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CROPCAST: A Special Purpose, Geographically Referenced, Information System for Crop Inventory Applications

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CROPCAST™: A SPECIAL PURPOSE, GEOGRAPHICALLY REFERENCED, INFORMATION SYSTEM FOR CROP INVENTORY APPLICATIONS

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I. ABSTRACT

CROPCAST™ is a special purpose, geographically referenced, information system that is being applied to operational global crop inventory. The CROPCAST system utilizes a two level geobased grid /cell coordinate system that is referenced to a cylindrical Mercator projection with earth intersections at 30°N and 30°S, which provides equal area coverage with minimum distortion for the 60°N to 60°S primary agricultural regions. Diagnostic and predictive models operating on remote sensing data from resource satellites, ground-based meteorological stations, physical and statistical data bases offer dynamic information grid/cell updates at 6 hourly and 24 hourly intervals. Predictive models extend the dynamic information udates on a daily basis to nay future day. Diagnostic and predictive information updates include: crop growth stage, root dynamics, soil moisture profiles, crop stress, physiological factors, yield changes, crop condition etc. The system is operational on PRIME Model 550 with 332 B bytes of disc, two tape drives and a Printronix printer. Interactive capabilities are provided using a Grinnel interactive color system and various standard CRT's. Mapped output with thematic depictions are displayed either at the CRT's or via the Printronix. The CROPCAST system has been in daily operation since 1977 over major areas of the agricultural world.

II. INTRODUCTION

The dependence of crop production on weather must have been recognized as soon as agriculture was practiced systematically. Similarly, the idea that one might forecast the probable harvest early in the growing season by comparing the current year's weather and soil moisture with that of previous year's must also be very old.

Two emerging technological tools which have evolved over the last twenty years have opened the door to new approaches to a very old science; computers and satellites provide the tools to account for the data complexity of the problem in a global geobased sence, and examine agricultural plant performance at the field or multi-field level.

Earth Satellite Corporation personnel have, over the past eight years, developed a computerized global geobased system called, "CROPCAST™", designed to incorporate satellite information with plant environmental information and other ground-based information to produce daily, past, current, and future, views of global crop conditions.

The following sections of this paper will examine the CROPCAST Agricultural Information System as an example of a special purpose geobased information system, emphasizing the current and future role of satellite-delivered information.

III. CROPCAST SYSTEM FUNCTIONAL DISCUSSION

A. Overview

The CROPCAST System (see Figure 1) is operational over the globe in over 11 countries for up to 10 different crops. The system operates on a PRIME Model 550 "Super-mini". The current configuration has 512 K bytes of real memory, 332 M bytes of disc memory and two 75 IPS 800/1600 BPI tape drives. Five standard 80/132 column CRT terminals are used for data editing, interactive analysis and job entry. Hard copy output is directed to a Printronix dot matrix printer; interactive access for inclusion of digital satellite analyses is provided through a Grinnel color terminal with four addressable 512 X 512 byte memory planes.

B. GRID STRUCTURE

The geobased in the system are structured to provide unique global agricultural coverage; a cylindrical Mercator bbased multi-level grid provides two fixed resolutions for data storage and display, i.e., 54 Km and 27 Km (see Figure 2). A research capability exists to provide small area grid resolution down to one kilometre (see site examples in Figure 2).

C. DATA BASE

The data bases (see Figure 3) currently operating in CROPCAST are specific to each crop. Some data, such as relate to the physical characteristics of the soils, land slope and the like, are permanent files. Planting data distributions, crop varieties, planted area, etc. are updated once per year. Derived quantities like soil moisture profiles, growth stage, stress/condition, etc. are updated at a daily cycle, while meteorological information is updated on a 6 hourly cycle. Meteorological satellite data enter at 6 hourly intervals, while Landsat currently enters only as historical data, and on a sampled location basis.

D. DIAGNOSTIC MODELING

The diagnostic models in CROPCAST operate on the data files in each cell, elg., the meteorological data, both ground-based and satellite, are digitally entered at the 54 Km level, either directly as is the case of the datellite, or via an objective analysis technique for temperature, dewpoint, wind, etc. Calculation of net radiation, potential evapotranspiration and rainfall are accomplished in each cell. (See example in Figure 4)

The agronomic calculations of soil moisture profile, growth stage, crop stress/crop condition, physiological hardening or softening are accomplished at the 27 Km grid level using models that interrogate files at both the 54 Km and 27 Km levels. Daily estimates of crop condition, three-layer soil moisture growth stage, yield potential, etc. are available for three or more planting date distributions in each 27 Km location (see example in Figure 5).

E. FORECAST MODELS

Forecast of future events are prepared on a daily basis for selected sample 27 Km cells using a Monte Carlo procedure which includes forecast data by estimating the skill distribution of the forecast as a function of time in the future, e.g., a one week forecast would have a high skill level, while a one month forecast would have no skill or very low skill. A first order Markov chain process model is used to assess day-to-day precipitation probabilities and thereby modulate maximum temperature and evaporation. Daily and end-of-growing season outputs are expressed as mean expected values and a one standard deviation uncertainty.

F. YIELD ACCURACY

Accuracy of the yield models used in the system have been tested for selected states. The raw model results (unadjusted for factors not contained in the model) are promising, averaging a state-level Standard Error of Prediction - ranging from 6.6 for corn to 13 percent for spring wheat - as compared to USDA "truth", (Figure 6 shows a scatter diagram for 1977-79). Adjusted forecasts suggest an average error at 5 percent at mid-growth and 3 percent at harvest.

G. RESEARCH AND INTERACTIVE CAPABILITIES

The CROPCAST System also includes an interactive ADSS (Agricultural Decision Support System) capability for use by internal CROPCAST staff, commodity analysts, and researchers who want to use the ongoing dynamic data bases in CROPCAST to interact with other data sets that may not be a regular part of CROPCAST; examples of independent data sets include ground reports of crop condition. Landsat analyses (currently not available in real time) etc.

The CROPCAST ADSS contains everything that is in the primary system (see Figure 3), but has capability to access other data, display changes, "look aheads" etc. Temporal, as well as spatial data are available in the system.

IV. 1980/81 APPLICATIONS DISCUSSION

CROPCAST operations in 1980 demonstrated the promise of the concept. 1980, in the U.S., was a year of greater variability in crop conditions and ultimate yield and production.

An example of the benefits of the spatial diagnostic display capabilities of the CROPCAST System is seen in this August 24, 1980 (Figure 7) display of potential and-of-year yield loss in soybeans. The sharp gradient shown in the outlined area near the Mississippi River south of Memphis was confirmed in a Landsat observation on 30 August.

CROPCAST 1980 end-of-year forecasts of corn and soybeans at the state level are presented in Figure 8. An additional unique product of the CROPCAST System is our forecast of the USDA monthly Crop Report; Figure 9 presents month-by-month results for 1980.

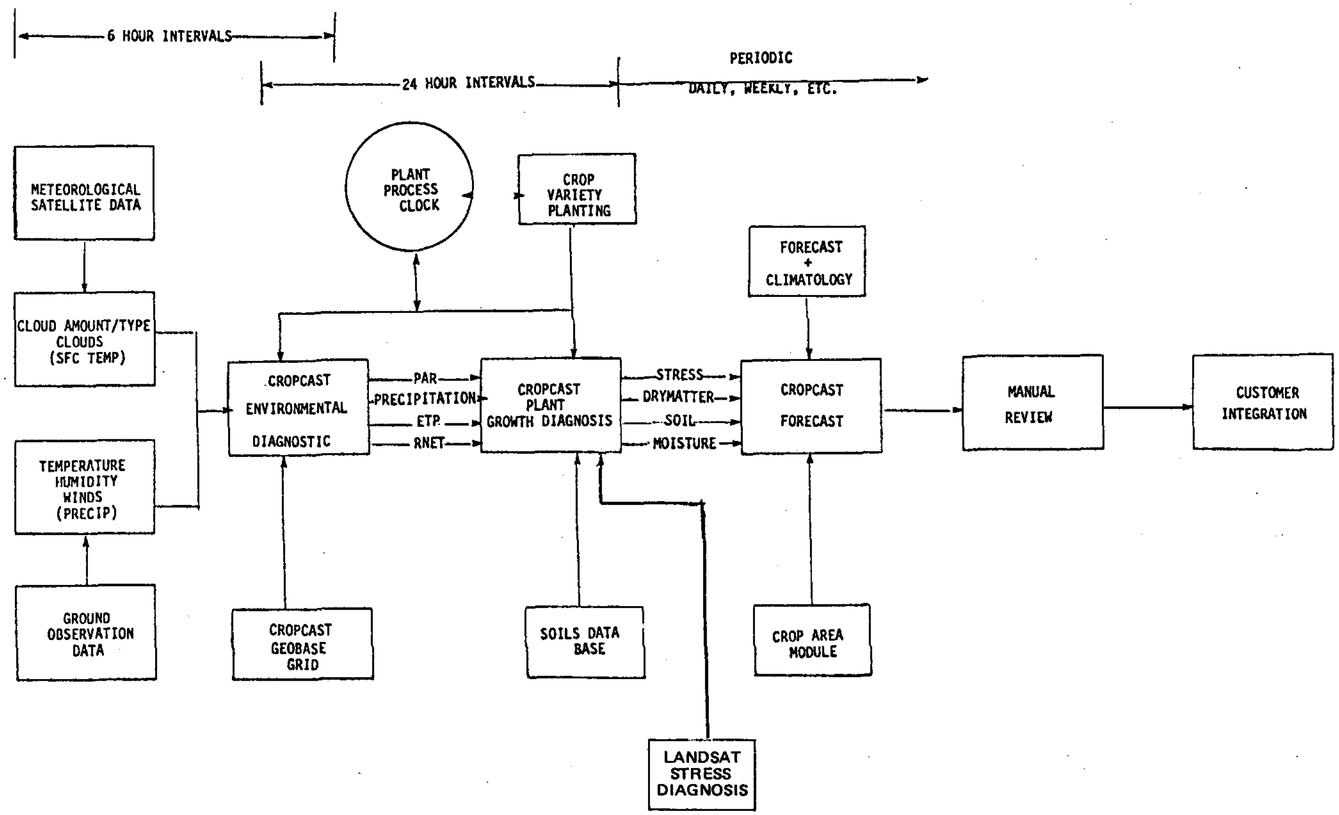
The CROPCAST ADSS display capability is illustrated by a display of soybean yield loss in Illinois for September 25, 1980. The values represent 27 X 27 Km cell samples photographed directly from the CRT scree (see Figure 10). Similar displays of change, time plots, etc. are also available.

V. FUTURE PLANTS

The CROPCAST System has proven itself as a special purpose geobased information system. Current activities are centered on merging the crop production oriented information with economic models directed toward assessments of crop area change, forecasts of future commodity prices, etc. A short term price model is now on-line.

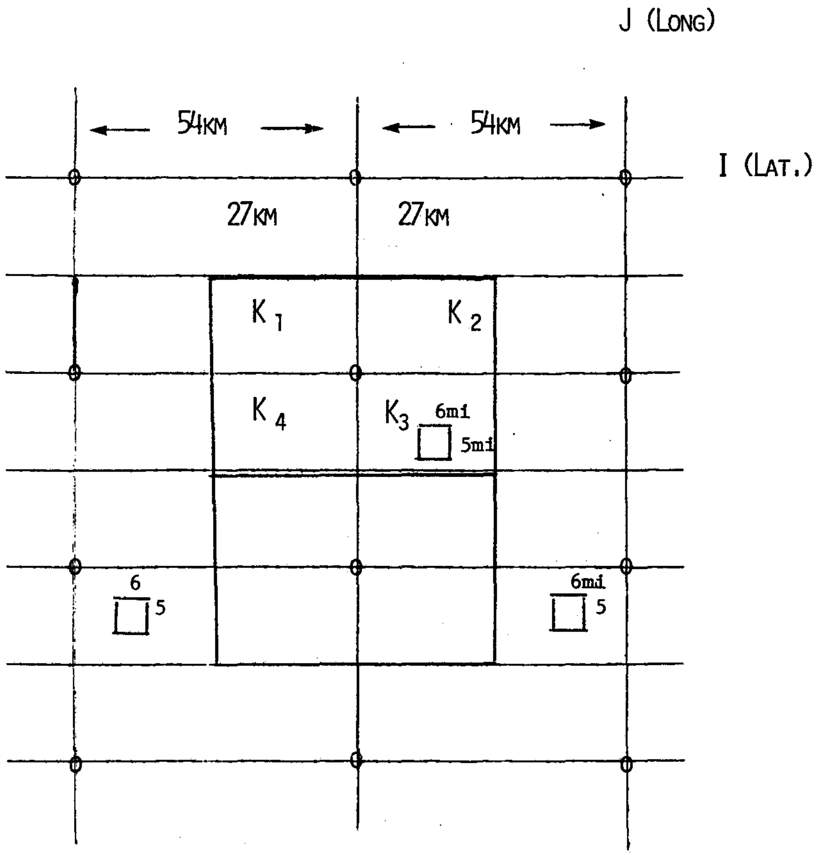
The future plans for the system are directed to the use of a greater input from earth resource satellites, such as SPOT and Landsat D. The application of these systems is, in part, aided by plans to provide (for SPOT, anyway) 48 to 96 hour turn-around of data for anywhere in the world. This turn-around rate, if achieved, will make the remotely sensed data extremely valuable for the commodity oriented user in the structure of the CROPCAST System.

In addition to the increased remote sensor use in the future, we are planning for improved interactive analysis capabilities through microcomputer adaptations of the ADSS to provide a distributed network capability.



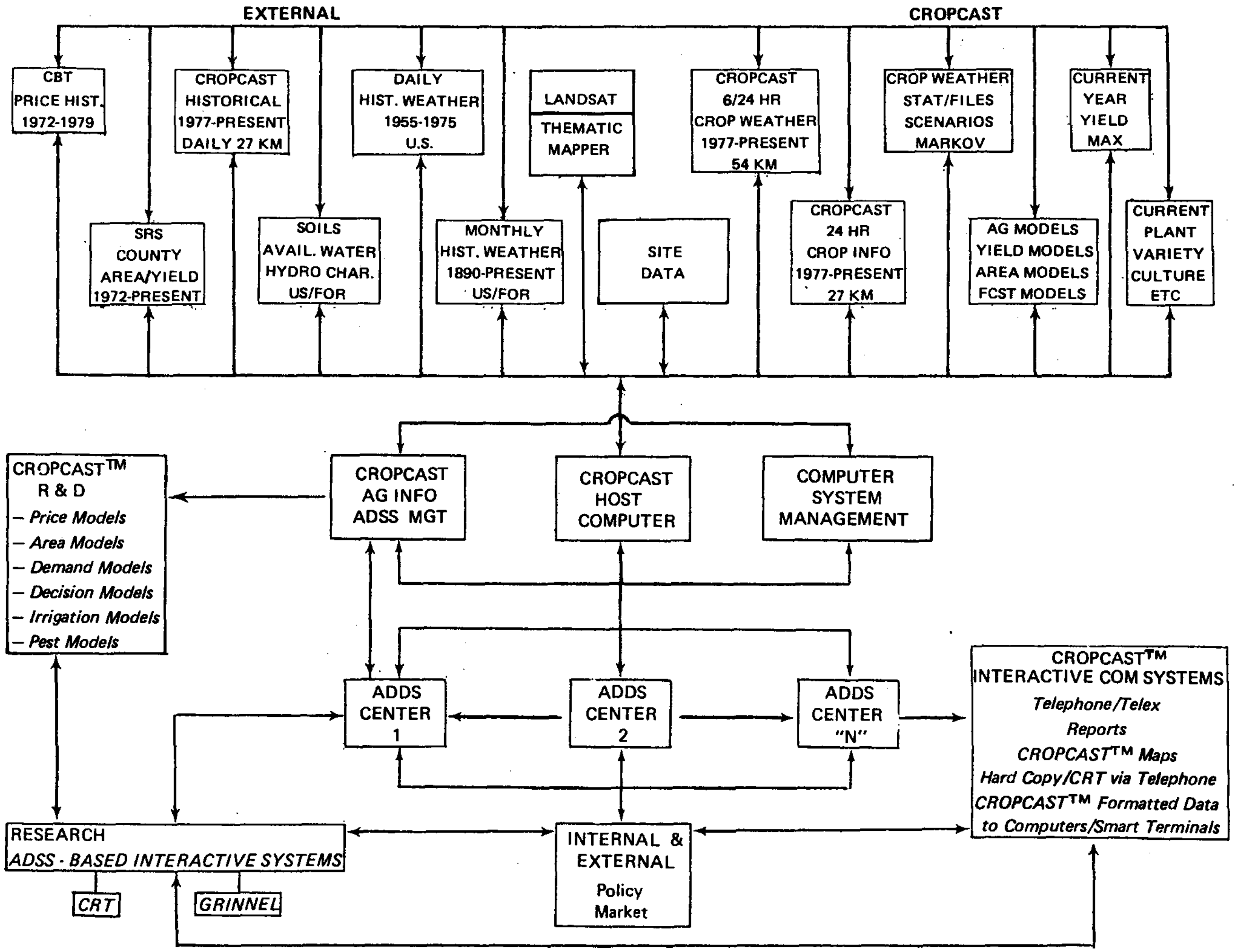
CROPCAST SYSTEM SCHEMATIC

FIGURE 1



CROPCAST GEOGRAPHIC GRID WITH SITES

FIGURE 2



EXTERNAL
CROPCAST
CBT PRICE HIST. 1972-1979
CROPCAST HISTORICAL 1977-PRESENT DAILY 27 KM
DAILY HIST. WEATHER 1955-1975 U.S.
LANDSAT
THEMATIC MAPPER
CROPCAST 6/24 HR CROP WEATHER 1977-PRESENT 54 KM
CROP WEATHER STAT/FILES SCENARIOS MARKOV
CURRENT YEAR YIELD MAX
SRS COUNTY AREA/YIELD 1972-PRESENT
SOILS AVAIL. WATER HYDRO CHAR. US/FOR
MONTHLY HIST. WEATHER 1890-PRESENT US/FOR
SITE DATA
CROPCAST 24 HR CROP INFO 1977-PRESENT 27 KM
AG MODELS YIELD MODELS AREA MODELS FCST MODELS
CURRENT PLANT VARIETY CULTURE ETC
CROPCAST™ R & D
– Price Models
– Area Models
– Demand Models
– Decision Models
– Irrigation Models
– Pest Models
CROPCAST AG INFO ADSS MGT
CROPCAST HOST COMPUTER
COMPUTER SYSTEM MANAGEMENT
ADDS CENTER 1
ADDS CENTER 2
ADDS CENTER "N"
CROPCAST™ INTERACTIVE COM SYSTEMS
Telephone/Telex
Reports
CROPCAST™ Maps
Hard Copy/CRT via Telephone
CROPCAST™ Formatted Data to Computers/Smart Terminals
RESEARCH
ADSS - BASED INTERACTIVE SYSTEMS
CRT
GRINNEL
INTERNAL & EXTERNAL
Policy
Market

FIGURE 3

NET

SOLAR

RADIATION

54 Km GRID

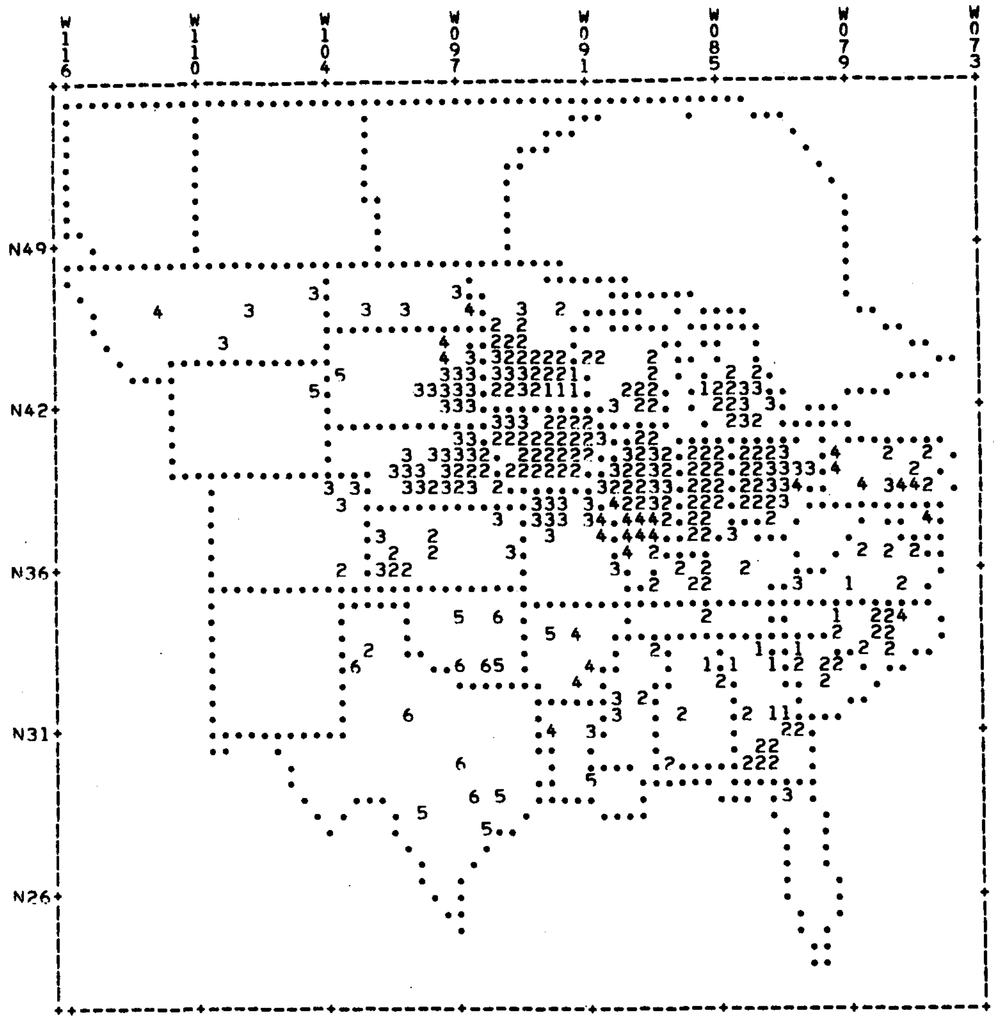
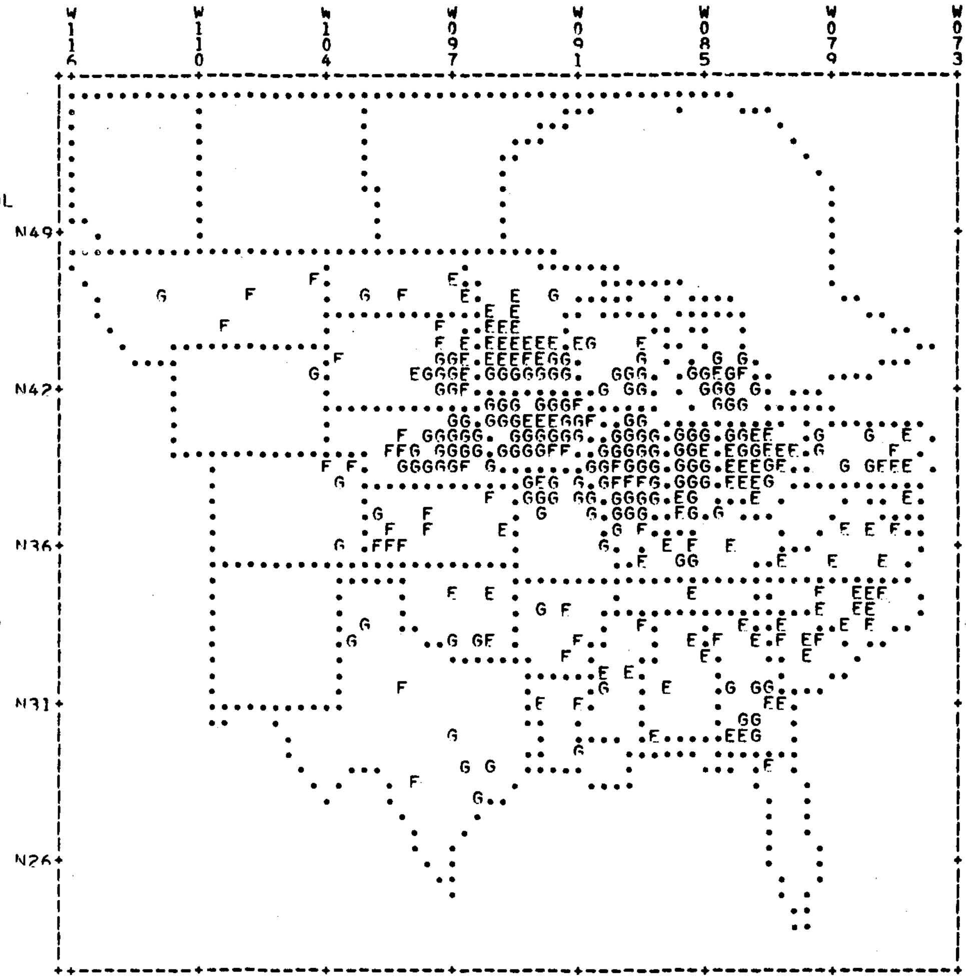


FIGURE 4

JUNE 24 (175)

CORN CROP STATUS

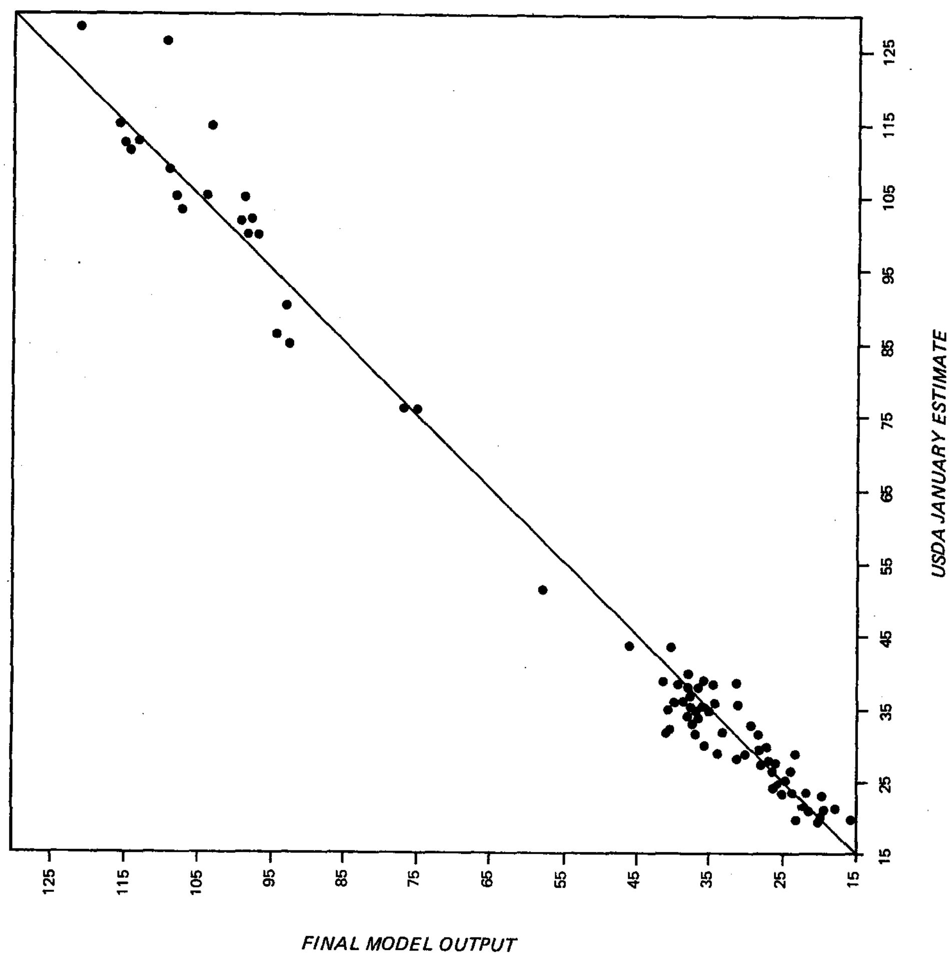
MAXVALUE	SYMBOL
1.00	P
2.00	F
3.00	G
+	E



CROP STATUS IS AN ASSESSMENT OF THE STATUS THAT WOULD BE ASSIGNED TO AN AREA BY AN OBSERVER IN THE FIELD.

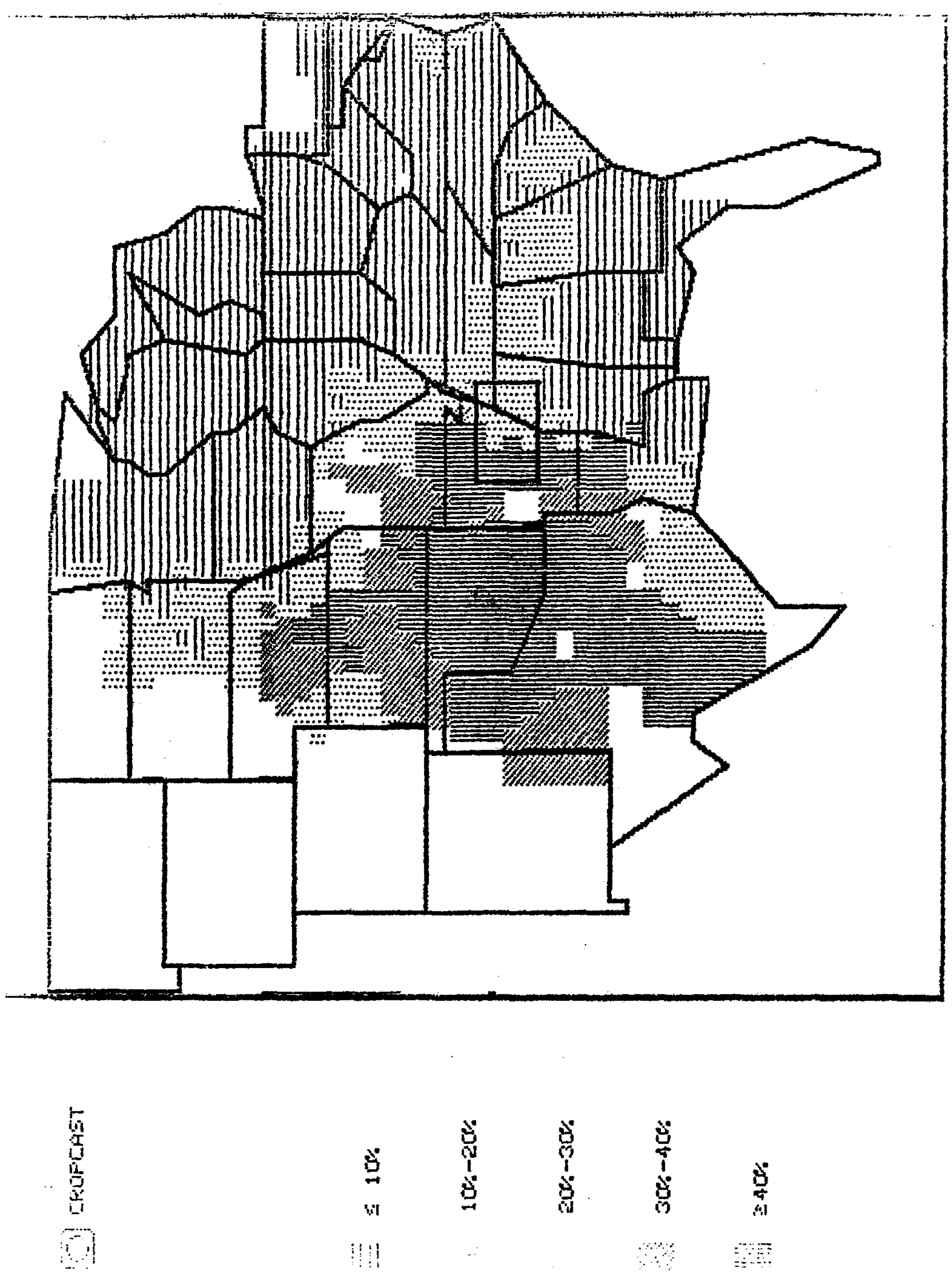
P-VERY POOR
F-POOR TO FAIR
G-FAIR TO GOOD
E-GOOD TO EXC.

FIGURE 5



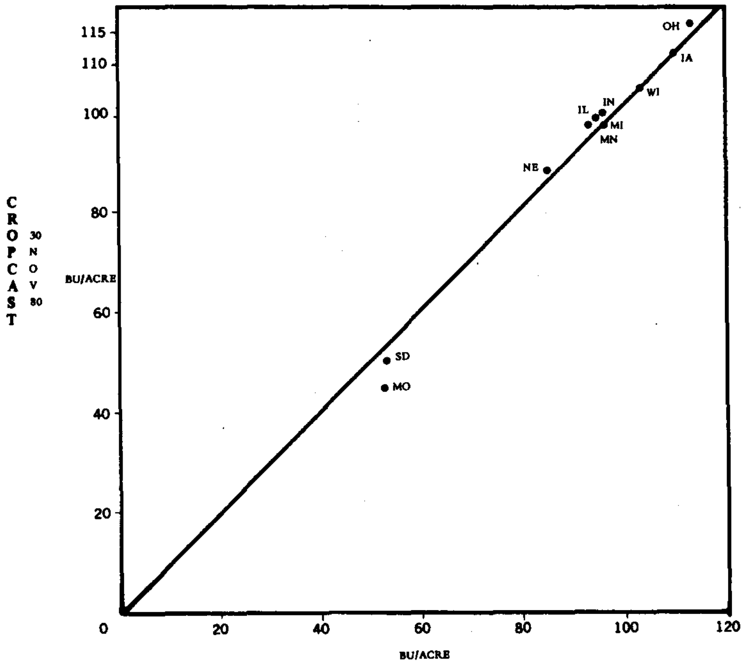
ALL CROP COMPARISONS – 1977-79
STATE DATA

FIGURE 6



1980 UNITED STATES SOYBEANS - AUGUST 24, 1980
EST. END-OF-YEAR YIELD LOSS(%)

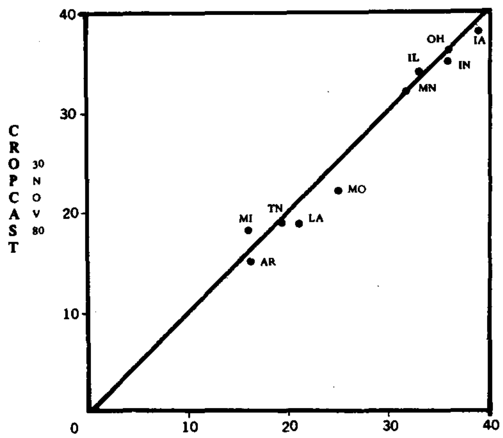
FIGURE 7



USDA 14 January 81

US Corn Yield

Key States



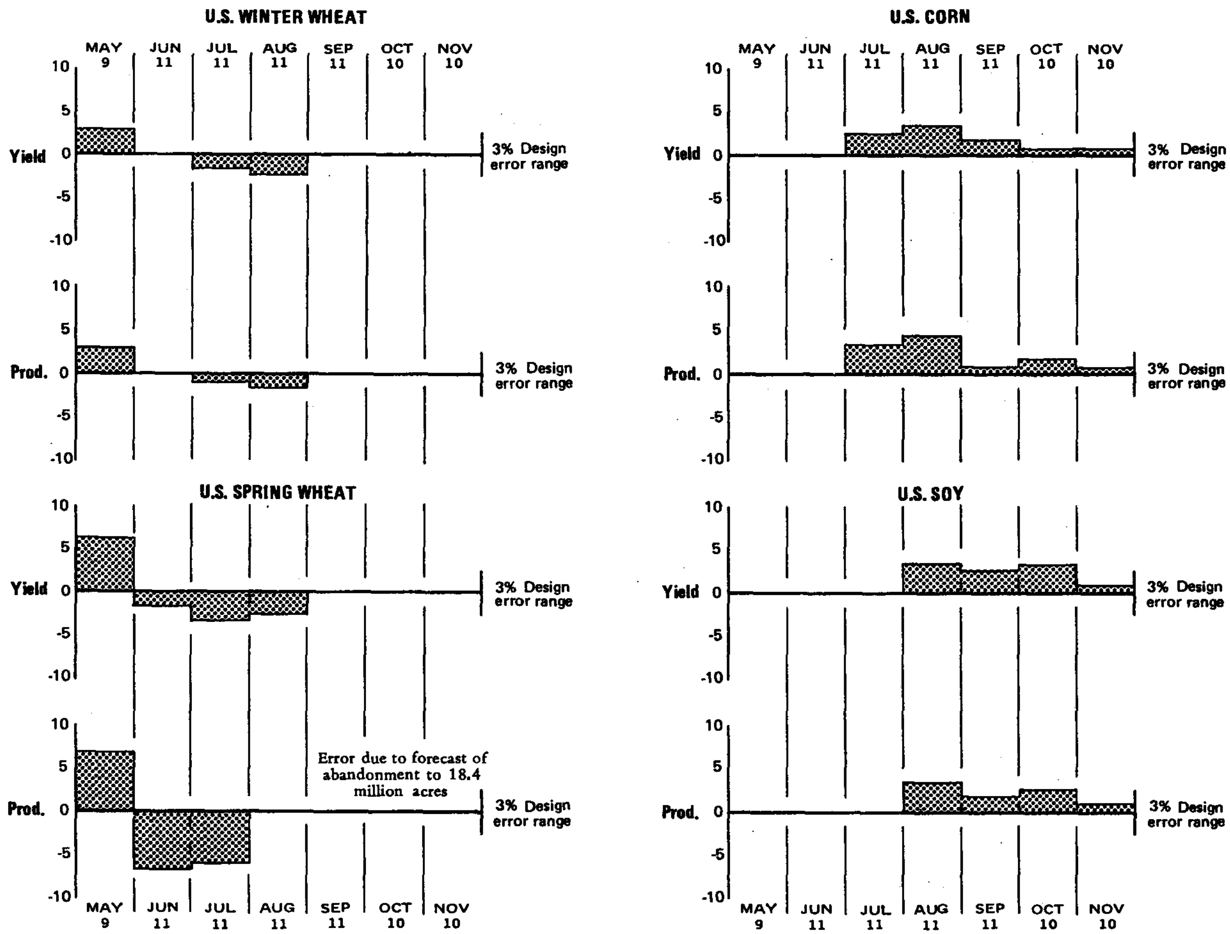
USDA 14 January 81

US Soybeans Yield

Key States

FIGURE 8

FIGURE 9



1980 CROPCAST - USDA forecast comparisons

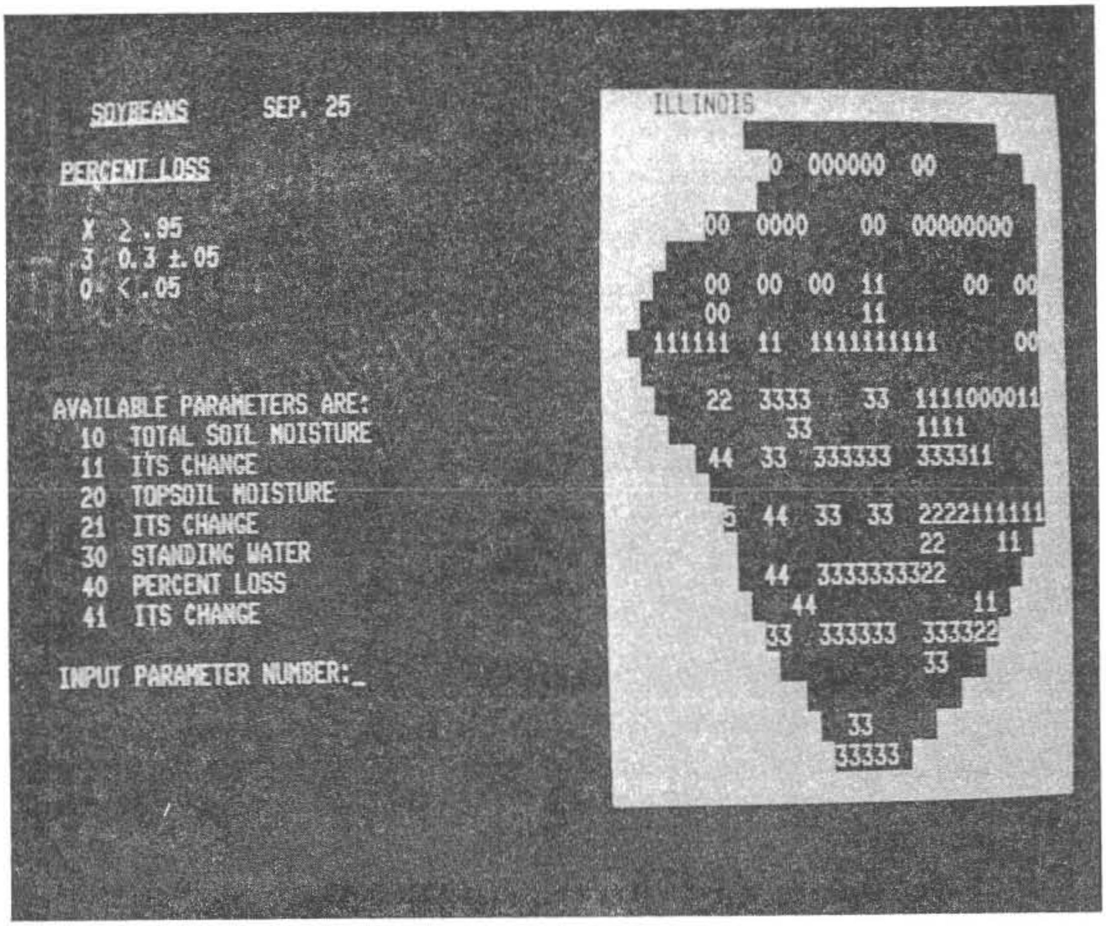

SOYBEANS SEP. 25
PERCENT LOSS
X ≥ .95
3 0.3 ±.05
0 < .05
AVAILABLE PARAMETERS ARE:
10 TOTAL SOIL MOISTURE
11 ITS CHANGE
20 TOPSOIL MOISTURE
21 ITS CHANGE
30 STANDING WATER
40 PERCENT LOSS
41 ITS CHANGE
INPUT PARAMETER NUMBER:_
ILLINOIS
000000 00
00 0000 00 00000000
00 00 00 11 00 00
00 11
111111 11 1111111111 00
22 3333 33 1111000011
33 1111
44 33 333333 333311
44 33 33 2222111111
22 11
44 3333333322
44 11
33 333333 333322
33
33
33333

FIGURE 10