LARS CONTRACT REPORT 022980

QUARTERLY PROGRESS REPORT (DECEMBER 1, 1979 TO FEBRUARY 29, 1980)

ON

REMOTE SENSING OF AGRICULTURE AND EARTH RESOURCES

CONTRACT NAS9-15466

PURDUE UNIVERSITY

LABORATORY FOR APPLICATIONS OF REMOTE SENSING
WEST LAFAYETTE, INDIANA

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NASA/JOHNSON SPACE CENTER
HOUSTON, TEXAS

MARCH 3, 1980

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Quarterly Review Presentation Agenda

1. SUPPORTING FIELD RESEARCH AND AGRICULTURAL SCENE UNDERSTANDING

Task 1A: Experiment Design and Data Analysis

Marvin Bauer and Vern Vanderbilt

SUPPORTING FIELD RESEARCH--EXPERIMENT DESIGN AND DATA ANALYSIS

OBJECTIVES

- DESIGN MULTIYEAR TECHNICAL PROGRAM OF SUPPORTING FIELD RESEARCH FOR CORN, SOYBEANS, AND SMALL GRAINS
- DESIGN EXPERIMENTS REQUIRING DATA COLLECTION IN 1980-81
- PERFORM ANALYSIS OF FIELD RESEARCH DATA IN SUPPORT OF CORN-SOYBEAN GROWTH STAGE AND YIELD TASKS
- ANALYZE FIELD RESEARCH DATA ON CORN, SOYBEANS, AND SMALL GRAINS IN TERMS OF DEVELOPING MODELS OF REFLECTANCE OF CROP CANOPIES AS FUNCTION OF IMPORTANT AGRONOMIC AND MEASUREMENT VARIABLES

General Approach

- EXPERIMENT DESIGN AND DATA ANALYSIS BASED ON TECHNICAL ISSUES AND NEEDS
- DATA ACQUISITION ON CONTROLLED EXPERIMENTS AND COMMERCIAL FIELDS; COOPERATIVE WITH USDA AND LAND GRANT UNIVERSITIES
- SPECTRAL MEASUREMENTS WITH LANDSAT MSS, AIRCRAFT MSS, HELICOPTER SPECTROMETER AND TRUCK-MOUNTED SPECTROMETER AND RADIOMETER
- DATA ANALYSIS INCLUDES PHYSICAL OR EXPLANATORY AS WELL AS CORRELATIVE MODELS OF SPECTRAL-AGRONOMIC PROPERTIES OF CROP CANOPIES

Specific Tasks

1. DESIGN OF MULTIYEAR SUPPORTING FIELD RESEARCH

   IN CONCERT WITH JSC, UPDATE CURRENT PLANS DESCRIBING TECHNICAL OBJECTIVES, DATA REQUIREMENTS, DESCRIPTIONS OF TEST SITES AND CONTROLLED EXPERIMENTS, PREPROCESSING, AND DATA ANALYSIS AND MODELING.

2. DEFINITION OF 1980-81 EXPERIMENTS/DATA REQUIREMENTS

   UPDATE SFR PROJECT PLAN INCORPORATING NEW SPRING WHEAT-BARLYE AND RICE TEST SITES AND PROVIDING MORE INFORMATION ON DATA ANALYSIS TASKS, OBJECTIVES AND APPROACHES, INCLUDING DATA REQUIREMENTS.

   RECOMMENDED DESIGN OBJECTIVES

   - TO DETERMINE THE REFLECTANCE AND RADIANT TEMPERATURE CHARACTERISTICS OF CORN AND SOYBEANS AS A FUNCTION OF MATURITY STAGE AND AMOUNT OF VEGETATION PRESENT.
   - TO DETERMINE THE EFFECTS OF STRESSES INCLUDING MOISTURE DEFICITS, NUTRIENT DEFICIENCIES AND DISEASE ON THE REFLECTANCE AND RADIANT TEMPERATURE PROPERTIES OF CORN, SOYBEANS, AND WINTER WHEAT.
   - TO DETERMINE THE EFFECT OF IMPORTANT AGRONOMIC PRACTICES (E.G. PLANTING DATE, PLANT POPULATION, FERTILIZATION) AND ENVIRONMENT FACTORS ON THE SPECTRAL CHARACTERISTICS OF CORN AND SOYBEANS.
   - TO SUPPORT THE DEVELOPMENT OF CORN, SOYBEANS AND SMALL GRAIN DEVELOPMENT STAGE AND YIELD MODELS WHICH USE AS AN INPUT SPECTRAL RESPONSE AS A FUNCTION OF CROP DEVELOPMENT STAGE.

- TO DETERMINE USING PRESENT AND FUTURE LANDSAS SPECTRAL BANDS THE SPECTRAL SEPARABILITY OF CORN, SOYBEANS, AND OTHER TYPICAL CORN BELT CROPS AND SPRING WHEAT AND BARLEY AS A FUNCTION OF DATE, MATURITY STAGE, SOIL BACKGROUND CONDITIONS, AND OTHER AGRONOMIC AND MEASUREMENT VARIABLES.

3. Data Analysis and Modeling

*1. Spectral crop development stage determination

*2. Estimation of canopy variables from spectral measurements

*3. Assessment of effects of agronomic factors on corn and soybean reflectance

4. Analysis of effects of nitrogen nutrition on spectral reflectance of corn and winter wheat

5. Analysis of effects of moisture stress on spectral response of corn

6. Analysis and model of relationship of percent soil cover, row direction and sun angle to reflectance of soybeans

7. Comparison of MSS and TM spectral bands for discrimination of corn and soybeans

8. Theoretical model of potential of polarization measurements to estimate crop development stage, leaf area and vigor; comparison of model and empirical results

9. Analysis and model of effects of sun angle and view angle on reflectance of spring wheat as a function of development stage

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* Summary plans included in this report

SUPPORTING FIELD RESEARCH

- FIELD RESEARCH PROVIDES BASIS FOR LARGER SCALE SATELLITE EXPERIMENTS, PILOT TESTS AND EVALUATIONS

OBJECTIVES

- ANALYSIS AND PHYSICAL MODELING OF SPECTRAL PROPERTIES OF CROPS AND SOILS IN RELATION TO AGRONOMIC AND OTHER PHYSICAL CHARACTERISTICS
  - DEVELOPMENT OF RELATIONSHIPS AND MODELS WHICH PREDICT AGRONOMICALLY IMPORTANT CROP CANOPY CHARACTERISTICS FROM SPECTRAL, ETC. INPUTS
    - GROWTH AND DEVELOPMENT STAGES
    - LEAF AREA INDEX, BIOMASS, PERCENT CANOPY COVER
    - CANOPY VIGOR OR STRESS
  - DEVELOP RELATIONSHIPS AND MODELS WHICH PREDICT SPECTRAL RESPONSE OF CROPS BASED ON CULTURAL AND ENVIRONMENTAL FACTORS
    - AGRONOMIC FACTORS - ROW WIDTH, VARIETY, ETC.
    - SOIL BACKGROUND CONDITIONS
    - ATMOSPHERIC EFFECTS
- ASSESS CAPABILITY OF CURRENT, PLANNED, AND FUTURE SATELLITE SENSOR SYSTEMS TO CAPTURE AVAILABLE INFORMATION

SUPPORTING FIELD RESEARCH (CON'T)

- 'LANDSAT MSS AND THEMATIC MAPPER
- 'MULTISPECTRAL RESOURCE SAMPLE (MRS)
- 'OPTICAL + RADAR/MICROWAVE MEASUREMENTS

'PROVIDE CANDIDATE MODELS, ANALYST AIDS, ANALYSIS TECHNIQUES AS INPUT TO SUPPORTING RESEARCH AND FCPF EXPLORATORY EXPERIMENTS AND PILOT TESTS

- 'GROWTH STAGE MODELS
- 'SPECTRAL AIDS (E.G. TRANSFORMATIONS OF TM)
- 'STRESS MODELS
- 'IMAGE PRODUCTS

Field Research Products

1. MODELS (CURRENT AND FUTURE S/C SENSORS)

   'SPECTRAL CROP GROWTH AND DEVELOPMENT

   'SPECTRAL STRESS MODELS (MOISTURE, DISEASE, NUTRITION)

   'MODELS TO PREDICT KEY AGRONOMIC VARIABLES, E.G. LAI, PERCENT INTERCEPTED RADIATION

   'CROP CANOPY MODELS WHICH PREDICT REFLECTANCE AS A FUNCTION OF AGRONOMIC VARIABLES

2. ANALYSES

   'CROP DISCRIMINATION - PERFORMANCE ANALYSIS

   - NEW CROPS - CROPS MIXES (E.G. RICE, COTTON, SOYBEANS, ETC.)
   - FUTURE SENSORS (TM, MRS, ETC.) - ALL CROPS

   'SOIL EFFECT ON SPECTRAL CROP CALENDAR, SPECTRAL STRESS MODEL AND CROP DISCRIMINATION

   'ATMOSPHERIC EFFECT ON SPECTRAL CROP CALENDAR, SPECTRAL STRESS MODEL AND CROP DISCRIMINATION

3. ANALYST AIDS AND ALGORITHMS

   'TRANSFORMATIONS

   'IMAGE PRODUCTS

   'SPECTRAL KEYS

FIELD RESEARCH PRODUCTS (CON'T)

4. STANDARD FIELD RESEARCH DATA SETS

'MULTITEMPORAL SPECTRAL, AGRONOMIC, AND METEOROLOGICAL MEASUREMENTS OF CROPS AND SOILS

5. SIMULATED DATA SETS

'FOR NEW SENSORS, E.G. LANDSAT THEMATIC MAPPER

'OF FOREIGN COUNTIES WITH LIMITED TESTING OF ALGORITHMS, E.G. BRAZIL - SPECTRAL CROP CALENDAR

'FOR SENSITIVITY STUDIES

- AGRONOMIC FACTORS - SOILS, ROW WIDTH, VARIETY
- CROP STRESS
- BI-DIRECTIONAL REFLECTANCE
- ATMOSPHERIC EFFECTS

SPECTRAL CROP DEVELOPMENT STAGE DETERMINATION

RATIONALE

- PROVIDES IMPORTANT INPUT TO YIELD MODELS AND IMAGE LABELING
- PROVIDES INFORMATION AT PIXEL, FIELD OR SEGMENT LEVEL

OBJECTIVE

- PREDICT REFLECTIVE CHARACTERISTICS OF CORN AND SOYBEAN DEVELOPMENT STAGE AS FUNCTION OF REFLECTANCE CHARACTERISTICS

APPROACH

- DEFINE JOINT PROBABILITY DENSITY FUNCTION

  f(GROWTH STAGE, GREENNESS)

- COMPUTE PROBABILITY OF DEVELOPMENT STAGE GIVEN GREENNESS = X

  f(GROWTH STAGE $\perp$ GREENNESS=X)

- CONSIDER ADDITIONAL VARIABLES SUCH AS METEOROLOGICAL VARIABLES

MODEL OUTPUTS

- PROBABILITY PIXEL OR FIELD IS AT A PARTICULAR DEVELOPMENT STAGE
- PREDICTION OF MOST LIKELY DEVELOPMENT STAGE
- ASSESSES ACCURACY OF PREDICTION BASED ON HISTORICAL DATA

DATA TO BE UTILIZED

- DEVELOPMENT OF INITIAL MODEL FORM

  'PURDUE AGRONOMY FARM, 1978-79 CORN AND SOYBEAN RADIOMETER/SPECTROMETER

- VERIFICATION OF INITIAL MODEL

  'WEBSTER CO., IOWA 1979 HELICOPTER SPECTROMETER

CURRENT STATUS/ACCOMPLISHMENTS

- INITIAL MODEL FORM DEFINED
- DATA SETS ASSEMBLED
- INITIAL EVALUATION SCHEDULED FOR JULY '80

ESTIMATION OF CANOPY VARIABLES FROM SPECTRAL MEASUREMENTS
(LEAF AREA INDEX, PERCENT SOIL COVER, INTERCEPTED SOLAR RADIATION)

RATIONALE/BACKGROUND

- BUNNIK HAS SHOWN USING THE SUITS MODEL THAT SEVERAL SPECTRAL PARAMETERS ARE MORE STRONGLY RELATED TO CANOPY VARIABLES THAN SIMPLY THE IR/RED RATIO

- THESE SPECTRAL PARAMETERS MAY PROVIDE A MEANS TO PREDICE LEAF AREA INDEX, PERCENT CANOPY COVER, AND INTERCEPTED SOLAR RADIATION FROM REFLECTANCE MEASUREMENTS

- CROP GROWTH-DEVELOPMENT, EVAPOTRANSIPIRATION AND YIELD MODELS COULD BE IMPROVED BY INCLUSION OF ADDITIONAL INFORMATION ON CANOPY CHARACTERISTICS

OBJECTIVE

- DEVELOP MODEL(S) TO PREDICT CANOPY CHARACTERISTICS FROM SPECTRAL MEASUREMENTS

ESTIMATION OF CANOPY VARIABLES FROM SPECTRAL MEASUREMENTS
(LEAF AREA INDEX, PERCENT SOIL COVER, INTERCEPTED SOLAR RADIATION)

APPROACH

- SURVEY LITERATURE FOR AND/OR THEORETICAL MODELS OF SPECTRAL PARAMETERS RELATED TO AGRONOMIC CHARACTERISTICS OF CANOPIES
  - PARAMETER SHOULD BE A PREDOMINANT FUNCTION OF CANOPY VARIABLE OF INTEREST
  - PARAMETER SHOULD BE INVARIANT TO OTHER CANOPY VARIABLES AND INDEPENDENT OF SOLAR AND OBSERVATION ANGLES
- COMPARE THEORETICAL MODEL PREDICTIONS TO EMPIRICAL MEASURES
- INITIAL VERIFICATIONS WILL BE PERFORMED WITH THE FOLLOWING DATA SETS

SPRING WHEAT	- WILLISTON, ND AES (1975-77)
WINTER WHEAT	- GARDEN CITY, KS AES (1975-77)
	PURDUE AGRONOMY FARM (1979)
CORN AND SOYBEANS	- PURDUE AGRONOMY FARM (1978-79)

PRODUCTS

- EVALUATION OF SPECTRAL PARAMETERS FOR PREDICTING AGRONOMIC VARIABLES
- FEEDS FY81 SFR TASKS ON IMPROVING CORN-SOYBEAN GROWTH MODELS
- SUPPORTS PROCEDURE 2 AND TM DEVELOPMENT DURING FY82 AND 83

ASSESSMENT OF EFFECTS OF AGRONOMIC FACTORS ON REFLECTANCE OF CORN AND SOYBEANS

RATIONALE

- THERE ARE MANY SOIL AND CULTURAL PRACTICE FACTORS WHICH INFLUENCE SPECTRAL RESPONSE
- AMOUNT AND KIND OF VARIATION INTRODUCED BY THESE FACTORS NEEDS TO BE QUANTIFIED FOR:
  - SENSITIVITY ANALYSIS OF CROP CALENDAR AND LEAF AREA MODELS TO SUCH VARIATION
  - ASSIST ANALYSTS IN UNDERSTANDING SPECTRAL RESPONSES OF CROPS

OBJECTIVE

- DETERMINE RELATIVE CONTRIBUTION ON EFFECT OF SOIL COLOR AND VARYING CULTURAL PRACTICES ON REFLECTANCE OF CORN AND SOYBEANS

APPROACH

- ANALYSIS OF VARIANCE OF DATA FROM FACTORIAL EXPERIMENTS CONDUCTED AT PURDUE AGRONOMY FARM IN 1979 AS FUNCTION OF DATE/DEVELOPMENT STAGE

CORN:	2 SOILS	SOYBEANS:	2 SOILS	2 ROW WIDTHS
	3 PLANTING DATES		2 CULTIVARS	3 PLANTING DATES
	3 PLANT POPULATIONS			

- QUANTITATIVE ASSESSMENT OF AMOUNT OF VARIATION ASSOCIATED WITH EACH FACTOR

ASSESSMENT OF EFFECTS OF AGRONOMIC FACTORS ON REFLECTANCE OF CORN AND SOYBEANS

ANALYSIS PRODUCTS

- SPECTRAL PLOTS SHOWING EFFECTS OF EACH FACTOR AND INTERACTIONS
  GREENNESS AND BRIGHTNESS

SCHEDULE

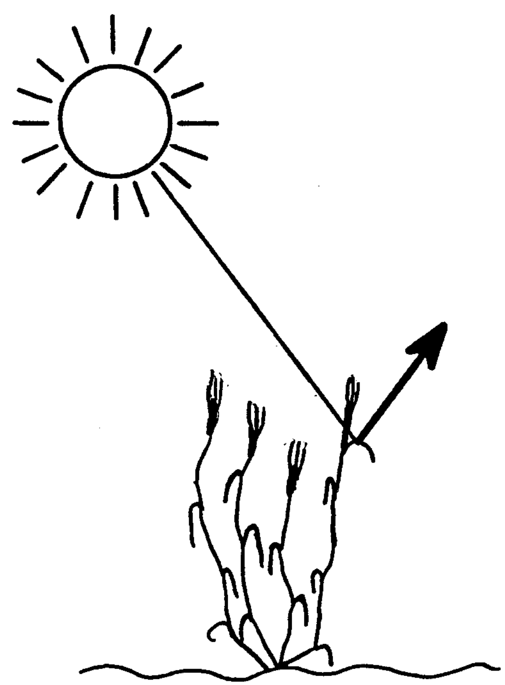
- ANALYSIS OF 1979 DATA SETS COMPLETED, AUGUST 1980
- SUPPORTS
  - FY81 CORN AND SOYBEAN PILOT
  - FY81 FIELD RESEARCH TASK ON SPECTRAL CROP CALENDAR SENSITIVITY ANALYSIS

PLANS FOR NEXT QUARTER

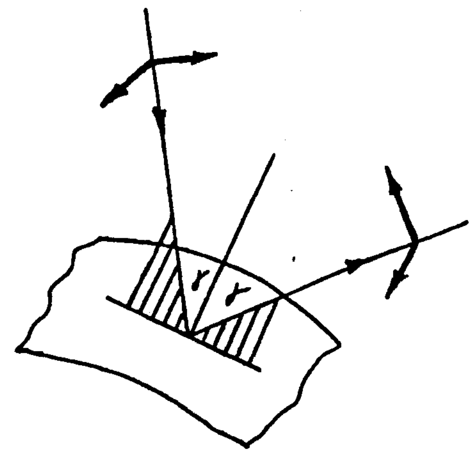
- COMPLETE PROJECT AND DATA ANALYSIS PLANS
- CONTINUE DATA ANALYSIS/MODELING
- SUBMIT REPORTS ON MODEL FORM FOR SPECTRAL ESTIMATION OF CORN AND SOYBEAN DEVELOPMENT STAGES AND THEORETICAL MODEL OF POLARIZATION MEASUREMENTS TO ASSESS CROP CONDITION

MODEL OF PLANT CANOPY
POLARIZATION RESPONSE

- SLIDES ILLUSTRATING CANOPY POLARIZATION
- POLARIZATION THEORY
- FLUX MEASURED BY RADIOMETER
- FIELD DATA



THEORY



- FRESNEL EQUATIONS

- STOKES VECTOR $\quad \hat{S} = (S_I, S_Q, \quad , \quad)$

$$S_I = \text{SPECULAR} + \text{DIFFUSE}$$
$$= S_S + S_D$$

$$S_S = \text{SPECULAR}$$
$$= (\rho_{90} + \rho_0)/2.0$$

$$S_Q = \text{LINEARLY POLARIZED PART OF } S_I$$
$$= (\rho_{90} - \rho_0)/2.0$$

- PERCENT LINEAR POLARIZATION

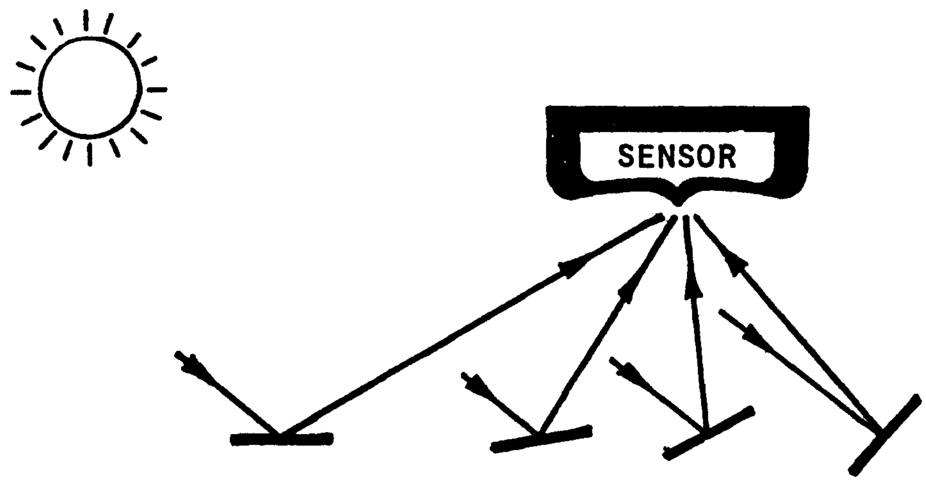
$$100\%\ S_Q/S_I$$

THEORY

- A LEAF WILL SPECULARLY REFLECT LIGHT TO SENSOR

  ONLY

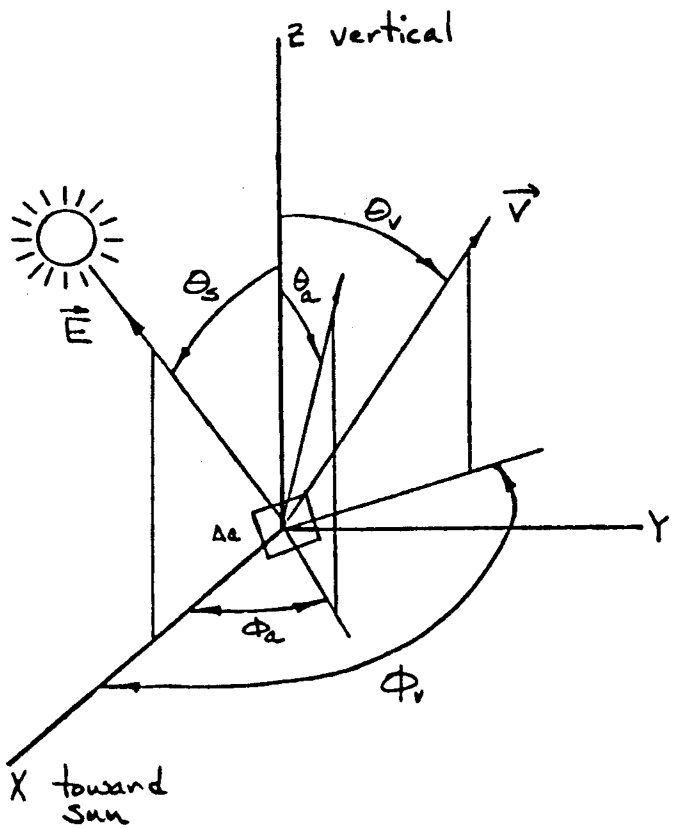
  IF LEAF IS CORRECTLY ORIENTED.



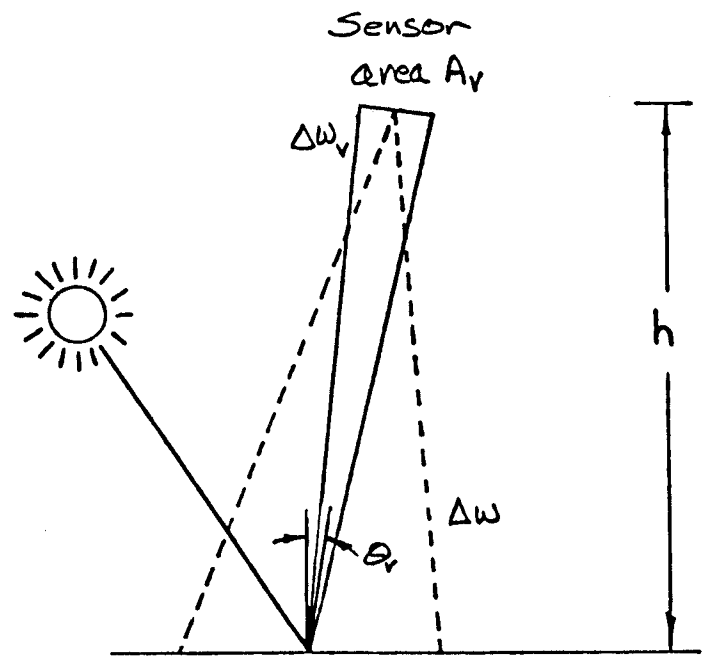
- SPECULAR REFLECTANCE IS DUE TO WAX LAYER ON CUTICLE.

POLARIZATION MODEL

MICRO SCALE AND MACRO SCALE PARAMETERS



SMALL LEAF AREA ΔA



SENSOR VIEWING CANOPY

Vanderbilt
24 December 1979

FLUX INTO SENSOR

- $$\Phi_I = \Phi_D + \Phi_S$$

$$= \Phi_D + \underbrace{\left[E\right]}_{\text{SOURCE}} \underbrace{\left[(LAI)\ F_A(\theta_A, \phi_A)\ KS_S P_S P_V\right]}_{\text{CANOPY}} \underbrace{\left[\Delta\omega A_V / 2\cos\theta_V\right]}_{\text{SENSOR}}$$

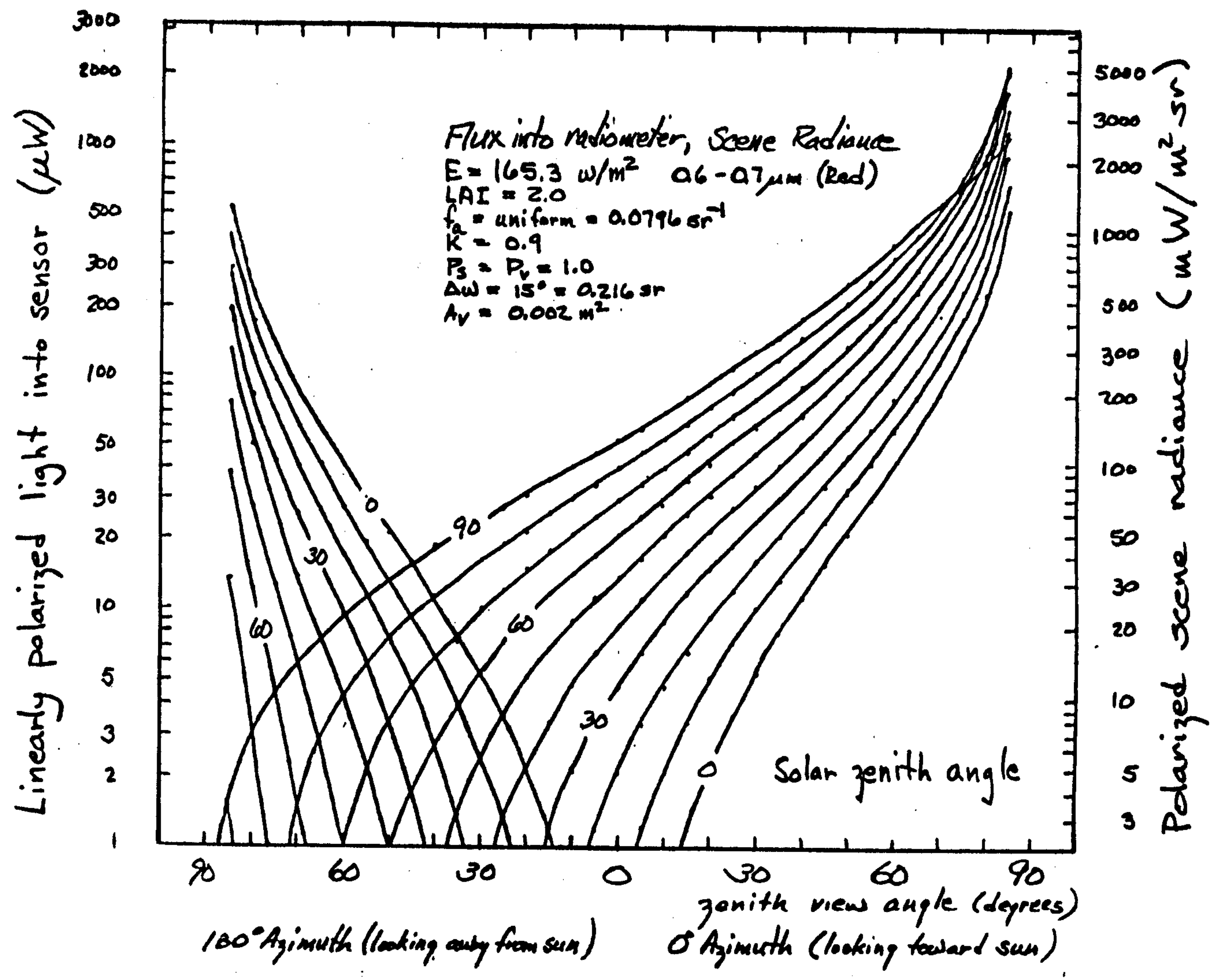
- $$\Phi_Q = \left[E\right] \left[(LAI)\ F_A(\theta_A, \phi_A)\ KS_Q P_S P_V\right] \left[\Delta\omega A_V / 2\cos\theta_V\right]$$

- $$\%\ \text{POL} = 100\%\ \Phi_Q / (\Phi_D + \Phi_S)$$

POLARIZATION MODEL PARAMETER STUDY

FLUX MEASURED BY RADIOMETER VS. VIEW ANGLE, SUN ANGLE

SCENE RADIANCE VS. VIEW ANGLE, SUN ANGLE



Vanderbilt

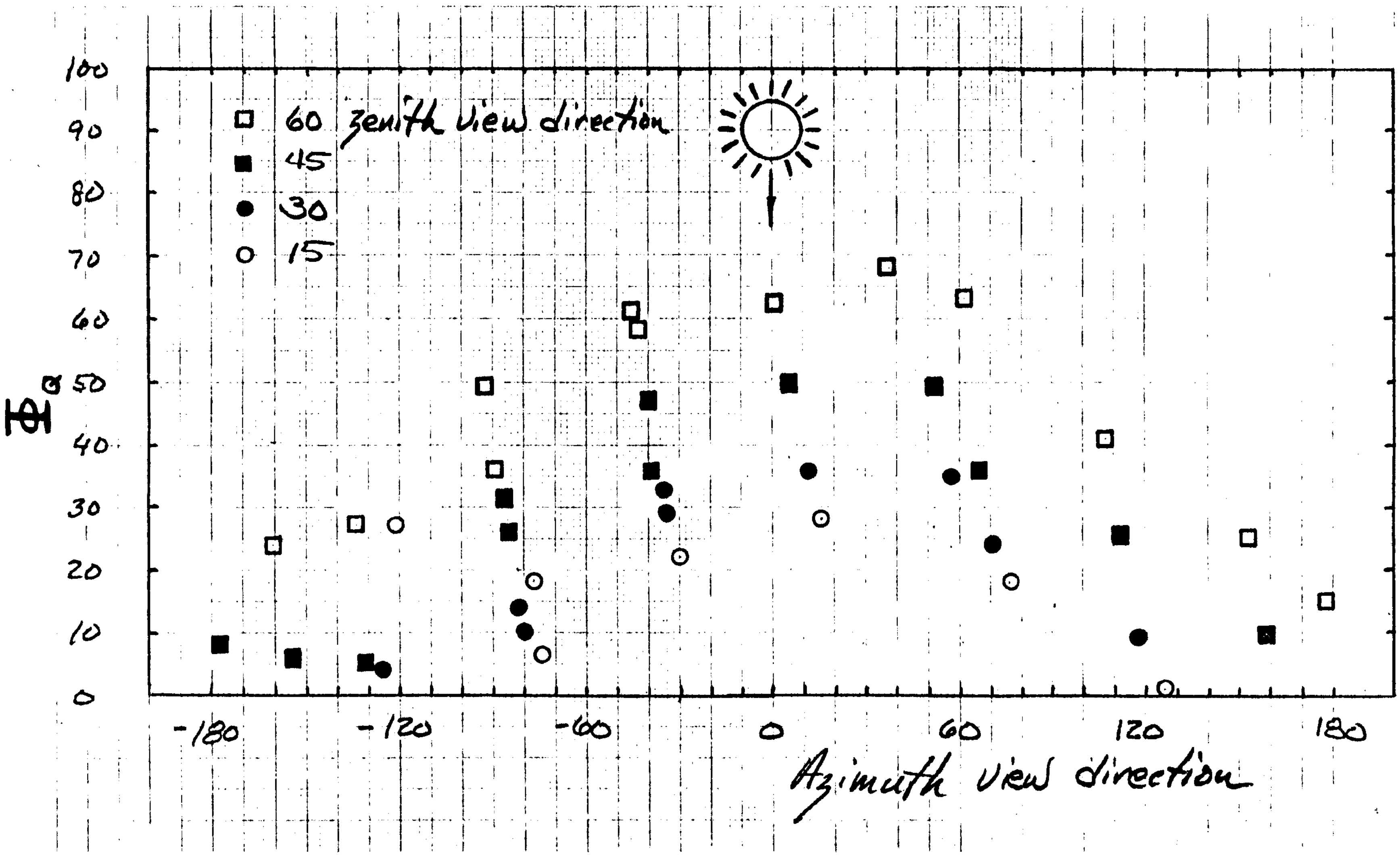
16 February 1980

FIELD DATA

- ACQUIRED NEAR NOON
- 33 VIEW DIRECTIONS
  - FIVE ZENITHS
  - EIGHT AZIMUTHS
- WAVELENGTH 0.45 - 0.72μM
- 50 TOTAL SPECTRA

LINEAR POLARIZATION WITH VIEW DIRECTION

WHEAT, BOOT GROWTH STAGE, 0.64μM

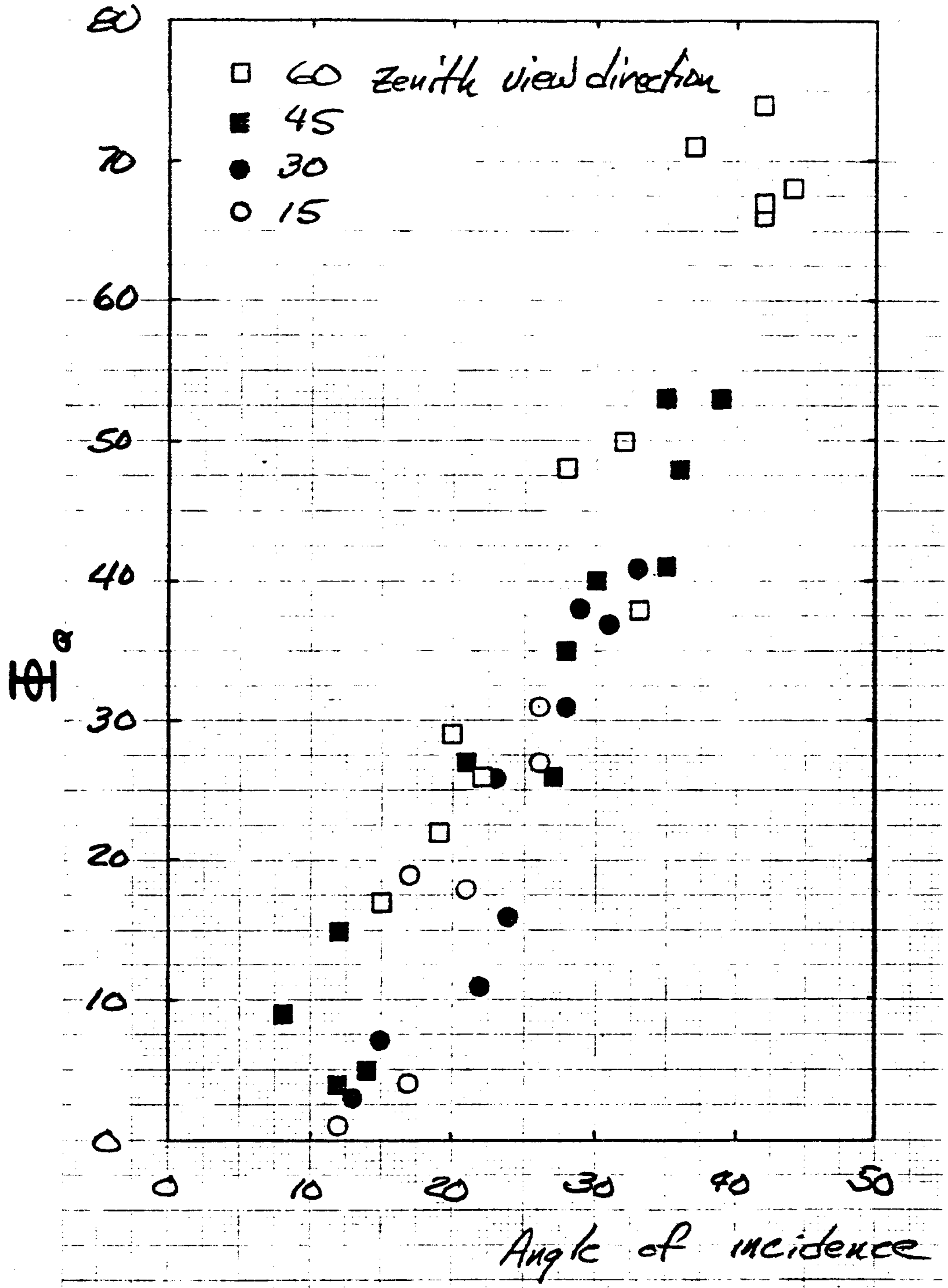


Vanderbilt

7 September 1979

LINEAR POLARIZATION WITH ANGLE OF INCIDENCE

WHEAT, BOOT GROWTH STAGE, 0.60μM

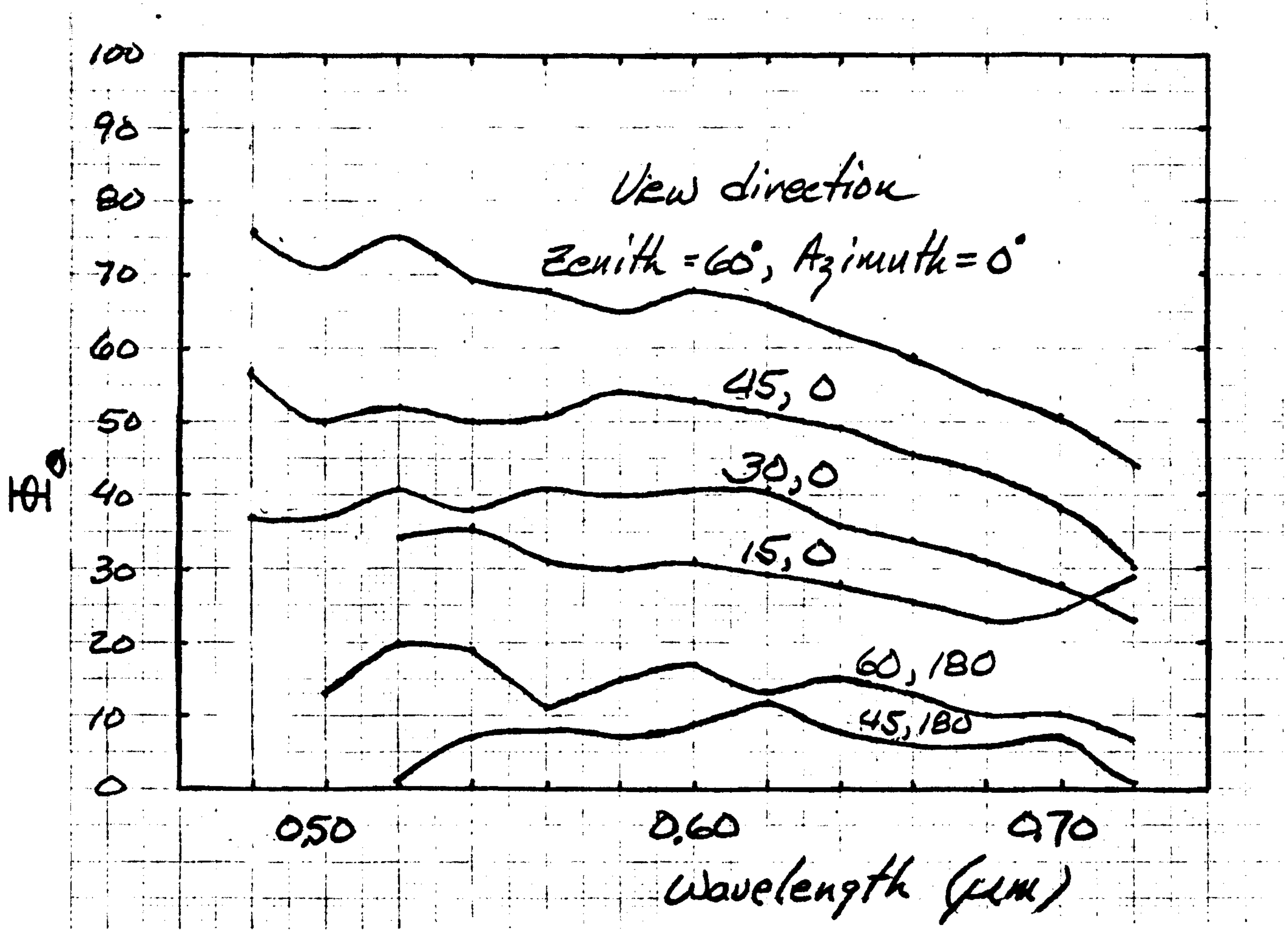


Vanderbilt

5 October 1979

LINEAR POLARIZATION WITH WAVELENGTH

WHEAT, BOOT GROWTH STAGE, 0.64μM



Vanderbilt

7 September 1979

DISCUSSION

- POLARIZATION PROPORTIONAL TO LEAF AREA INDEX
- POLARIZATION OF WHEAT CHANGES AT HEADING GROWTH STAGE
- POLARIZATION AFFECTED BY
  - WHEAT RUST
  - MOISTURE STRESS
  - HAIL DAMAGE
- POLARIZATION POTENTIALLY WILL AID CROP DISCRIMINATION
- MAX POLARIZATION LOOKING TOWARD SUN AZIMUTH
- HIGH SPECTRAL RESOLUTION IN VISIBLE NOT NECESSARY
- FREQUENT SATELLITE POLARIZATION DATA USEFUL
- LIGHT POLARIZED FROM ANY CANOPY WITH SHINY LEAVES
- WIND EXPECTED TO BE SOURCE OF NOISE IN SATELLITE POLARIZATION DATA

Task 1B: Field Research Data Acquisition and Preprocessing

Larry L. Biehl

1B. FIELD RESEARCH DATA ACQUISITION AND PREPROCESSING

OVERALL OBJECTIVE.

COORDINATE AND/OR ACQUIRE AND PREPROCESS THE REQUIRED MULTICROP FIELD RESEARCH DATA TO SUPPORT THE AGRISTARS PROGRAM.

SPECIFIC OBJECTIVES FOR 1980 (AND TARGET COMPLETION DATES) CON'T.

2. DATA PREPROCESSING

- COMPLETE PROCESSING OF 1979 DATA
  - PURDUE AGRONOMY FARM (SPECTRAL - 2/1/80, AGRONOMIC - 4/1/80)
  - WEBSTER CO., & HAND CO. FSS (4/1/80)
  - WEBSTER CO., HAND CO., & MCPHERSON CO. AIRCRAFT SCANNER (5/1/80)
  - WEBSTER CO., & HAND CO. LANDSAT SCANNER (5/1/80)
- PREPROCESS FIELD RESEARCH DATA ACQUIRED IN 1980
  - PURDUE AGRONOMY FARM (1/1/81)
  - WEBSTER CO., & CASS CO. FSS (2/1/81)
  - WEBSTER CO., CASS CO., & MCPHERSON CO. AIRCRAFT SCANNER (1/1/81)
  - WEBSTER CO., & CASS CO. LANDSAT SCANNER (1/1/81)

1B. FIELD RESEARCH DATA ACQUISITION AND PREPROCESSING

SPECIFIC OBJECTIVES FOR 1980 (AND TARGET COMPLETION DATES)

1. DATA ACQUISITION

- PLAN AND COORDINATE 1980 ACQUISITION OF REQUIRED FIELD RESEARCH DATA IDENTIFIED IN EXPERIMENT DESIGN PLANS DEVELOPED UNDER TASK 1A (4/1/80)
- ACQUIRE 1980 PURDUE AGRONOMY FARM DATA (10/15/80)
- ACQUIRE DETAILED AGRONOMIC MEASUREMENTS FOR WEBSTER CO., & CASS CO. SITES (10/15/80)
- PREPARE AND CALIBRATE FIELD REFLECTANCE STANDARDS (5/1/80)
- PREPARE PLAN FOR 1981-82 FIELD RESEARCH DATA ACQUISITION (11/1/80)

ACCOMPLISHMENTS THIS QUARTER

1. Implementation Plan Prepared & Presented

2. Data Acquisition

   - Plans being prepared & implemented for 1980 Purdue Agronomy farm data acquisition

   - Plans being prepared for acquisition of detailed agronomic measurements and support of FSS missions for Cass Co., ND and Webster Co., IA test sites

   - Test sites identified for 1980

ACCOMPLISHMENTS THIS QUARTER (CON'T)

3. DATA PREPROCESSING

- 1979 PURDUE AGRONOMY FARM SPECTRAL DATA COMPLETED
- 1979 WEBSTER CO. AND HAND CO. FSS AND AGRONOMIC DATA PREPARED FOR PREPROCESSING
- 1979 WEBSTER CO., HAND CO., AND MCPHERSON CO. AIRCRAFT SCANNER DATA PROCESSING TIMES DETERMINED AND DELIVERED TO NASA/JSC.
- ADDITIONAL 1979 PURDUE AGRONOMY FARM AGRONOMIC DATA PREPARED FOR PROCESSING

SUMMARY OF 1980 FIELD RESEARCH EXPERIMENTS

1. WEBSTER CO., IOWA
   - SPECTRAL CHARACTERISTICS AND SEPARABILITY OF CORN, SOYBEANS AND OTHER AS FUNCTION OF GROWTH STAGE AND CULTURAL PRACTICES
   - VERIFICATION OF SPECTRAL-AGRONOMIC RELATIONSHIPS
2. CASS CO., NORTH DAKOTA
   - SPECTRAL CHARACTERISTICS AND SEPARABILITY OF SPRING WHEAT, BARLEY, SUNFLOWERS AND SOYBEANS AS FUNCTION OF GROWTH STAGE AND CULTURAL PRACTICE
3. TIPPECANOE CO., INDIANA PURDUE AGRONOMY FARM
   - EFFECTS OF FERTILIZATION AND DISEASE ON REFLECTANCE AND RADIANT TEMPERATURE CHARACTERISTICS OF WINTER WHEAT (ALSO GROWTH STAGE AND LEAF AREA INDEX RELATIONSHIPS)
   - RELATIONSHIP OF CROP CANOPY VARIABLES TO (GROWTH STAGE, LAI, BIOMASS, SOIL BACKGROUND ETC.) REFLECTANCE AND RADIANT TEMPERATURE OF CORN AND SOYBEANS
   - EFFECTS OF VARYING AGRONOMIC PRACTICES (PLANTING DATE, ROW SPACING, PLANT POPULATION, CULTIVAR, SOIL TYPE) ON SPECTRAL RESPONSE OF CORN AND SOYBEANS
   - EXPERIMENTS ON INSTRUMENT PARAMETERS, CALIBRATION AND MEASUREMENT VARIABLES
4. MCPHERSON CO., NEBRASKA, SANDHILLS EXPERIMENT STATION
   - RELATIONSHIP OF MOISTURE STRESS EFFECTS ON REFLECTANCE AND THERMAL CHARACTERISTICS OF CORN

1980 FIELD RESEARCH TEST SITES AND MAJOR CROPS

TIPPECANOE CO. INDIANA	WEBSTER CO. IOWA	CASS CO. N. DAKOTA	MCPHERSON CO. NEBRASKA	WHARTON CO. TEXAS
CORN	CORN	SPRING WHEAT	CORN	RICE
SOYBEANS	SOYBEANS	BARLEY		SOYBEANS
WINTER WHEAT		SUNFLOWERS		
		SOYBEANS		

ORGANIZATIONS INVOLVED IN ACQUISITION OF 1980 FIELD RESEARCH DATA

NASA/JOHNSON SPACE CENTER

PURDUE/LABORATORY FOR APPLICATIONS OF REMOTE SENSING

NORTH DAKOTA STATE UNIVERSITY

UNIVERSITY OF NEBRASKA

PLANS FOR NEXT QUARTER

1. DATA ACQUISITION

- COMPLETE PLANS FOR 1980 DATA ACQUISITION

- PREPARE AND/OR CALIBRATE FIELD REFLECTANCE STANDARDS

- BEGIN ACQUISITION OF PURDUE AGRONOMY FARM DATA

- BEGIN ACQUISITION OF DETAILED AGRONOMIC MEASUREMENTS FOR WEBSTER CO., IA OR CASS CO., ND TEST SITES

PLANS FOR NEXT QUARTER (CON'T)

2. DATA PREPROCESSING

- COMPLETE PROCESSING OF 1979 WEBSTER CO., & HAND CO. FSS DATA
- COMPLETE PROCESSING OF ADDITIONAL 1979 PURDUE AGRONOMY FARM AGRONOMIC DATA
- COMPLETE PROCESSING OF 1979 WEBSTER CO., HAND CO., & McPHERSON CO. AIRCRAFT SCANNER DATA
- COMPLETE PROCESSING OF 1979 WEBSTER CO., AND HAND CO. LANDSAT SCANNER DATA
- COMPLETE PROCESSING OF SPECTRAL 1979 PURDUE AGRONOMY FARM LEAF REFLECTANCE MEASUREMENTS - CLEVENGER SPECTROMETER SYSTEM DATA

ISSUES/NEEDS TO BE RESOLVED

1. DATA ACQUISITION

   - ADDITIONAL SUPPORT FOR FSS AND AIRCRAFT MISSIONS FOR 1980

2. DATA PREPROCESSING

   - NEED 6 DATES OF 1979 FSS DATA FROM NASA/JSC
   - NEED 7 DATES OF 1979 AIRCRAFT SCANNER DATA FROM NASA/JSC
   - NEED 1979 LANDSAT SCANNER DATA FROM NASA/GSFC

Task 1C: Development of Multiband Radiometer System

Barrett F. Robinson

OBJECTIVE: To complete the development, testing, and documentation of a multiband radiometer system for remote sensing field research.

APPROACH

- Purdue/LARS will complete the acquisition of a prototype multiband radiometer and data logger
- Purdue/LARS will prepare a test plan for the systems and test them accordingly. In concert with the technical monitor, Purdue/LARS will establish a review panel for the test plan and test results
- Purdue/LARS will prepare specifications for production units - to appear in final report
- Purdue/LARS will prepare
  Revised system manual
  Agricultural users manual
- Purdue/LARS will continue to develop software and hardware to interface data logger to the LARS PDP11/34 computer and input to the IBM 3031.

PLANNED OUTPUT PRODUCTS

- SPECIFICATIONS FOR PRODUCTION MODELS OF THE MULTIBAND RADIOMETER/DATA RECORDING SYSTEMS
- SYSTEM MANUALS
- USERS MANUAL
- DATA ENTRY PROCEDURES. (TO ACCOMPANY REFORMATTING AND ANALYSIS PROCEDURES DEVELOPED IN 1979 FOR MULTIBAND DATA ANALYSIS BY LARSPEC.)

ACCOMPLISHMENTS FOR THE QUARTER

- FINAL DESIGN REPORT AT BARNES - ROBINSON & JUDAY (JAN. 21)
- DESIGN FOR DATA LOGGER, CIRCUIT DESIGNS PREPARED, MAJOR HARDWARE ITEMS RECEIVED.
- CONTRACT FOR SPECTRAL BAND FILTERS (JAN. 29)
- FINAL OUTLINE FOR USER MANUAL - PARTIAL DRAFT
- INSTALLATION OF COMPUTER INTERFACE COMPLETE AND TESTING BEGUN
- PRELIMINARY TEST PLAN PREPARED

PLANS FOR NEXT QUARTER

- CONSTRUCTION OF DATA LOGGER (NEARLY COMPLETE)
- MONITOR CONSTRUCTION OF RADIOMETER
- SYSTEM MANUAL - REVISED DRAFT
- SOFTWARE AND HARDWARE FOR INTERFACE AND DATA HANDLING
- USER MANUAL - NEAR FINAL DRAFT
- TEST PLAN REVIEWED AND COMPLETE

2. RESEARCH IN THE APPLICATION OF SPECTRAL DATA TO CROP IDENTIFICATION AND ASSESSMENT

TASK 2B

SPECTRAL-METEOROLOGICAL CROP DEVELOPMENT STAGE ESTIMATION FOR CORN AND SOYBEANS

CRAIG DAUGHTRY, HAROLD REETZ, AND VIC POLLARA

SPECTRAL-METEOROLOGICAL CROP DEVELOPMENT STAGE ESTIMATION FOR CORN AND SOYBEANS

OVERALL OBJECTIVE

DEVELOP METHODS TO ESTIMATE CROP DEVELOPMENT STAGES USING SPECTRAL AND METEOROLOGICAL DATA.

SPECIFIC OBJECTIVES FOR 1980

1. DEFINE, TEST AND DELIVER FIRST GENERATION SPECTRAL-METEOROLOGICAL METHODS TO ESTIMATE CROP PHENOLOGY FOR CORN AND SOYBEANS IN THE U.S.
2. IDENTIFY AND BEGIN INITIAL RESEARCH AND DEVELOPMENT OF SECOND GENERATION CROP PHENOLOGY MODELS.
3. DEFINE DATA REQUIREMENTS FOR DEVELOPING AND TESTING CROP PHENOLOGY MODELS IN U.S. AND FOREIGN AREAS.

CURRENT STATUS AND ACCOMPLISHMENTS

- LITERATURE SURVEY IS 90% COMPLETED
- INITIAL ANALYSES OF SPECTRAL DATA ARE IN PROGRESS
    - SPECTROMETER/PLOTS
    - LANDSAT/SEGMENTS
- SEGMENTS SELECTED AND DATA BASE DEVELOPMENT INITIATED
    - DATA SET TO BE ASSEMBLED MARCH 15
- METEOROLOGICALLY-BASED MODELS FOR CORN AND SOYBEANS SELECTED
    - CORN - HEAT UNIT MODELS (CROSS AND ZUBER, 1972)
        - PHOTOTHERMAL MODEL (COLIGADO AND BROWN, 1975)
    - SOYBEANS - HEAT UNITS MODELS (LAWN AND BYTH, 1973)
        - PHOTOTHERMAL MODEL (MAJOR ET. AL. 1975)
- FORMULATED INITIAL APPROACH FOR SPECTRAL-METEOROLOGICAL MODELS
    - PROBABILITY DENSITY FUNCTION APPROACH

RESULTS OF LITERATURE SURVEY

THREE MAJOR APPROACHES TO ESTIMATE CROP DEVELOPMENT STAGE

1. NORMAL OR AVERAGE PHENOLOGY

   - BASED ON ACCUMULATION OF DAYS BETWEEN PHENOLOGICAL EVENTS
   - DO NOT ACCOUNT FOR YEAR TO YEAR VARIATIONS IN CROP DEVELOPMENT DUE TO WEATHER DIFFERENCES
   - SPATIAL RESOLUTION IS GENERALLY FOR CROP REPORTING DISTRICT SIZED AREAS

2. METEOROLOGICAL METHODS

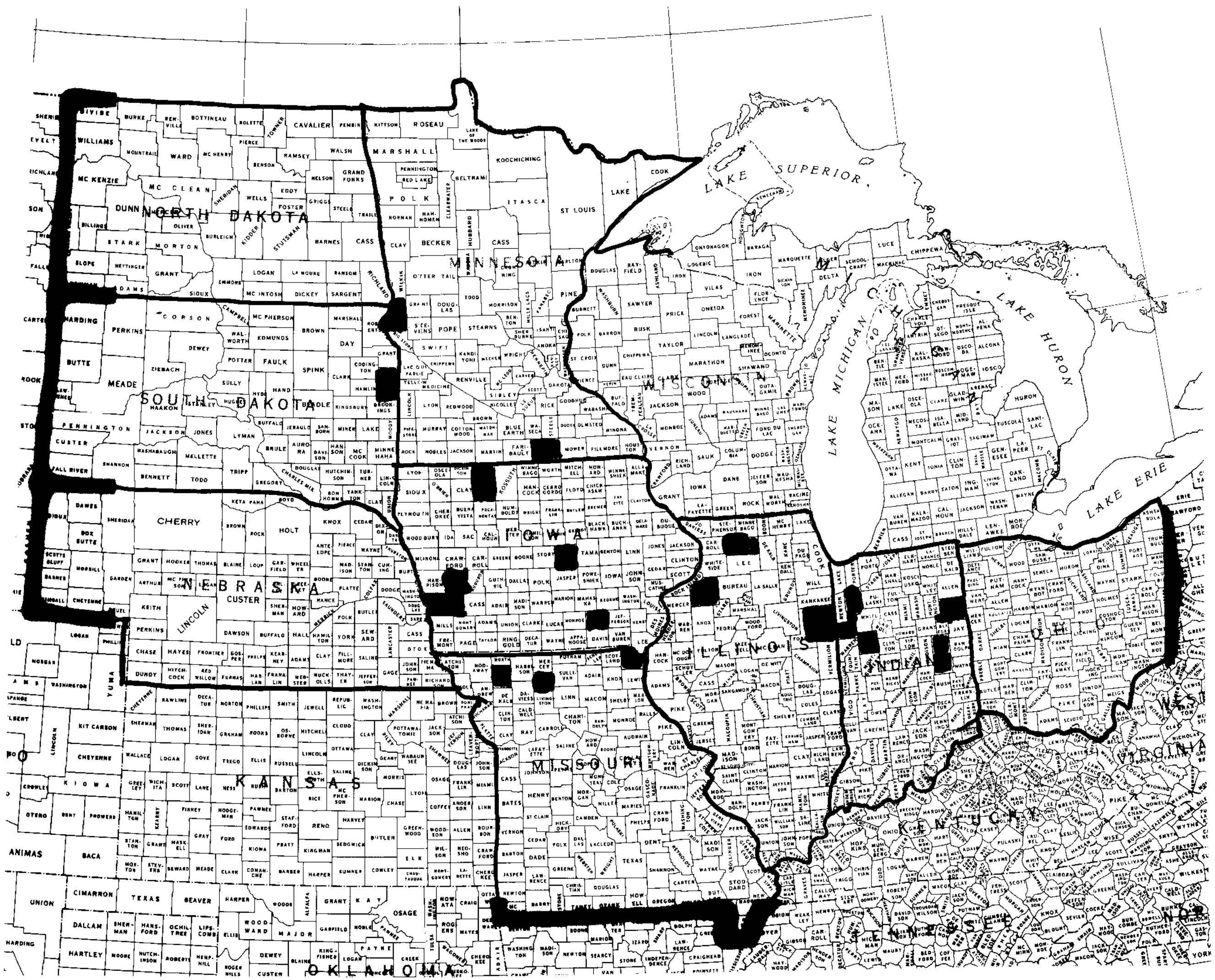
   - BASED ON ACCUMULATION OF THERMAL OR PHOTO-THERMAL UNITS BETWEEN PHENOLOGICAL EVENTS
   - REQUIRE PLANTING DATE AS A STARTING POINT WHICH CAN BE DIFFICULT TO OBTAIN FOR LARGE AREAS
   - WIDELY USED BY SEED INDUSTRY TO RANK CULTIVARS
   - SPATIAL RESOLUTION LIMITED BY DISTRIBUTION OF WEATHER STATIONS

3. SPECTRAL METHODS

   - BASED ON CROP REFLECTANCE (APPEARANCE) CHANGES AS A FUNCTION OF PHENOLOGY
   - INTEGRATE WEATHER AND MANAGEMENT EFFECTS ON CROP DEVELOPMENT
   - SPATIAL RESOLUTION DEPENDS ON SENSOR (E.G. 0.45 HA FOR LANDSAT MSS)
   - SPECIAL PROBLEMS WITH LANDSAT MSS DATA

     - ATMOSPHERIC INTERFERENCE
     - MISSING DATA
     - INFREQUENT TEMPORAL COVERAGE
     - HAVE NOT BEEN TESTED

LOCATION OF SELECTED LANDSAT 5 X 6 MILE SEGMENTS WITH PERIODIC OBSERVATIONS IN 1978.



STATE	SEGMENT	COMMENT
IN	832	NO JULY DATA
	837	
	840	
	843	
	844	
	854	
	860	
IL	807	NO JULY DATA
	809	NO JULY DATA
	824	NO JULY DATA
IA	144	NO JULY DATA
	804	
	867	NO JUNE, JULY DATA
	883	
	886	
	892	

HEAT UNIT MODELS

DESCRIPTION

- LINEAR RESPONSE OF DEVELOPMENT TO TEMPERATURE IS ASSUMED. NONLINEAR RESPONSE VERSIONS ARE GENERALLY BETTER.
- PREDICTS DEVELOPMENT OVER FAIRLY LONG PERIODS (I.E., PLANTING TO TASSELING OR PLANTING TO MATURITY).
- EASY TO APPLY BECUASE NO RESPONSE OF COEFFICIENTS IS REQUIRED.

DATA REQUIREMENTS

- DAILY MAXIMUM TEMPERATURE
- DAILY MINIMUM TEMPERATURE
- THRESHOLD TEMPERATURE (A CONSTANT)
- VARIETAL HEAT UNITS FOR EACH STAGE

EXAMPLE

- CROSS AND ZUBER. 1972 AGRONOMY J. 64:351-355.

HEAT UNIT MODELS

'DAILY ADJUSTED AVERAGE MODEL

$$\sum_{i=1}^{n} (TX_1 + TN_1)/2$$

where:

TH_1 = high temp on day i

T_L = low temp on day i

$TX_i = TH_i$ if $TH_i < 86$

$= 86$ if $TH_i \geq 86$

$TN_i = TL_i$ if $TL > 50$

$= 50$ if $TH_i \leq 50$

'DAILY HEAT STRESS MODEL

$$\sum_{i\ 1}^{n} (TX_i + TN_i)/2$$

where:

$TX = TH_i$ if $TH_i < 86$

$= 86 - (TH_i - 86)$ if $TH_i \geq 86$

'ONTARIO MODEL

$$\sum_{i\ 1}^{n} (TO_i + TN_i)/2$$

where:

$TO_i = 0.256(TH_i)^2 + 4.39(TH_i) - 155.18$

$TN_i = TL_i$ if $TL > 40$

$= 40$ if $TH_i \leq 40$

PHOTOTHERMAL MODELS

DESCRIPTION

- SIMILAR TO BIOMETEOROLOGICAL TIME SCALE (BMTS) MODEL OF ROBINSON (1968)
- INCORPORATES NONLINEAR RESPONSES OF DEVELOPMENT TO TEMPERATURE AND PHOTO PERIOD
- PREDICTS DEVELOPMENT OVER FAIRLY SHORT INTERVALS (I.E., EMERGENCE TO FLOWERING, FLOWERING TO GRAINFILLING)
- COEFFICIENTS NEED TO BE REDERIVED FOR MATURITY GROUPS OF SOYBEANS.
- NO REPORTED BMTS MODEL FOR CORN

DATA REQUIREMENTS

- DAILY MAXIMUM TEMPERATURE
- DAILY MINIMUM TEMPERATURE
- PHOTO PERIOD
- INITIAL COEFFICIENTS
- PHENOLOGICAL DATA FOR DERIVATION OF COEFFICIENTS FOR MATURITY GROUPS OF CORN AND SOYBEANS

EXAMPLES

- MAJOR ET. AL. 1975 CROP SCI. 15:174-179
- ROBINSON. 1968. INT. J. BIOMETEORO. 12:191-223

PLANNED OUTPUT PRODUCTS

- METEOROLOGICAL DATA FOR SELECTED SEGMENTS IN U.S.
- HISTORICAL CROP PHENOLOGY DATA
- TRAJECTORY PLOTS OF LANDSAT MSS DATA FOR CORN AND SOYBEANS FOR SELECTED SEGMENTS
- EVALUATION OF SELECTED METEOROLOGICAL MODELS FOR PREDICTING CROP PHENOLOGY
- INITIAL EVALUATION OF METEOROLOGICAL MODELS ADJUSTED BY SPECTRAL DATA FOR PREDICTING CROP PHENOLOGY
- FIRST GENERATION SPECTRAL-METEOROLOGICAL MODEL FOR PREDICTING CROP PHENOLOGY
- RECOMMENDATION FOR DEVELOPING ADVANCED MODELS

PLANS FOR NEXT QUARTER

1. PREPARE BIBILIOGRAPHY
2. ACQUIRE AND ASSEMBLE METEOROLOGY DATA
3. ACQUIRE AND ASSEMBLE CROP PHENOLOGY DATA
4. ESTIMATE CROP DEVELOPMENT USING METEOROLOGICAL MODELS FOR CRD'S
5. PLOT TEMPORAL TRAJECTORIES OF SPECTRAL DATA
6. ADJUST CROP DEVELOPMENT STAGE USING SPECTRAL DATA
7. CONDUCT INITIAL EVALUATIONS OF SPECTRALLY-ADJUSTED METEOROLOGICAL MODELS

ISSUES

1. RECEIPT OF METEOROLOGICAL DATA FROM NOAA IN ASHVILLE, NC.

2. RECEIPT OF PHENOLOGICAL DATA FROM USDA-ESCS.

Task 2D

Determination of the value of Spectral Information in Estimation of Agronomic Variables Associated with Yield of Corn and Soybeans

CRAIG DAUGHTRY, DON HOLT, AND CHRIS SEUBERT

DETERMININATION OF THE VALUE OF SPECTRAL INFORMATION IN ESTIMATION OF AGRONOMIC VARIABLES ASSOCIATED WITH YIELD OF CORN AND SOYBEANS

OVERALL OBJECTIVE

EVALUATE SPECTRAL DATA AS A SOURCE OF INFORMATION FOR CROP YIELD MODELS.

SPECIFIC OBJECTIVES FOR 1980

- IDENTIFY IMPORTANT FACTORS DETERMINING YIELD WHICH MAY BE ESTIMATED FROM SPECTRAL DATA.

- DEVELOP REPRESENTATIVE APPROACHES WHICH POTENTIALLY CAN USE SPECTRAL INFORMATION.

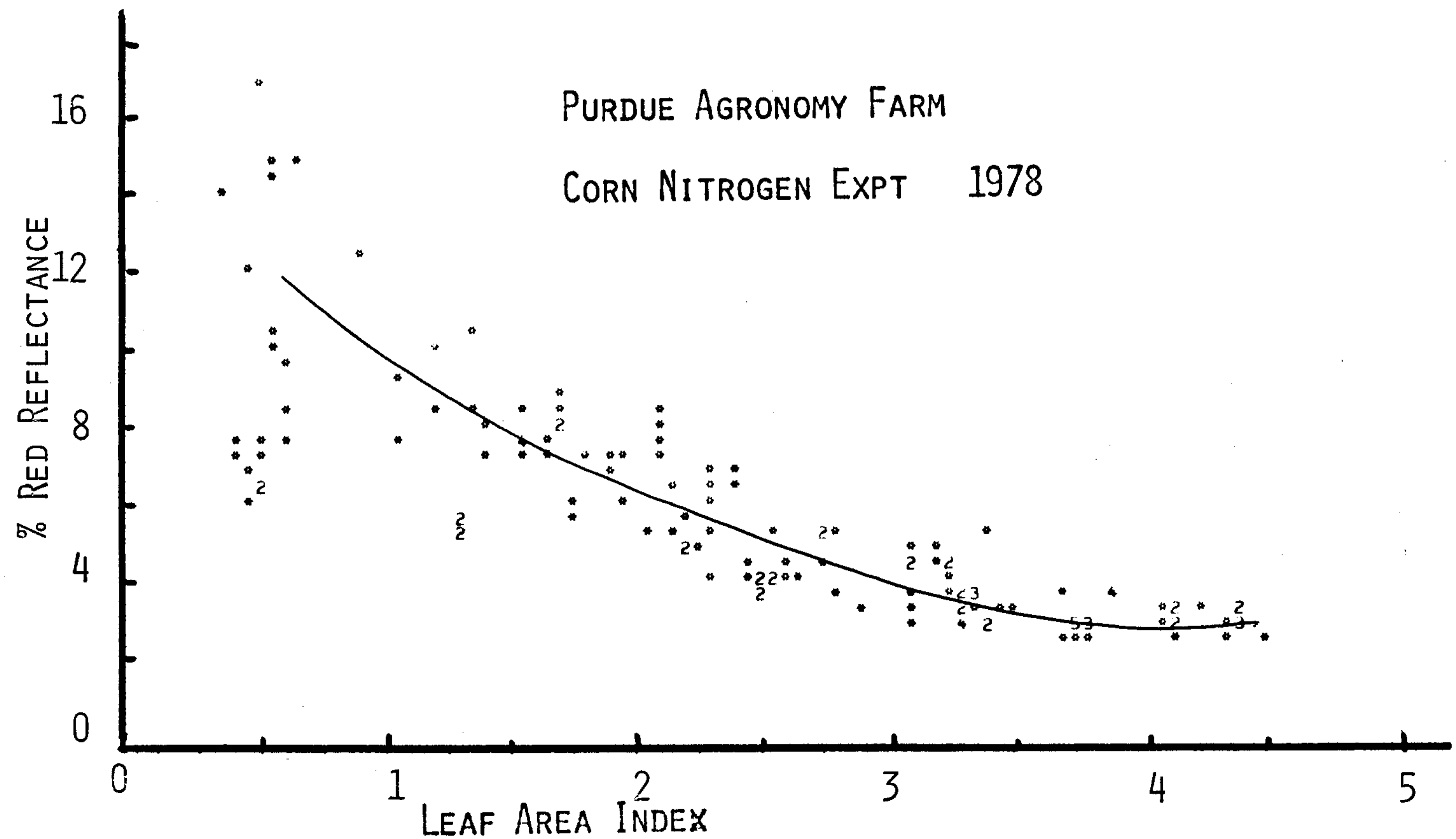
- EVALUATE SOIL PRODUCTIVITY INDICES FOR YIELD MODELS. EXPLORE METHODS TO ASSESS SOIL PRODUCTIVITY USING SPECTRAL DATA.

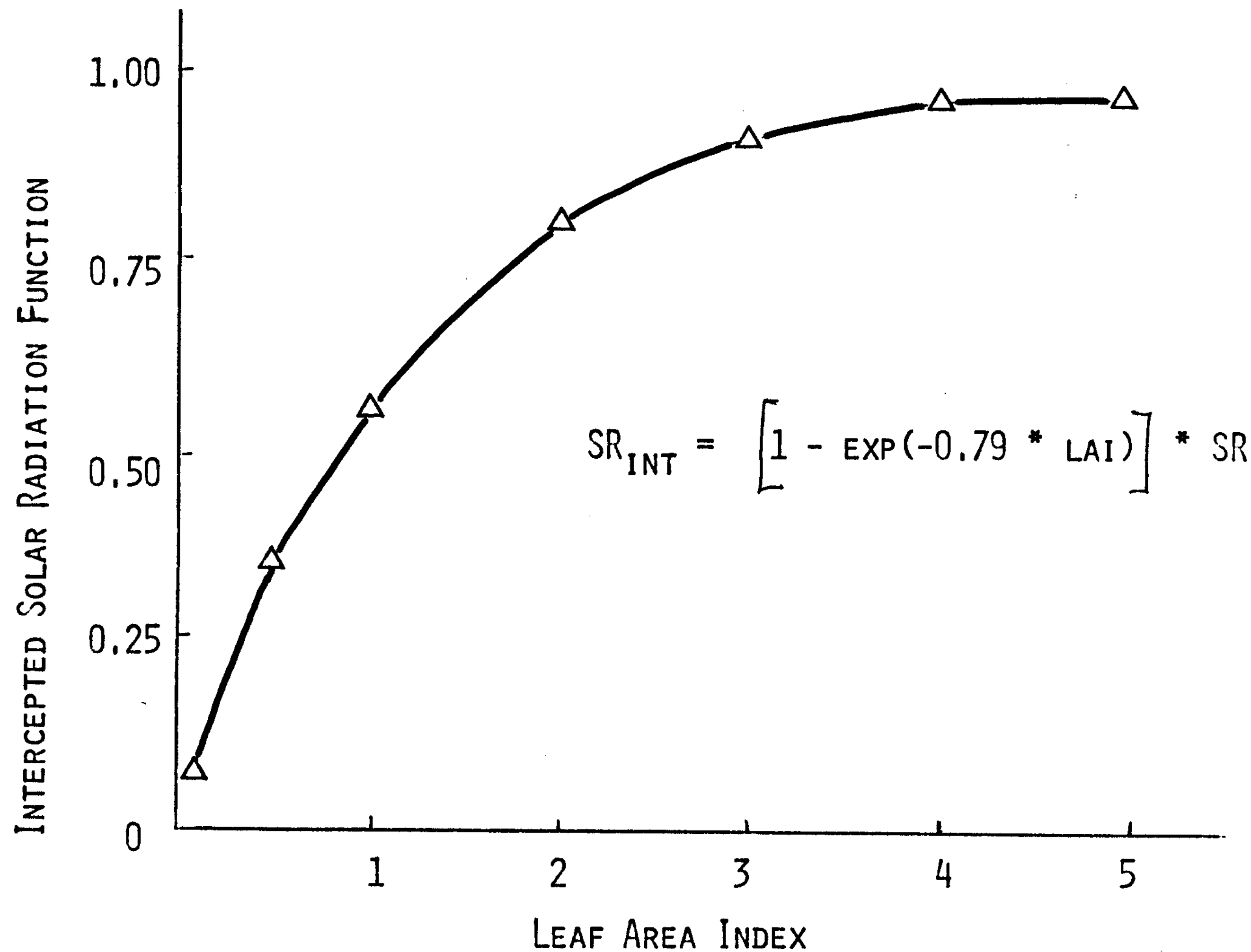
APPROACH

- REVIEW THE LITERATURE.
- ASSEMBLE DATA SETS. ADJUST LANDSAT MSS DATA.
- SELECT IMPORTANT VARIABLES IN DETERMINING YIELD. DEVELOP METHODS TO ESTIMATE THESE VARIABLES FROM SPECTRAL DATA.
- SELECT, ACQUIRE, AND MODIFY, YIELD MODELS TO INCLUDE SPECTRAL DATA.
- EVALUATE SOIL PRODUCTIVITY INDICES. EXPLORE METHODS OF DETERMINING SOIL PRODUCTIVITY FROM SPECTRAL DATA.
- IDENTIFY CRITICAL ISSUES FOR EXTENSION OF CONCEPTS TO FOREIGN AREAS.

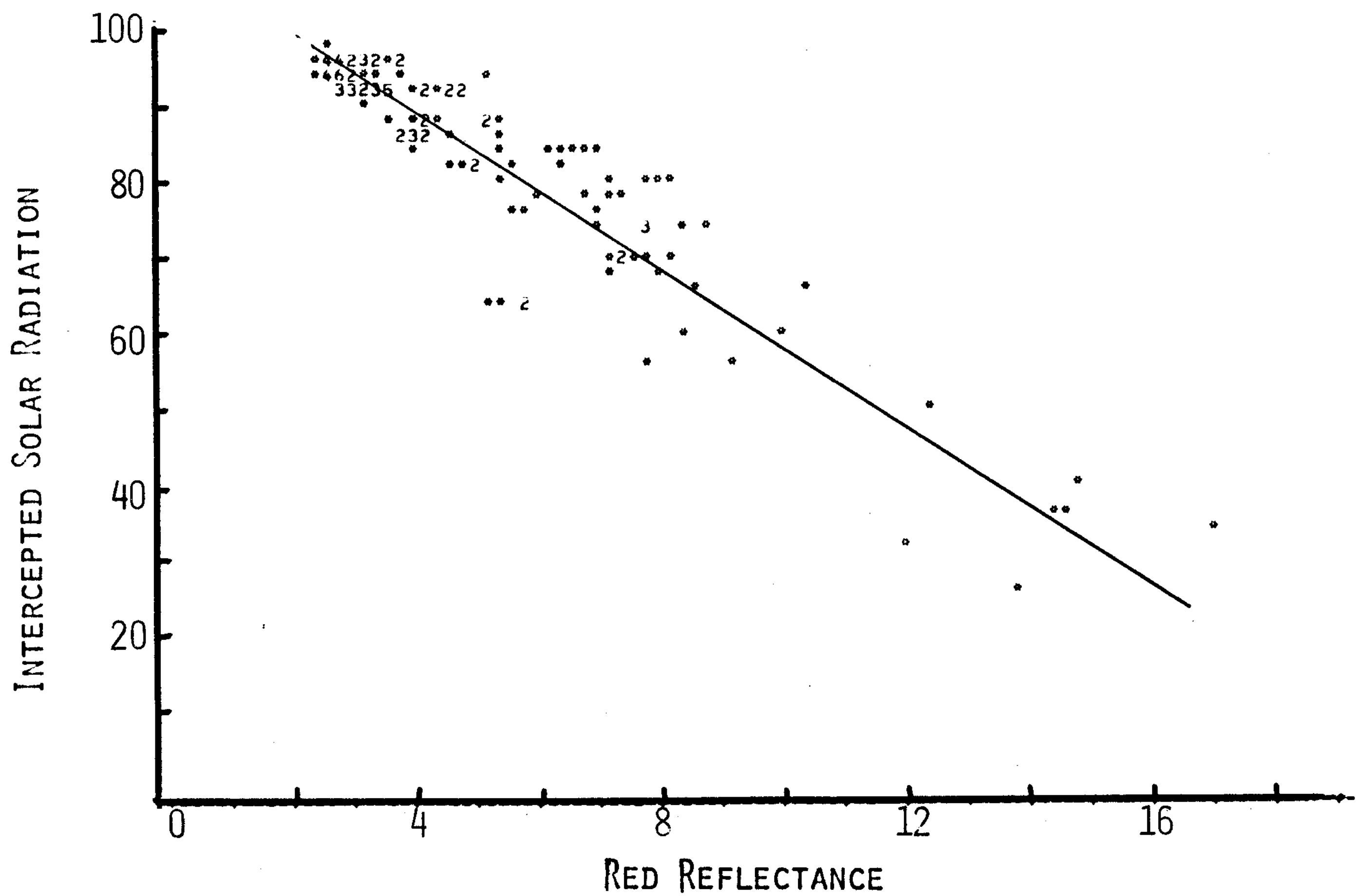
Current Status and Accomplishments

- LITERATURE SURVEYS
  - CROP YIELD 90% COMPLETE
  - SOIL PRODUCTIVITY 60% COMPLETE
- SEGMENTS SELECTED AND DATA BASE DEVELOPMENT INITIATED
  - 'SPECTRAL DATER SET TO BE ASSEMBLED BY MARCH 15
  - 'METEOROLOGICAL DATA ON ORDER
- INITIAL ANALYSES OF SPECTRAL DATA
  - 'SPECTROMETER DATA AT PURDUE AGRONOMY FARM
  - 'LANDSAT MSS DATA FOR SEGMENTS
- CORRELATIONS OF SPECTRAL DATA TO GRAIN YIELD
  - 'DATA SET DEPENDENT
  - 'ADJUSTMENTS TO METEOROLOGICALLY-BASED YIELD MODEL ESTIMATES
    - INITIAL TESTS USING SPECTROMETER DATA IN 1978
- PERCENT INTERCEPTED SOLAR RADIATION VARIABLE
  - 'ESTIMATE OF"USEFUL" ENERGY TO CROP
  - 'POTENTIAL INTERFACES WITH YIELD AND EVAPOTRANSPIRATION MODELS


PURDUE AGRONOMY FARM
CORN NITROGEN EXPT 1978
% RED REFLECTANCE
LEAF AREA INDEX
0
4
8
12
16
0
1
2
3
4
5



LINVILLE, DALE AND HODGES. 1978. AGRON. J. 70:257-263



100
80
60
40
20
0
4
8
12
16
INTERCEPTED SOLAR RADIATION
RED REFLECTANCE

Plans for Next Quarter

- COMPLETE LITERATURE REVIEWS

- ASSEMBLE SPECTRAL AND METEOROLOGICAL DATA SETS

- CONDUCT INITIAL EVALUATIONS OF INTERCEPTED SOLAR RADIATION VARIABLE

  'SPECTROMETER DATA FROM PURDUE AGRONOMY FARM 1978, 1979

  'LANDSAT MSS SEGMENTS TO BE SELECTED

- SELECT TEST SITES FOR INITIAL EVALUATION OF SOIL PRODUCTIVITY INDICES

- ASSEMBLE SOIL PRODUCTIVITY DATA SETS

Task 4A

Application and Evaluation of Landsat Training, Classification and Area Estimation Procedures for Crop Inventory

MARILYN M. HIXSON

A. APPLICATION AND EVALUATION OF LANDSAT TRAINING, CLASSIFICATION, AND AREA ESTIMATION PROCEDURES FOR CROP INVENTORY

BACKGROUND

- THIRD YEAR OF A.N. TASK
- WORK ON CORN/SOYBEANS SUPPORTIVE OF CLASSIFICATION, SAMPLING AND AGGREGATION PHASES OF AgRISTARS

PREVIOUS ACCOMPLISHMENTS

- ASSESSMENT OF IMPACT OF LANDSAT DATA ACQUISITION HISTORY ON CORN AND SOYBEAN AREA ESTIMATION. ACQUISITIONS FROM AROUND EMERGENCE AND AFTER TASSELING OF THE CORN PROVIDE A MINIMAL SET FOR ACCURATE IDENTIFICATION OF CORN AND SOYBEANS.

- SEVERAL CLASSIFIERS WERE COMPARED AND AN AVERAGE 1-2% RANGE OF PERFORMANCE WAS OBTAINED. MINIMUM DISTANCE, MAXIMUM LIKELIHOOD, SUM-OF-DENSITIES, ECHO, AND LAYERED WERE USED WITH THE SAME SET OF TRAINING STATISTICS. TRAINING METHOD AFFECTED PERFORMANCE MORE THAN CLASSIFIER USED.

- USE OF ONE VISIBLE AND ONE IR BAND FROM EACH ACQUISITION DATE DID NOT SIGNIFICANTLY DECREASE PERFORMANCE. USE OF FEWER FEATURES DECREASED PERFORMANCE.

- STRATIFICATION AND SAMPLING PLAN FOR NASA/JSC 1978 CORN/SOYBEANS DATA ACQUISITION WAS DEFINED.

OBJECTIVES

- COMPARE SEVERAL METHODS FOR OBTAINING TRAINING STATISTICS
- RELATE CLASSIFICATION PERFORMANCE TO SCENE CHARACTERISTICS
- ASSESS EFFECT OF SEPARATING THE FUNCTIONS OF SAMPLING FOR TRAINING AND SAMPLING FOR AREA ESTIMATION.

APPROACH

- TRAINING PROCEDURES

  SAMPLE UNIT SIZE FOR TRAINING

  - VARIABLE SIZE UNITS (FIELDS) VS. FIXED SIZE UNITS (FIXED CELL SIZE)
  - VARIABLE SIZE MAY SAMPLE SMALL FIELDS BETTER
  - FIXED SIZE MAY REDUCE POTENTIAL BIAS TOWARD COVER TYPES OCCURRING IN LARGE FIELDS
  - COMPARISON WILL BE MADE ON SEVERAL SEGMENTS

  USE OF SPECTRAL/SPATIAL CLUSTERING ALGORITHM AS A TRAINING TOOL

  - UNSUPERVISED ECHO USED IN TRAINING
  - SUPERVISED ECHO USED IN CLASSIFICATION
  - CLUSTER LABELING SIMILAR TO PROCEDURE 1
  - SOFTWARE BEING DEVELOPED BY TASK 3

APPROACH

'RELATIONSHIP OF SCENE CHARACTERISTICS AND CLASSIFICATION PERFORMANCE

CLASSIFICATION

- ONE VISIBLE AND ONE NEAR IR BAND PER ACQUISITION
- ACQUISITIONS AROUND EMERGENCE AND AFTER TASSELING OF CORN
- MAXIMUM LIKELIHOOD CLASSIFIER

WIDE VARIETY OF SEGMENTS IN CORN BELT AND FRINGE AREAS

VARIABLES

- CLASSIFICATION PERFORMANCE (COMPARED TO INVENTORY, ON TEST FIELDS)
- ANALYST LABELING ACCURACY
- GEOGRAPHICAL LOCATION
- FIELD SIZE
- SOIL TYPE AND COMPLEXITY
- CROP MIXTURE
- WEATHER VARIABLES

SEGMENTS ANALYZED TO DATE

SEGMENT NUMBER	COUNTY	STATE	APU*	COMMENTS
141	MADISON	IA	25W	SMALL, NONRECTANGULAR FIELDS. PASTURE AND TREES.
146	BALLARD	KY	43	SMALL, NONRECTANGULAR FIELDS. SOME TABACCO.
185	TRAVERSE	MN	20	MANY CONFUSION CROPS (SUNFLOWERS, SORGHUM).
209**	GENTRY	MO	25	COMPLEX SCENE, NONRECTANGULAR FIELDS.
800	CLINTON	IA	25E	PRIMARILY CORN AND SOYBEANS.
809	OGLE	IL	25	SMALL TO MEDIUM FIELDS, SOME STRIP AND NONRECTANGULAR.
837	BENTON	IN	28	PRIMARILY CORN AND SOYBEANS. LARGER FIELDS.
843	HENRY	IN	28	SMALL, RECTANGULAR FIELDS.
854	TIPPECANOE	IN	28	PRIMARILY CORN AND SOYBEANS.
860	WELLS	IN	28	LARGE AREA OWNED BY ARMY CORPS OF ENGINEERS.
862	CALHOUN	IA	24W	MEDIUM SIZE, MOSTLY RECTANGULAR FIELDS. SMALL STREAMS THROUGHOUT.
881	MONONA	IA	14N	ROLLING TERRAIN, MUCH PASTURE
883	PALO ALTO	IA	24W	LARGE WATER BODY.
886	POTTAWATTOMIE	IA	14S	IRREGULAR FIELD SHAPES. TOWN.
892	SHELBY	IA	14S	SMALL FIELDS. MOSTLY AGRICULTURAL.
895**	WOODBURY	IA	14N	IRREGULAR FIELD SHAPES. PASTURE, SOME OATS.

* AS SUBDIVIDED FOR YIELD MODELING IN IOWA.

** NOT COMPLETED.

APPROACH

'FULL-FRAME SAMPLING

- USE FULL-FRAME DATA
- STRATIFICATION FOR CLASSIFICATION CONDUCTED USING FULL-FRAME IMAGE PRODUCTS
- STRATA CLASSIFIED WITH TRAINING DATA FROM SAMPLE SEGMENTS IN THAT STRATUM
- SEVERAL SAMPLING SCHEMES WILL BE COMPARED

PLANS FOR NEXT QUARTER

- PRELIMINARY EVALUATION OF ECHO AS A TRAINING AID
- CONTINUE CLASSIFICATION OF A WIDE VARIETY OF SEGMENTS
- COMPLETE ANCILLARY DATA BASES FOR SCENE CHARACTERISTICS
- PERFORM INITIAL ANALYSES OF RELATIONSHIP OF CLASSIFICATION PERFORMANCE TO SCENE CHARACTERISTICS

ISSUES

ONE FULL-FRAME IMAGE AND ONE FULL-FRAME TAPE HAVE NOT YET BEEN RECEIVED.

3. SAMPLING AND AGGREGATION RESEARCH

TASK 4B

DETERMINATION OF THE OPTIMUM LEVEL FOR COMBINING ACREAGE AND YIELD ESTIMATES

MARILYN M. HIXSON

B. DETERMINATION OF THE OPTIMAL LEVEL FOR COMBINING ACREAGE AND YIELD ESTIMATES

BACKGROUND

'GOAL OF CROP INVENTORY STUDIES IS PRODUCTION ESTIMATION

'LEVELS OF AREA AND YIELD STRATA AFFECT LEVEL OF PRODUCTION ESTIMATE

OBJECTIVE

'OBJECTIVE IS TO DETERMINE THE OPTIMAL LEVEL FOR COMBINING AREA AND YIELD ESTIMATES

APPROACH

'OPTIMAL LEVEL TO BE ASSESSED USING CURRENT TECHNOLOGY

- ANALYSIS OF LANDSAT MSS DATA OVER SAMPLE SEGMENTS FOR AREA
- CCEA-TYPE REGRESSION MODELS FOR YIELD

'OPTIMIZATION FOR MULTIPLE CROPS CONSIDERED

- IOWA FOR CORN AND SOYBEANS
- NORTH DAKOTA FOR WHEAT

'SEVERAL LEVELS OF ESTIMATION CONSIDERED FOR BOTH ACREAGE AND YIELD

- COUNTY
- REFINED STRATA
- CROP REPORTING DISTRICT
- STATE
- OTHER UNIONS OF COUNTIES

STATUS

- PLANNING PHASE COMPLETED
- HISTORICAL ACREAGE AND YIELD DATA BASE BEGUN
- CCEA MODEL FORM BEING ACQUIRED
- LITERATURE REVIEW OF SMOOTHING METHODS (PARTICULARLY OF WEATHER DATA) UNDERWAY

PLANS FOR NEXT QUARTER

- COMPLETE HISTORICAL AREA AND YIELD DATA BASES
- ASSESS VARIABILITY OF REFINED STRATA TO DETERMINE "OTHER UNIONS OF COUNTIES" TO BE TESTED
- ACQUIRE FROM JSC AND BEGIN ORGANIZATION OF METEOROLOGICAL DATA
- ACQUIRE WITHIN COUNTY AREA VARIANCES; COMPUTE AREA VARIANCES FOR LEVELS TO BE EVALUATED

ISSUES

TASK AS CURRENTLY PLANNED DEPENDENT UPON ACQUISITION OF DATA FROM JSC. TO MAKE COUNTY-LEVEL YIELD ESTIMATES TO ASSESS LEVEL WITH RESPECT TO CURRENT TECHNOLOGY, HISTORICAL WEATHER DATA FOR THE PAST 30-40 YEARS FROM ALL THE COOPERATIVE METEOROLOGICAL STATIONS IN IOWA AND NORTH DAKOTA ARE REQUIRED. IF THESE DATA CANNOT BE SUPPLIED, AN ALTERNATIVE APPROACH TO THE TASK MUST BE DEFINED.

4. DATA PROCESSING RESEARCH AND TECHNIQUES DEVELOPMENT

TASK 2A

DETERMINING THE EFFECTS OF MISREGISTRATION

PAUL ANUTA

TASK 2A. DETERMINING THE EFFECTS OF MISREGISTRATION

OBJECTIVE

DEVELOP MATHEMATICAL MODEL TO REPRESENT TEMPORAL MISREGISTRATION USING FOURIER ANALYSIS AND IMAGE PROCESSING TECHNIQUES. THIS APPROACH WILL THEN BE COMPARED TO CONVENTIONAL CORRELATION TECHNIQUES.

ALSO DEVELOP A MATHEMATICAL MODEL TO RELATE CLASSIFICATION ERROR TO MISREGISTRATION. TEST ON EXAMPLE LACIE TEMPORAL DATA.

APPROACH AND TASKS

1. DEVELOP AND TEST MODEL FOR MISREGISTRATION

   - SPECIFY MODEL FOR MISREGISTRATION USING FOURIER TECHNIQUES
   - SELECT TEMPORAL DATA SETS AND TEST MODEL FOR VARYING MISREGISTRATION INTRODUCED
   - COMPARE RESULTS TO CONVENTIONAL CORRELATION METHODS

2. DEVELOP AND TEST A MODEL FOR CLASSIFICATION ERROR DUE TO MISREGISTRATION

   - DEVELOP ERROR MODEL BASED ON ESTIMATED NOISE VARIANCE DUE TO MISREGISTRATION
   - EVALUATE MODEL ON SEGMENT DATA USING ACAP OR OTHER ERROR-DETERMINATION METHOD

RESULTS IN QUARTER

- PROGRESS MADE IN SPECIFYING MODEL FOR MISREGISTRATION.

- MISREGISTRATION WAS FOUND TO RELATE TO PEAK OF DIFFERENCE SPECTRUM MAGNITUDE, AND TOTAL ENERGY IN DIFFERENCE SPECTRUM.

- A PILOT TEMPORAL DATA SET WAS PROCESSED BY TAKING 2-DIMENSIONAL TRANSFORMS OF TIME 1, TIME 2, AND DIFFERENCE IMAGE. DATA CHOSEN WAS SEPT., OCT., NOV. 1972, JUNE 1973 TEMPORAL DATA SET. RESULTS WERE NOT READY FOR THIS REPORT.

DEVELOPMENT OF MISREGISTRATION MODEL

- MODEL IS BASED ON TEMPORAL DIFFERENCE IMAGE

$$\Delta P_{IJ}(T_1, T_2) = P_{IJ}(T_2) - P_{IJ}(T_1)$$

WHERE: $P_{IJ}(T)$ IMAGE PIXEL VALUE IN

ROW I AND COLUMN J AT TIME T.

ΔP_{IJ} IS THE DIFFERENCE IMAGE PIXEL

- THE FOURIER TRANSFORM IS THEN TAKEN OF THE DIFFERENCE IMAGE

$$FT_{UV}\left[\Delta P_{IJ}(T_1, T_2)\right] = \sum_{I}\sum_{J} \Delta P_{IJ}(T_1, T_2) \mathrm{EXP}\left[-\sqrt{-1}\; 2\pi\left(\frac{IU}{N} + \frac{JV}{M}\right)\right]$$

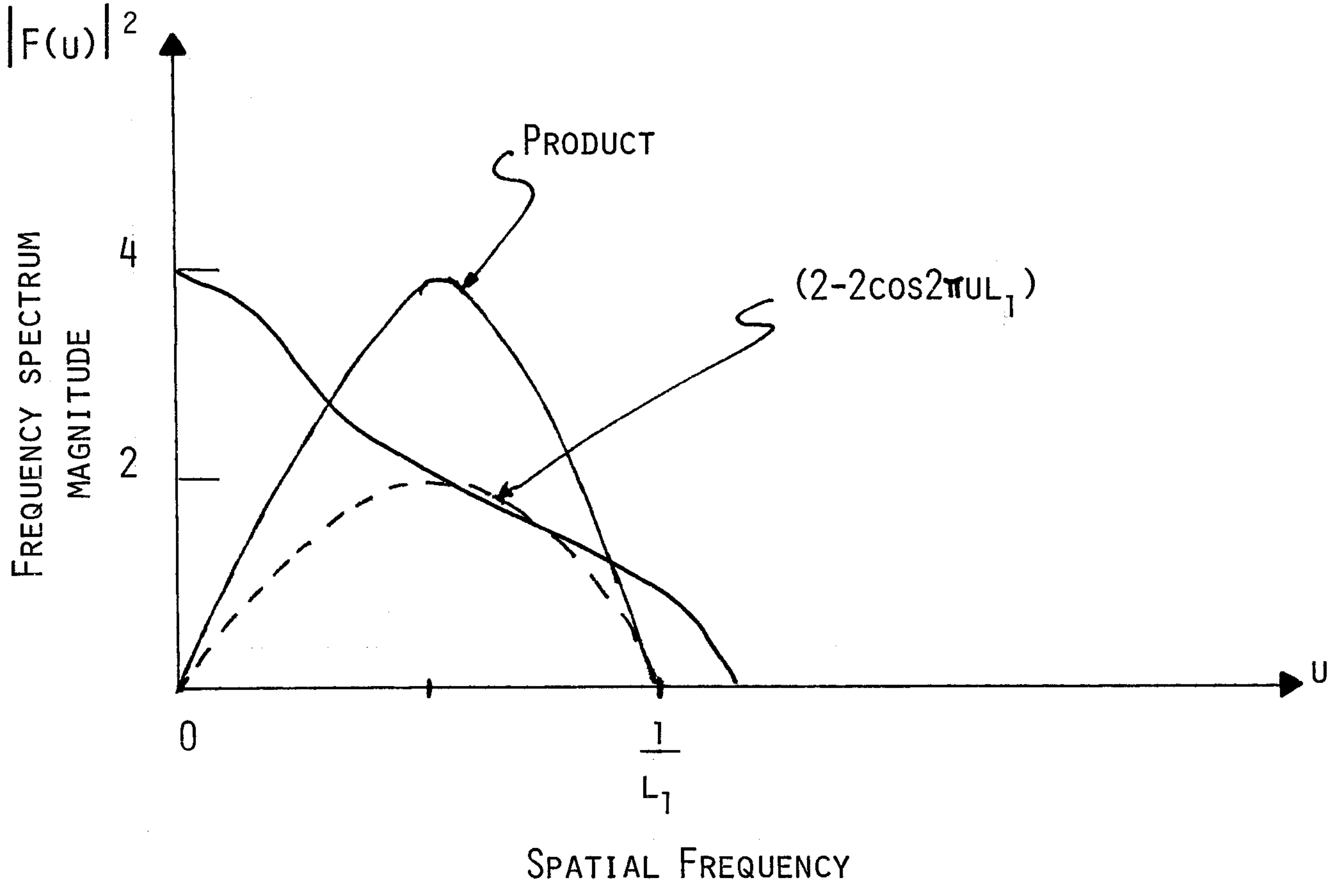
$$= \sum_{I}\sum_{J} P_{IJ}(T_2) \mathrm{EXP}\left[-\sqrt{-1}\; 2\pi\left(\frac{IU}{N} + \frac{JV}{M}\right)\right]$$

$$+ \sum_{I}\sum_{J} P_{IJ}(T_1) \mathrm{EXP}\left[-\sqrt{-1}\; 2\pi\left(\frac{IU}{N} + \frac{JV}{M}\right)\right]$$

$$= FT_{UV}\left[P_{IJ}(T_2)\right] - FT_{UV}\left[P_{IJ}(T_1)\right]$$

WHERE: N, M ARE THE NUMBER OF ROWS AND COLUMNS IN THE IMAGE

DIFFERENCE SPECTRUM MAGNITUDE EXAMPLE



L_1 IS THE MISREGISTRATION

LOCATION OF THE PEAK RELATES TO MISREGISTRATION

AS DOES TOTAL ENERGY IN DIFFERENCE SPECTRUM

PLANS FOR NEXT QUARTER

- Select and compute Time 1, Time 2, and difference Fourier transforms for test sites.
- Analyze transforms for nature of temporal effects.
- Introduce misregistration and recompute transforms.
- Analyze difference spectrum under misregistration to relate transform characteristics to misregistration.

TASK 2C

ADVANCED CLASSIFICATION METHODS

PHILIP H. SWAIN, DAVID A. LANDGREBE, HOWARD J. SIEGEL

2C1. MULTISTAGE CLASSIFICATION

POTENTIAL BENEFITS

1. MORE EFFICIENT USE OF CLASSIFIER COMPUTATION

2. MORE ACCURATE CLASSIFICATION FOR A GIVEN AMOUNT OF COMPUTATION

3. MORE EFFECTIVE USE OF MULTITEMPORAL DATA

4. DEVELOPMENT OF FLEXIBLE CLASSIFIER MODELS FOR INCORPORATING MULTITYPE (SENSOR AND ANCILLARY) DATA

2C1. MULTISTAGE CLASSIFICATION

I. OBJECTIVES

A. DETERMINE SUITABLE FEATURE SELECTION METHODS

B. DEVELOP A SATISFACTORY TRAINING PROCEDURE

C. DEVISE A DECISION TREE DESIGN ALGORITHM

2C1. MULTISTAGE CLASSIFICATION

II. WORK ACCOMPLISHED

A. NEW DATA SET CHOSEN

B. DATA SET SIMULATED

C. NEW SEPARABILITY MEASURE CHOSEN

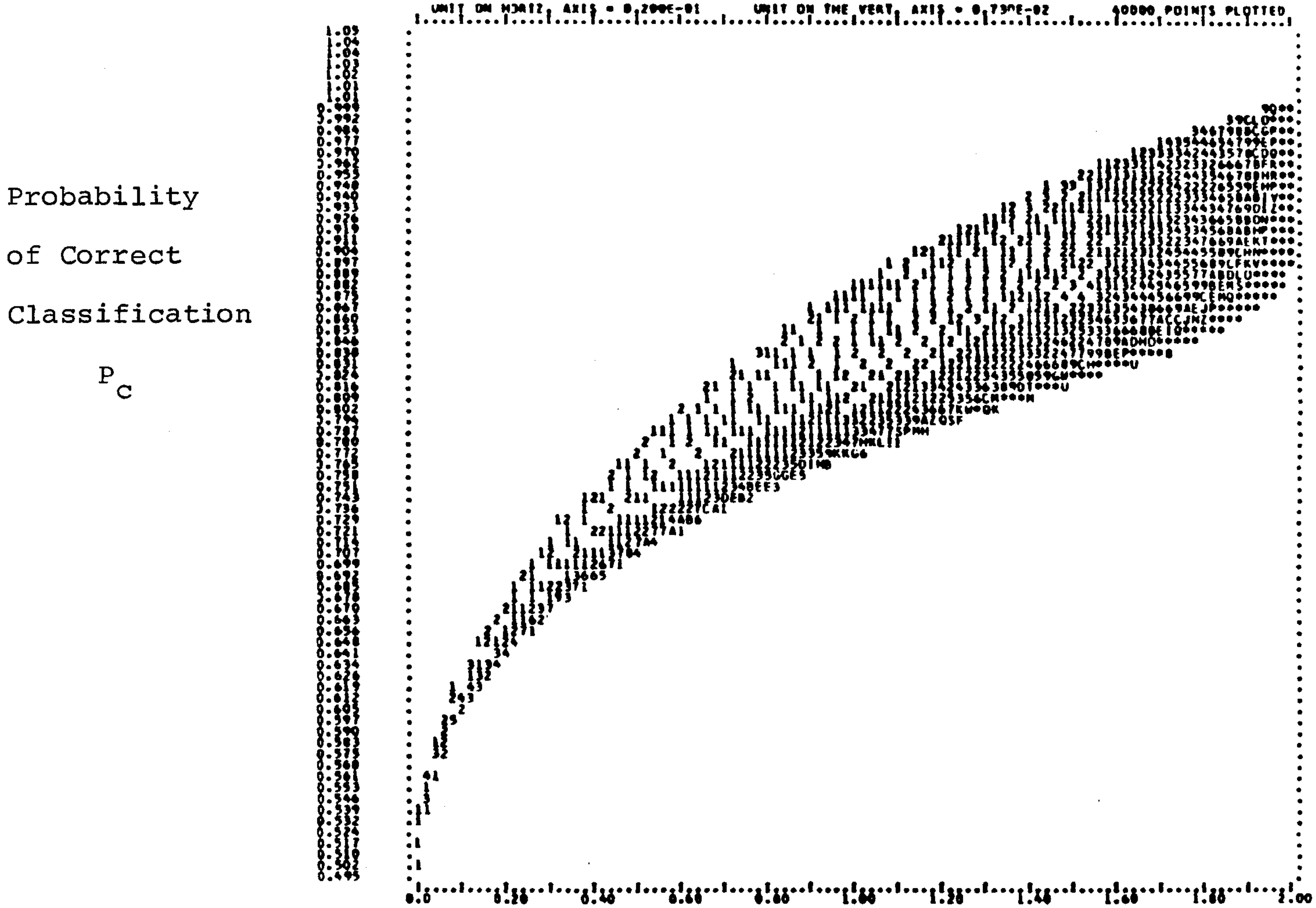


Figure 1. Simulation Result for P_c Versus 2[1 - exp(-D/8)

Probability

of Correct

Classification

P_c

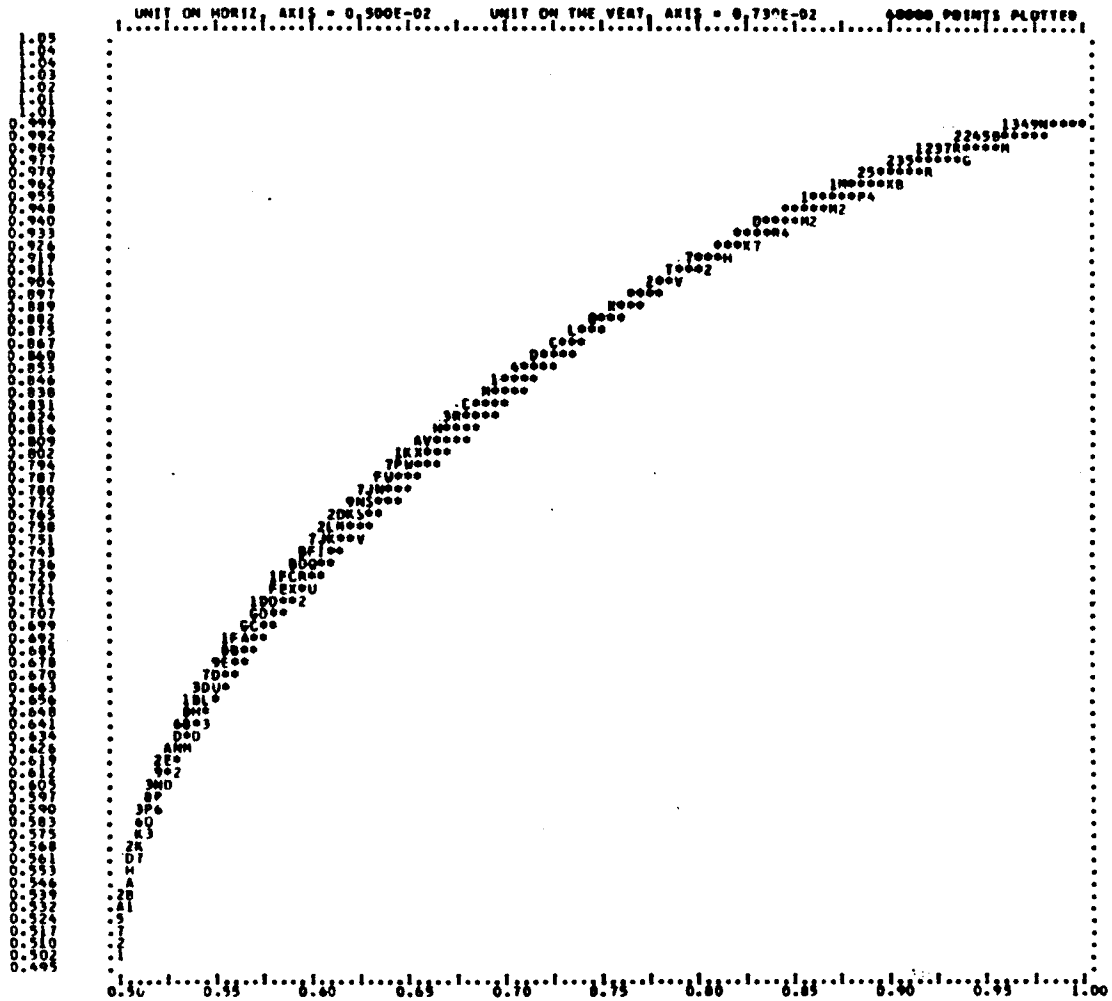


Figure 2. **Simulation Results for P_c Versus $1 - \rho_B$†**

†The printing characters represent the number of times that a simulation value fell within the boundary of that print position. Blank=0, 1=1, . . ., 9=9, A=10, B=11, . . ., Z=35, *=more than 35.

Probability

of Correct

Classification

P_c

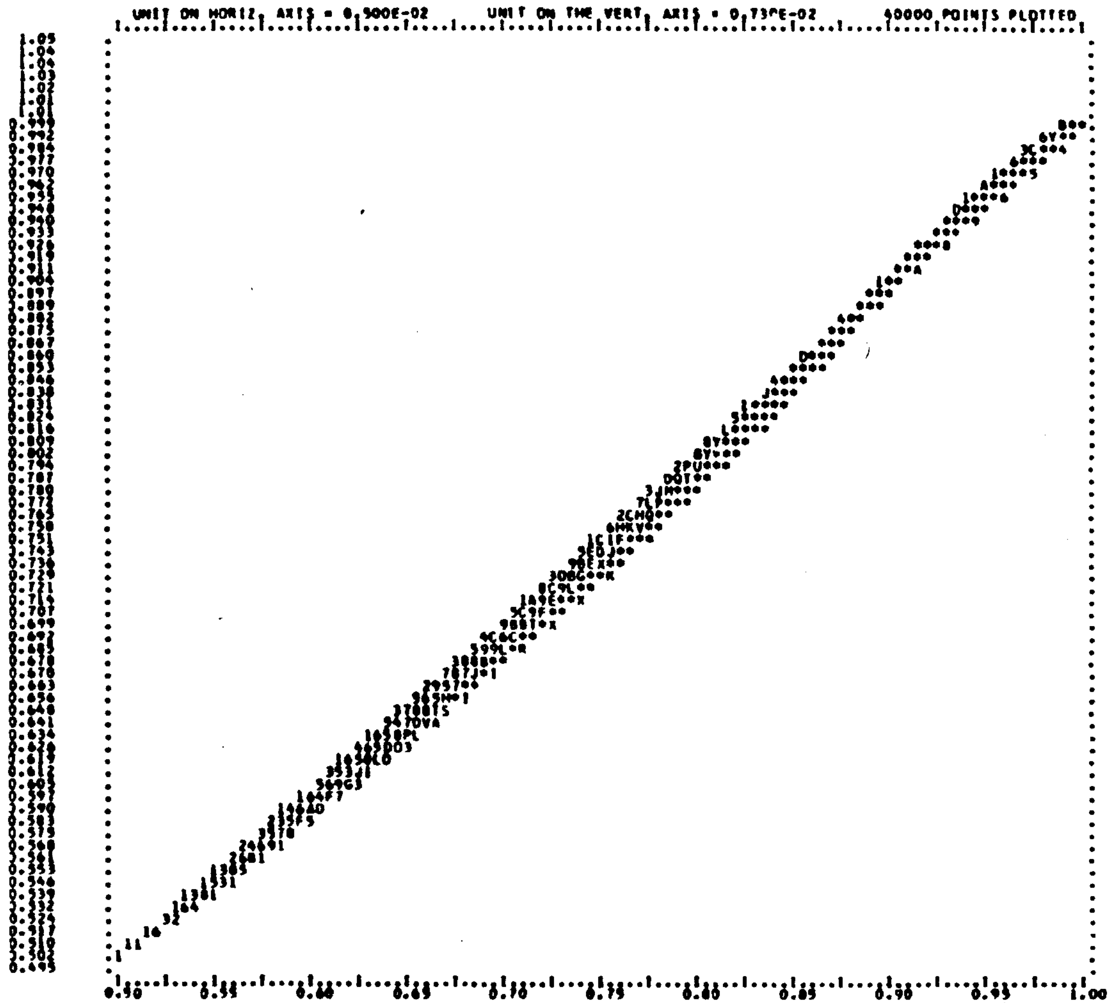


Figure 3. Simulation Result for P_c Versus $B_{erf} = \mathrm{erf}\left(\sqrt{2B}\right)$

2C1. MULTISTAGE CLASSIFICATION

III. PLANS FOR NEXT PERIOD

A. DOCUMENTATION OF SIMULATION ALGORITHM

B. TESTING A NEW "BOTTOM-UP" TREE DESIGN APPROACH

C. TESTING THE EFFECTIVENESS OF NEW SEPARABILITY MEASURE

D. BEGINNING OF FORMULATION OF A TREE DESIGN APPROACH

2C2. CONTEXTUAL CLASSIFICATION

POTENTIAL BENEFITS

1. INCORPORATION OF SPATIAL INFORMATION TO IMPROVE CLASSIFICATION ACCURACY

2. EXPLORATION OF USE OF POWERFUL MULTIPROCESSOR SYSTEM FOR EARTH RESOURCES DATA ANALYSIS

3. DEVELOPMENT OF METHODS FOR IMPLEMENTING AND EVALUATING IMAGE DATA ANALYSIS ALGORITHMS ON PARALLEL PROCESSING SYSTEM

4. EVALUATION OF CDC CYBER-IKON SYSTEM FOR CONTEXTUAL CLASSIFICATION

5. ANALYSIS OF WHICH ARCHITECTURAL FEATURES OF ADVANCED COMPUTER SYSTEMS ARE MOST IMPORTANT FOR EFFICIENT CONTEXTUAL (AND OTHER FORMS OF) CLASSIFICATION

2C2. CONTEXTUAL CLASSIFICATION

OBJECTIVES

1. REFINE CONTEXT DETERMINATION AND REPRESENTATION METHODS

2. DEVELOP METHOD FOR DETERMINING THE OPTIMAL CONTEXTUAL CONFIGURATION

3. DEVELOP MORE EFFICIENT IMPLEMENTATION OF THE CONTEXTUAL CLASSIFIER FOR CONVENTIONAL COMPUTERS

4. INVESTIGATE INCLUSION OF NONSPECTRAL FEATURES

5. EVALUATE CYBER-IKON IMPLEMENTATION OF THE CLASSIFIER
   - -- THROUGH SIMULATION
   - -- ON REAL CYBER-IKON SYSTEM

6. CONSIDER LARGE-SCALE MULTIMICROPROCESSOR IMPLEMENTATIONS

2C2. CONTEXTUAL CLASSIFICATION

FIRST QUARTER ACCOMPLISHMENTS

ALGORITHM DEVELOPMENT

1. EXTENDED TESTS OF MODIFIED CONTEXT ESTIMATION METHOD SUCCESSFUL BUT REQUIRES BLOCKS OF TRAINING DATA

2. IMPLEMENTATION SOFTWARE REFINED TO PREPARE FOR CYBER-IKON IMPLEMENTATION

3. APPROXIMATE ALGORITHM IMPLEMENTED, TESTS BEGUN

4. INITIAL CONTEXT MEASURE IMPLEMENTED FOR PREDICTING BEST CONTEXT CONFIGURATION, TESTS BEGUN

5. "POWER METHOD" IMPLEMENTED FOR CLEANING UP CONTEXT ESTIMATION

2C2. CONTEXTUAL CLASSIFICATION

FIRST QUARTER ACCOMPLISHMENTS (CONT.)

CYBER-IKON IMPLEMENTATION

6. CYBER-IKON SIMULATOR SUCCESSFULLY MOVED TO PDP-11/UNIX SYSTEM AT LARS

7. TECHNICAL INFORMATION RECEIVED FROM CDC AFTER LONG DELAY

8. LARS AND CDC FLOATING-POINT ROUTINES COMPARED

9. TEST OF SIMULATED MAXIMUM LIKELIHOOD CLASSIFIER EXTENDED

10. MODIFIED FLOATING-POINT NUMBER REPRESENTATION DEVELOPED TO MEET REQUIRE-METNS OF CONTEXTUAL CLASSIFIER

11. COMPLETED DEVELOPMENT AND BEGAN MICROCODING CONTEXTUAL CLASSIFIER FOR CYBER-IKON (LINEAR NEIGHBORHOOD VERSION)

2C2. CONTEXTUAL CLASSIFICATION

PROBLEMS ENCOUNTERED

1. METHODS FOR ESTIMATING CONTEXT DISTRIBUTION NOT YET SUFFICIENTLY GENERAL

2. STRONG PREDICTOR OF OPTIMAL CONTEXT CONFIGURATION NOT FOUND

3. BRINGING UP UNIX OPERATING SYSTEM ON PDP-11/34 -- SOLVED THIS QUARTER

4. AVAILABILITY OF CDC CYBER-IKON SYSTEM REMAINS UNCERTAIN. CDC NOW SUPPLYING TECHNICAL DATA REQUESTED

5. INSUFFICIENT EXPONENT RANGE OF AVAILABLE FLOATING-POINT NUMBER FORMAT (FLEXIBLE PROCESSOR). FIX PROPOSED.

2C2. CONTEXTUAL CLASSIFIER

PLANS FOR SECOND QUARTER

ALGORITHM DEVELOPMENT

1. INVESTIGATE IMPACT OF "POWER METHOD" ON PERFORMANCE OF FULL BOOTSTRAP APPROACH TO CONTEXT DISTRIBUTION ESTIMATION
2. CONTINUE SEARCH FOR PREDICTOR OF OPTIMAL CONTEXT CONFIGURATION
3. CONTINUE EVALUATION OF APPROXIMATE ALGORITHM
4. BEGIN INVESTIGATION OF "HYBRID" ALGORITHM WHICH USES CONTEXTUAL INFORMATION IN SELECTIVE, POTENTIALLY MORE EFFICIENT MANNER

2C2. CONTEXTUAL CLASSIFICATION

PLANS FOR SECOND QUARTER (CONT.)

5. COMPLETE TESTS OF MAXIMUM LIKELIHOOD ALGORITHM ON CYBER-IKON SIMULATOR
6. IMPLEMENT AND TEST LINEAR-NEIGHBORHOOD VERSION OF CONTEXTUAL CLASSIFIER ON CYBER-IKON SIMULATOR.
7. IMPLEMENT GENERALIZED-NEIGHBORHOOD VERSION OF CONTEXTUAL CLASSIFIER ON CYBER-IKON SIMULATOR
8. ADD INTER-PROCESSOR COMMUNICATION FACILITIES TO THE CYBER-IKON SIMULATOR
9. OBTAIN TECHNICAL INFORMATION REQUIRED FOR HARDWARE CYBER-IKON IMPLEMENTATION AND NEGOTIATE ACCESS TO THE MACHINE

TASK 2E

AMBIGUITY REDUCTION

FOR TRAINING SAMPLE LABELING

DAVID LANDGREBE

TASK OBJECTIVE

TO DEVISE AND DETERMINE QUANTITATIVE AND OBJECTIVE MEANS FOR OPTIMALLY ARRIVING AT CLASSIFIER TRAINING DOT, FIELD, OR OBJECT LABELS USING REMOTELY SENSED OBSERVATIONS THEMSELVES TOGETHER WITH ANY OTHER TYPES OF ANCILLARY DATA AND KNOWLEDGE WHICH MAY BE AVAILABLE

APPROACH - GENERAL

- ANCILLARY DATA FREQUENTLY IMPRECISE AND SOMETIMES SELF-CONFLICTING
- AMBIGUITY REDUCTION VIEWPOINT APPROPRIATE
- RELAXATION METHODS HAVE BEEN STUDIED FOR A SOMEWHAT SIMILAR PROBLEM

THE FINAL ALGORITHM

$$P(\lambda) \longrightarrow P(\lambda)Q(\lambda)$$

$$P(\lambda) = P(\lambda) \cdot \sum_J D_J \sum_{\lambda'} P_{IJ}(\lambda|\lambda')P_J(\lambda')$$

AND THEN NORMALIZE -- THERE IS A SET OF $P(\lambda)$ ON THE PIXEL, EACH MEMBER OF WHICH IS UPDATED BY THE ABOVE RULE.

AFTER UPDATING, IT IS IMPORTANT THAT THE SET BE NORMALIZED SO THAT THE RESULTS ARE PROPERLY PROBABILITIES

RULE IS

$$P(\lambda) = \frac{P(\lambda) \sum_J D_J \sum_{\lambda'} P_{IJ}(\lambda|\lambda')P_J(\lambda')}{\sum_{\lambda} P(\lambda) \sum_J D_J \sum_{\lambda'} P_{IJ}(\lambda|\lambda')P_J(\lambda')}$$

MOST CLASSIFIERS USED WITH REMOTE SENSING DATA ARE

PIXEL - SPECIFIC

I.E., ALL PIXELS ARE CLASSIFIED (USING SPECTRAL INFORMATION) INDEPENDENTLY OF THE CLASSIFICATION OF NEIGHBORING PIXELS. NO SPATIAL INFORMATION IS USED.

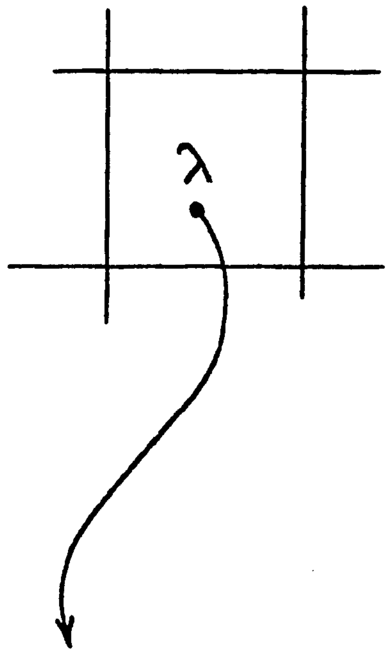
ECHO AND OTHER CONTEXT CLASSIFIERS INCORPORATE SPATIAL INFORMATION (I.E., CONTEXT) IN A REDEFINITION OF THE CLASSIFIER ALGORITHM. (A PRIORI)

CAN SPATIAL CONTEXT BE DEVELOPED ON A CLASSIFICATION MAP (E.G., CLASSIFYPOINTS RESULTS FILE) AFTERWARDS? (A POSTERIORI)

ANSWER LIES IN <u>LABEL RELAXATION PROCEDURES</u>

(NOTE "CLASSIFICATION" $\equiv$ "LABELING")

DEVELOPMENT OF
RELAXATION LABELING ALGORITHM



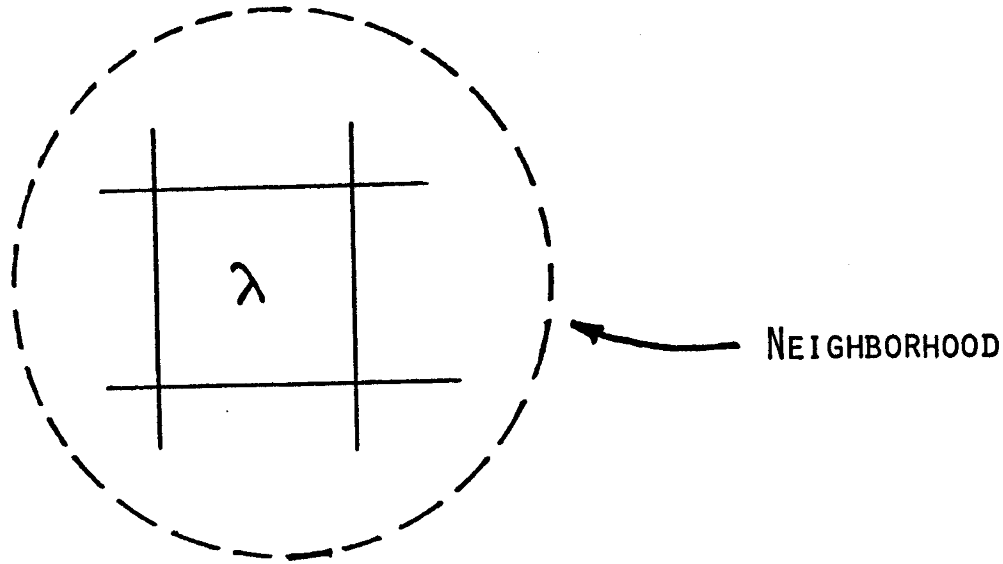
λ IS A LABEL

E.G., WHEAT, CORN, NON-WHEAT, ETC.

-- ASSIGNED BY A CLASSIFIER

DESCRIBE THE RELATIVE LIKELIHOODS OF THE LABELS FOR A PARTICULAR PIXEL BY A SET OF PROBABILITIES

$P(\lambda)$ -- I.E. $P(\lambda_1)$, $P(\lambda_2)$, . . .

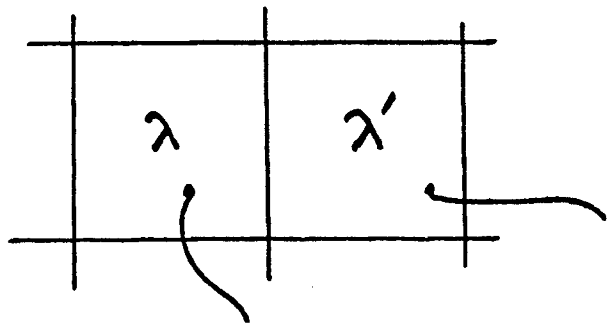


$$P(\lambda) \xrightarrow{\text{UPDATE}} P(\lambda)Q(\lambda)$$

"CONTRIBUTION" FROM

THE NEIGHBORHOOD

FORM OF THE NEIGHBORHOOD FUNCTION $Q(\lambda)$



CALL THIS PIXEL J

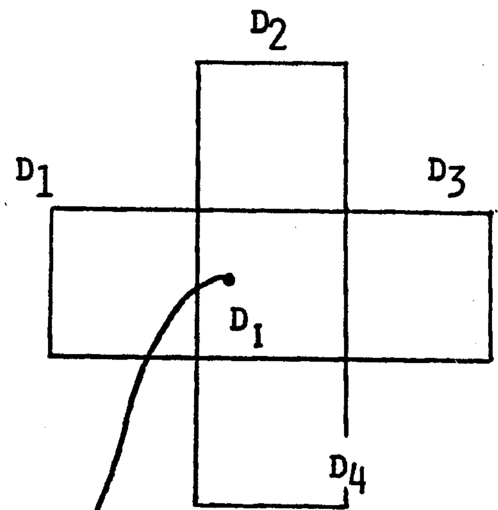
CALL THIS PIXEL I

FOR THIS PIXEL $\quad Q_I(\lambda) \sim \dfrac{P_{IJ}(\lambda|\lambda')P_J(\lambda')}{\sum_{\lambda'} P_{IJ}(\lambda|\lambda')P_J(\lambda')}$

$P_{IJ}(\lambda|\lambda')$ = PROBABILITY THAT I HAS LABEL λ

IF J HAS LABEL λ'.

THE NEIGHBORHOOD



$$Q(\lambda) = \sum_{J} D_J \sum_{\lambda'} P_{IJ}(\lambda|\lambda')P_J(\lambda')$$

SUMMED OVER THE NEIGHBORHOOD, INCLUDING THE PIXEL ITSELF

CALL THESE THE "NEIGHBOR WEIGHTS" --THEY TURN OUT TO BE QUITE IMPORTANT

THE RELAXATION PROCEDURE

1. FOR EACH PIXEL IN AN IMAGE, OBTAIN A COMPLETE SET OF PROBABILITIES $P(\lambda)$

   -- THESE ARE CALLED THE INITIAL LABEL ESTIMATES --

ITERATE

2. MOVE OVER THE IMAGE PIXEL BY PIXEL, UPDATING THE LABEL PROBABILITY ESTIMATES BY REFERENCE TO THE NEIGHBORHOOD INFORMATION

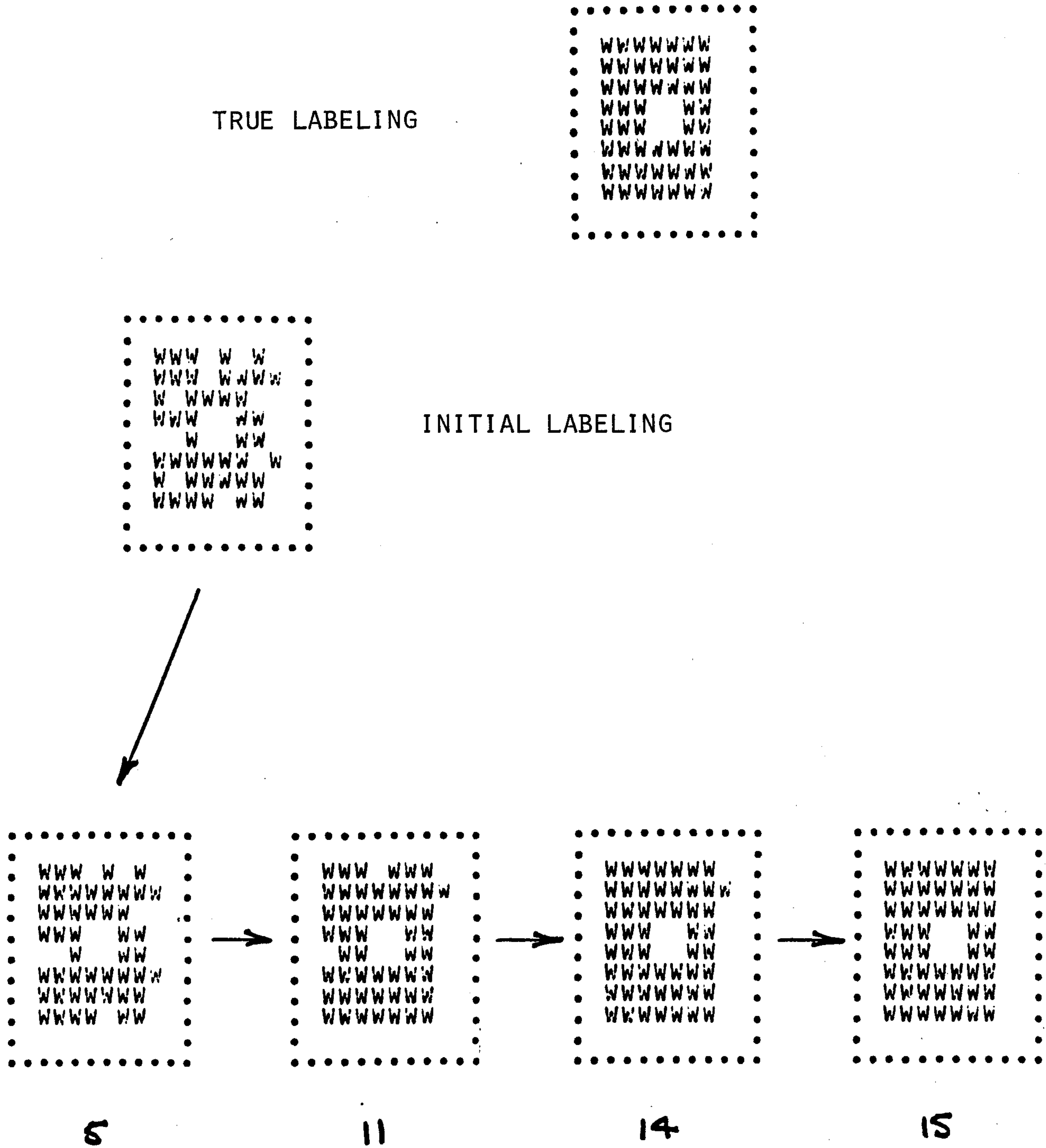
3. AS SPATIAL CONSISTENCY IS DEVELOPED, THE SET OF PROBABILITIES AT EACH PIXEL WILL MOVE TOWARDS SOMETHING LIKE

   $$0,0,1,0,0$$

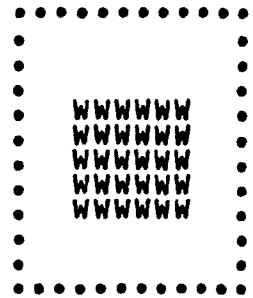
   I.E., ONLY <u>ONE</u> LABEL IS RECOMMENDED SINCE ALL OTHERS HAVE ZERO PROBABILITY OF OCCURRENCE **IN** VIEW OF BOTH SPECTRAL INFORMATION (FROM THE INITIAL CLASSIFICATION) AND SPATIAL INFORMATION (APPLIED BY THE RELAXATION ALGORITHM)

   SUCH A SITUATION IS CALLED A <u>FIXED POINT</u>.

   AT THIS STAGE THE LABELING IS UNAMBIGUOUS, WHEREAS THERE WAS INITIAL AMBIGUITY FROM THE CLASSIFIER AS EVIDENT IN THE <u>SET</u> OF (NON-ZERO) PROBABILITIES FOR EACH PIXEL.

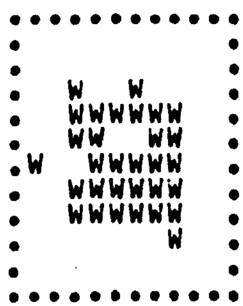


NUMBER OF ITERATIONS OF RELAXATION

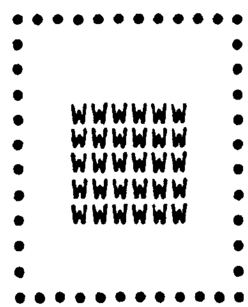


TRUE
LABELING

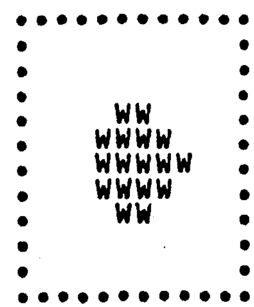
$p_{ij}(W|W) = 0.817$
$p_{ij}(\underline{b}|\underline{b}) = 0.908$
$\underline{b} \equiv$ blank



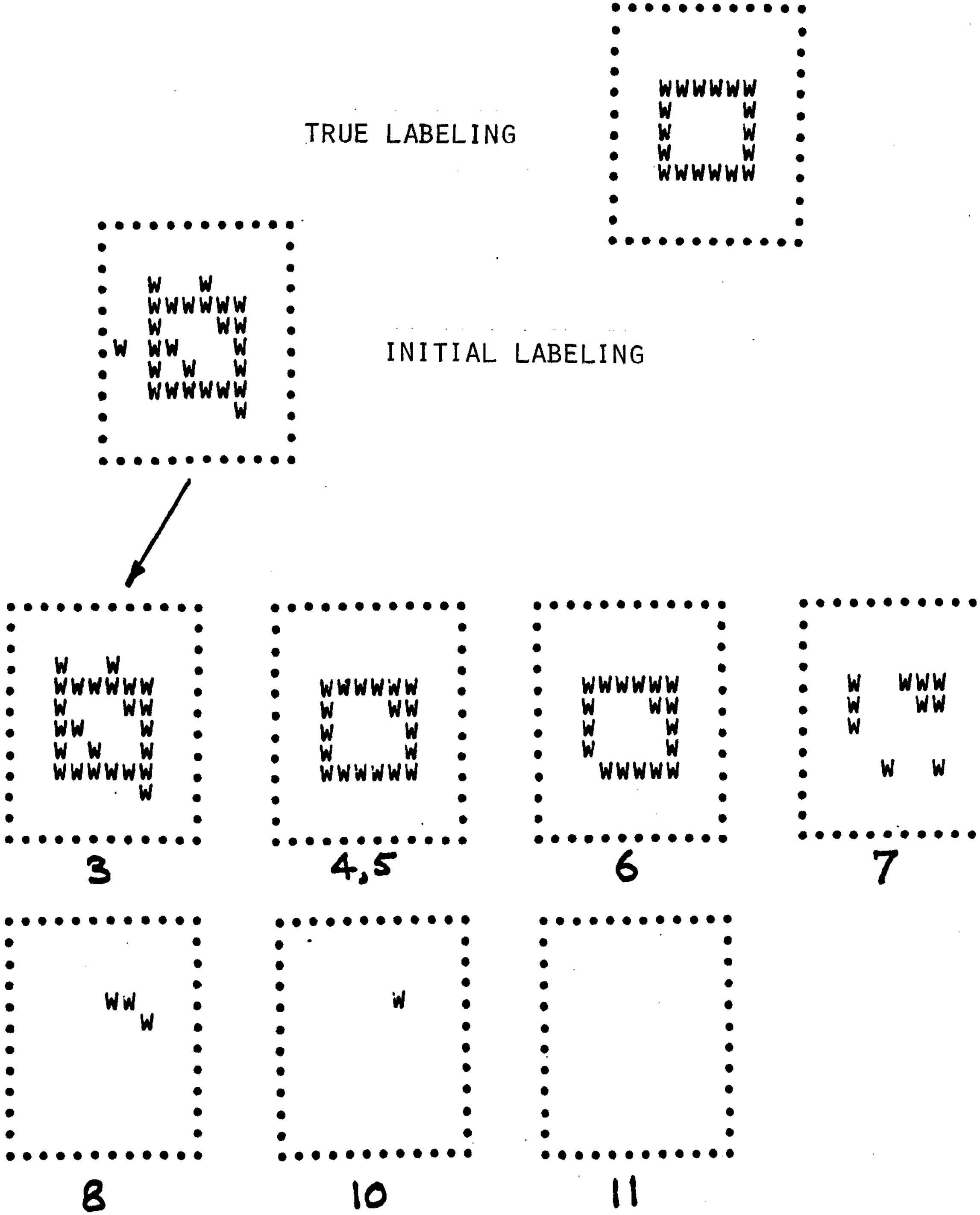
INITAL
LABELING

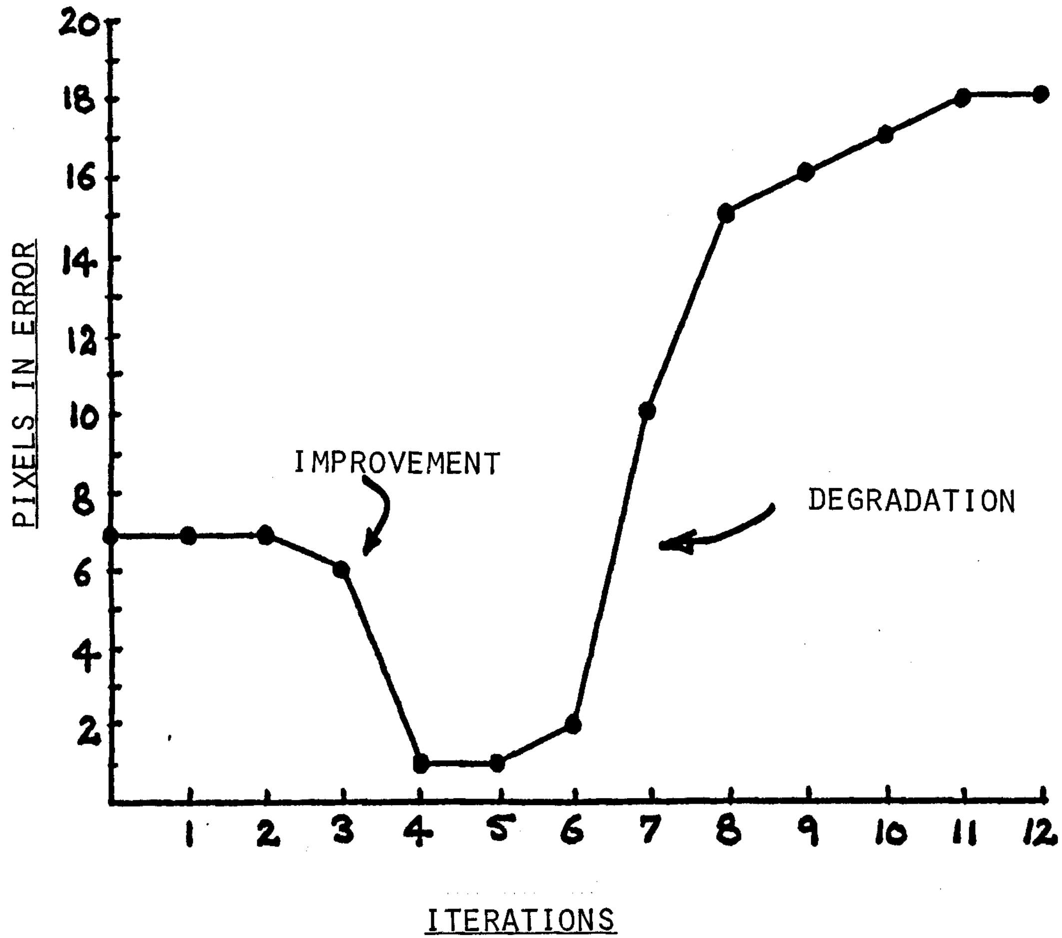


7 ITERATIONS



FINAL
LABELING
110 ITERATIONS
(Fixed point at
~125 Iterations)


TRUE LABELING
INITIAL LABELING
3
4,5
6
7
8
10
11



PIXELS IN ERROR
20
18
16
14
12
10
8
6
4
2
IMPROVEMENT
DEGRADATION
1
2
3
4
5
6
7
8
9
10
11
12
ITERATIONS

TEST OF RELAXATION ON REAL DATA

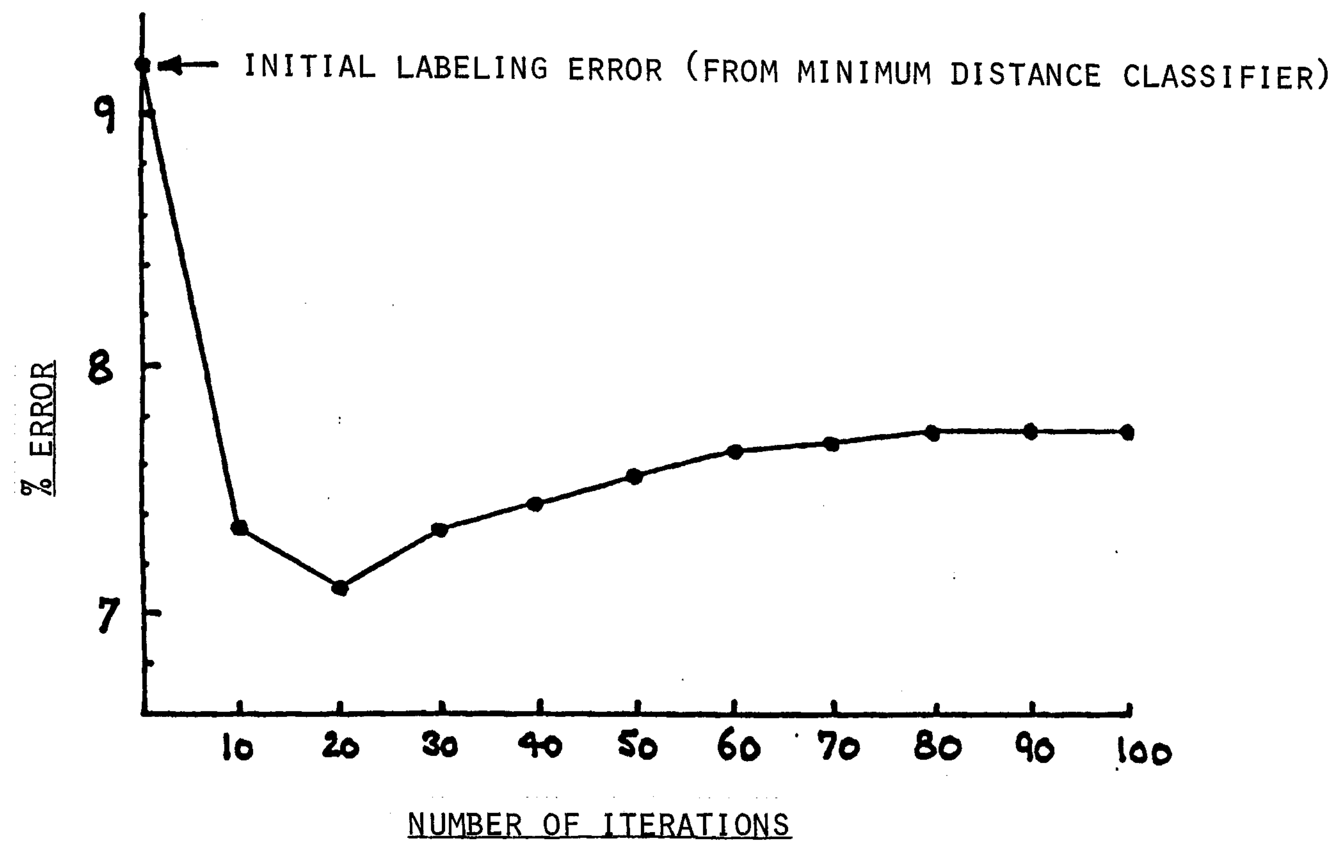
LACIE SEGMENT 1163

(COFFEE COUNTY, KANSAS)

CLASSIFIED INTO WHEAT AND NON-WHEAT (FALLOW, NON SMALL GRAINS AND OTHER) USING A MINIMUM DISTANCE TO MEANS CLASSIFIER. ONLY THE BEST THREE OF THE 16 POSSIBLE CHANNELS WERE USED.

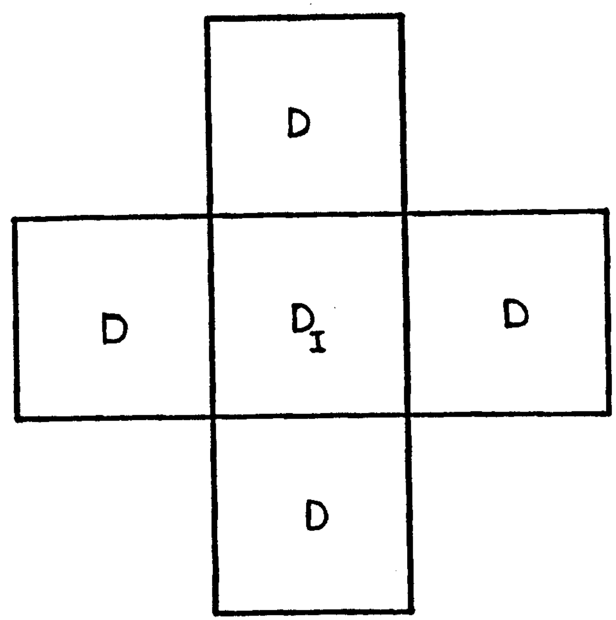
TOTAL CLASSIFICATION ERROR = 9.2% BEFORE RELAXATION. MEASURED BY USING ERIM GROUND TRUTH TAPE FOR THE SEGMENT.

RELAXATION APPLIED TO LACIE 1163



RECALL $Q(\lambda) = \sum_J D_J \sum$ etc...

NEIGHBOR WEIGHTS

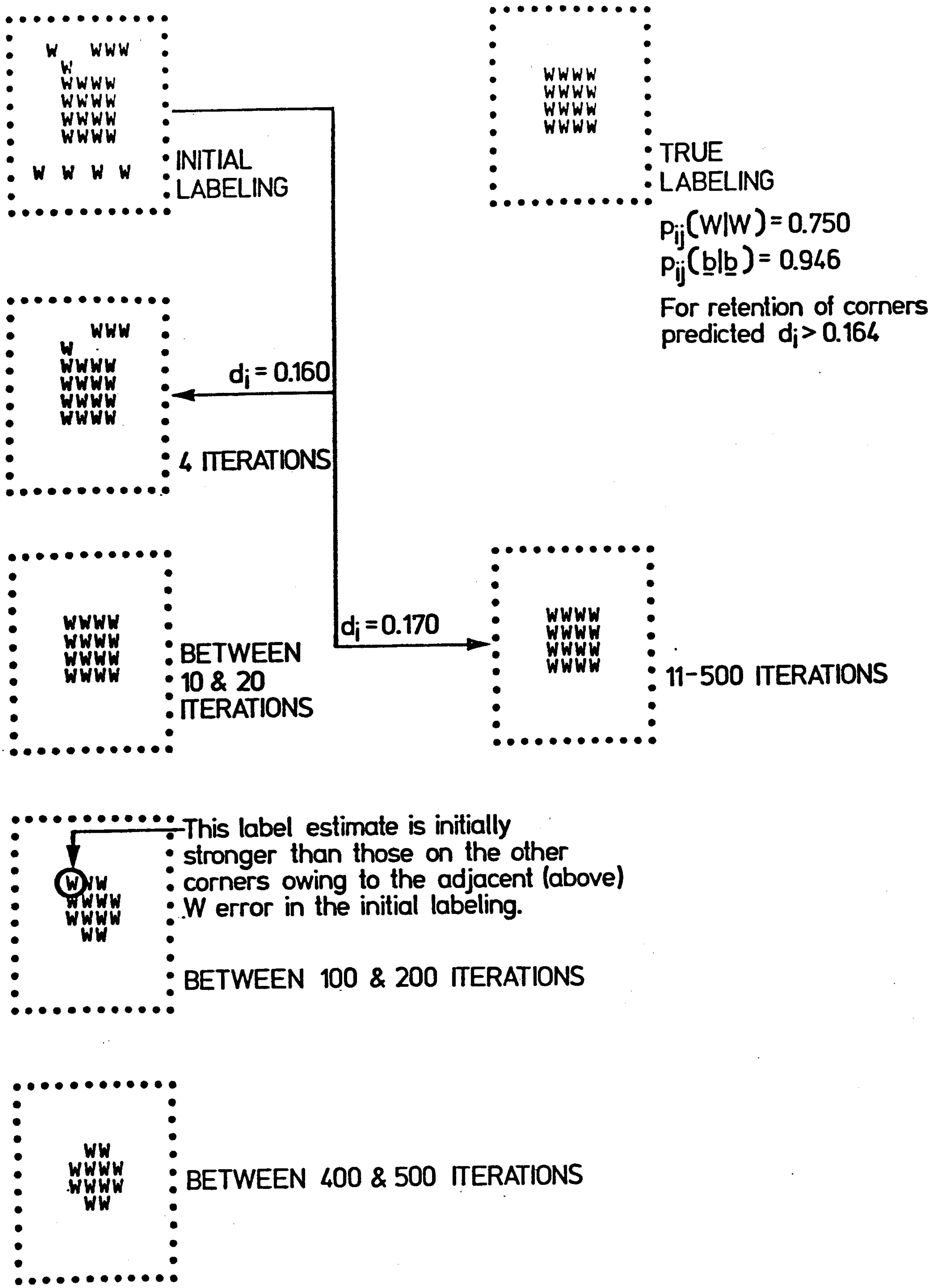


NEED TO CHOOSE D_I RELATIVE TO D TO PRESERVE GEOMETRIES IN EACH CLASS (LABEL)

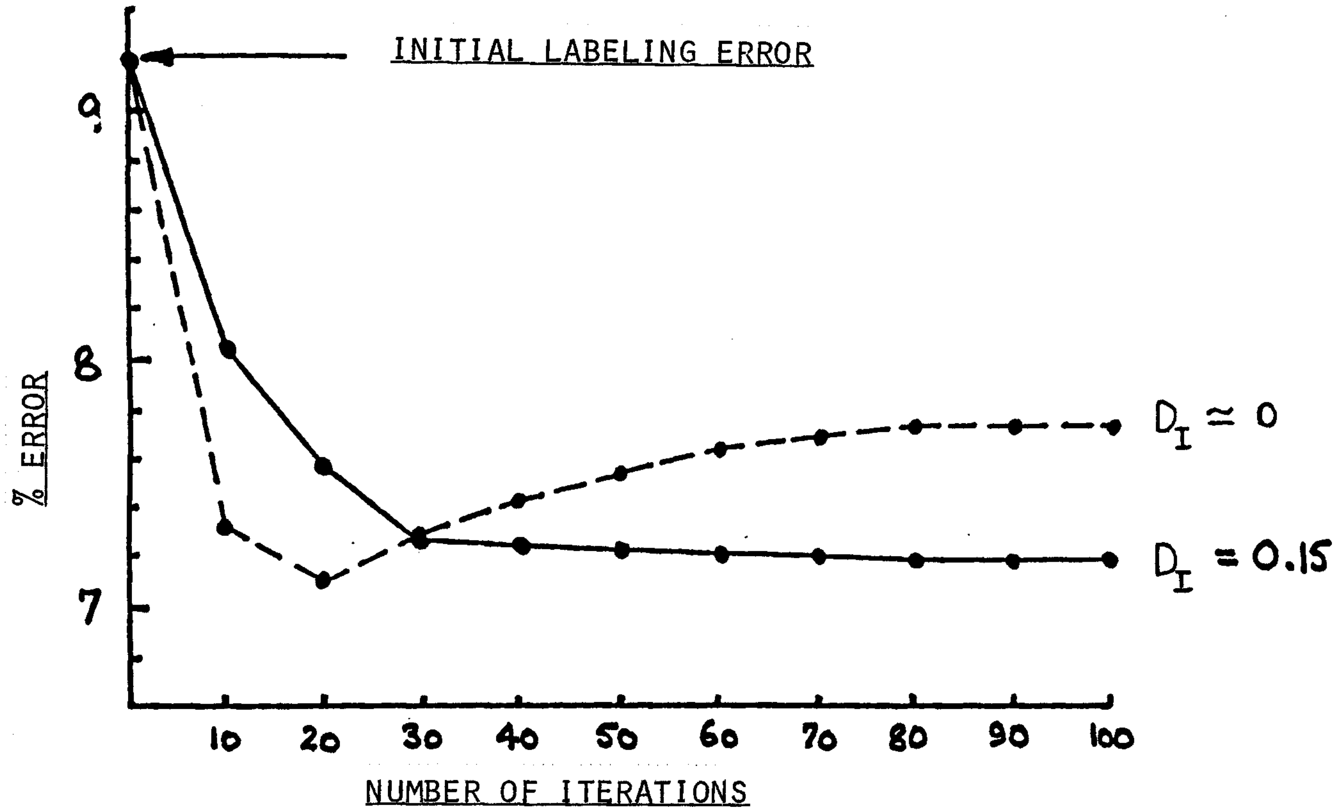
FOR EXAMPLE: CORNERS

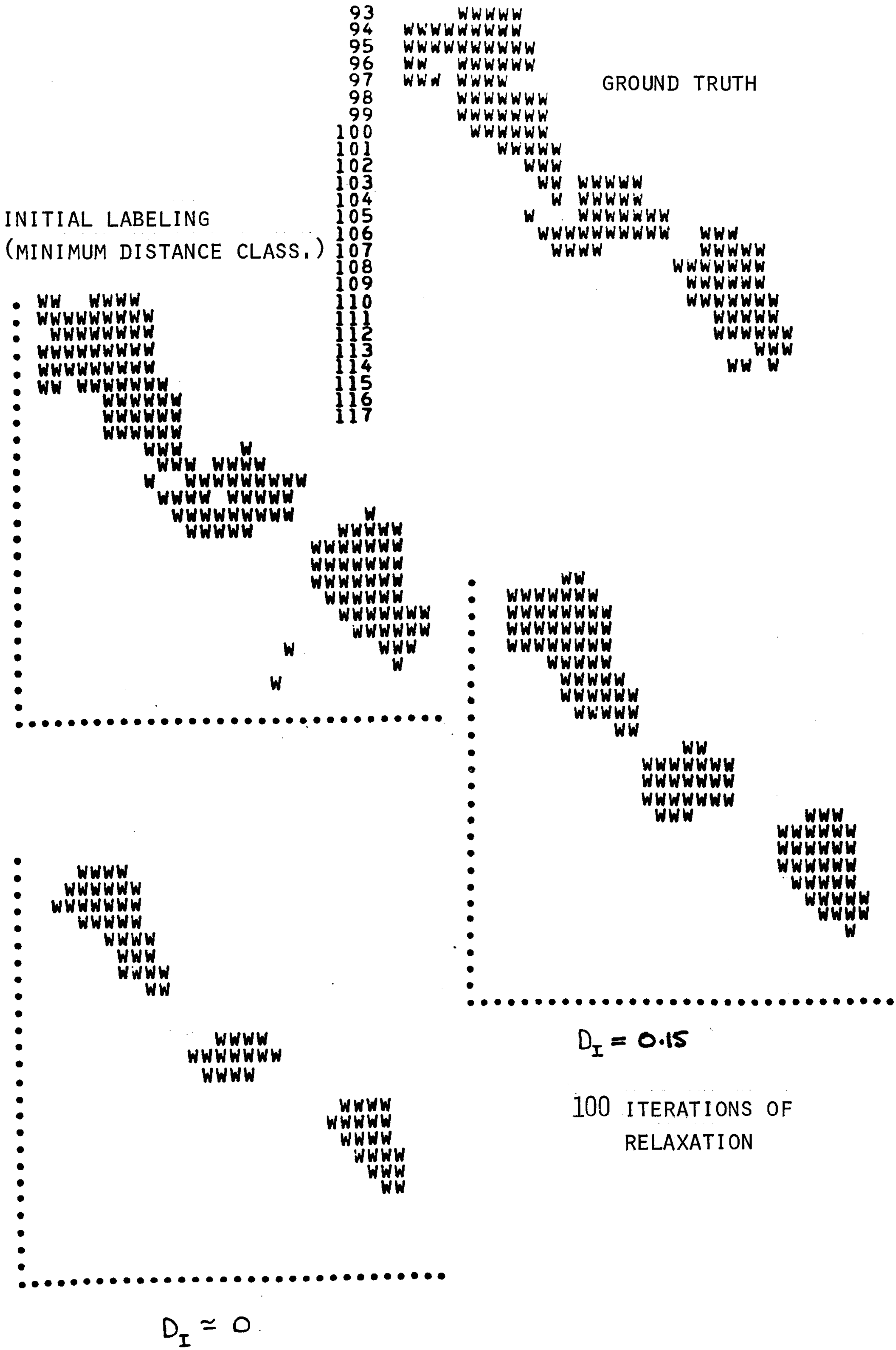
ENDS OF LINES

SINGLE PIXELS

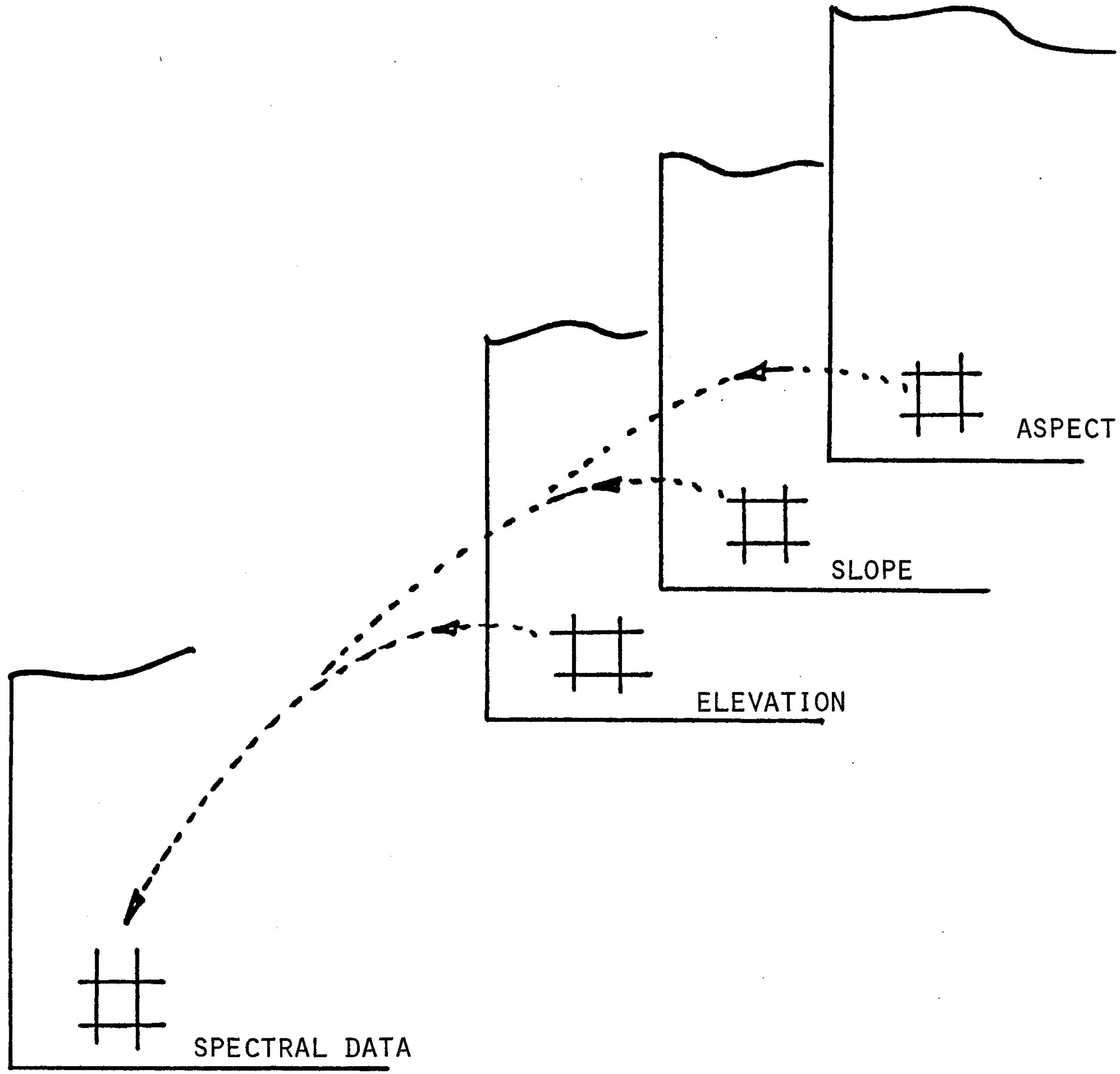

W WWW
W
WWWW
WWWW
WWWW
WWWW
W W W W
INITIAL LABELING
WWWW
WWWW
WWWW
WWWW
TRUE LABELING
$p_{ij}(W|W) = 0.750$
$p_{ij}(\underline{b}|\underline{b}) = 0.946$
For retention of corners predicted $d_i > 0.164$
WWW
W
WWWW
WWWW
WWWW
WWWW
$d_i = 0.160$
4 ITERATIONS
WWWW
WWWW
WWWW
WWWW
BETWEEN 10 & 20 ITERATIONS
$d_i = 0.170$
WWWW
WWWW
WWWW
WWWW
11-500 ITERATIONS
This label estimate is initially stronger than those on the other corners owing to the adjacent (above) W error in the initial labeling.
WWW
WWWW
WWWW
WW
BETWEEN 100 & 200 ITERATIONS
WW
WWWW
WWWW
WW
BETWEEN 400 & 500 ITERATIONS

RELAXATION APPLIED TO LACIE 1163

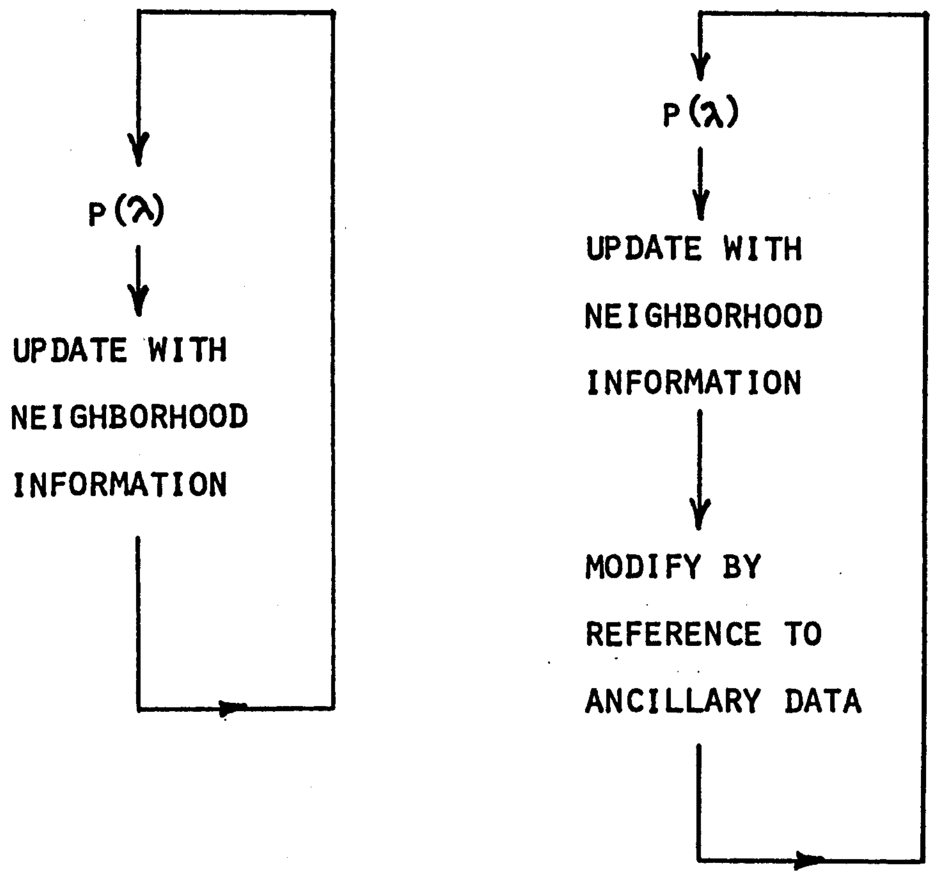



93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
GROUND TRUTH
INITIAL LABELING
(MINIMUM DISTANCE CLASS.)
$D_I = 0.15$
100 ITERATIONS OF RELAXATION
$D_I \simeq 0$

USE OF ANCILLARY DATA



RELAXATION USING ANCILLARY DATA

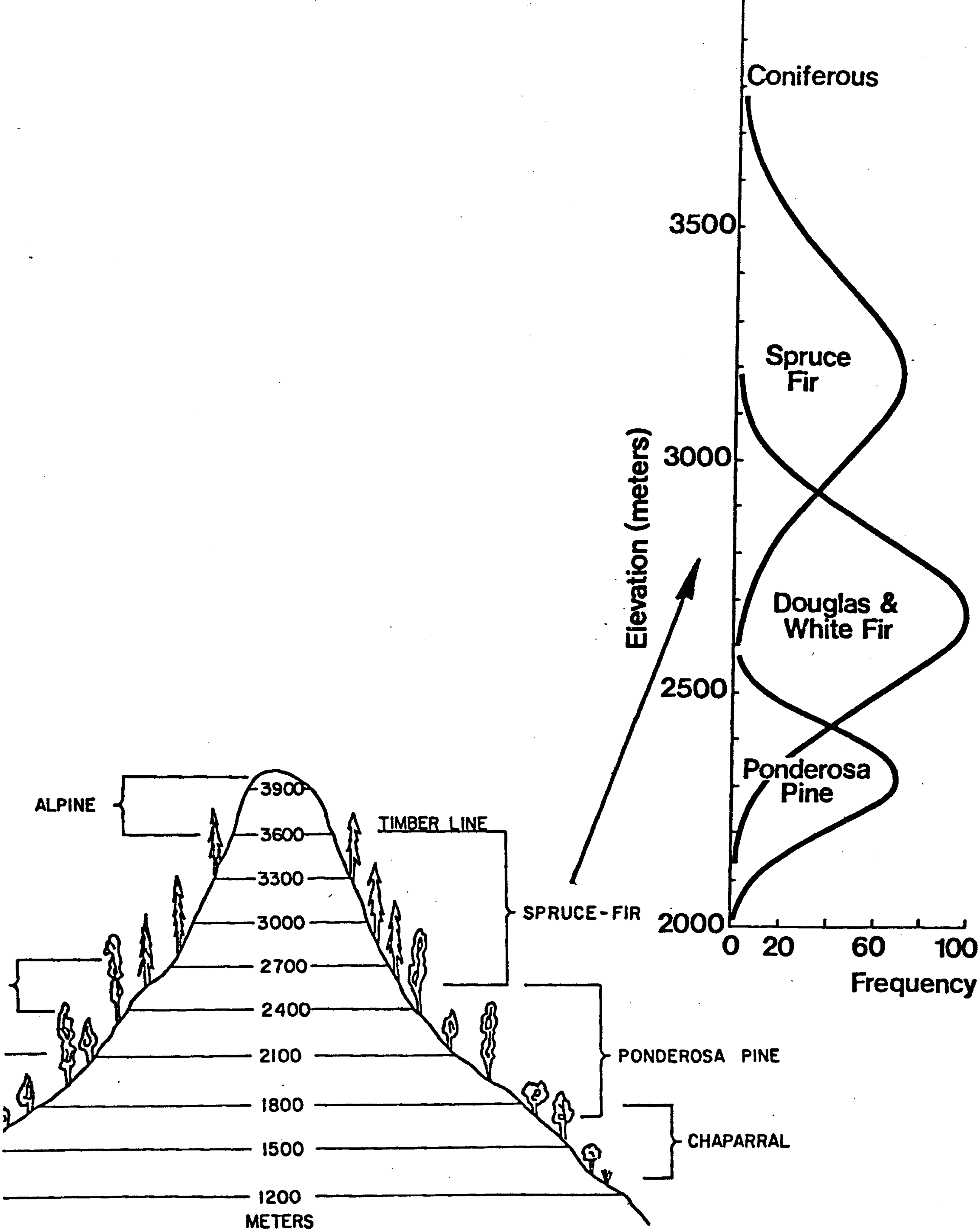


UNSUPERVISED

(NORMAL ALGORITHM)

SUPERVISED

SPECIES DISTRIBUTIONS VS ELEVATION
AS ANCILLARY DATA



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ASPECTS TO BE INVESTIGATED

- o INITIAL LABEL METHODS AND SENSITIVITY
- o MULTILABEL RELAXATION METHODS
- o ANCILLARY DATA QUESTIONS
  - CLASSES OF ANCILLARY DATA
  - MULTIPLE ANCILLARY DATA METHODS
- o PARAMETER SENSITIVITY QUESTIONS
- o APPLICATION SCENARIO

WE WILL NEXT GIVE PRIMARY ATTENTION TO THE SECOND AND THIRD OF THESE ITEMS.

ASPECTS TO BE INVESTIGATED

- o INITIAL LABEL METHODS AND SENSITIVITY
- o MULTILABEL RELAXATION METHODS
- o ANCILLARY DATA QUESTIONS
  - CLASSES OF ANCILLARY DATA
  - MULTIPLE ANCILLARY DATA METHODS
- o PARAMETER SENSITIVITY QUESTIONS
- o APPLICATION SCENARIO

WE WILL NEXT GIVE PRIMARY ATTENTION TO THE SECOND AND THIRD OF THESE ITEMS.

Task 3A

Computer Processing Support

James L. Kast

COMPUTER PROCESSING SUPPORT

OBJECTIVE: PROVIDE JSC AND ITS ASSOCIATED RESEARCH COMMUNITY WITH THE ENVIRONMENT NECESSARY FOR THE IMPLEMENTATION OF A SHARED DATA PROCESSING SYSTEM FOR RESEARCH OF REMOTE SENSING.

PURDUE'S SUPPORT HAS INCLUDED:

* A COMPUTER AND SUPPORTING HARDWARE
* SOFTWARE
* DATA
* PERSONNEL
* PROCEDURES
* TRAINING

The Full Implementation of a Shared Data Processing Environment (network or centralized facility) Would Provide the Following Potential Benefits:

* The opportunity to better mold geographically-dispersed research groups into a more informed and integrated research team;

* A mechanism for efficient transfer of information between research centers, NASA, and other participating government agencies;

* Faster, less redundant software development;

* Faster transfer of newly developed analysis techniques and research results to and from participating research groups;

* Concentration of systems programming, data acquisition, data base and certain computer services at a small number of locations (frequently one).

IN ORDER FOR A PROMISING NEW ANALYSIS TECHNIQUE TO BE SHARED, WITHIN THE RESEARCH COMMUNITY, RECIPIENTS OF THE NEW TECHNIQUE MUST HAVE:

* ACCESS TO THE SOFTWARE SUPPORTING THE TECHNIQUE;

* ACCESS TO HARDWARE WHICH SUPPORTS THE SOFTWARE;

* ACCESS TO THE DATA REQUIRED BY THE TECHNIQUE;

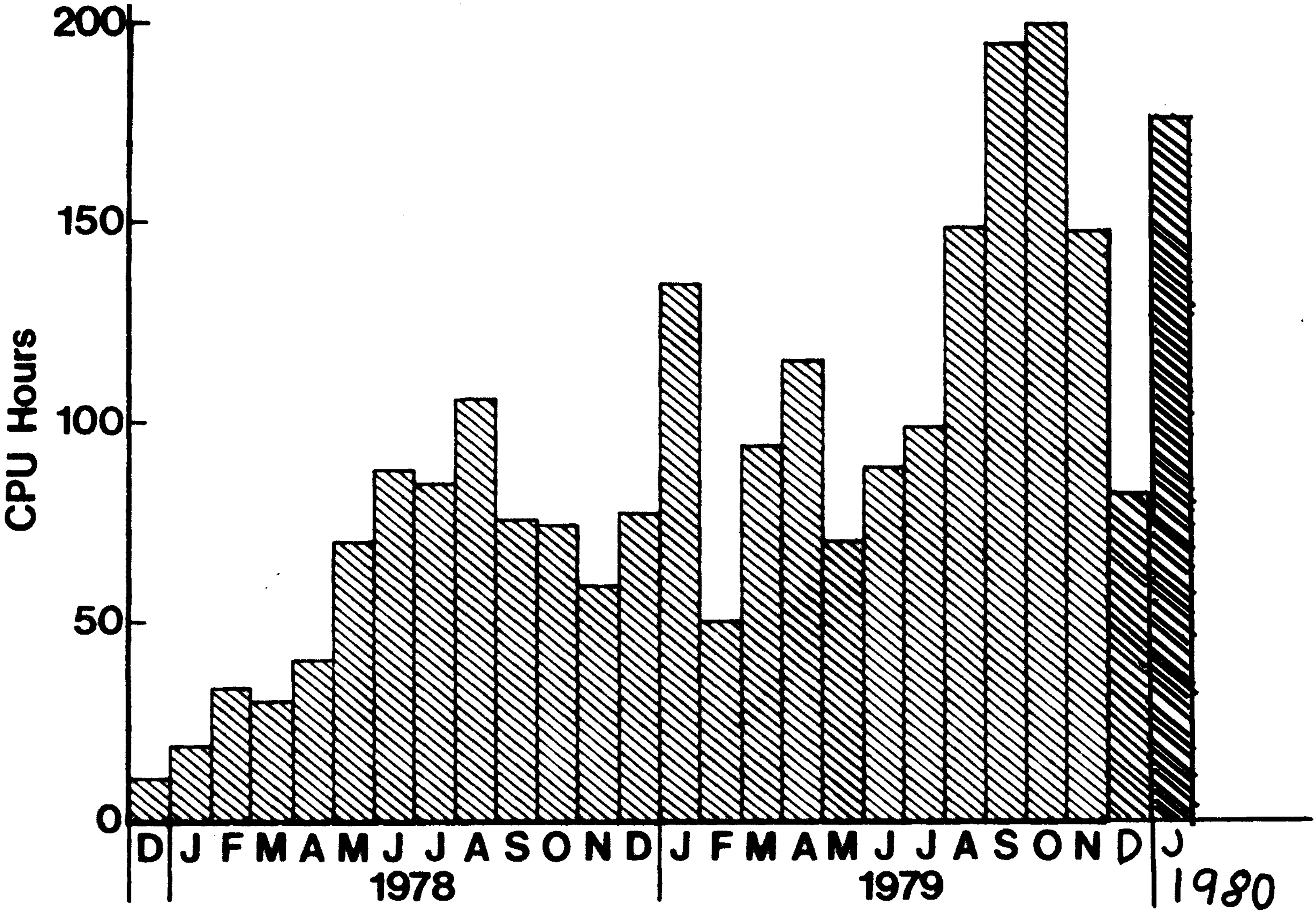
* A TECHNICAL UNDERSTANDING OF THE TECHNIQUE; AND

* KNOWLEDGE OF HOW TO OPERATIONALLY USE THE IMPLEMENTATION (SOFTWARE AND PROCEDURES).

JLK:12/4/79

COMPUTER RESOURCES CONSUMED

	Dec '77	Nov '78	Nov '79	Feb '80
JSC Users	26	71	96	129
Total ID's	29	95	123	164
370/148 CPU Hours, *year ending	70	694	1374	



Computer Processing Support
370/148-equivalent CPU Consumption

Goals for Support of ERSYS/EODLS

Expand the shared data processing environment to more fully include ERIM and FCPF.

Help prepare for the installation of a 4341-class computer at JSC/EOD.

Support the design and development of ERSYS

Software Related Tasks

Accomplishments:

- Prepared and conducted the CMS Portion of the 4341 Benchmark (Jan. 1980)
- Upgraded the User Group Accounting Program (Jan. 1980)
- Acquired SAS at University Rates (Feb. 1980)

Plans:

- Upgrade of Computer Resource Request Software (March 1980)
- Identification of status of all LARS software of interest for ERSYS (April 1980)
- Generation of bare-machine OS/VS1 system (March 1980)
- * Support OS/VS1 Benchmarks (real, virtual, CMS loaded) (March-April 1980)
- Support Development of Software and Documentation Conventions and Standards (May 1980)
- Installation of Edition 7 Mod 1 of IMSL (April 1980)
- Develop Tektronix-GCS Interface (June 1980)

Related Milestones:

- Installation of Release 6 of CP and CMS, Installation of BSEPP 2 (Feb. 1980)
- Installation of ERIPS on LARS (April 1980)
- Spectro-Met Crop Calendar Delivery (Aug. 1980)
- Remove CMS 360 from the system (Dec. 1979)

* Not yet funded

HARDWARE TASKS

ACCOMPLISHMENTS:

RECOMMEND APPROACH FOR ERIM ACCESS TO JSC/PURDUE COMPUTER (JAN. 1980)

HARDWARE PLANS:

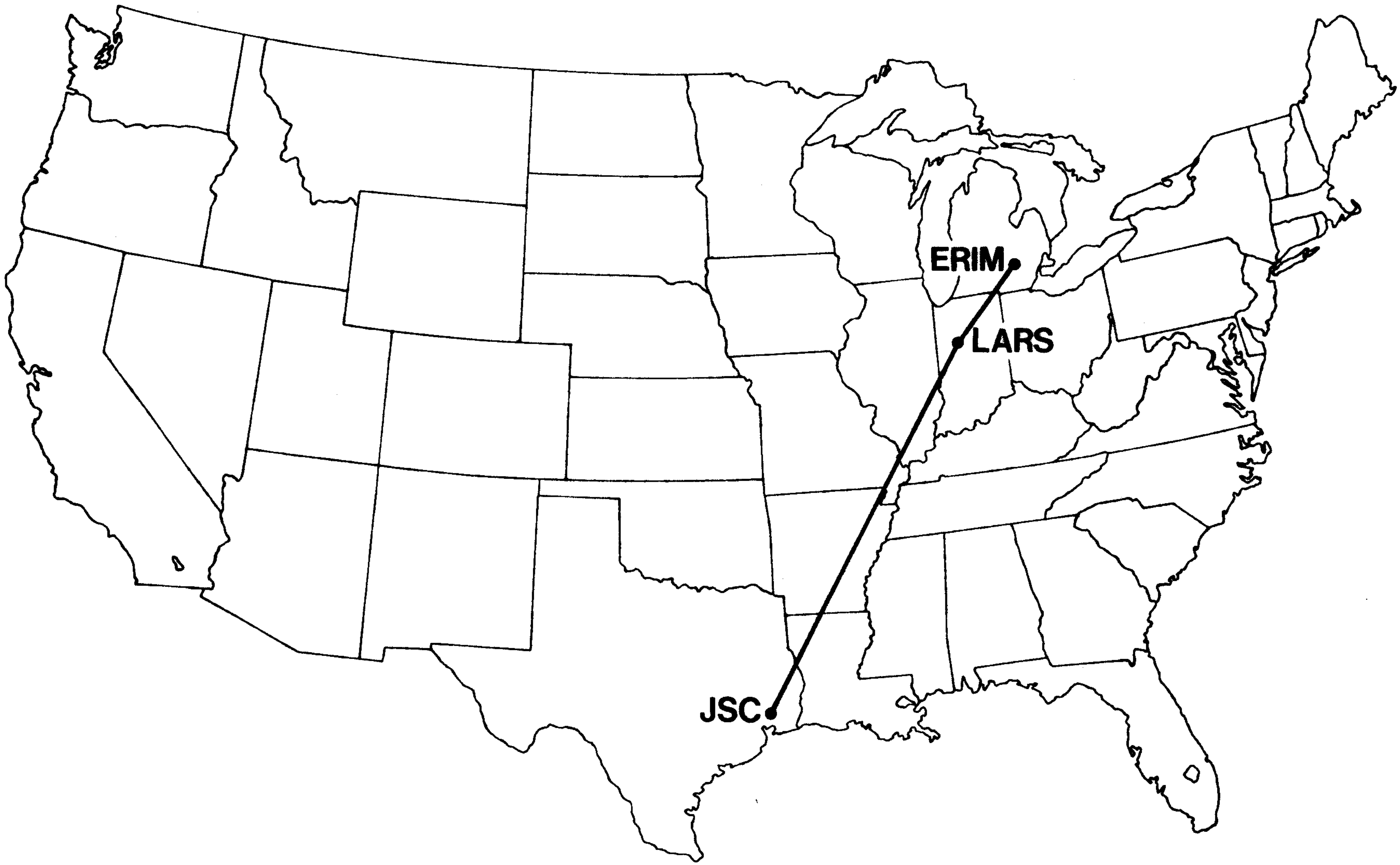
- * DEDICATION OF TWO 3330-COMPATIBLE DISKS TO JSC (APRIL 1980)
- INSTALL ERIM HARD-WIRED TERMINALS (APRIL-MAY 1980)
- INSTALL ADDITIONAL JSC PORTS (APRIL-MAY 1980)
- * MODIFY COMMUNICATIONS CONFIGURATION TO SUPPORT NETWORK (NOV. 1980)

RELATED MILESTONES:

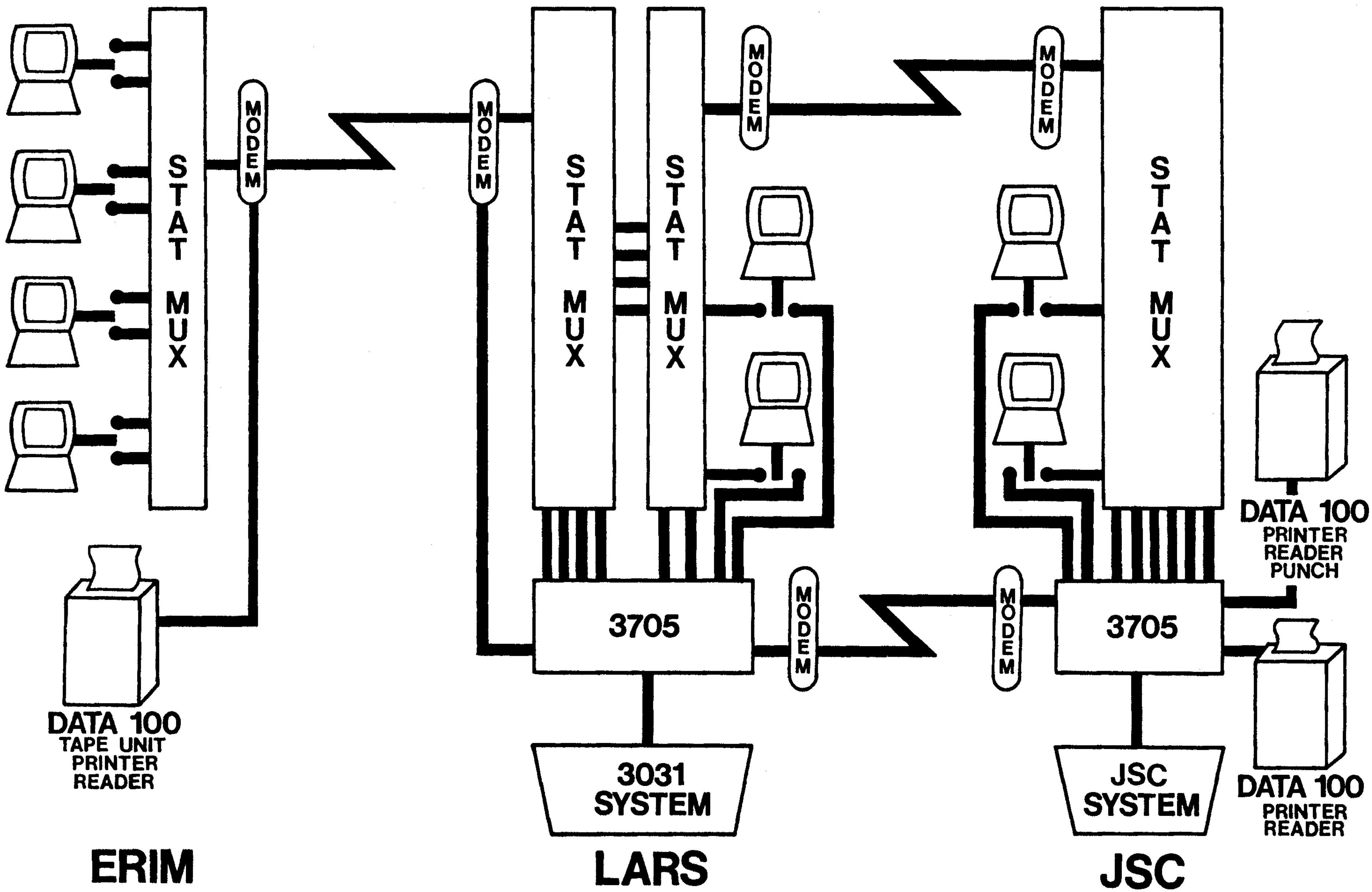
INSTALLATION OF 33502 DISK SYSTEM (APRIL 1980)

6250 BPI TAPE INSTALLATION (OCT. 1980)

*NOT YET FUNDED


ERIM
LARS
JSC

EOD TERMINAL NETWORK



Data Base Tasks

Accomplishments:

- Received, verified, and entered into data base Crop Year 1978 Corn/Soybean Segments (Feb. 1980)
- Supported Alternative System Design Committee (Jan. 1980)
- Design "Dot" augmentation to RTE Data Base (Feb. 1980)

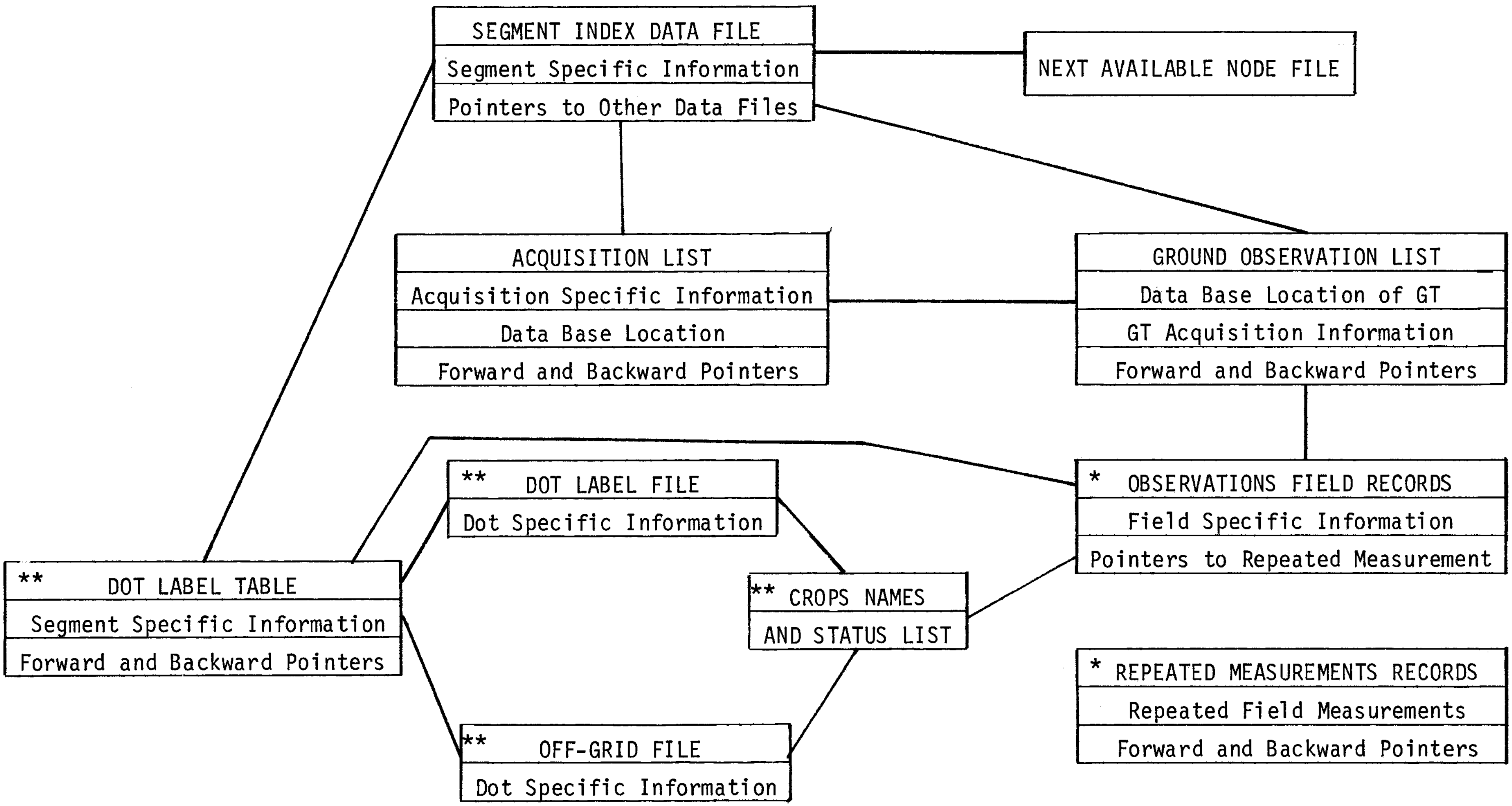
Plans:

- Integration of "Dot" Ground Inventory System in RT&E Data Base (Apr. 1980)
- Enter Crop Year 1978 Small Grains Segments in RT&E Data Base (Mar. 1980)
- Enter Crop Year 1979 Data in RT&E Data Base (May-June 1980)
- Re-organize Tape Library (March 1980)

Related Milestones:

- Installation of IMS Data Base to support ERIPS (May 1980)
- Installation of ERSYS Data Base Management System (May 1980)

SEGMENT CATALOG



* Not implemented
** Implementing

Consulting, Training and Communication

Accomplishments:

- Present CMS Short Course at JSC (Dec. 1979)
- Support Alternative Systems Design Committee (Jan.1980)
- Visiting Consultant Trips (Feb. 1980)
- Support ERSYS Design Planning (Feb. 1980)

Plans:

- Present CMS Short Course at ERIM (April-May 1980)
- Visiting Consultant Trips (bi-monthly)
- Provide opportunity for VM systems maintenance experience at LARS to IBM personnel
- Consult with IBM on ERSYS development
- Publish Major Operating and Applications Systems Modifications in SCAN LINES and SRTNEWS
- CMS Short Course Tape/Slide Module available (May 1980)

Related Milestone:

- LARSPEC Users' Guide available (Feb. 1980)

ISSUES

SHOULD A SECOND CMS SHORT COURSE BE PRESENTED AT JSC?

SHOULD IBM FSD AND NASA PERSONNEL BE STATIONED AT LARS FOR A MONTH TO SIX WEEKS TO LEARN HOW THE LARS COMPUTER FACILITY IS RUN AND MAINTAINED (SYSTEMS, ORGANIZATION, PROCEDURES, ETC.)?

CAN LARS' KNOWLEDGE OF CMS, EXPERTISE IN REMOTE SENSING APPLICATIONS AND DATA CORRELATION, AND EXPERIENCE WITH AN IMAGE FILE MANAGER (THE RT&E DATA BASE) BE UTILIZED IN THE DESIGN OF THE ERSYS DATA BASE?

WHAT IS THE STATUS OF THE WEATHER DATA BASE?

WHEN WILL DOCUMENTATION STANDARDS AND PROGRAMMING CONVENTIONS BE ESTABLISHED FOR ERSYS?

WHAT IS THE LONG TERM ROLE OF THE LARS COMPUTATIONAL FACILITY?

Task 3B

Field Research Data Base Management and Data Distribution

LARRY L. BIEHL

FIELD RESEARCH DATA BASE MANAGEMENT AND DISTRIBUTION

OVERALL OBJECTIVE

- ASSURE TIMELY AVAILABILITY TO RESEARCHERS OF THE JOHNSON SPACE CENTER FIELD RESEARCH DATA STORED AT PURDUE/LARS.

SPECIFIC OBJECTIVES FOR 1980 (AND TARGET COMPLETION DATE)

1. DISTRIBUTE FIELD RESEARCH DATA FOR ALL APPROVED REQUESTS

2. MAINTAIN AND UPDATE PRESENT DATA BASE

    - INCLUDE BALANCE OF 1979 DATA (4/1/80)

    - INCLUDE AVAILABLE 1980 (11/30/80)

    - ADD ADDITIONAL IDENTIFICATION INFORMATION TO SOILS DATA (7/1/80)

    - ADD ADDITIONAL IDENTIFICATION INFORMATION TO CROP DATA (11/30/80)

3. REVISE AND UPDATE FIELD RESEARCH CATALOG. (5/1/80 & 11/30/80)

SPECIFIC OBJECTIVES FOR 1980 (AND TARGET COMPLETION DATE) CON'T.

4. SOFTWARE DEVELOPMENT & DOCUMENTATION

- PROCESSING SOFTWARE
  - REVISE FSS SOFTWARE FOR MORE EFFICIENT HANDLING OF THE DATA (2/15/80)
  - UPDATE DOCUMENTATION FOR PROCESSING SOFTWARE: (8/31/80)
  - REVISE CLEVENGER SPECTROMETER SYSTEM SOFTWARE (4/30/80)
- ANALYSIS SOFTWARE
  - COMPLETE LARSPEC USER'S MANUAL (2/15/80)
  - EXPAND LARSPEC PUNCH CAPABILITY FOR IDENTIFICATION RECORD DATA (4/30/80)
  - ADD DECWRITER TERMINAL AS MEDIUM RESOLUTION GRAPHICS DEVICE (4/30/80)
  - ADD CAPABILITY TO LARSPEC TO PLOT DIFFERING WAVELENGTH RESOLUTION DATA ON SAME GRAPH (7/1/80)

ACCOMPLISHMENTS FOR THIS QUARTER

1. Implementation plan prepared and presented.

2. 1979 Purdue Agronomy Farm spectrometer/radiometer data available.

3. LARSPEC User's Manual completed.

4. New LARSPEC data storage guidelines determined for FSS data collected during 1979 and after

   - Actual FSS wavelength bands will be used for LARSPEC data base. Data will not be stored in 'forced' finer wavelength format.

   - FSS data at 1.3 μm and 1.9 μm water absorption bands will be deleted.

SUMMARY OF FIELD RESEARCH TEST SITE LOCATIONS AND MAJOR CROPS

Test Site	Crop Year 1975	1976	1977	1978	1979
Finney Co., KS	Winter Wheat	Winter Wheat	Winter Wheat		
Williams Co., ND	Spring Wheat	Spring Wheat	Spring Wheat		
Hand Co., SD	---	Spring Wheat Winter Wheat	Spring Wheat Winter Sheat	Spring Wheat Winter Wheat	Spring Wheat Winter Wheat
Tippecanoe Co., IN	---	---	---	Corn Soybeans	Corn Soybeans Winter Wheat
'U.S. & Brazil'	---	---	---	'Soils'	---
Webster Co., IA					Corn Soybeans
McPherson Co., NE	---	----	---	---	Corn

SUMMARY OF FIELD RESEARCH DATA BASE

INSTRUMENT/DATA TYPE	CROP YEAR(S) AND STATUS		
	1975-1978	1979	
	COMPLETE	COMPLETE	IN PROCESSING
LANDSAT MSS WHOLE FRAME CCT (FRAMES)	124	---	---
AIRCRAFT MULTISPECTRAL SCANNER (DATES/FLIGHTLINES)	46/301	1/5	7/
HELICOPTER MOUNTED FIELD SPECTROMETER (DATES/OBSERVATIONS)			
FIELD AVERAGES	74/6870	---	17/
INDIVIDUAL SCANS	74/114,829	---	17/
TRUCK MOUNTED FIELD SPECTROMETER (DATES/OBSERVATIONS)			
NASA/JSC FSAS	45/813	---	---
PURDUE EXOTECH 20C	99/7055	25/897	---
NASA/ERL EXOTECH 20D	45/645	---	---
TRUCK MOUNTED FIELD MULTIBAND RADIOMETER (DATES/OBSERVATIONS)			
PURDUE EXOTECH 100	32/6077	26/7947	---

PLANS FOR NEXT QUARTER

1. DATA DISTRIBUTION

    - 1979 WEBSTER CO., IA AND HAND CO., SD FSS DATA WILL BE MADE AVAILABLE FOR RESEARCHERS
    - 1979 WEBSTER CO., IA, HAND CO., SD, AND MCPHERSON CO., NE AIRCRAFT SCANNER DATA WILL BE MADE AVAILABLE FOR RESEARCHERS
    - ADDITIONAL AGRONOMIC INFORMATION ADDED TO 1979 PURDUE AGRONOMY FARM DATA

2. CATALOG

    - CATALOG WILL BE UPDATED.

3. DATA BASE SOFTWARE

    - EXPANDED LARSPEC IDENTIFICATION INFORMATION PUNCH CAPABILITY IMPLEMENTED.
    - DECWRITER TERMINAL AVAILABLE AS GRAPHICS OUTPUT DEVICE.
    - NEW FSS PROCESSING SOFTWARE COMPLETED.
    - REVISED CLEVENGER SPECTROMETER PROCESSING SOFTWARE COMPLETED.

ISSUES/NEEDS TO BE RESOLVED

1. CAUSE OF ANOMOLY IN FSS DATA AROUND .7 UM.

2. REVIEW OF FSS REFLECTIVE WAVELENGTH BANDS. IS IT POSSIBLE/DESIREABLE TO PROCESS FSS DATA AT NASA/JSC INTO FINER BANDS?