated Experiment Implementation Plan
- Initiated Reconsideration of Order for Foreign Applications (Possible switch of Brazil and Argentina)
- Initiated Development of Alternative Foreign Agronomic Data Sources

ACTIVITIES AND ACCOMPLISHMENTS (CONTINUED)

(14 FEB '80 - 14 MAY '80)

TASK 1: CURRENT AREA ESTIMATION TECHNOLOGY DEVELOPMENT

- INITIATED R&D OF IMPROVED AT-HARVEST CLASSIFICATION STRATEGIES
- INITIATED R&D OF MID AND EARLY SEASON LABELING TECHNOLOGY
  - DEVELOPED APPROACH
  - DEVELOPED WORKING DEFINITIONS OF "MID" AND "EARLY"
- INITIATED CORN AND SOYBEAN SPECTRAL FEATURE DEFINITION
  - DEVELOPED APPROACH
  - IMPLEMENTED ERIM CROP-CALENDAR-SHIFT TECHNOLOGY AT UCB

ACTIVITIES AND ACCOMPLISHMENTS (CONTINUED)
(14 FEB 80 - 15 MAY 80)

TASK 2: ADVANCED AREA ESTIMATION TECHNOLOGY DEVELOPMENT

- INITIATED FORMATION OF A P-2 DESIGN TEAM
- REVIEWED A FULL FRAME DESIGN BEING UTILIZED IN A FOREIGN APPLICATION (WHEAT IN ITALY)

OBJECTIVE LABELING TECHNOLOGY DEVELOPMENT

FOR

SUPPORTING RESEARCH PROJECT

ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN

15 MAY 1980 SR PROJECT REVIEW

OBJECTIVES

- To Advance the State-of-the-Art in Labeling Technology
- To Develop Candidate Labeling Procedures for Test and Evaluation in Exploratory Experiments and Pilot Experiments Within the SR and FCPF Projects
- These Procedures Should Be:
  - Objective
  - Representative of the then-current state-of-the-art

OVERALL APPROACH

- BASIC PHILOSOPHY:
  - R&D AND PROCEDURES SHOULD BE BASED ON AN UNDERSTANDING OF THE AGRONOMIC AND PHYSICAL CHARACTERISTICS OF CROPS, TOGETHER WITH UNDERSTANDINGS OF SENSOR CHARACTERISTICS, ENVIRONMENTAL CONDITIONS, AND INTERACTIONS
  - A "SIGNATURE" IS A CONDITIONAL COLLECTION OF INFORMATION ELEMENTS
  - EXTENSION TO FOREIGN SITUATIONS TO BE FACILITATED BY DETERMINING HOW AGROPHYSICAL VARIABLES DIFFER FROM THOSE IN U.S. STUDY AREAS AND PREDICTING DIFFERENCES FOR CONDITIONAL COLLECTION OF INFORMATION ELEMENTS
- DELIVERY APPROACH
  - SHOULD MEET SELECTED EXPLORATORY EXPERIMENT SCHEDULES
  - PROCEDURES MUST BE ADAPTABLE TO FOREIGN APPLICATIONS
  - FOREIGN ADAPTATION AND IMPLEMENTATION PERFORMED BY RECEIVING AREA-ESTIMATION ORGANIZATION

TECHNICAL THRUSTS OF LABELING TECHNOLOGY DEVELOPMENT

- FY81
  - Spring Wheat
  - Machine-Oriented
  - End of Season
  - Binary Labels
- FY82
  - Corn/Soybeans and Wheat/Barley
  - Machine-Analyst Integration
  - Mid-Season Technology
- FY83
  - Multicrop
  - Thematic Mapper
  - Probability Labels
  - Condition Assessment Function
- FY84
  - New Crops (Co,So,Su)

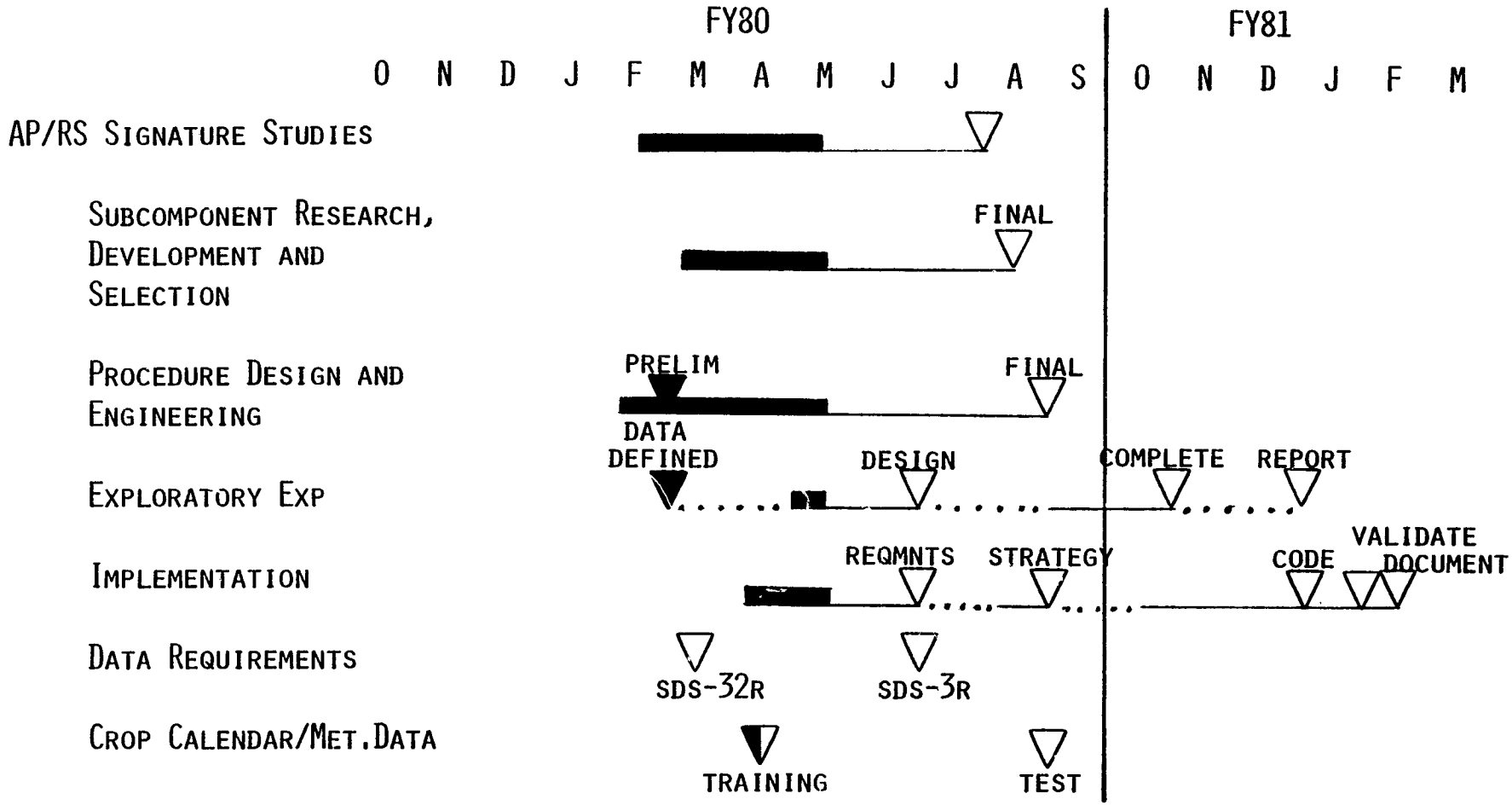
OBJECTIVE LABELING TECHNOLOGY DEVELOPMENT

ACTIVITIES AND ACCOMPLISHMENTS

(15 FEB '80 - 15 MAY '80)

- FY80-85 EXPERIMENT IMPLEMENTATION PLAN DELIVERED
- ERIM CROP-CALENDAR-SHIFT PROCEDURE FOR SMALL GRAINS DELIVERED TO JSC AND UCB
- DEVELOPMENT OF MACHINE-ORIENTED LABELING PROCEDURE FOR SPRING WHEAT INITIATED
  - PRELIMINARY DESIGN COMPLETED
  - AVAILABLE DATA PREPARED
  - SUPPORTING DEVELOPMENT TASKS INITIATED
- DATA NEEDS HAVE BEEN PARTIALLY MET

MACHINE-ORIENTED LABELING PROCEDURE FOR SPRING WHEAT



OBJECTIVE LABELING TECHNOLOGY DEVELOPMENT

NEAR TERM PLANS

(16 MAY '80 - 15 AUG '80)

- CONTINUE DEVELOPMENT OF MACHINE-ORIENTED LABELING PROCEDURE
  - CONTINUM DETAILED PROCEDURE DESIGN/DEVELOPMENT
  - COMPLETE SUBCOMPONENT DEVELOPMENT
    - PROFILE TECHNOLOGY FOR LABELER
    - CROP CALENDAR UTILIZATION
    - ACQUISITION SELECTION
  - INITIATE DETAILED PLANNING FOR IMPLEMENTATION
- INITIATE ADVANCED DEVELOPMENT TASKS
  - INCORPORATING MET-DRIVEN GROWTH MODEL INTO SEED-TO-SATELLITE MODEL FOR WHEAT
  - TEMPORAL-SPECTRAL PROFILE MODELING FOR CORN AND SOYBEANS

OBJECTIVE LABELING TECHNOLOGY DEVELOPMENT

ISSUES

- None

ERIM/UCB PARTICIPATION IN
SR/FCPF DATA SYSTEMS IMPLEMENTATION

15 May 1980 SR Seminannual Project Review

ERIM/UCB DATA SYSTEMS IMPLEMENTATION

OVERALL OBJECTIVE

To support the development and application of ERSYS as a practical and useful system supporting the SR and FCPF Projects through:

- technical design advice
- implementation of procedures
- use of system
- access to data

FY80 OBJECTIVE

Implement, document and validate at JSC an Area Estimation (Classification) Procedure for the FY81 U.S. C/S Pilot

ACTIVITIES AND ACCOMPLISHMENTS

(15 FEB '80 - 15 MAY '80)

- IMPACT OF DELIVERY ON BUILDING 30 COMPUTERS TO ERIM/UCB PROGRAM IDENTIFIED
- FUNDING FOR ERIM DATA LINK APPROVED BY JSC
- DATA LINK COMPONENTS ORDERED
- INTERIM TERMINAL CONNECTION TO LARS ESTABLISHED
- PREFOR/FORTRAN SELECTED AS PRINCIPLE ERIM IMPLEMENTATION LANGUAGE
- LARS TRAINING OF ERIM IMPLEMENTATION STAFF INITIATED
- IMPLEMENTATION FOR U.S. C/S FY81 PILOT INITIATED
- DIRECT ACCESS TO FIELD MEASUREMENT AND WEATHER DATA ON LARS INITIATED

NEAR TERM PLANS
(16 MAY 80 - 15 AUG 80)

- ERIM DATA LINK TO LARS WILL BE COMPLETED
- IMPLEMENTATION FOR U.S. C/S FY81 PILOT WILL CONTINUE

ERIM/UCB DATA SYSTEMS IMPLEMENTATION

ISSUES

- None

DEVELOPMENT OF A MACHINE-ORIENTED LABELING PROCEDURE FOR WHEAT

PROJECT: SUPPORTING RESEARCH

PROJECT ELEMENT: AREA ESTIMATION DESIGN

TASK: LABELING PROCEDURES DEVELOPMENT

PERFORMING ORGANIZATION: ERIM

PRESENTOR: E. CRIST

MAY 19, 1980

OBJECTIVES

To Develop an End-of-Season Labeling Procedure for Spring Wheat Which Utilizes Temporal-Spectral Profile Technology and is

- Objective
- Accurate
- Adaptable

To Provide a Tool With Which the Utility of Profile Technology for Labeling Applications May Be Evaluated and Developed

KEY ISSUE ADDRESSED

THE LABEL ASSIGNMENT STEP HAS BEEN THE GREATEST SOURCE OF ERROR IN PROPORTION ESTIMATION PROCEDURES. THERE IS A NEED FOR MORE ACCURATE AND CONSISTENT LABELING TO SUPPORT AREA ESTIMATION.

SUMMARY

- PRELIMINARY DESIGN FORMULATED
- RESEARCH AND DEVELOPMENT DATA SETS PREPARED
- ANALYSIS UNDERWAY

GENERAL APPROACH

- Examine Existing Data and Approaches
  - Analyst labeling results
  - Advanced feature extraction techniques
  - Agronomic information
- Formulate Preliminary Design
- Carry Out Research and Development of Procedural Elements Using
  - Agronomic Information
    - Historical crop calendars
    - Field observations
    - Crop growth and development research
  - Landsat Data Sets
    - Broad geographical distribution
    - Several growing seasons

GENERAL APPROACH (CONT'D)

- DEFINE AND IMPLEMENT LABELING PROCEDURE
- CONDUCT EXPLORATORY EXPERIMENT USING AN INDEPENDENT, MULTIYEAR LANDSAT DATA SET
- DELIVER PROCEDURE TO SF3

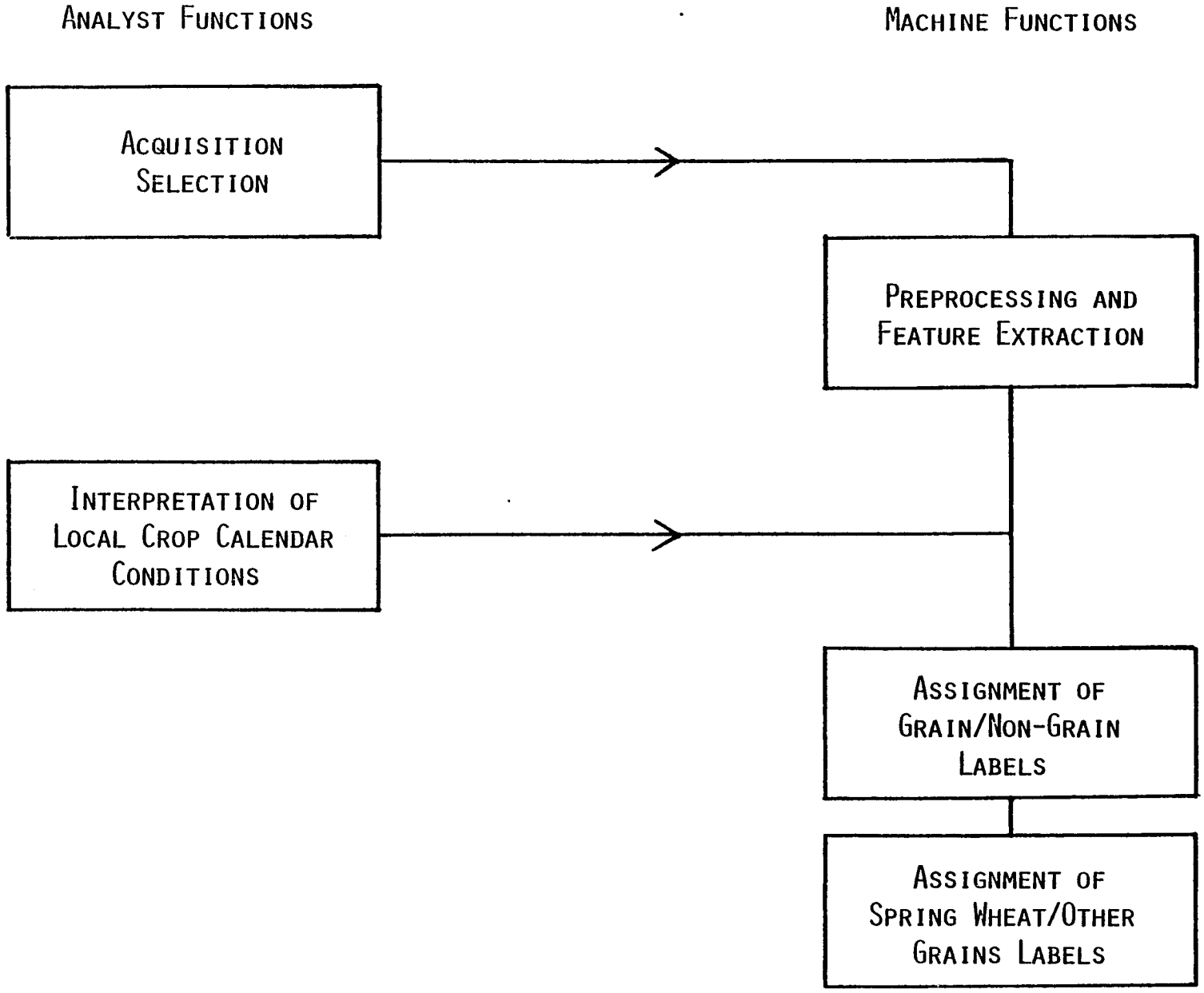
PRELIMINARY DESIGN OF LABELING PROCEDURE

- Analyst Selection of Landsat Acquisitions
  - For all processing
  - For quasi-field definition
- Preprocessing and Feature Extraction
  - Satellite calibration
  - Cosine sun angle correction
  - Detection of defective data, clouds, etc. (ERIM's SCREEN)
  - Haze correction (ERIM's Spatially-Varying XSTAR)
  - Tasseled-Cap Transformation
  - Quasi-field definition (ERIM's SUPERB)
- Interpretation of Local Crop Calendar
  - Primarily analyst function
  - Potential for use of machine techniques

PRELIMINARY DESIGN OF LABELING PROCEDURE (CONT'D)

- ANALYST IDENTIFICATION OF PARTICULAR RELEVANT CONDITIONS
  - STRIP FALLOW
  - UNUSUAL PHENOMENA
- ASSIGNMENT OF GRAIN/NON-GRAIN LABELS BASED ON MULTI-DIMENSIONAL TEMPORAL-SPECTRAL DEVELOPMENT PATTERNS
- ASSIGNMENT OF SPRING WHEAT/OTHER GRAIN LABELS USING ERIM'S WHEAT/BARLEY LABELING TECHNIQUE

PRELIMINARY DESIGN OF LABELING PROCEDURE
BLOCK DIAGRAM

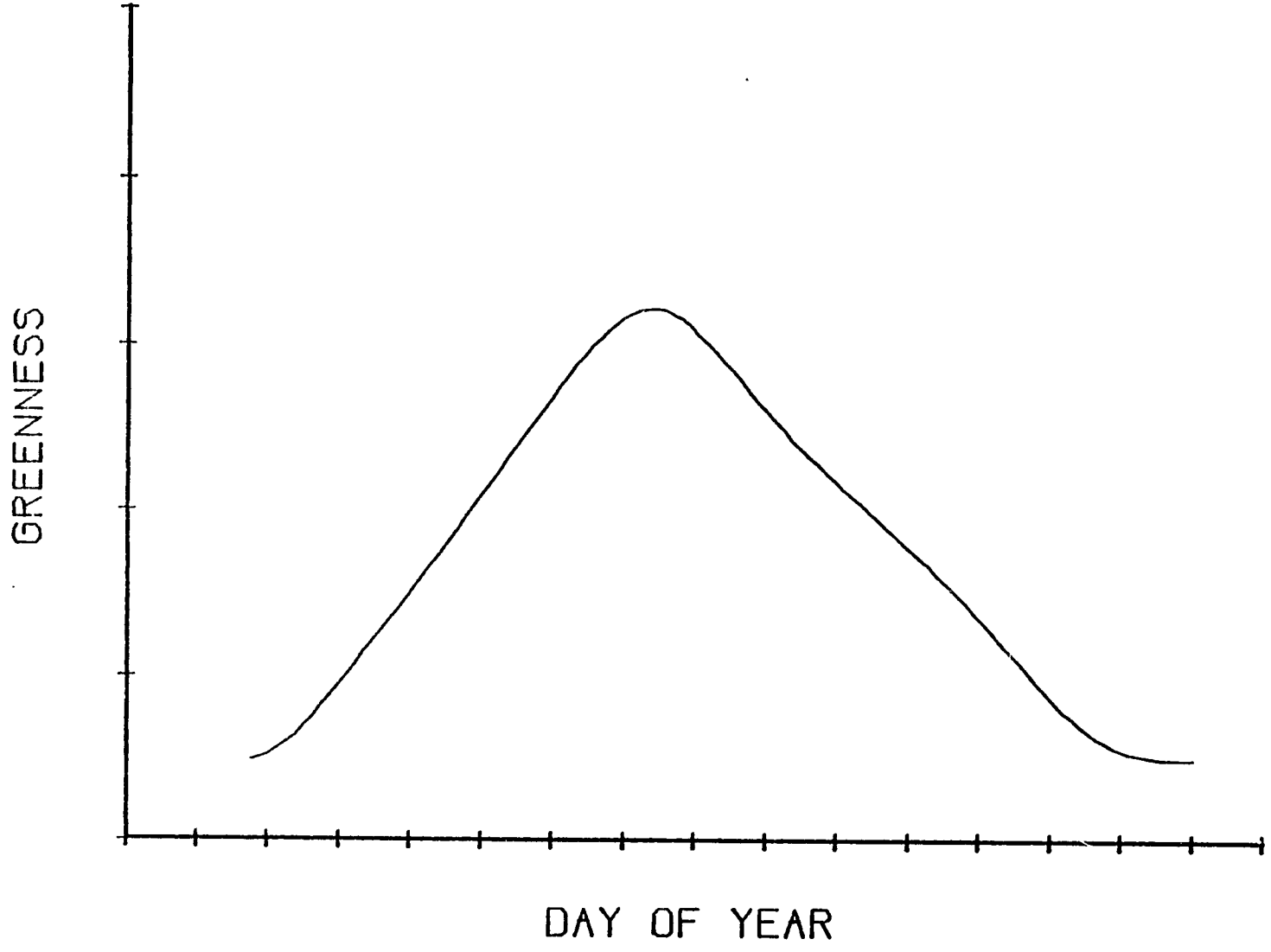


PRELIMINARY DESIGN OF SMALL GRAIN LABELING TECHNIQUE

- COMPARE EACH SAMPLE TO A SERIES OF GREENNESS DEVELOPMENT PROFILES REPRESENTING RELEVANT CROPS OR CROP GROUPS
  - COMPUTE CROP CALENDAR SHIFT AND GOODNESS-OF-FIT TO EACH PROFILE
- STRATIFY TO ELIMINATE SAMPLES WITH LOW PROBABILITY OF BEING SMALL GRAINS
  - BASED ON COMPARATIVE MEASURES COMPUTED IN PREVIOUS STEP
- COMPARE REMAINING SAMPLES TO TWO-DIMENSIONAL PROFILES
  - PROBABILITY COMPUTED BASED ON CROP CALENDAR SHIFT ESTIMATE AND GOODNESS-OF-FIT TO GREENNESS AND BRIGHTNESS PROFILES
- ASSIGN LABELS BASED ON COMPUTED PROBABILITIES

LABELING TECHNIQUE

ILLUSTRATION OF APPROACH



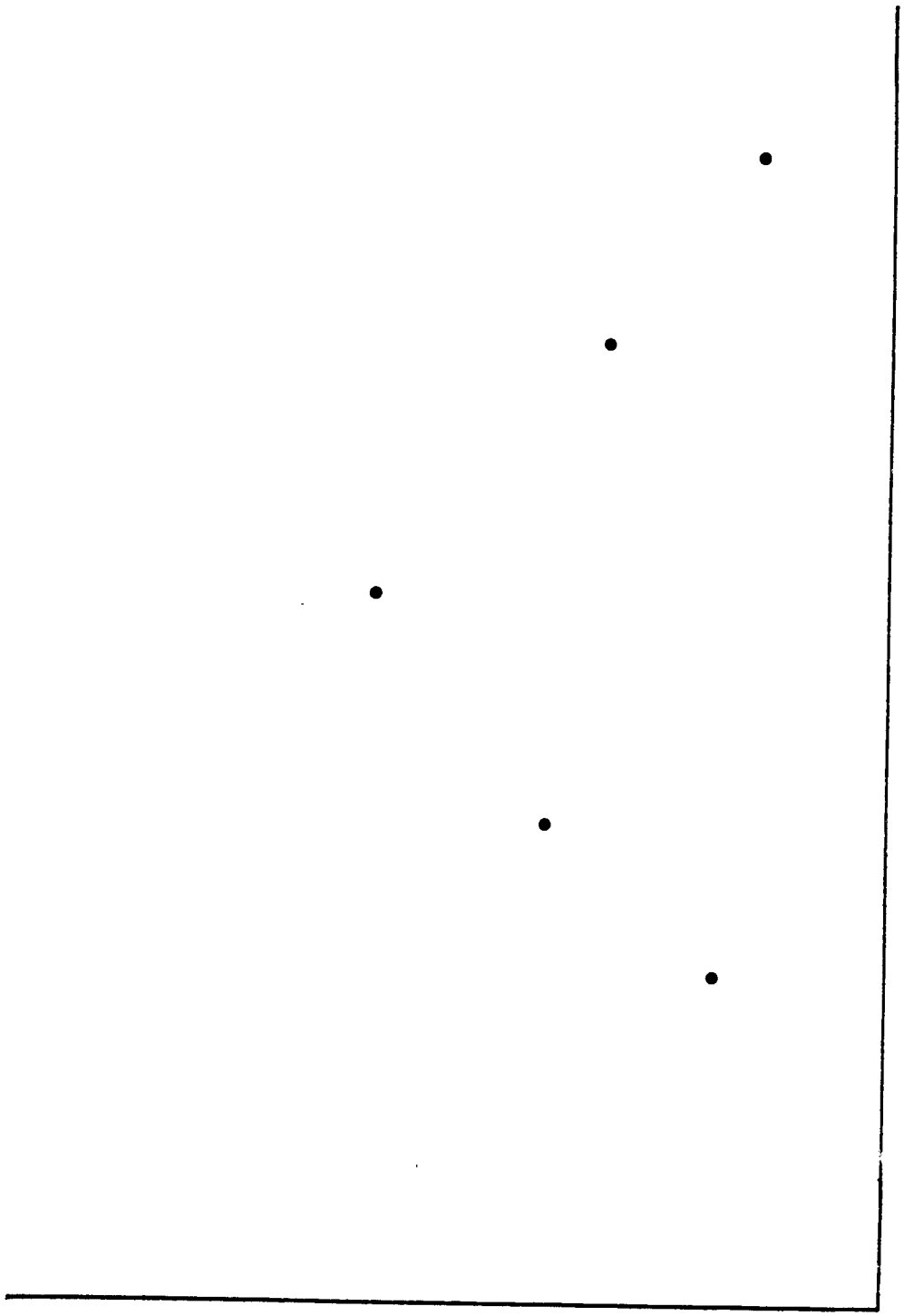
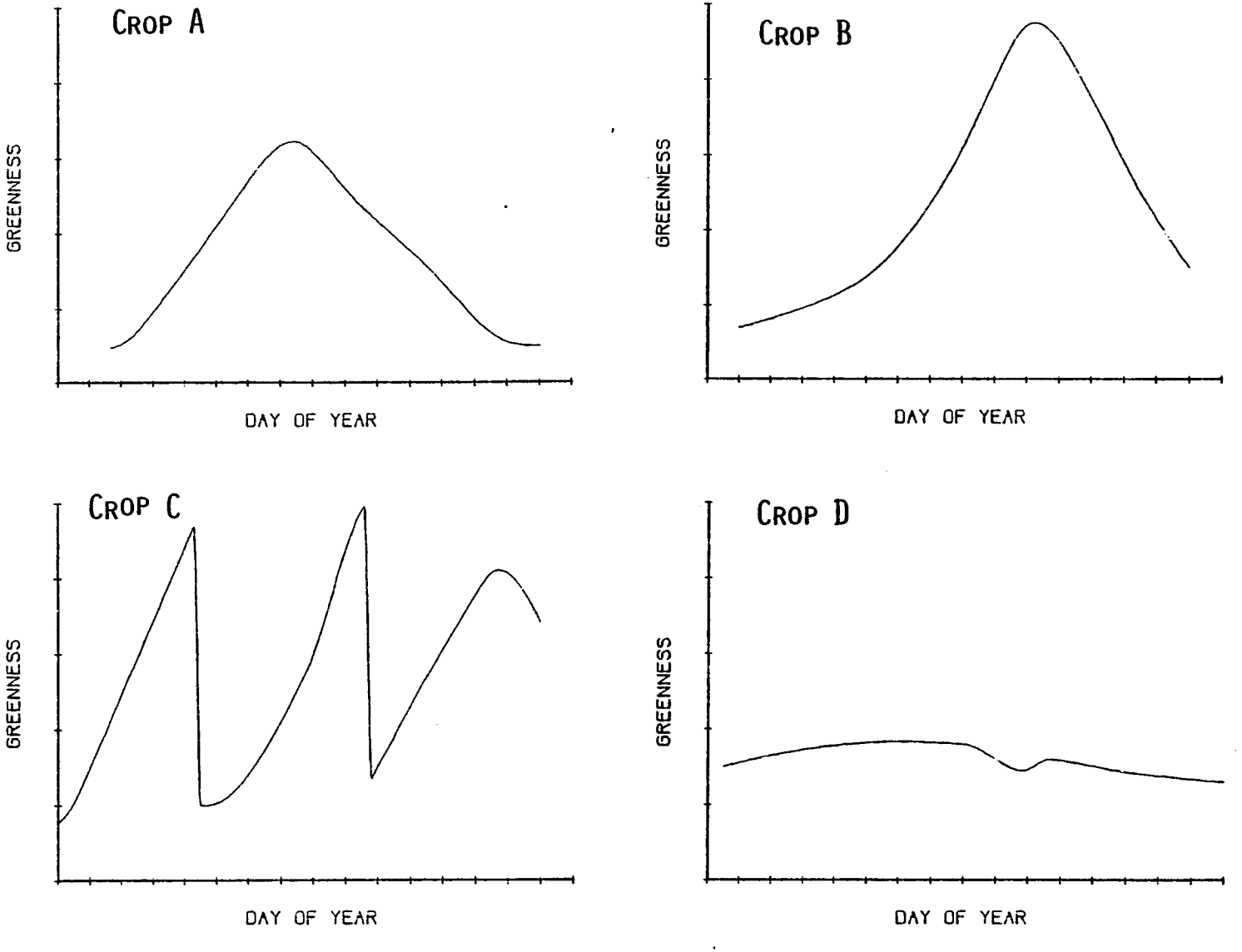


ILLUSTRATION OF APPROACH (CONT'D)



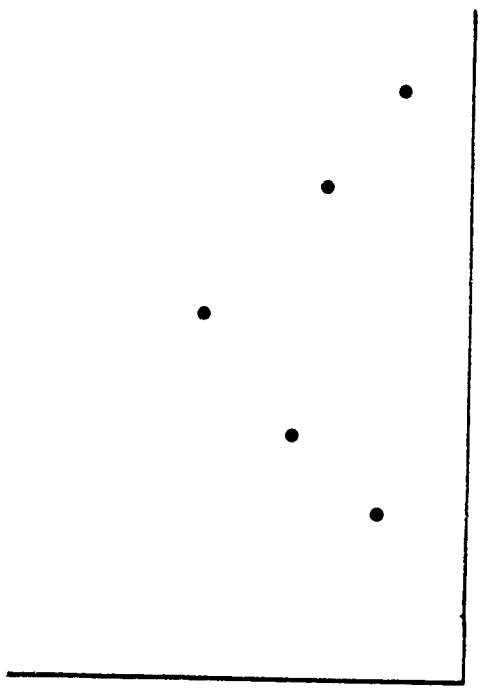
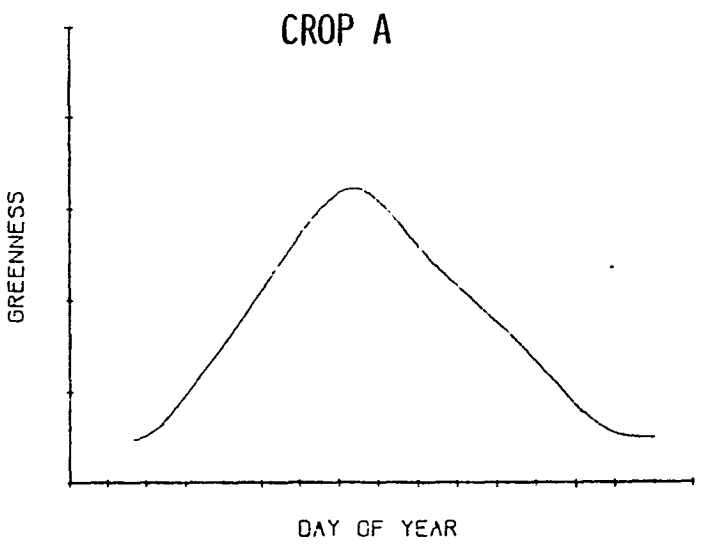
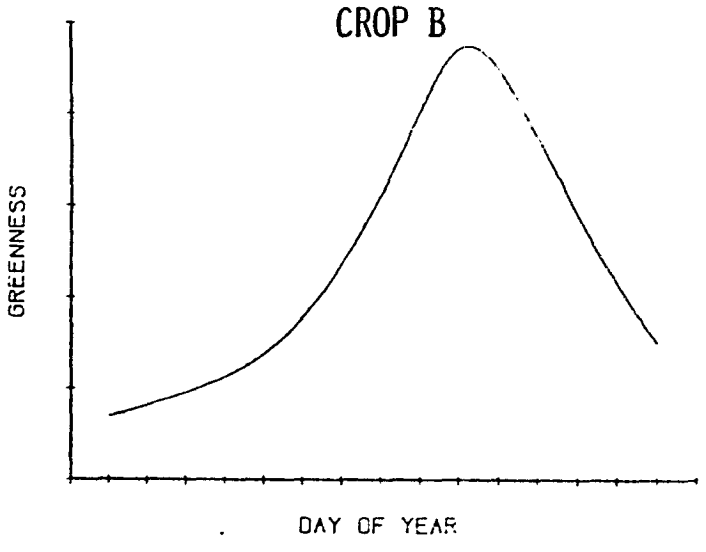
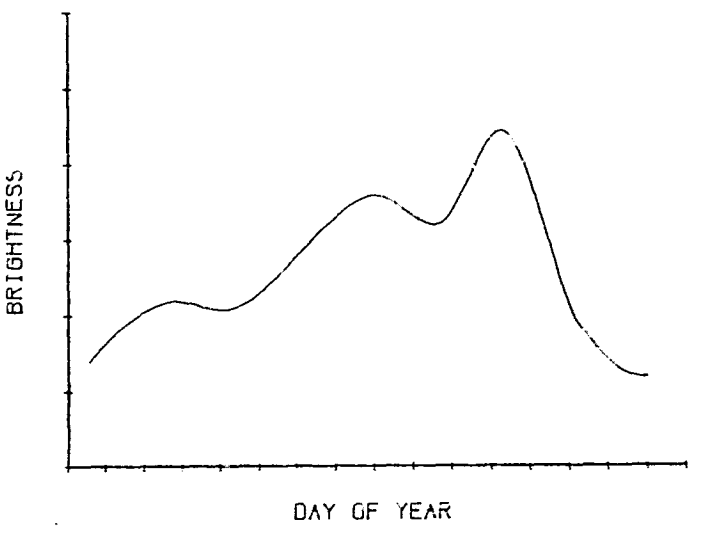
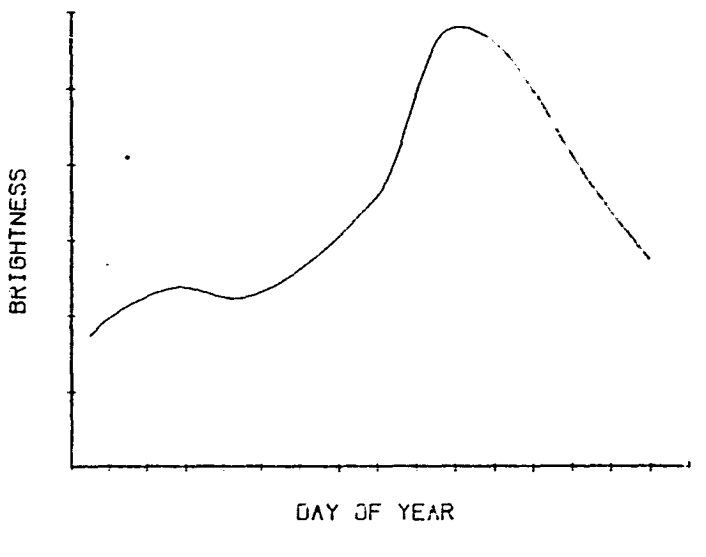


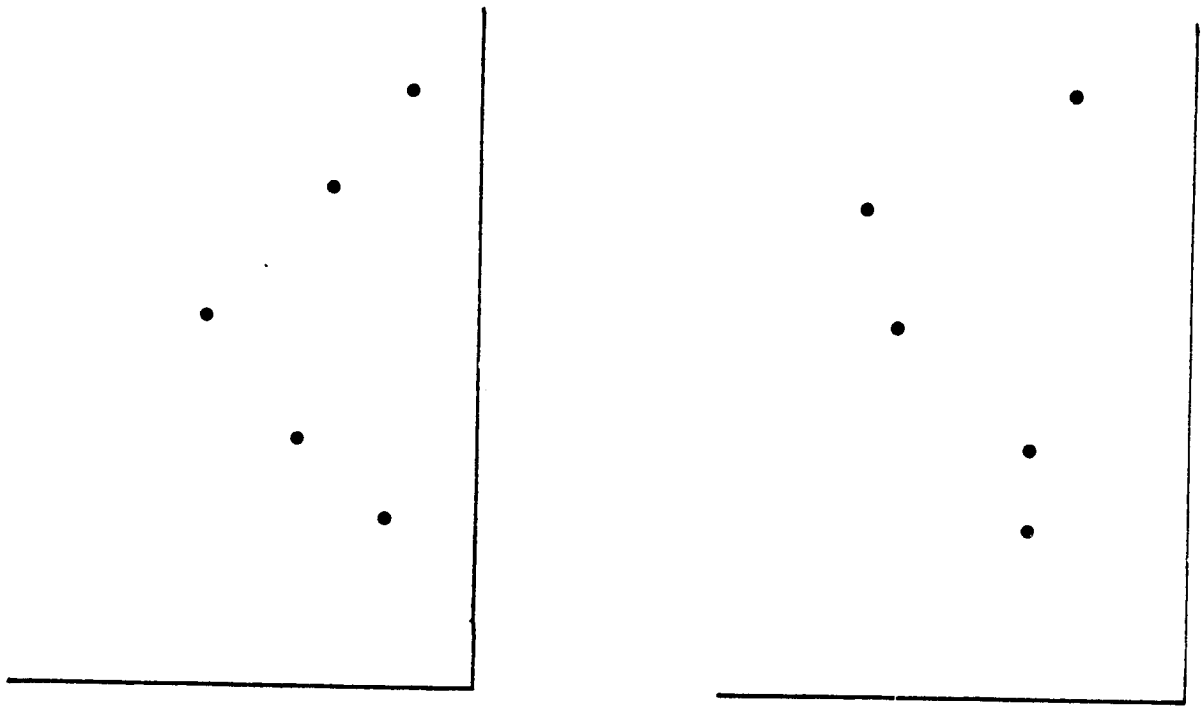
ILLUSTRATION OF APPROACH (CONT'D.)











DEVELOPMENT POTENTIAL OF DESCRIBED TECHNIQUE

- Single-Pass Multiple-Crop Labeling
- Probabilistic Labeling

RESEARCH AND DEVELOPMENT PLAN
SMALL GRAIN LABELING TECHNIQUE

- Analyze Multi-Temporal Clusters of Pure Quasi-Fields
  - Temporal-Spectral Characteristics of Small Grain and Relevant Non-Grains
    - Range of Variation Among "Normal" Samples
    - Frequency and Nature of "Abnormal" Samples
  - Potential Sources of Labeling Confusion
    - Properties of Grain Samples in Predominantly Non-Grain Clusters
    - Properties of Non-Grain Samples in Predominantly Grain Clusters
- Develop Temporal-Spectral Profiles for Small Grains and Relevant Non-Grains
  - Analyze Historical Crop Calendar Information
    - Pattern and Variation of Development Within and Between Crops
  - Utilize Results of Cluster Analysis

RESEARCH AND DEVELOPMENT PLAN (CONT'D.)

SMALL GRAIN LABELING TECHNIQUE

- DEFINE PROFILES TO BE USED
  - •• MATHEMATICAL MODEL FORMS
  - •• EMPIRICAL FIT TO DATA
- DEFINE METHODS FOR LIKELIHOOD DETERMINATION
  - GOODNESS-OF-FIT CRITERION
  - RELATIVE WEIGHTING BETWEEN GREENNESS AND BRIGHTNESS
  - RELATIVE WEIGHTING BETWEEN SHIFT AND FIT
  - PROBABILITY COMPUTATION
- EVALUATE LIKELIHOOD COMPUTED FOR DEVELOPMENT DATA
  - ESTABLISH FEASIBILITY OF APPROACH
  - DEFINE INITIAL PARAMETERS, ALGORITHMS

PRELIMINARY PLAN FOR EXPLORATORY EXPERIMENT

- Utilize Independent, Multi-Year Landsat Data Set
- Simulate Analyst Functions By Multiple Acquisition Selections, Crop Calendar adjustments
- Label All Quasi-Fields
- Evaluate

1. Labeling Accuracy and Variability
   - Overall
   - By Crop or Crop Group
   - By Year
   - By APU
   - As a Function of Sample Purity
2. Machine Technique vs. Phase 3 Analyst Dot Labels (previously obtained)
   - Compare Analyst Labels for Dots Falling in Quasi-Field Interiors to Machine Labels for Those Quasi-Fields
3. Impact of Errors in Analyst Functions on Procedure

PRIMARY DEVELOPMENT DATA SET

- 5 x 6 Mile U.S. Northern Great Plains Segments from 3 Growing Seasons

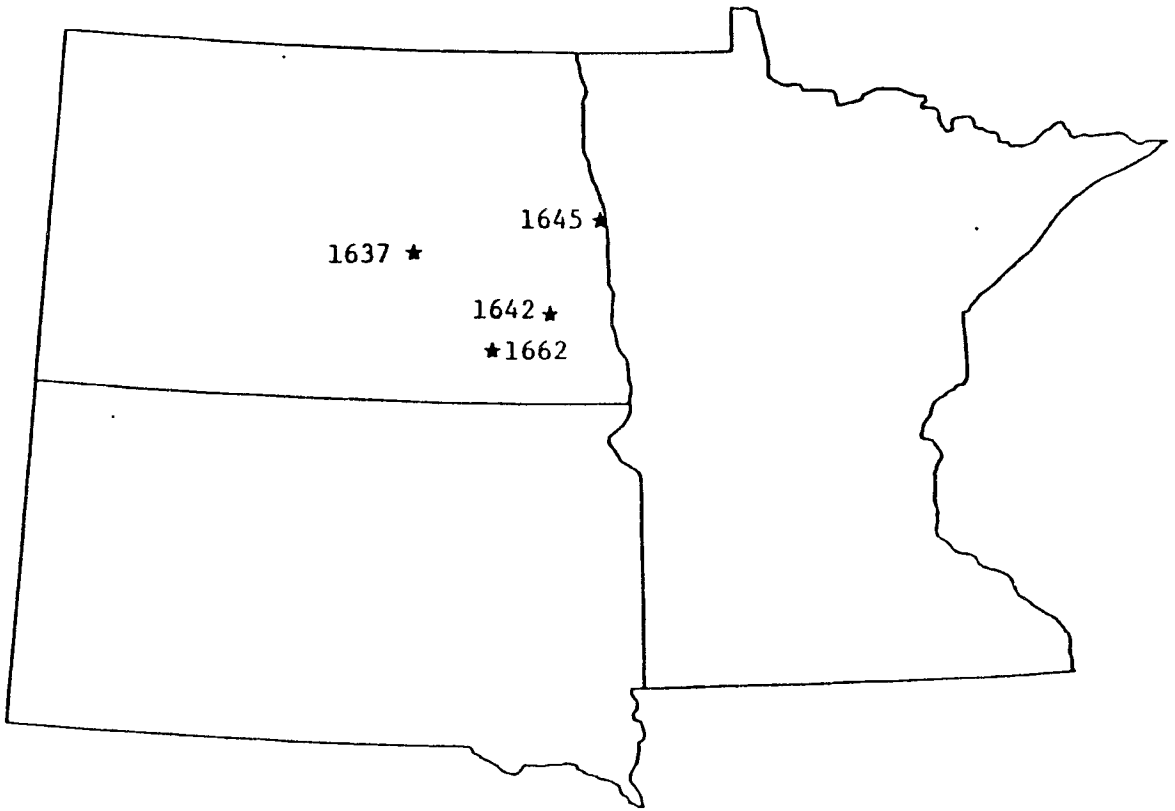
Year	# of Sides
1976	4
1977	8
1978	16

  - Mostly North Dakota and Minnesota
  - Three APU's

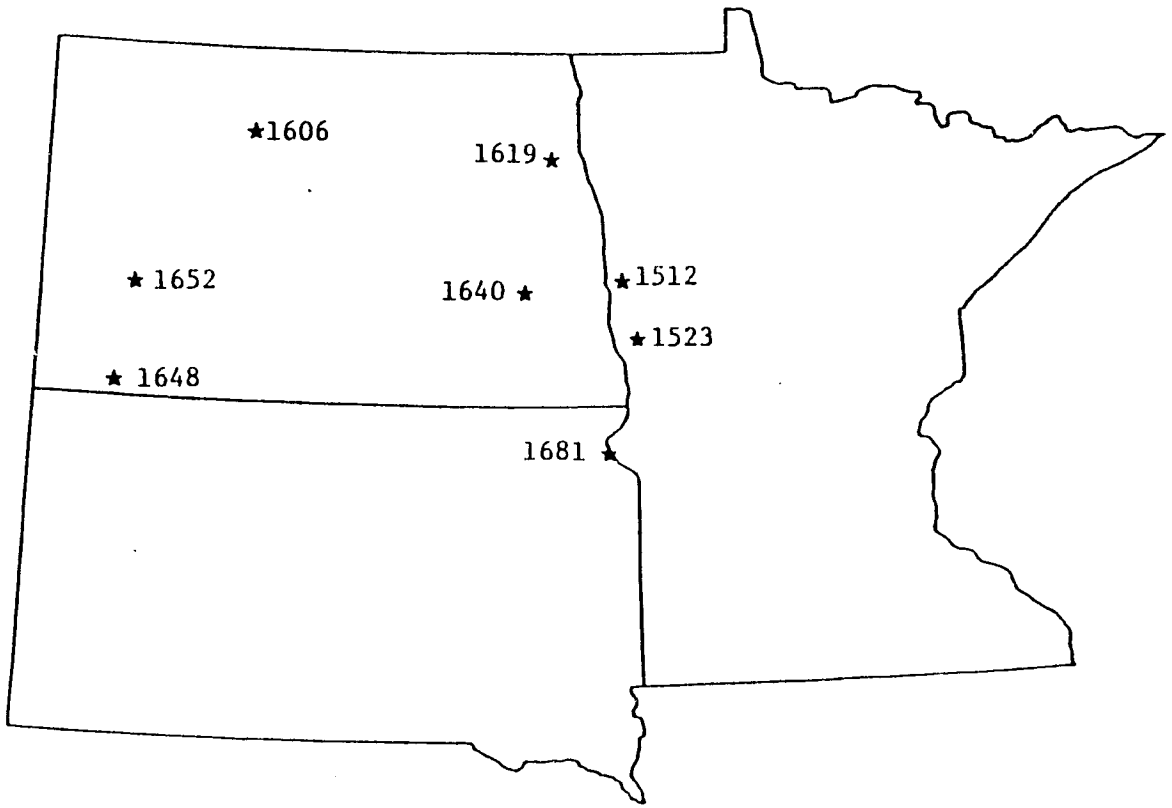
- 5 x 6 Mile Corn Belt Segments - 1978 Growing Season
  - 4 Sites
  - For Use in Profile Characterization

- Historical Crop Calendar Information for U.S. Northern Great Plains
  - Long-Term Averages
  - Recent Year-by-Year

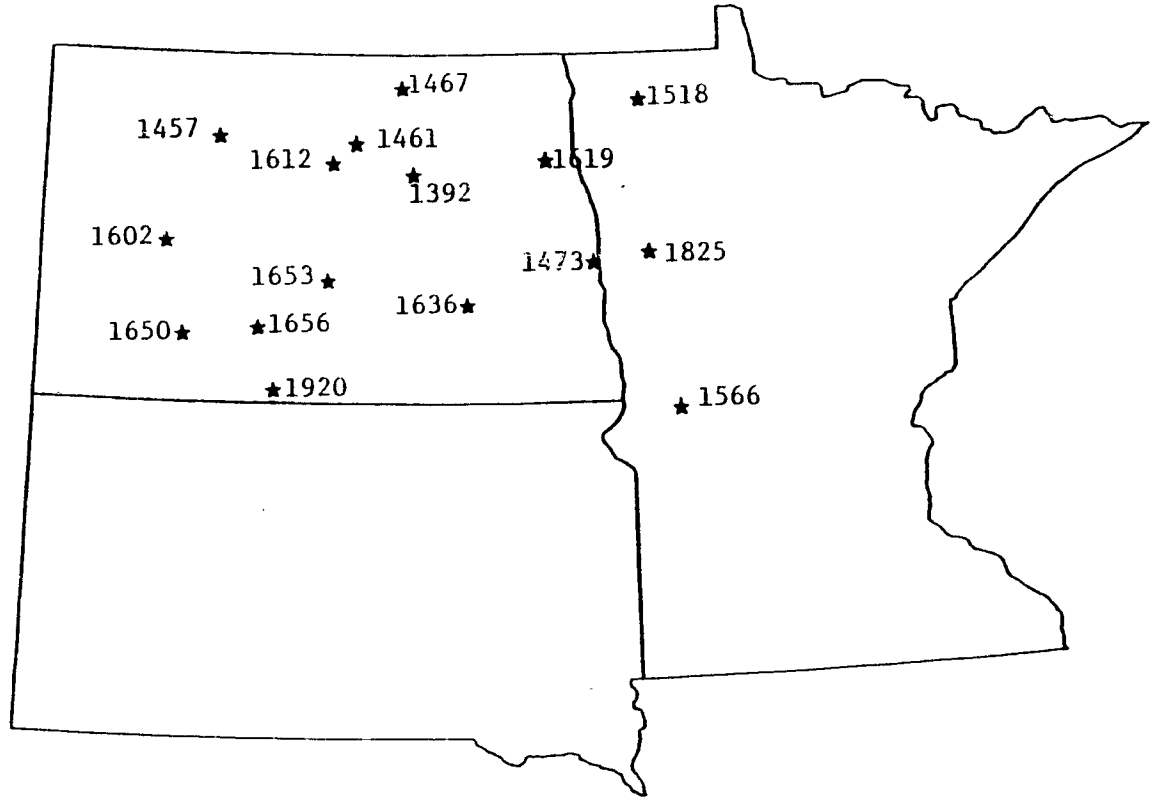
PHASE 2 SEGMENTS (1976)



PHASE 3 SEGMENTS (1977)



TRANSITION YEAR SEGMENTS (1978)

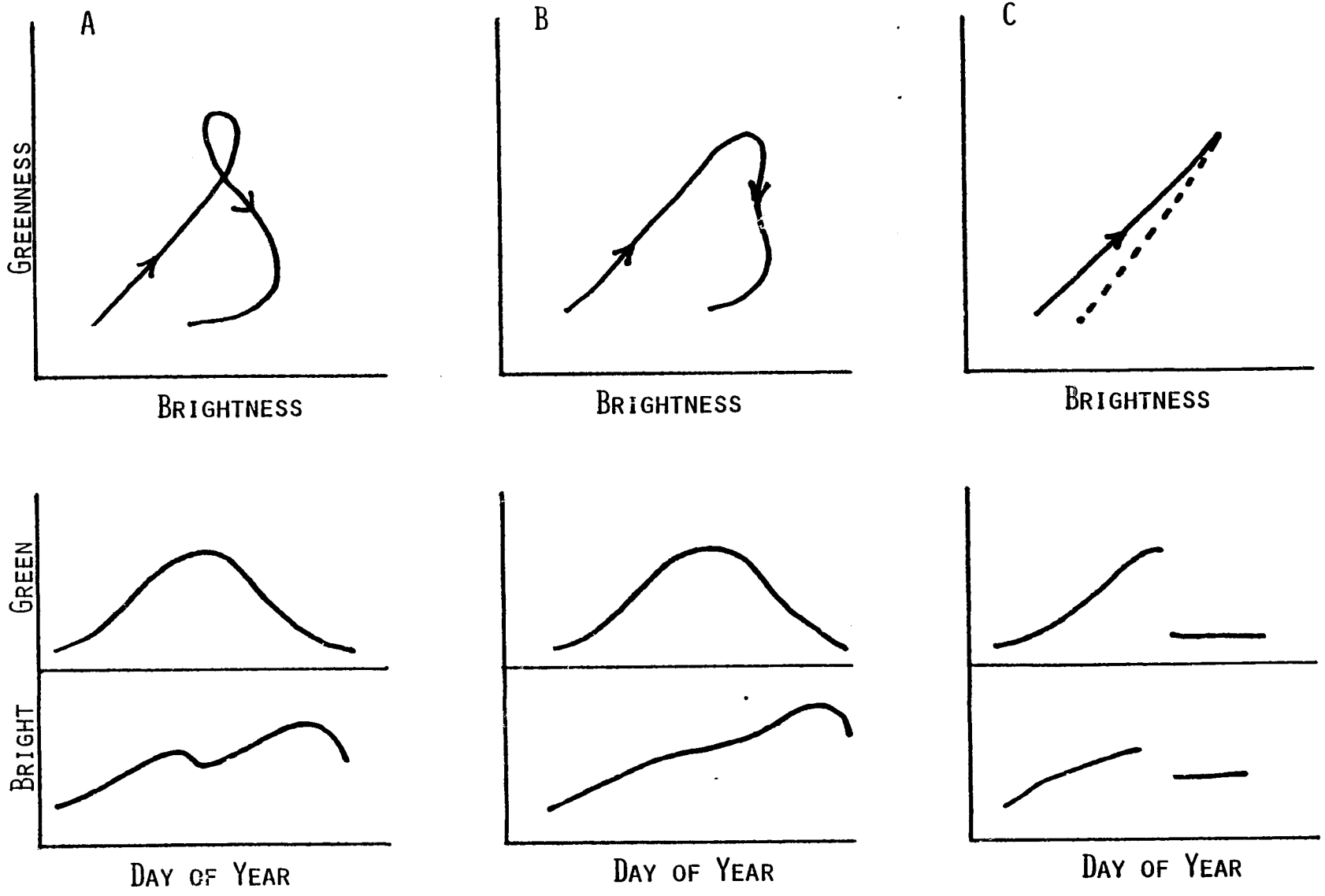


ANALYSIS TO DATE

- SUPERVISED CLUSTERING OF GRAIN AND NON-GRAIN DATA COMPLETED
- TEMPORAL-SPECTRAL DEVELOPMENT PATTERNS OF GRAIN CLUSTERS CATEGORIZED BASED ON A SET OF CHARACTERISTIC TRAJECTORIES
  - USED CLUSTERS WITH MORE THAN ONE BLOB (CONTAIN AVERAGE OF 85% OF THE BLOBS IN A SEGMENT)

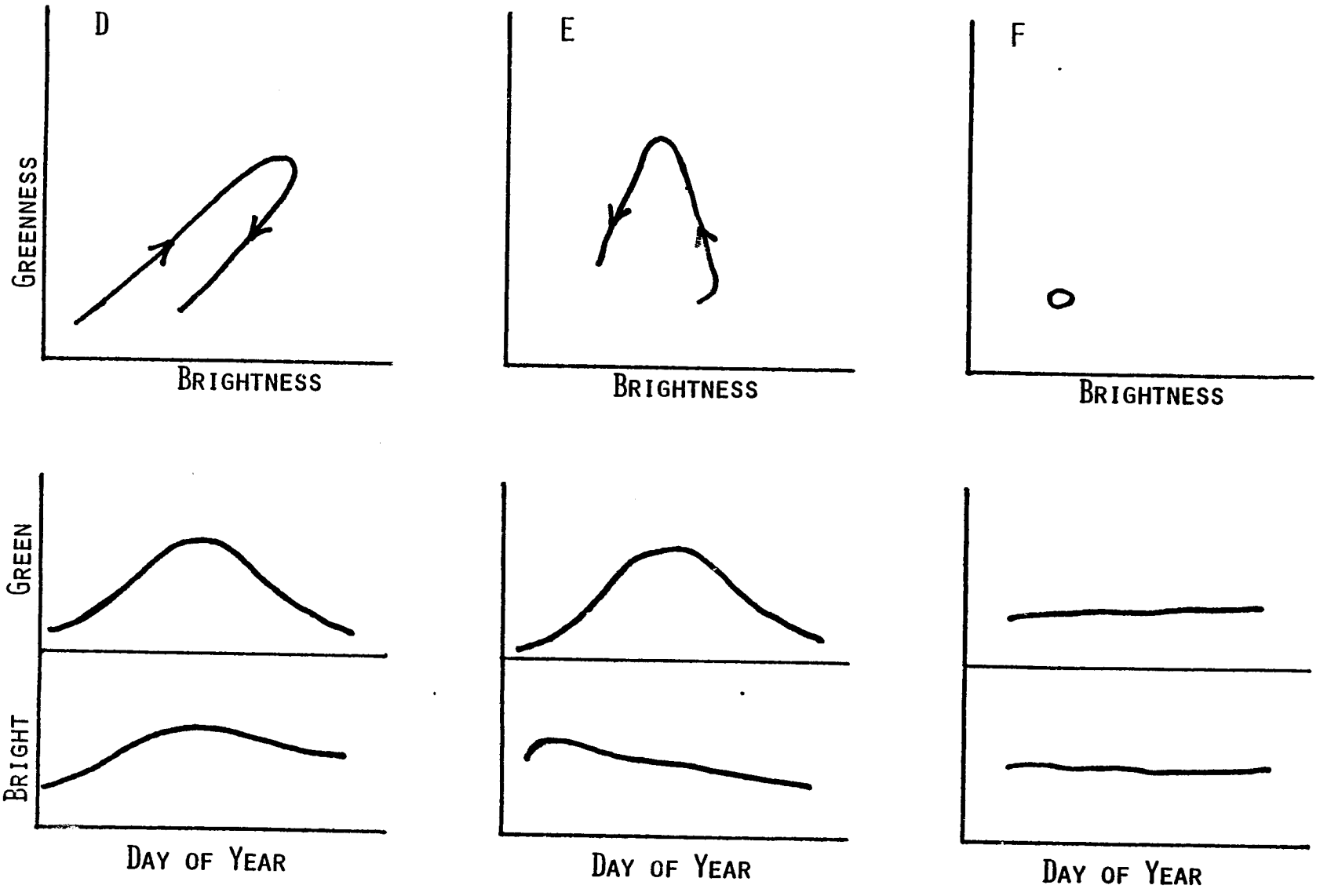
CHARACTERISTIC TEMPORAL-SPECTRAL DEVELOPMENT PATTERNS

GRAIN CLUSTERS



CHARACTERISTIC TEMPORAL-SPECTRAL DEVELOPMENT PATTERNS

GRAIN CLUSTERS (CONT'D.)



GRAIN CLUSTER DEVELOPMENT PATTERN COMPARISONS

RESULTS

- 98% OF THE GRAIN BLOBS WERE IN ASSIGNABLE CLUSTERS (I.E., 2% LABELED "UNKNOWN")
- 96% HAD "TYPICAL" DEVELOPMENT PATTERN IN GREENNESS
- 90% HAD ONE OF THE THREE "TYPICAL" BRIGHTNESS-GREENNESS DEVELOPMENT PATTERNS

GRAIN CLUSTER DEVELOPMENT PATTERN COMPARISONS

OBSERVATIONS

- Omission of Grain Samples Due to Unexpected Temporal-Spectral Development Patterns Should Not Be a Major Factor Affecting Labeling Accuracy

- Number and Timing of Acquisitions Has a Substantial Effect on the Ability to Accurately Detect a Particular Development Pattern

PLANS

- Complete Cluster Analysis, Profile Development
- Define Analyst Procedures
- Complete Final Design of Procedure

CORN AND SOYBEAN CLASSIFICATION TECHNOLOGY DEVELOPMENT FOR AREA ESTIMATION

QUARTERLY TECHNICAL REVIEW

MAY, 1980

ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN

UNIVERSITY OF CALIFORNIA AT BERKELEY

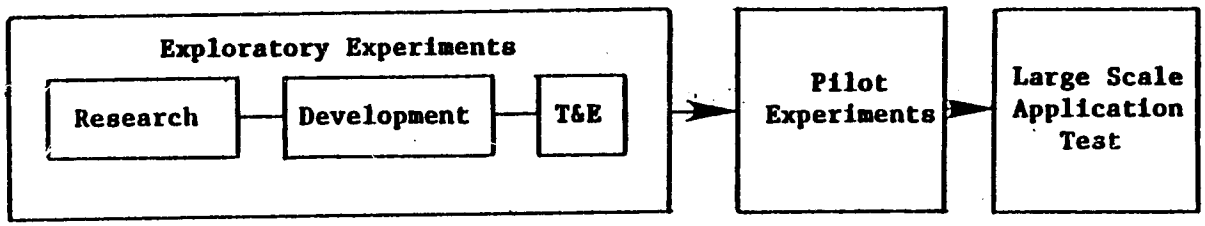
JOHNSON SPACE CENTER

CORN AND SOYBEAN CLASSIFICATION TECHNOLOGY DEVELOPMENT FOR AREA ESTIMATION

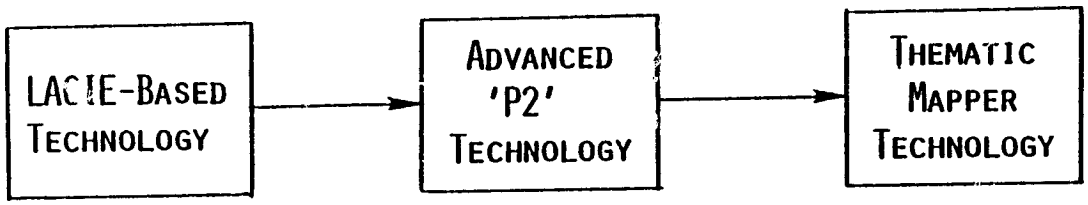
OBJECTIVES

- CONDUCT END-TO-END EXPLORATORY EXPERIMENTS IN CLASSIFICATION TECHNOLOGY FOR CORN AND SOYBEANS IN SUPPORT OF PILOT EXPERIMENTS
- DELIVER PILOT-COMPATIBLE C/S AREA ESTIMATION PROCEDURES
- SUPPORT PILOT EXPERIMENT

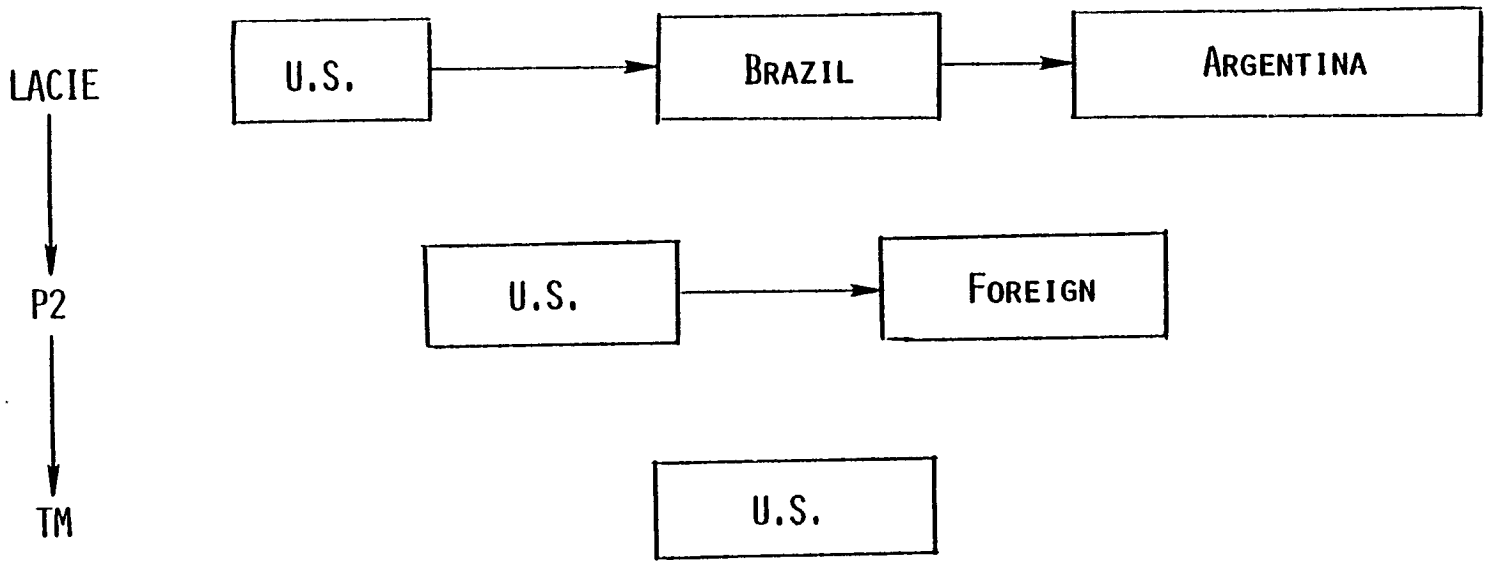
AgRISTARS TECHNICAL APPROACH



PLANNED TECHNICAL DIRECTION



SIX TECHNICAL PHASES



TEMPORAL SEQUENCE OF EACH TECHNOLOGY PHASE

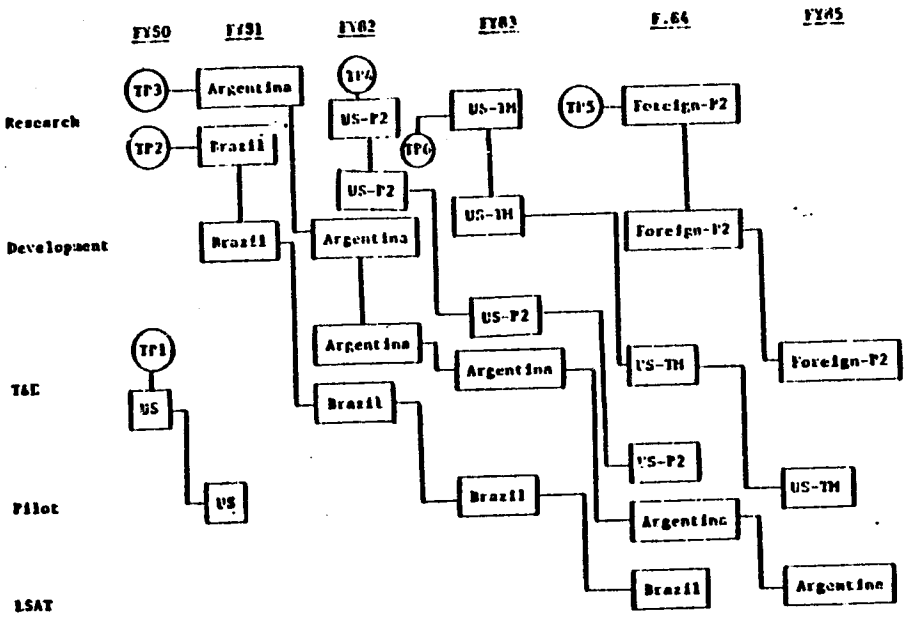


TABLE 4. TECHNICAL MILESTONES IN C/S CLASSIFICATION TECHNOLOGY DEVELOPMENT FOR AREA ESTIMATION

EVENT	U.S. Pilot FY 81	Brazil Expl. Exp. FY 82	Argentina Expl. Exp. FY 83	U.S. P2 Expl. Exp. FY 83	U.S. TM Expl. Exp. FY 84	Brazil/Argentina P2 Expl. Exp. FY 85
TECHNICAL THRUST	End of Season	Throughout Season Estimates Foreign Understanding	Objective Labeling Throughout Season Small Fields Foreign Understanding	Multisegment Full-Frame	Advanced Labeling Small Fields Multisensor	Self Assessment Foreign Understanding
FUNDAMENTAL EMPHASIS	Baseline	Accuracy Timeliness	Accuracy Timeliness	Efficiency	Accuracy	Objectivity Efficiency

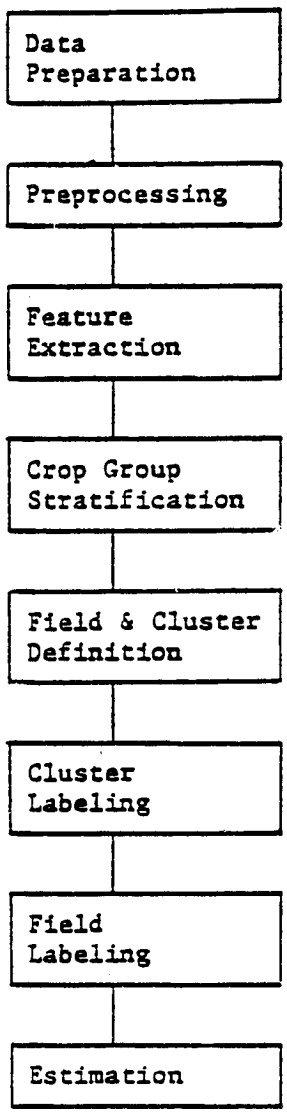


Figure 1. Baseline Procedure for Corn and Soybean Classification Procedure Flow

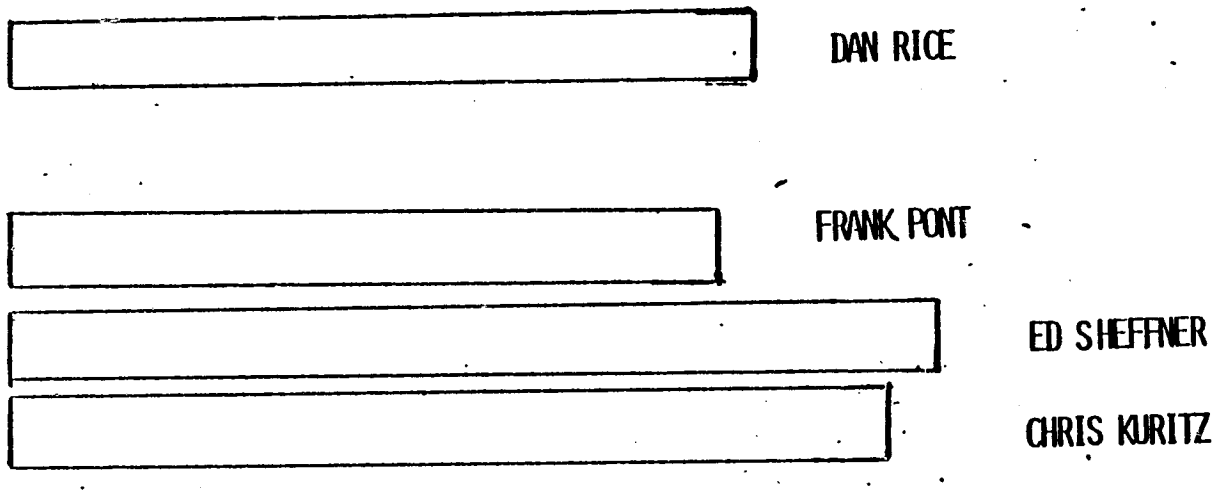
MAJOR TASKS

SUPPORTING RESEARCH

- CURRENT CLASSIFICATION FOR AREA ESTIMATION TECHNOLOGY DEVELOPMENT
- ADVANCED (P2) CLASSIFICATION FOR AREA ESTIMATION TECHNOLOGY DEVELOPMENT
- CLASSIFICATION FOR AREA ESTIMATION TECHNOLOGY DEVELOPMENT WITH THEMATIC MAPPER

FOREIGN COMMODITY PRODUCTION FORECASTING

- CLASSIFICATION PROCEDURE DESIGN
- LABELING LOGIC AND ANALYST PROCEDURES DEVELOPMENT
- PROCEDURE IMPLEMENTATION
- EXPLORATORY TEST AND EVALUATION
- CLASSIFICATION IN SUPPORT OF PILOT EXPERIMENT


DAN RICE
FRANK PONT
ED SHEFFNER
CHRIS KURITZ

Currently Active Tasks

- Design of Baseline Corn & Soybean Classification Procedure
- Implementation of Baseline Procedure
- Corn and Soybean Labeling Logic Development (at UCB)
- At-harvest Classification Research
- Early and Mid-season Labeling Research (at UCB)
- Corn and Soybean Features Research (at UCB)
- Procedure M/DFS Labeling Development
- P2 Design
- Baseline Exploratory T&E (at JSC)
- Support to Pilot Experiment (with JSC)

USE OF PRIORS IN SAMPLE ALLOCATION

PROJECT: SUPPORTING RESEARCH

PROJECT ELEMENT: CORN AND SOYBEAN CLASSIFICATION TECHNOLOGY DEVELOPMENT FOR AREA ESTIMATION

SUBTASK: IMPROVED END OF SEASON CLASSIFICATION TECHNIQUES

PERFORMING ORGANIZATION: ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN

RESEARCH TEAM: H. HORWITZ AND F. PONT

DATE: MAY 1980

OBJECTIVE

Improved at-Harvest Classification Technology for Corn and Soybeans

DETAILED OBJECTIVES

- Evaluate Use of Static Strata
- Evaluate Use of Empirical Derived Priors With Auxillary Information
- Optimize Allocation in Presence of More Than Two Crops

KEY ISSUE ADDRESSED

LABELING SAMPLES IS EXPENSIVE. METHODS WHICH MINIMIZE THE NUMBER OF LABELS NECESSARY TO ACHIEVE A GIVEN ERROR BUDGET ARE BENEFICIAL.

APPROACH

- Studied the Allocation of Samples to Stratum for the 3 Crop Case
  - Minimize Variances Subject to Sample Size Constraints
  - Minimize Sample Size Subject to Constraints on Variances
  - Use of Priors for Statically Defined Strata in Allocation
- Studied the Concept of Statically Defined Strata
  - Compiled a List of Possible Benefits
  - Defined Several Candidate Static Stratifications
  - Carried Out Small Experiment in the Two Crop Case Using Priors Obtained from 3 Segments to Allocate Samples to the Strata in a 4th Segment

FROM COCHRAN'S SAMPLING TECHNIQUES WE HAVE THEOREM 5.8 IF THE N_H/N_H ARE IGNORED,

$$V_{OPT} \leq V_{PROP} \leq V_{RAN} \quad \text{WHERE}$$

V_{OPT} IS THE VARIANCE OBTAINED WITH OPTIMUM ALLOCATION (CALLED NEYMAN ALLOCATION) FOR FIXED N, I.E., $N_H \propto N_H S_H$,

V_{PROP} IS THE VARIANCE OBTAINED WITH PROPORTIONAL ALLOCATION, I.E., $N_H \propto N_H$

V_{RAN} IS THE VARIANCE OBTAINED WITH SIMPLE RANDOM SAMPLING

BACKGROUND

- Procedure M
  - BCLUSTER Stratification
  - Sample Allocation Proportional to Size
- Corn and Soybean Baseline Procedure
  - BCLUSTER within Crop Group Strata
  - Some Strata May be Flagged as Not Summer Crop
  - Sample Allocation to Summer Crop Strata Proportional to Size
- Small Grain Baseline Procedure (P1A)
  - Classie Clusters Used as Strata
  - Historical Based Priors
  - 2 Dots are labeled
  - Labels are Used to Update Priors
  - Samples are Allocated to Strata with Highest Expected Variance
  - Continued Allocation Until Constraints on the Total Sample Size or Variance are Reached

STATIC STRATIFICATION

- Stratification Defined in Such a Way that Strata in One Segment can be Compared to Corresponding Strata in Other Segments/Years
- Possible Advantages in Using Static Strata Include
  - Allows the Collection of Stratum Specific Information Concerning the Distribution of
    - Crops of interest
    - Confusion crops
    - Companion crops
    - Labeling errors
  - Allocation of Samples to Strata
    - More samples allocated to strata with historically high variance
    - Less amples allocated to strata with historically low variance
  - Bias Correction in Strata with Poor Labeling Accuracy

2 CROP CASE

THE USE OF PRIORS IN SAMPLE ALLOCATION

IF WE ASSUME THE NUMBER OF GRAIN TARGETS X_H IN STRATUM H OF THE N_H TARGETS IS DISTRIBUTED ACCORDING TO A BINOMIAL (N_H, P_H),

THEN THE BETA PRIOR FOR THE PROPORTION OF P IS

$$G_H(P) = \frac{(S + F + 1)!}{S!F!} P^S(1 - P)^F$$

WHERE S IS THE NUMBER OF GRAIN TARGETS, AND

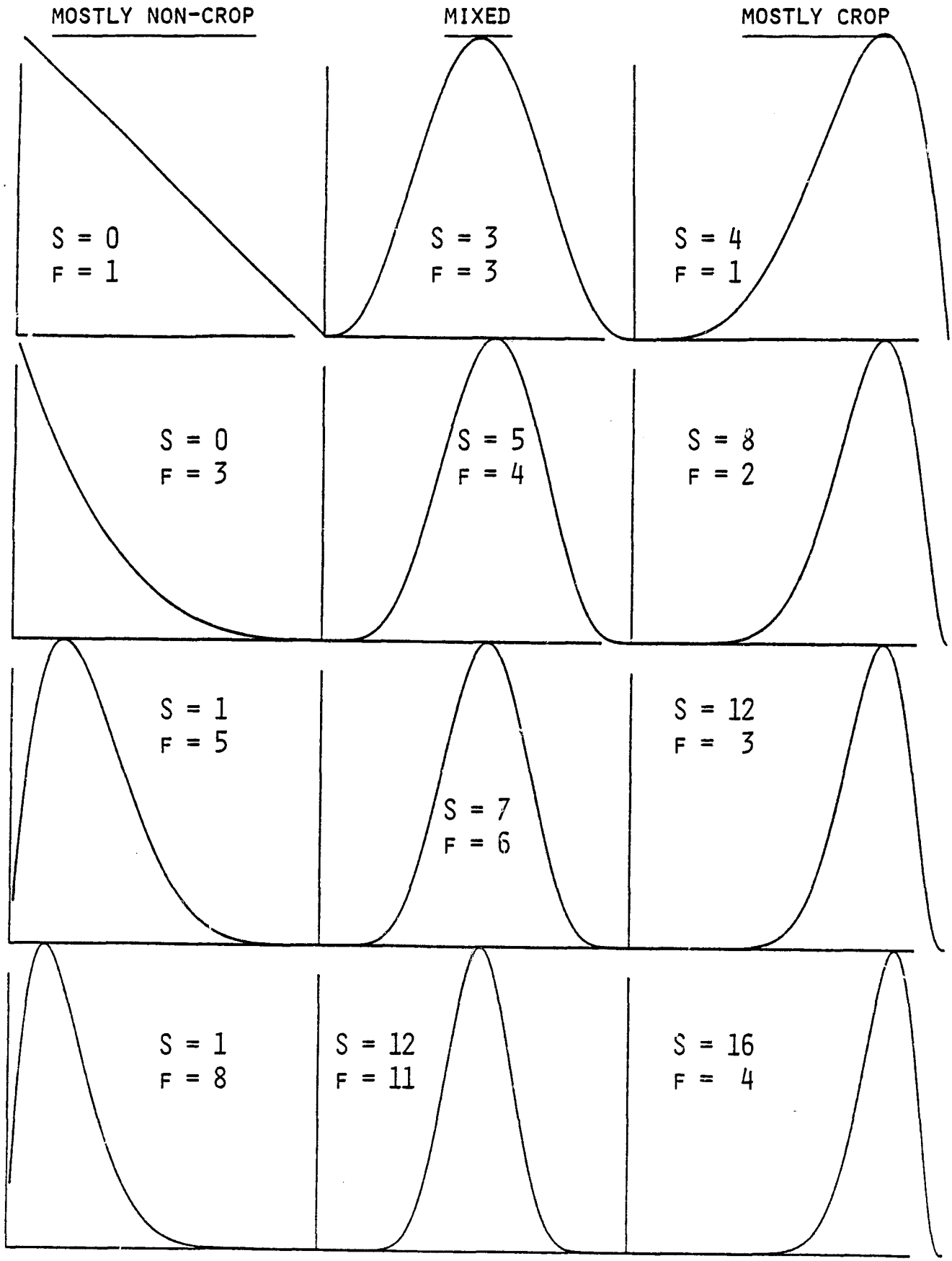
F IS THE NUMBER OF NON-GRAIN TARGETS IN STRATUM H FROM TRAINING SEGMENTS

STRATA SAMPLE SIZES N_H ARE ALLOCATED IN SUCH A WAY AS TO MINIMIZE

$$\sum_H \left(\frac{N_H}{N_.}\right)^2 \left(\frac{N_H - n_H}{N_H - 1}\right) \int_0^1 \frac{P(1 - P)}{n_H} G_H(P)\, dP = \sum_H \left(\frac{N_H}{N_.}\right)^2 \left(\frac{N_H - n_H}{N_H - 1}\right) \frac{1}{n_H} \frac{(S + 1)(F + 1)}{(S + F + 2)^2(S + F + 2)}$$

SUBJECT TO THE CONSTRAINT $\sum_H n_H = n$.

SOME EXAMPLES OF BETA PRIORS



TWO CROP CASE CONTINUED

IF P_H IS NOT CONSTANT BUT VARIES ACCORDING TO SOME UNDERLYING DISTRIBUTION

THEN BETA PRIORS MAY NOT BE APPROPRIATE SINCE THESE PRIORS

TEND TO CONCENTRATE THE PROBABILITY AROUND THE MEAN OF P_H

WHICH CAN CAUSE OVER ALLOCATION

SEVERAL OTHER APPROACHES ARE BEING INVESTIGATED

3 CROP CASE

USE OF PRIORS IN SAMPLE ALLOCATION WITH THREE CROP ESTIMATION (SAY CORN, SOYBEAN, AND OTHER)

- THE CONSTRUCTION AND UPDATING OF THE PRIORS IN 2 DIMENSIONS EXTENDS FROM THE ONE DIMENSIONAL CASE. FOR EXAMPLE THERE IS A DISTRIBUTION BASED ON PRIORS OF THE FORM $P_1^{R1}P_2^{R2}(1 - P_1 - P_2)^{R2}$ WHICH ARE RELATED TO MULTINOMIAL IN THE SAME WAY THAT PRIORS OF THE FORM $P^S(1 - P)^F$ ARE RELATED TO THE BINOMIAL.

- THE ALLOCATION IS SOMEWHAT HARDER. THERE ARE SEVERAL APPROACHES

  - MINIMIZE SUM OF EXPECTED VARIANCES

$$\sum_H \left(\frac{N_H}{N_\cdot}\right)^2 \left(\frac{N_H - n_H}{N_H - 1}\right) \frac{1}{n_H} \int_0^1 \int_0^1 \left[P_1(1 - P_1) + P_2(1 - P_2)\right] g_H(P_1, P_2)\, dP_1\, dP_2$$

3 CROP CASE (CONTINUED)

- MINIMIZE EXPECTED VARIANCES OF THE SUM OF THE TWO PROPORTION ESTIMATES

$$\sum_H \left(\frac{N_H}{N.}\right)^2 \left(\frac{N_H - n_H}{N_H - 1}\right) \frac{1}{n_H} \int_0^1 \int_0^1 (P_1 + P_2 - \mu_H)^2 g_H(P_1, P_2)\, dP_1 dP_2$$

WHERE $\mu_H = \int_0^1 \int_0^1 (P_1 + P_2) g_H(P_1, P_2)\, dP_1 dP_2$.

THESE TERMS IN THIS SUM DIFFER FROM THE CORRESPONDING TERMS ABOVE BY

$2\ \mathrm{cov}(\bar{P}_1, \bar{P}_2)$.

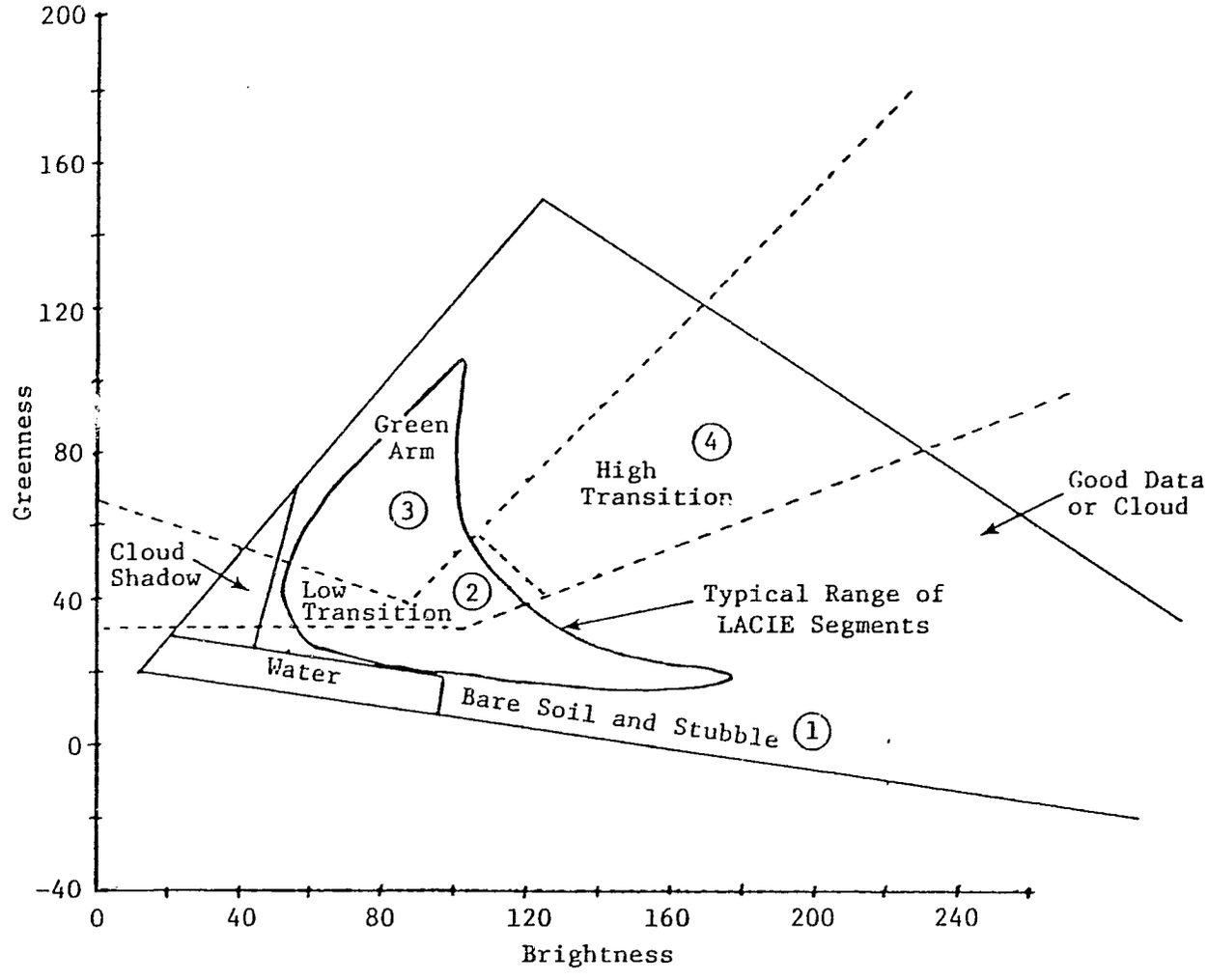
- MINIMIZE MAXIMUM EXPECTED VARIANCE

$$\max_{I=1,2} \sum_H \left(\frac{N_H}{N}\right)^2 \left(\frac{N_H - n_H}{N_H - 1}\right) \frac{1}{n_H} \int_0^1 \int_0^1 P_I(1 - P_I) g_H(P_1, P_2)\, dP_1 dP_2$$

SOME POSSIBLE STATICALLY DEFINED STRATIFICATIONS

- ANALYST STRATIFICATION BASED ON SPECTRAL, SHAPE, ETC., CHARACTERISTICS OF SAMPLE TARGETS
- STRATIFICATION BASED ON BINARY SEQUENCES OF 0'S AND 1'S BASED ON THE SEQUENCE THAT THE TARGET IS ABOVE OR BELOW A NOMINAL SOIL LINE DURING KEY TIME PERIODS (E.G., UCB DFS TECHNOLOGY)
- STRATIFICATION USING CLUSTERING WITH FIXED SEEDS OBTAINED FROM OTHER SEGMENTS (E.G., BCLUST)
- STRATIFICATION BASED ON ERIM'S STSS SEQUENCES OF {1,2,3,4}'S DEPENDING ON THE SEQUENCE OF 4 REGIONS OF THE GREENESS/BRIGHTNESS PLANE THE TARGET PASSES THROUGH DURING KEY TIME PERIODS

PRINCIPLE ZONES OF CROP DEVELOPMENT FOR THE TEMPORAL/SPECTRAL STRATIFICATION



TEST DEFINITION OF STATIC STRATA TWO CROP CASE

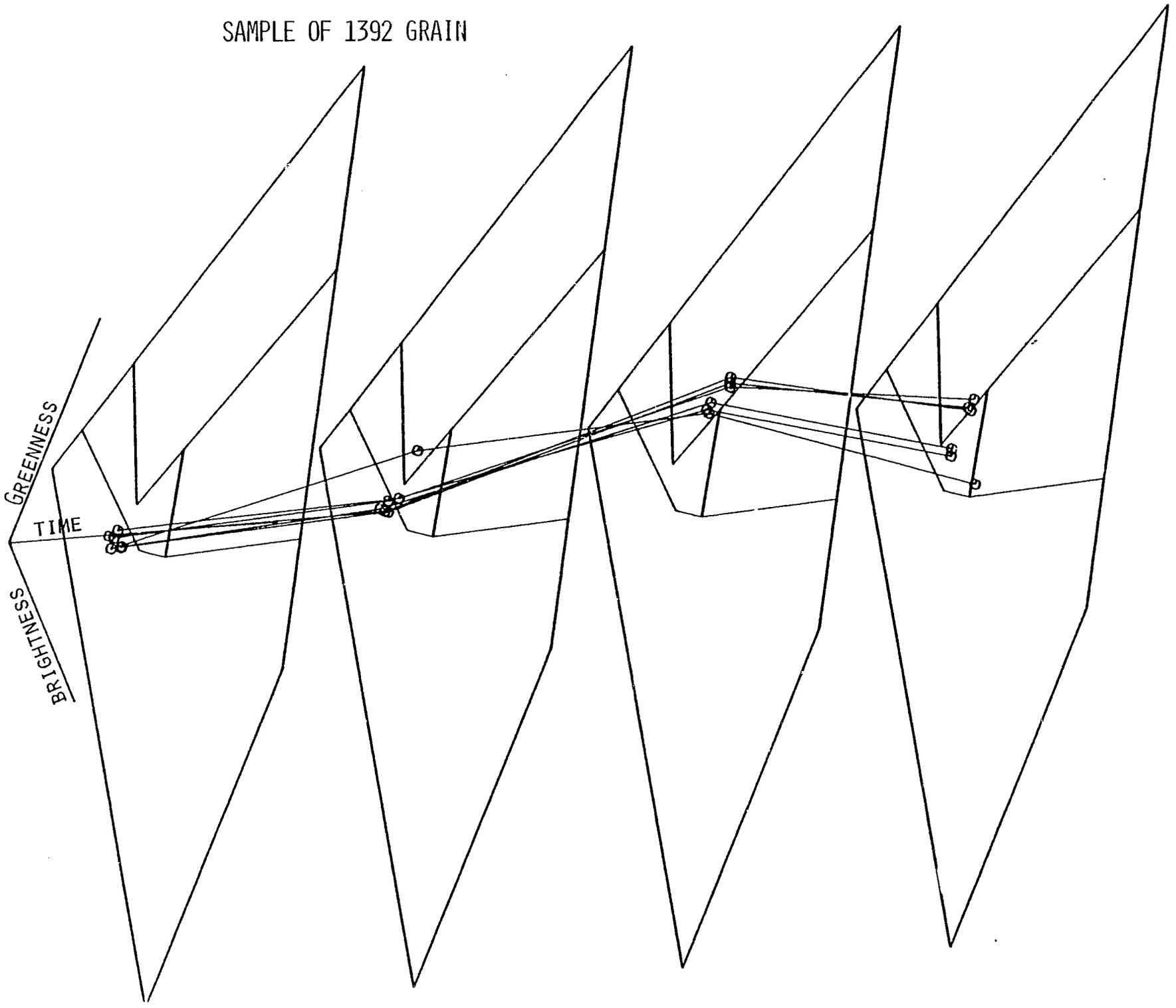
ONE ACQUISITION IS CHOOSEN TO REPRESENT EACH TIME PERIOD

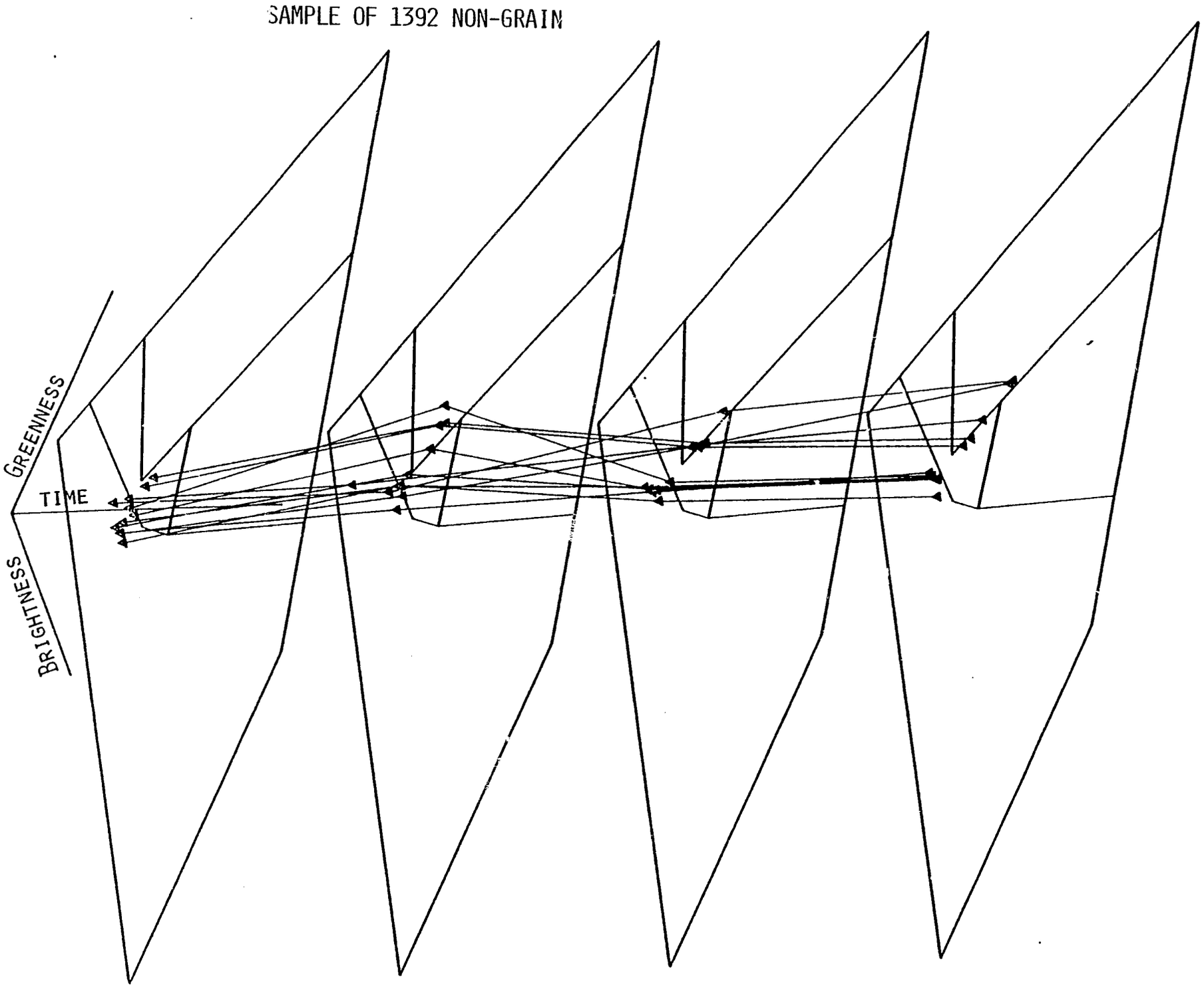
1.	PRE-EMERGENCE	85-100
2.	EMERGENCE	130-145
3.	HEADING	150-170
4.	TURNING	186-203
5.	HARVEST	210-230

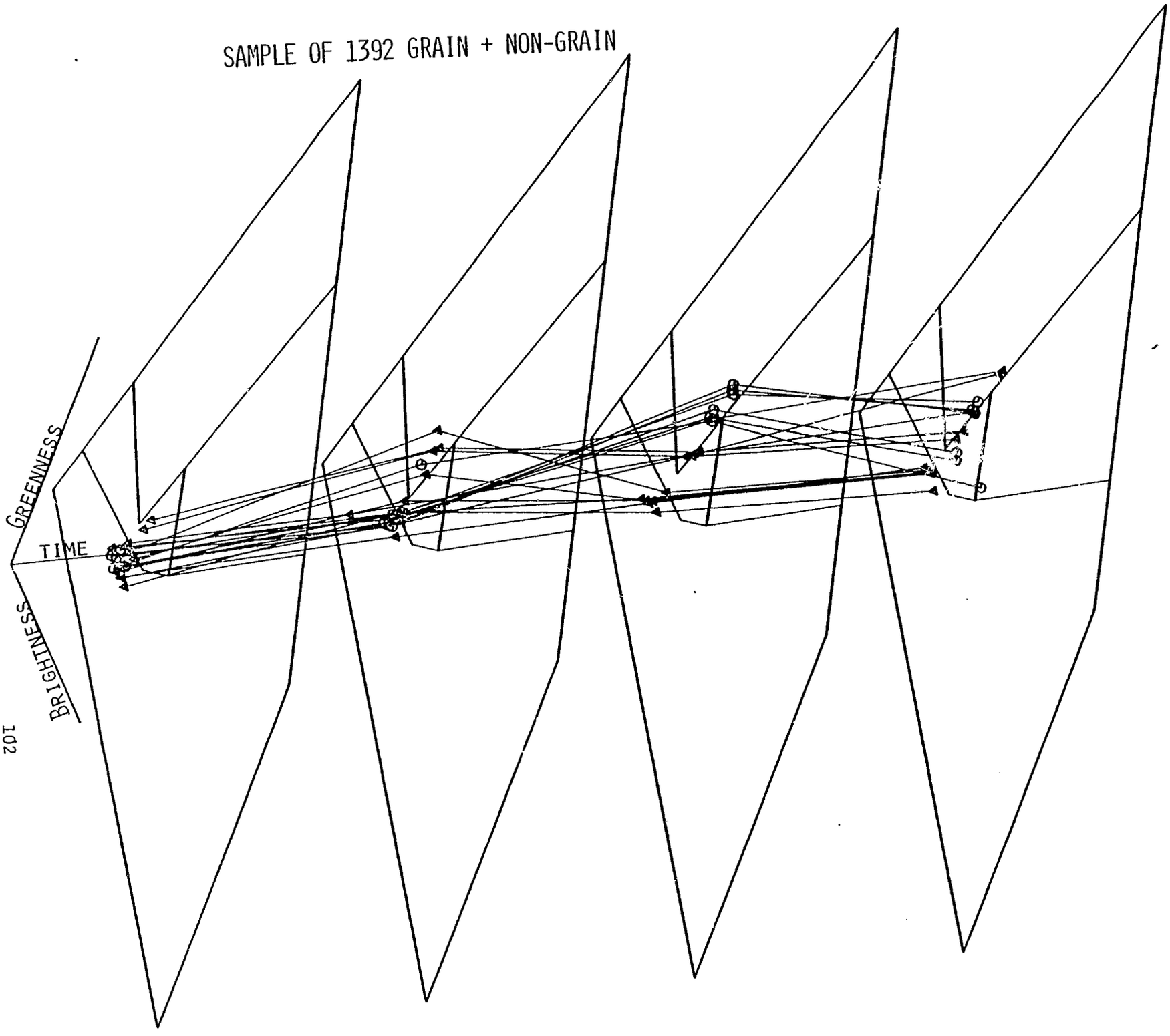
EACH TARGET IS GIVEN THE SEQUENCE $R_1, R_2, \ldots R_5 \in \{0,1,2,3,4\}$ WHERE $R_I = 0$ IF ACQUISITION IN I^{TH} TIME PERIOD

EXPERIMENT PARAMETERS

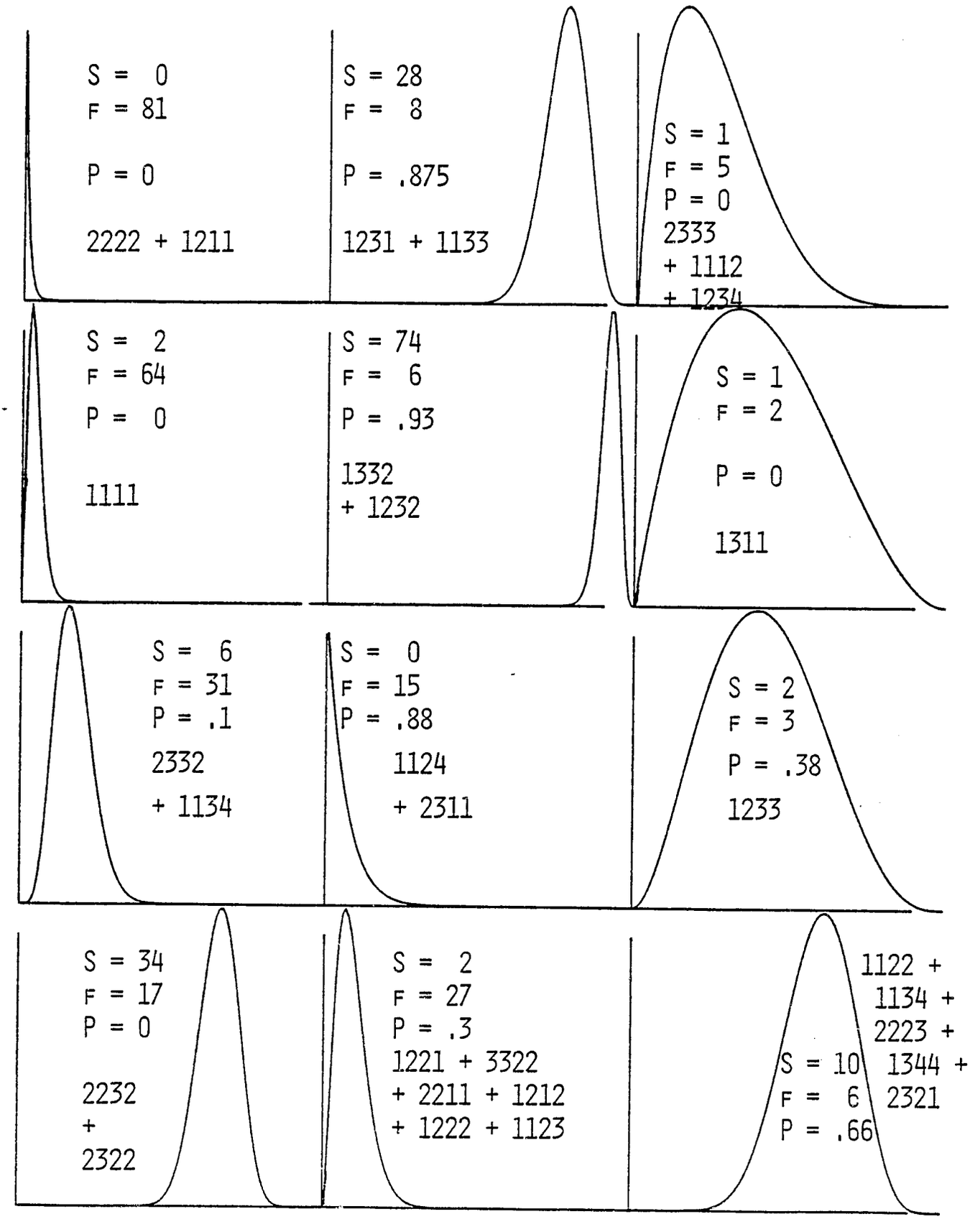
- 4 SEGMENTS: 1392 1461 1636 1653
  - PRIORS CONSTRUCTED FROM 1461, 1636, AND 1653 (CHOSEN AT RANDOM)
  - ALLOCATION USING PRIORS FOR SEGMENT 1392


SAMPLE OF 1392 GRAIN
GREENNESS
TIME
BRIGHTNESS


SAMPLE OF 1392 NON-GRAIN
GREENNESS
TIME
BRIGHTNESS


SAMPLE OF 1392 GRAIN + NON-GRAIN
GREENNESS
TIME
BRIGHTNESS

PRIORS USED IN ALLOCATION



SUMMARY OF RESULTS

- 28% OF THE BLOBS OF SEGMENT 1392 HAD POOR PRIORS ($S + F < 10$)
- 68% OF THE SAMPLES WERE ALLOCATED TO THE STRATA WITH POOR PRIORS
- 5% OF THE BLOBS OF SEGMENT 1392 HAD NO PRIORS ($S = F = 0$)
- 20% OF THE SAMPLES WERE ALLOCATED TO THE STRATA WITH NO PRIORS
- THE VARIANCE OBTAINED WITH ALLOCATION USING PRIORS WAS 38% HIGHER THAN THAT OBTAIN WITH PROPORTIONAL ALLOCATION
  - UNDER ALLOCATION TO STRATA WITH GOOD PRIORS
  - OVER ALLOCATION TO STRATA WITH POOR PRIORS BECAUSE THESE STRATA WERE MOSTLY PURE
    - 54% PURE NON-GRAIN
    - 32% MIXED
    - 14% PURE GRAIN
- THE VARIANCE OBTAINED WITH PROPORTIONAL ALLOCATION TO STRATA WITH POOR PRIORS AND PRIOR ALLOCATION TO THE STRATA WITH GOOD PRIORS WAS 36% LOWER THAN THAT OBTAINED USING ONLY PROPORTIONAL ALLOCATION

PLANS

- Define a Workable Static-Stratification Definition for Corn and Soybeans
- Complete the Extensions of Two Crop Allocation Techniques to the Three Crop Case
- Design and Implement an Experiment to Test the Performance of Sample Allocation Based on Priors for Statically Defined Strata

IMPLEMENTATION STRATEGY FOR BASELINE C/S CLASSIFICATION PROCEDURE

PROJECT: FOREIGN COMMODITY PRODUCTION FORECASTING

PROJECT ELEMENT: CLASSIFICATION

TASK: U.S. CORN/SOYBEAN PROCEDURE IMPLEMENTATION

PERFORMING ORGANIZATION: ERIM/UCB

PRESENTOR: D. RICE

MAY 19, 1980

OBJECTIVE

- Implement an End-to-End Corn/Soybean Segment Proportion Estimation
- Train FCPF Analyst Interpreters to Use It

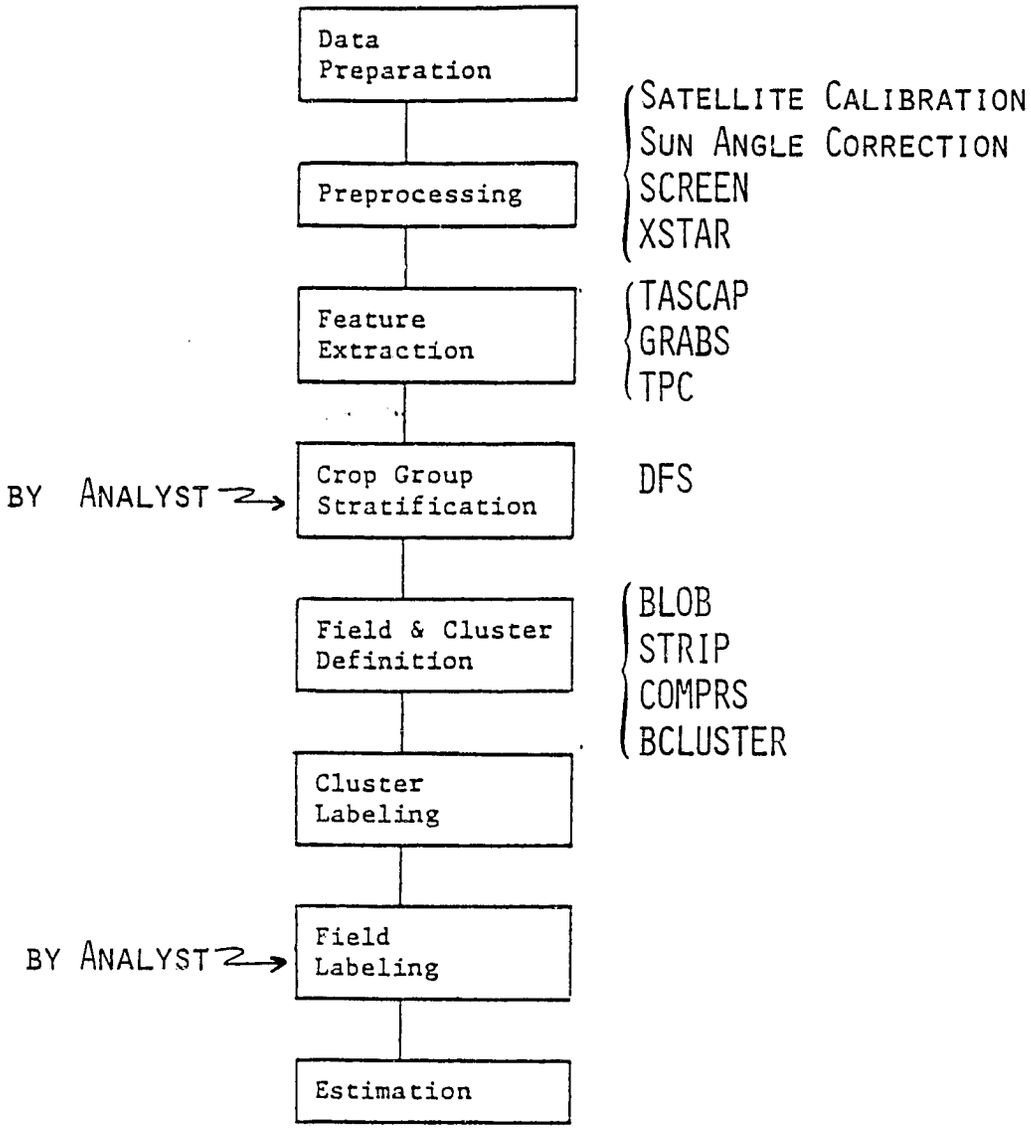
KEY ISSUE ADDRESSED

AN IMPLEMENTED CAPABILITY FOR PERFORMING SEGMENT PROPORTION ESTIMATION FOR THE FY81 U.S. C/S PILOT DOES NOT EXIST

OUTLINE

- Procedure to Be Implemented
- Framework for Implementation
- Overall System Organization
- The User
- The Application Module
- Data Services
- Status and Tracking
- The "Scenario"
- Summary

U.S. FY81 C/S AREA ESTIMATION PROCEDURE FLOW



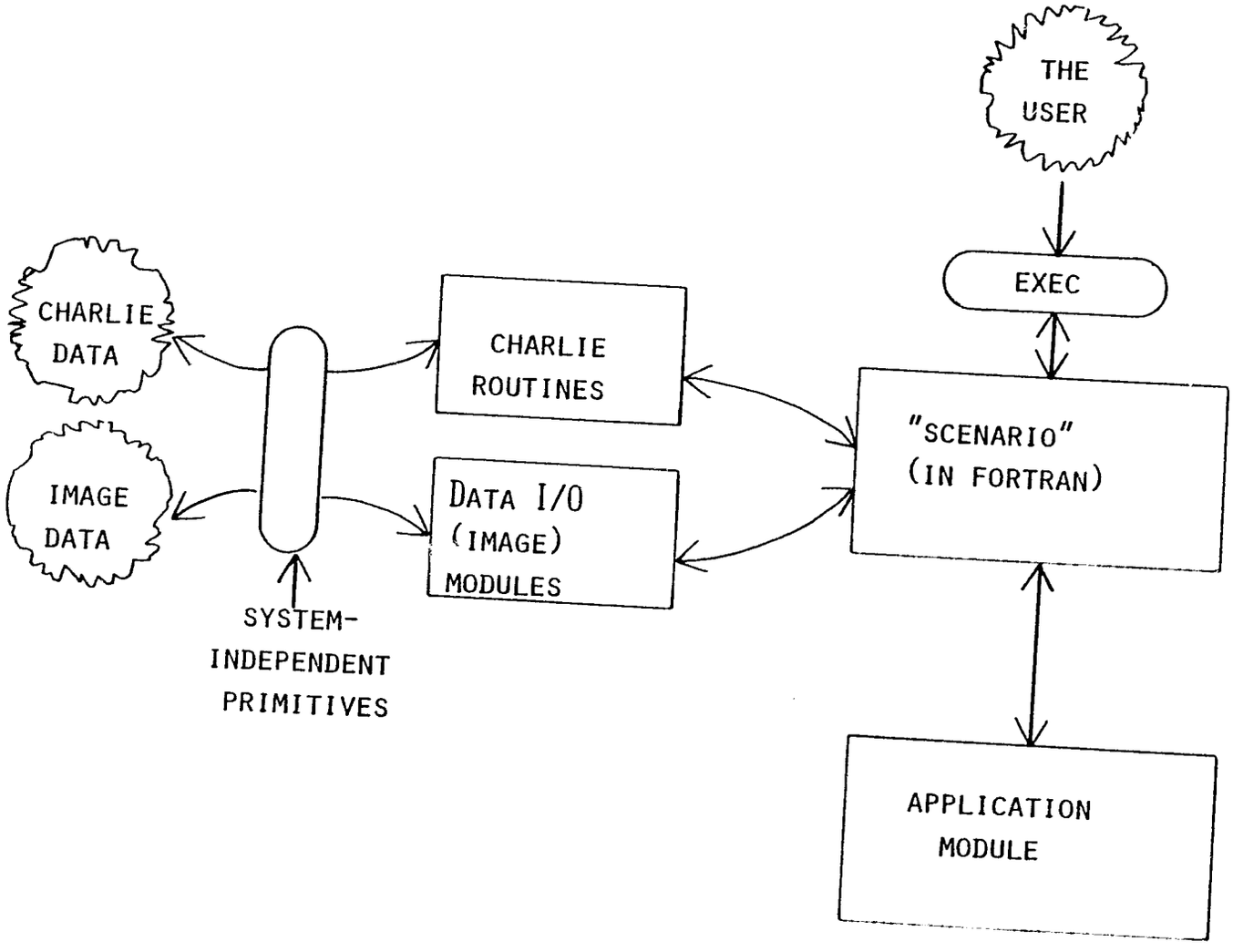
PROCEDURE HIGHLIGHTS

- Random Sampling of Quasi-Fields for Analyst Labeling
- Integration of Analyst-Interpreter Procedures into "Procedure M" Environment Configured for Corn and Soybean
- Decisions Made from General to Specific -- e.g., General Crop Group Stratification ... Corn/Soybean Area Estimates
- Estimates Made Only to Extent Justified by Available Data
- Uses Existing Technology "Only"

IMPLEMENTATION REQUIREMENTS

- It Must Work
  - Robust
  - Error protection
  - Adequate testing
- Simple and Convenient User Interface
- Maintainable Code
  - Readable, structured code
  - Documentation
- Status and Tracking
- Follow ERSYS Standards/Proctocols/Services if Available Sufficiently Early
- Use FORTRAN-compatible Language
- Deliver to Vanilla CMS op System Envnironment for IBM/370-compatible Architecture

SYSTEM ORGANIZATION



SYSTEM ORGANIZATION

- APPLICATION MODULE:
  - THE ESSENCE OF THIS DELIVERY
  - CAREFULLY DESIGNED PROTOCOL STANDARDS
- SCENARIO:
  - PROVIDES FOR CARE AND FEEDING OF APPLICATION MODULE
  - WRITTEN IN FORTRAN
- EXEC:
  - MAKES SCENARIO LOOK LIKE SIMPLE COMMAND TO USER
- CHARLIE:
  - COLLATERAL HOLDING AND REFERENCE LIBRARY FOR INFORMATION EXTRACTION
  - IS THE NON-IMAGE DATA BASE MANAGER
- IMAGE MODULES:
  - IMAGES MIGHT BE TOO BIG FOR CHARLIE

SYSTEM ORGANIZATION (CONT'D.)

- SYSTEM INDEPENDENT ROUTINES:
  - NARROW, CAREFUL, BUT POWERFUL INTERFACE HERE ISOLATES BULK OF SYSTEM FROM OPERATING SYSTEM DEPENDENCIES
- THE USER:
  - THE USER IS KING!

THE USER

- SEES SIMPLE COMMAND LANGUAGE
- SUPPLIES ONLY A MINIMUM NUMBER OF CONTROL PARAMETERS TO A COMMAND
- CAN OPERATE IN BATCH OR INTERACTIVE MODE
- DOES NOT NEED TO REMEMBER FILE NAMES
- DOES NOT REQUIRE DEEP COMPUTER KNOWLEDGE

THE APPLICATION MODULE

RULES:

- MAY SERVE ONLY ONE SIMPLE PURPOSE
- MAY NOT READ OR WRITE
- RECEIVES DATA ONLY VIA PARAMETER LIST (FROM THE SCENARIO)
- MAY NOT INTERACT WITH OPERATION OR NON-SUPPLIED SUBROUTINES
- CALLS STATUS-AND-TRACKING SERVICES
- FOR IMAGES, AN APPLICATION MODULE IS CALLED WITHIN A HIGHLY STANDARDIZED LOOP OVER SCAN LINES

DATA SERVICES

- CHARLIE ROUTINES
  - MOVE DATA BETWEEN VIRTUAL MEMORY AND PERMANENT CACHE CALLED CHARLIE
- IMAGE I/O ROUTINES
  - READ OR WRITE MULTISPECTRAL IMAGES BETWEEN A MEMORY DATA AND AN EXTERNAL FORMAT
- OTHER I/O ROUTINES
  - TALK TO PRINTER OR PFC
  - READ DATA NOT YET IN CHARLIE, PLACING IT IN MEMORY

CHARLIE

Collateral Holding And Reference Library for Information Extraction

- Creates/Sets "Data Entities" in Virtual Memory
- Stores/Retrieves "Data Entities" To/From a Permanent Cache
- A "Data Entity" is a Single Fortran-Declarable Item, Plus its Name (40 chars), Plus its Mode, Plus its Dimensions (scaler, vector, or array bounds)
- There is One CHARLIE (cache) Per Segment Being Processed
- Intermediate Results Automatically Stored; Hence
- Much of Status-and-Tracking is Implicit in CHARLIE

IMAGE PROCESSING

Data Modules

- Look Like Application Modules, Except
- They Have the System Priviledge of Reads or Writes
- Keys to Images May be Stored in CHARLIE

Data Format

- Requirement for Decimal Significance (Floating Point)
- Simple Self-Documentation Needs
- Need for Simplicity (Only One Possible Dialect; Optional Ancillary Parameters Not Proliferated)
- Coupled Closely with Internal Data Can

IMAGE PROCESSING (CONT'D.)

IMAGE DATA CAN. CONTAINS:

- NUMBER OF PIXELS (NPIX)
- NUMBER OF CHANNELS (NCHAN)
- DATA ARRAY FOR ONE SCAN LINE (DIMENSION NCHAN*NPIX)
- MASK FOR ONE SCAN LINE
- LINE NUMBER OF CURRENT SCAN LINE
- DATA ARRAY MODE VECTOR (REAL VS. INTEGER, 32-BIT WORDS)
- CHANNEL LABEL VECTOR (16 CHARACTERS PER CHANNEL)
- ACQUISITION DATE VECTOR (INTEGER YYDDD FOR EACH CHANNEL, OR 0)
- IMAGE DOCUMENTATION (TITLES, PIXEL NUMBERING, IMAGE NAMES, ETC. -- 360 BYTES)

NOTES

- MORE THAN ONE IMAGE MAY COEXIST
- CHANNELS NEVER ADDED TO IMAGE, BUT BECOME NEW IMAGE

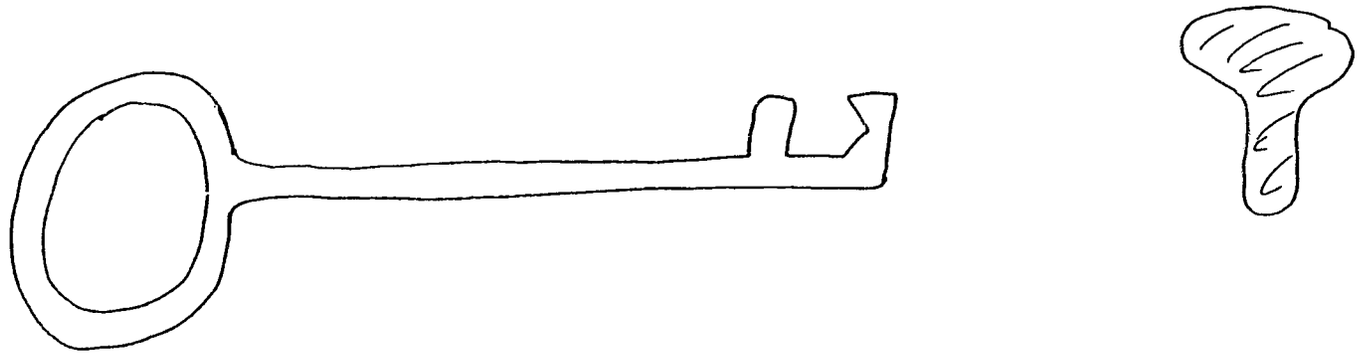
STATUS AND TRACKING

- CHARLIE (TRACKS DATA ENTITIES IN ELECTRONIC FORM)
  - IMPLICIT IN CHARLIE DESIGN
- SAL (CHARLIE'S GIRLFRIEND) "SEGMENT ANALYSIS LOG" FOR NON-ELECTRONIC DATA/ USE OF "PACKET" CONCEPT
  - HANDLED MANUALLY BY ANALYST
- AUDIT TRAIL (LOG OF SCENARIO ENTRY, SCENARIO EXIT, APPLICATION MODULE ENTRY, APPLICATION MODULE EXIT, CHARLIE ACTIVITY, ETC.)
  - SERVED BY A SUBROUTINE PACKAGE
  - ONE FOR EACH SEGMENT
- S & T OF THE MANY CHARLIE'S (WITH MANAGEMENT INFORMATION QUERY)
  - FED BY ACTIVITY OF OTHER S & T COMPONENTS

PROTECTION

- SOME PROTECTION WILL BE PROVIDED TO PREVENT ACCIDENTAL (OR OTHERWISE) MEDDLING WITH CHARLIE'S AND IMAGE'S

- PROTECTION IS IMPERFECT -- WE'RE NOT WRITING A COMPLETE DBMS



SCENARIOS

- Written in FORTRAN
- Acts as a Command Definition
- Provides Care and Feeding for Application Modules
- Carries This Out Using
  - Command parameters passed in
  - Data services (CHARLIE routines, image I/O routines)
  - Looping for images
- Also Calls Status-and-Tracking
- Intended to be Functionally Parallel With IBM Scenario Approach

SUMMARY

- On Schedule for 30 Sep 1980 Delivery to an Existing CMS Facility
- Application Modules are the Central Core of the Delivery

  (all else can be considered temporary services)
- Sufficient System Definition and Services Exist Now to Support

  Application Module Coding and Testing (but not integrated testing)

  by ERIM

EVALUATION OF MULTI-YEAR SAMPLING/ESTIMATION AND CHANGE ANALYSIS

PROJECT: FCPF

PROJECT ELEMENT: SAMPLING AND AGGREGATION

PERFORMING ORGANIZATION: ERIM

PRESENTOR: F. PONT

MAY 22, 1980

OUTLINE

- OBJECTIVES
  - KEY ISSUES
- ACCOMPLISHMENTS
  - DISCUSSION OF COVARIATES
- PLANS

OBJECTIVES

- EVALUATE MULTI-YEAR ESTIMATION PROCEDURE AS DEFINED BY TAMU
  - EFFECT OF VARIOUS ROTATION DESIGNS
- DEFINE A SAMPLING STRATEGY BASED ON CHANGE ANALYSIS
  - USE SAME MODEL,
    - + VARIANCE STABILIZING TRANSFORM
    - + VARIANCE COMPONENT ESTIMATION
- EVALUATE A SAMPLING STRATEGY BASED ON CHANGE ANALYSIS
  - EFFECT OF A CHANGE ANALYSIS DRIVEN SAMPLING STRATEGY ON MULTIYEAR ESTIMATION
  - COMPARISON OF CHANGE ANALYSIS SAMPLING STRATEGIES WITH VARIOUS ROTATION DESIGNS

KEY ISSUED ADDRESSED

- MULTI-YEAR SAMPLING/ESTIMATION PROCEDURES PRESENT AN OPPORTUNITY TO REDUCE THE NUMBER OF SEGMENTS PROCESSED WHILE MAINTAINING A FIXED PRECISION

- CHANGE ANALYSIS OFFERS AN OPPORTUNITY TO STOP SAMPLING IN A STRATUM IF ANALYSIS INDICATES NO CHANGE FROM PREVIOUS YEARS

- MULTI-YEAR SAMPLING IS DRIVEN BY A ROTATION DESIGN WHILE A CHANGE ANALYSIS IS DRIVEN BY A "STOP OR CONTINUE SAMPLING" RULE; THERE CAN BE A CONFLICT BETWEEN THESE TWO APPROACHES

ACCOMPLISHMENTS

- PERFORMED PRELIMINARY SIMULATION OF MULTIYEAR AND CHANGE ANALYAIS SAMPLING/ESTIMATION STRATEGIES
  - USING LOGIT TRANSFORM
  - USING ANOVA METHOD OF ESTIMATING THE COMPONENT OF VARIANCE
  - SAMPLING DRIVEN BY CHANGE ANALYSIS
- COMPILED A PRELIMINARY LIST OF SEGMENT DERIVED COLLATERAL VARIABLES TO POSSIBLY USE IN MULTIYEAR MODEL
- OBTAINED THE CAM'S PHASE II, PHASE III, AND TY GRAIN ESTIMATES
- LARS-ERIM DATA LINK NEAR COMPLETION

GENERAL CONSIDERATIONS REGARDING SEGMENT DERIVED COLLATERAL VARIABLES

- SHOULD BE REASONABLY COMPATIBLE WITH BASELINE AREA ESTIMATION PROCEDURE
- SHOULD BE SUPPORTED BY AN UNDERLYING PHYSICAL OR AGRONOMIC RATIONALE RELATING TO TRUE AREA, PROBABILITY OF LABELING ERROR, OR TRUE YIELD
- FOR DEVELOPMENT, CAN USE GROUND TRUTH FOR ANALYST DESIGNATED CLASSES

EXAMPLES

- MOISTURE STRESS INDICATOR BASED ON PIXELS DESIGNATED PASTURE
  - CONSISTENT WITH EARLY STEPS IN PROCEDURE M BASELINE
  - COMPUTE PEAK GREENNESS FROM TEMPORAL PROFILE FIT
  - RELATES TO THE PROBABILITY OF LABELLING ERROR (E.G. MISSED WHEAT)
  - RELATES TO POTENTIAL YIELD OF THE SEGMENT

- QUALITY ESTIMATES OF ACQUISITION HISTORY BASED ON GOODNESS OF FIT TO CROP PROFILES
  - FOR LABELLED TARGETS COMPUTE ACCURACY OF FIT TO RESPECTIVE PROFILE
  - RELATES TO PROBABILITY OF LABELLING ERROR

- PROPORTION ESTIMATE FOR SEGMENT BASED ON STATIC STRATA PRIOR PROPORTIONS
  - STATIC STRATA MAY BE INTRODUCED INTO PROCEDURE M BASELINE
  - A DIFFICULTY IS HOW TO DEAL WITH VARIABLE ACQUISITION HISTORY
  - RELATES TO TRUE PROPORTION IN SEGMENT

- WEATHER DATA INTERPOLATED TO SEGMENT LOCATION
  - MOISTURE STRESS
  - STATIC STRATA PROP. INDICATOR
  - QUALITY RATING OF ACQUISITION HISTORY
  - WEATHER COVARIATES

COVARIANCE MODEL

$$T(P_{TS}) = Y_{TS} = \alpha_T + \beta_S + \gamma(X_{TS} - \bar{X}_{..}) + \varepsilon_{TS}$$

Y_{TS} = TRANSFORMED GRAIN PROPORTION ESTIMATE

α_T = MEAN FOR YEAR T

β_S = RANDOM SEGMENT EFFECT
($\sim$ NORMAL $(0, \sigma^2_\beta)$)

γ = REGRESSION COEFFICIENT

$\varepsilon_{TS} \stackrel{\sim}{=}$ NORMAL $(0, \sigma^2$

ADJUSTED ANALYSIS OF VARIANCE

$$Y_{TS} - \bar{Y}_{..} = \gamma(X_{TS} - \bar{X}_{..})$$

$$W_{TS} = Y_{TS} - \gamma(X_{TS} - \bar{X}_{..})$$

$$W_{TS} = \alpha_T + \beta_S + \varepsilon_{TS}$$

PLANS

- RECEIVE AND IMPLEMENT THE MULTIYEAR SAMPLING/ESTIMATION STRATEGY
- DEVELOPMENT AN EXPERIMENT DESIGN WITH TAMU FOR MULTIYEAR EVALUATION
- IMPLEMENT A CHANGE DETECTION BASED ON SAMPLING STRATEGY
- CONSTRUCT COLLATERAL VARIABLES FOR A LARGE SUBSET OF THE CAMS DATA
- CARRY OUT TEST OF MULTIYEAR SAMPLING/ESTIMATION AND CHANGE DETECTION ON CAMS DATA AND SIMULATED DATA