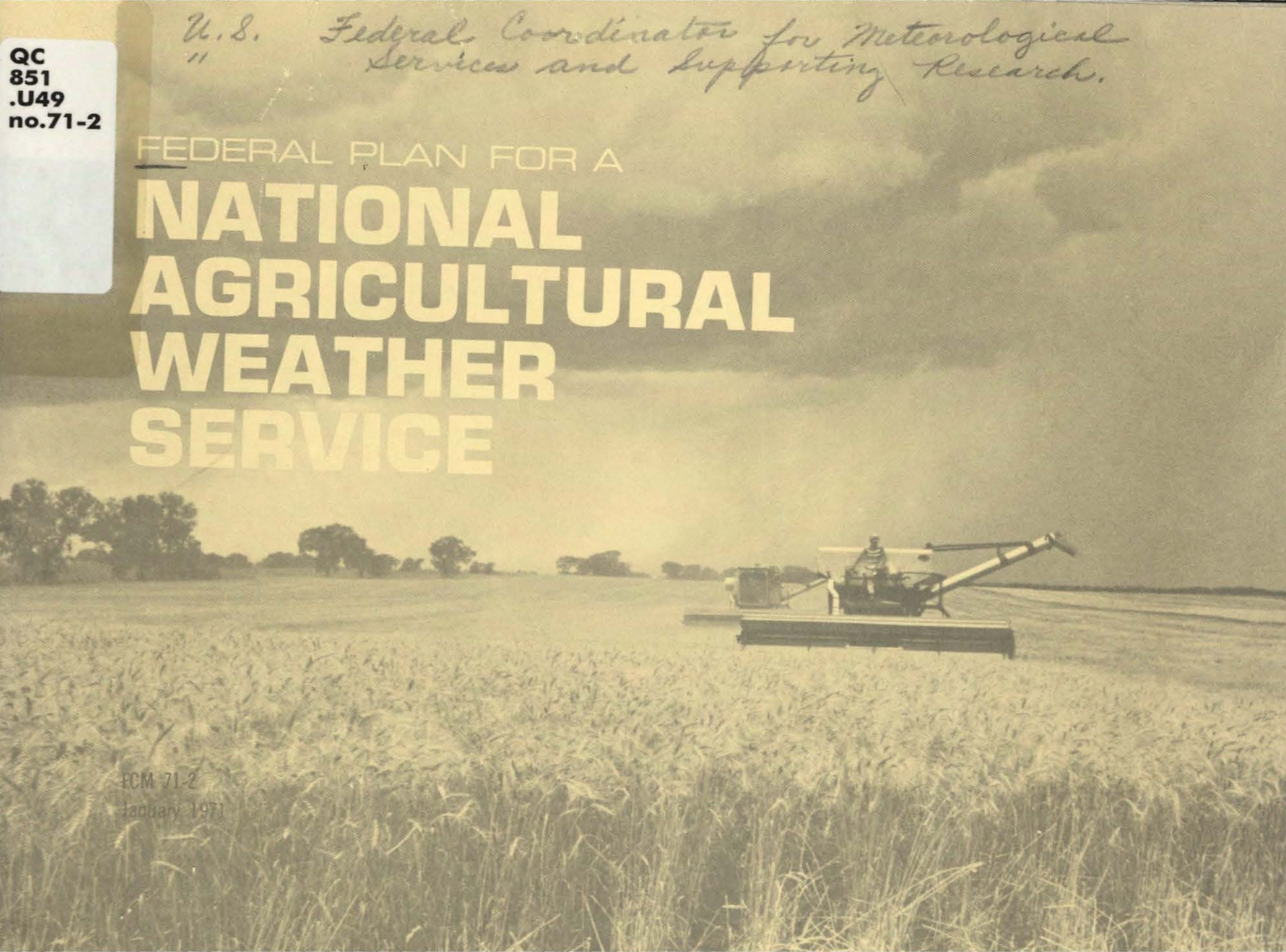
U.S. Federal Coordinator for Meteorological
" Services and Supporting Research.

FEDERAL PLAN FOR A

NATIONAL AGRICULTURAL WEATHER SERVICE



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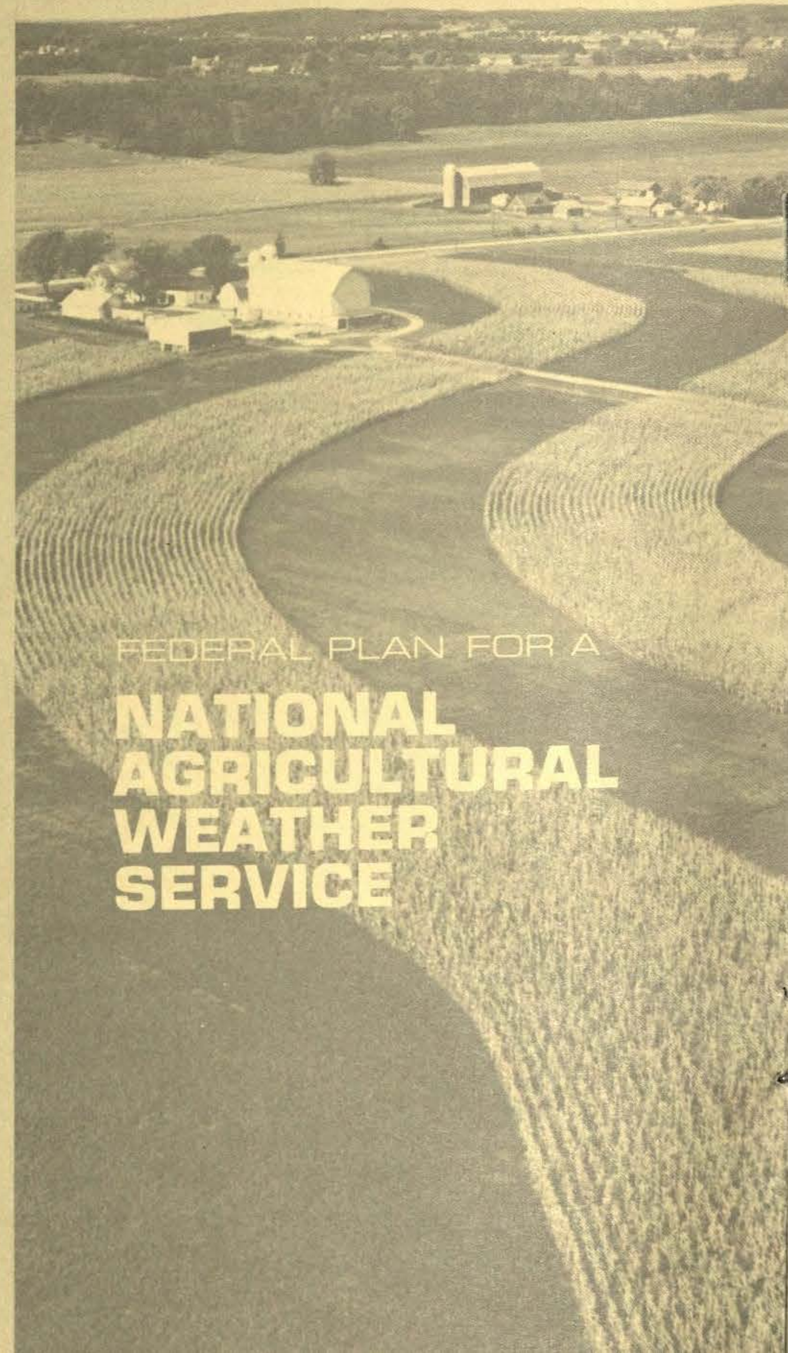

FEDERAL PLAN FOR A

NATIONAL AGRICULTURAL WEATHER SERVICE

FOREWORD

This Federal Plan for a National Agricultural Weather Service focuses on the need for providing specialized weather services to farmers and other agribusiness interests. It is one in a series of plans being prepared by the Federal Coordinator for Meteorological Services and Supporting Research to describe present and planned services for specialized user groups. It has been prepared in response to Bureau of the Budget Circular A-62, with the advice and assistance of the Interdepartmental Committee for Meteorological Services, and is endorsed by the Department of Agriculture and the Department of Commerce.

This Plan is directed toward improving and expanding existing agricultural weather services in the 1972-1976 time period. It makes maximum use of the observational networks and the data-processing and disseminating facilities of the Basic Meteorological Service of the Department of Commerce. The Plan includes the agricultural applications of climatology. It does not include related programs such as fire weather service, hydrology, or public weather service.

ROBERT M. WHITE
Federal Coordinator for Meteorological
Services and Supporting Research

COVER: *Harvesters race storm which threatens major damage to crop. USDA Photograph.*

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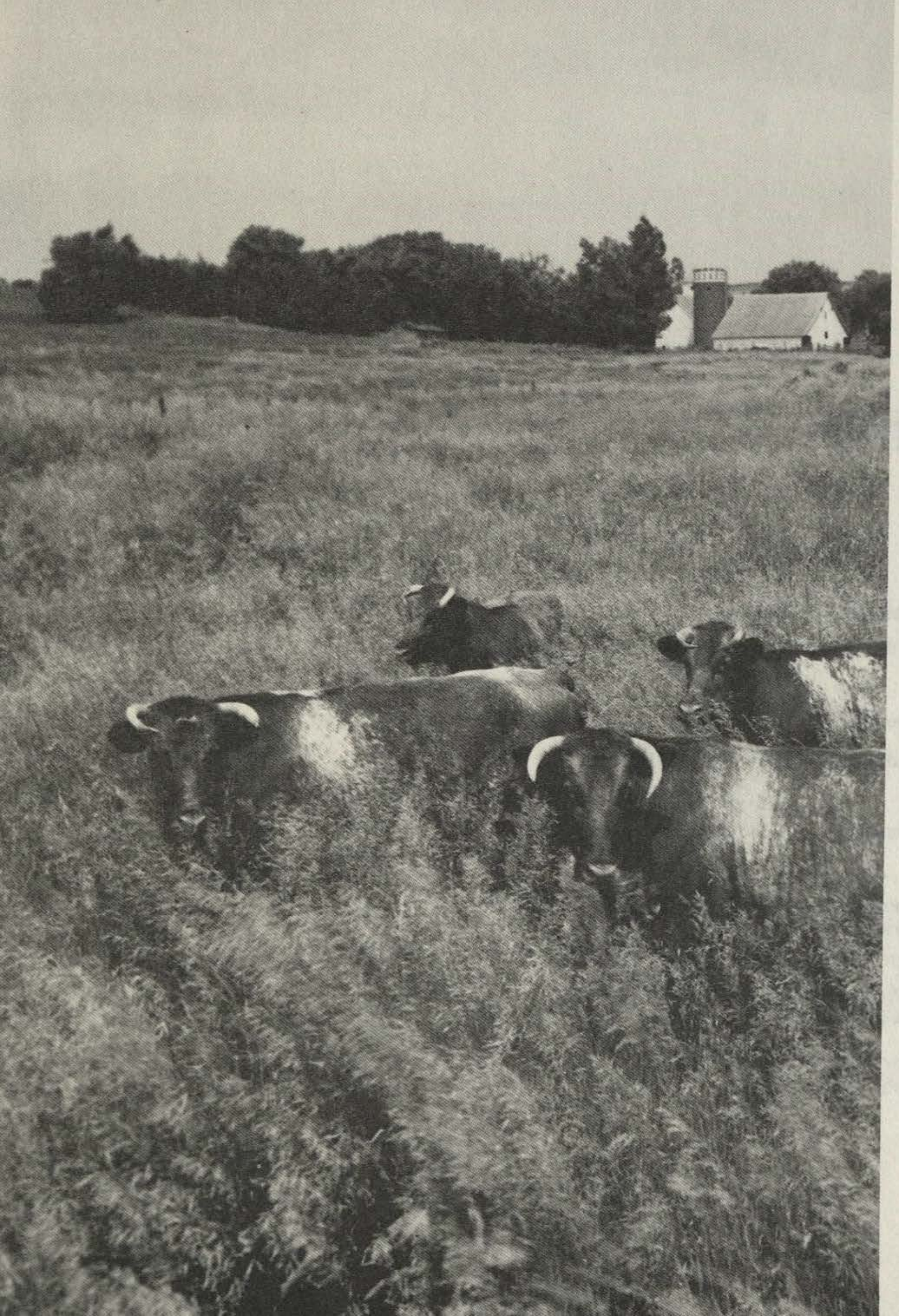


INTRODUCTION

Natural resources are not unlimited. Years ago, under conditions of sparse population and minimum industrial exploitation, the earth appeared to be the provider of unlimited natural resources. However, as the population has increased and industrialization expanded, we are becoming increasingly aware of the limits to the earth's resources. Forests can be used up or destroyed, soils can be eroded away, mineral deposits can be depleted, and the air and water can become so polluted that they no longer provide a satisfactory environment for plant and animal life.

Food and fiber surpluses formerly plaguing this Nation have dwindled. Furthermore, existing food surpluses would be almost imperceptible in alleviating hunger and malnutrition which exists among one-half of the world's population. If this growing world population is to be fed at even a minimum acceptable level, world food production will need to be increased, crop and livestock losses be minimized, and agricultural efficiency be improved.

It is no longer acceptable for man to exploit the natural resources of an area (soil, water, and air), then move to another site for further assaults on the environment. The agribusiness community has long since discontinued such land practices; however, present methods in agricultural production are beginning to tax the air, water, and land environment.

The application of chemicals in the production of crops and livestock is a nationwide agricultural practice. The use of pesticides, fertilizers, growth regulators, and hormones is common in many phases of agricultural production, and the abundance of food and fiber is to a large degree attributable to their use. However, the quality of the environment has suffered as a result.

The transport of these chemicals into other than the desired areas is to a large degree effected by meteorological factors. Wind, rainfall, sunshine, air, soil and leaf temperature, dew, surface water, and ground water play a role in the dispersion and activity of these substances as they move from the target areas to become pollutants of the biosphere. To minimize the undesirable effects of chemicals applied to plants and soils, it is necessary to devise cultural methods which provide pest control and ultimate yield by adapting each crop production system to the expected weather in its locality. Some crops must be grown only when and where natural weather conditions do not favor the development of insects and diseases. Because these restrictions in time and place will reduce effective production acreage, greater efficiency is required from the fields that are planted; this efficiency will come from increased knowledge of crop weather relations, improved measurements of weather and plant or animal responses, and new techniques of making *all* agricultural weather decisions promptly and accurately.

Weather is the pivotal point for many phases of the agricultural production cycle. Many decisions in agricultural planning must take into account past, present, and expected weather conditions. Farming has become heavily dependent upon machines and chemicals. Buying tractors and implements too large or too small for the expected number of field-work days is a poor allocation of capital which already is excessive in relation to return. Climatological risk assessment is the key to optimum selection. Each operation that has to be omitted or repeated because of adverse weather conditions adds to the production cost and makes American agriculture less competitive on the world market. Proper utilization of accurate weather forecasts in farm operations can save a washed-off chemical application, reduce the spread of pesticide materials to other than the target area, add to the overall farm efficiency, and help maintain a healthy and wholesome environment. Each seed that is planted at the wrong time and rots in a cold, wet soil adds to farm inefficiency. Livestock, although able to adjust to a wide range of adverse weather conditions, are quite sensitive to weather. Weather plays a major role at calving, farrowing, and lambing time, and frequently determines the number of surviving young. In all stages of animal growth, weather influences the prevalence of parasites, diseases, and the efficiency of feed conversion which figure so importantly in economically sound livestock enterprises.

Precise correlations between weather conditions and agricultural output have been made for certain crops and localities in the Nation, but, to date, no general information is available other than the fact that weather is the most significant variable explaining year-to-year fluctuations in the yield of most commodities. The yield-depressing effects of less-than-optimum growing conditions for 79 of the principal crops have been estimated by the Interdepartmental Committee for Atmospheric Sciences to reduce farm income by an average of $1.6 billion per year. Income losses and wasted production costs because of adverse weather for livestock and agricultural marketing and processing industries are significant also, as are damages to land and capital investments. There is no doubt that, while avoidance of all these losses is an impractical objective, better and more complete information on pending weather events as envisaged in this Plan would provide the basis for a more efficient agriculture in all areas of the Nation.

Weather support to agriculture should be designed to contribute to user decisions which will minimize losses resulting from adverse weather conditions and will improve the yield and quality of agricultural products through effective planning, cultivation, processing and marketing procedures, and control of pests and diseases.

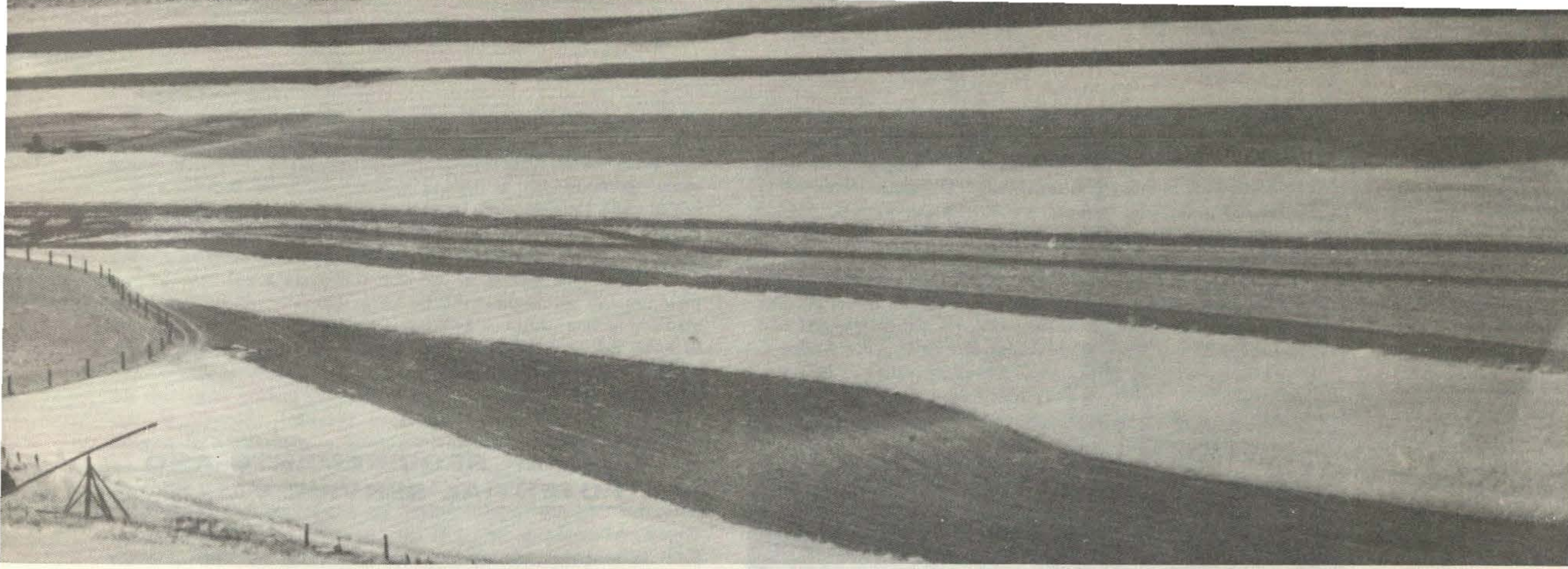
Implementation of the Plan for Agricultural Weather Service reported in this document will result in the application, on a nationwide basis, of improved techniques of weather interpretation and communications, many of which have been tested in the field, to the day-to-day problems of the users. The planned Service will feature: (1) collection, analysis, and interpretation of weather data pertinent to optimum planning of the allocation of agricultural land, labor, and capital; (2) technical studies in agriculture-weather relationships at one or more Federal and State Agricultural Experiment Stations in each State aimed at future improvements in weather service; (3) agricultural weather forecasts designed to support specific types and phases of farm operations, including processing and marketing decisions; and (4) rapid and efficient dissemination of forecasts, warnings, outlooks, and advisories.

ROLE OF FEDERAL AGENCIES

The importance of agriculture to the national economy is well known. Decisions associated with the efficient production of food and fiber in agricultural enterprises touch the life of every individual.

The summary of this Plan highlights the dependence of most agricultural endeavors on day-to-day weather conditions. Recognizing the need for improved weather forecasting services to the Nation's farmers, a Senate Resolution passed in July 1955 (84th Congress, 1st Session) requested a survey from the Secretaries of Agriculture and Commerce to ascertain what steps should be taken to remedy expressed deficiencies. The resulting report pointed out the need for an expanded Agricultural Weather Service program for the country. To gain the most efficient and effective Agricultural Weather Service, two Federal agencies, the Department of Agriculture and the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce, have cooperated closely in the preparation of this Federal Plan.

As the agency responsible for providing weather forecasting services to all public interests, the Department of Commerce's NOAA/National Weather Service manages and operates the agricultural weather forecasting program. In the operation of the program, weather forecast formats and techniques tailored to meet the needs of farmers are devised by National Weather Service agricultural meteorologists and utilized daily through rapid mass dissemination outlets. The Department of Commerce's NOAA/Environmental Data Service (EDS) provides program management of the NOAA State Climatologists who devote an appreciable portion of their time to agricultural problems in each State. They



provide data and analytical expertise in the interdisciplinary team approach which university and Experiment Station workers use now to advise on planting and fertilizer rates and cultural practices, including the amount of accumulated soil moisture, expected precipitation during the growing season, and wintering effects upon insect populations. The Agricultural Climatology Service Office which EDS maintains in the Department of Agriculture at Washington, D. C., provides a focal point for the cooperative Weather and Crop Reporting and Advisory Service carried on in each State by the State Climatologists, the Agricultural Meteorologists, and the Agricultural Statisticians of the Department of Agriculture's Statistical Reporting Service. This Office monitors cumulative weather developments, summarizes State Weather and Crop Bulletins, and publishes the National Weekly Weather and Crop Bulletin; it also provides data and consultation within the Department of Agriculture for planning and operating national programs dealing with the production of food and fiber.

The National Weather Service and Environmental Data Service both conduct research directed toward the forecasting and climatological needs of agriculture, often cooperating on the same project when collocated.

The role of the Department of Agriculture in the National Agricultural Weather Service program is twofold: one, supporting research; and two, cooperative release of agricultural weather advisories for farming and other agribusiness interests. A sustained research program by the Department of Agriculture for determining the specific effects of weather elements upon all facets of agricultural production contributes the basic knowledge necessary to elucidate the needs for specialized agricultural weather forecasting techniques. The Department of Agriculture also plays a very important role with the National Oceanic and Atmospheric Administration in issuing joint releases which recommend ways and means of increasing yield or minimizing crop losses anticipated from pending weather conditions.

Portable drill sets access tubes for annual survey of soil moisture available to crops at start of growing season. Weather service contributes to this joint Federal, State, and local program of planning irrigation for efficient crop production and water use.

1.0 USER REQUIREMENTS AND POTENTIAL SERVICE VALUE

Of the many factors affecting the success or failure of agricultural enterprises, none plays a more decisive role than weather. Farmers are particularly vulnerable to this elemental force over which they have little control. Weather manifests its influence in agricultural production through its effects on the soil; on plant growth, development, yield, and composition; and on practically every phase of animal growth and production. The fact that basic relationships exist between weather and yield or productivity of agricultural pursuits has been well established; however, the degree to which weather information may be profitably applied to the solution of agricultural problems by the users depends upon several interrelated considerations:

a. The detailed extent of crop or livestock response to one or more weather factors;
b. The climatic probability of occurrence of several influential weather elements; and
c. The ability of the agriculturist to make and act upon alternative decisions, based upon timely weather information, which result in economic gain (or avoidance of loss).

To design an Agricultural Weather Service, it is necessary to determine the user requirements in terms of specific information which is needed to support equally specific operational decisions.

Agricultural Weather Service begins at the planning stage through the introduction of appropriate climatological data. Initial planning includes answering questions of when, for how long a period, or how frequently will weather conditions be favorable or unfavorable for a particular activity. A second step in planning the operation is to devise a set of alternatives for dealing with adverse conditions that may be expected to occur, and to evaluate the capability of the Service to warn in advance of the onset of unfavorable weather conditions. A complete picture of the weather for the entire period in question (growing period, harvest period, etc.) is desirable. However, the period in question is usually too long to be covered by a forecast obtained by extrapolating from an initial set of conditions. Therefore, climatological data form the basis of prediction for the second planning phase.

In executing the operation, conventional weather forecasts, based on the extrapolation of a set of initial and boundary conditions, become one of the key factors in the decision process. This is true as long as conventional forecasts have a higher informational content and credibility than do other sources of information on expected weather conditions. At present, conventional forecasts are superior to other sources of weather data for periods out to about 72 hours under most conditions. In certain situations, such forecasts may remain usable up to 5 days. For maximum utility, however, the forecasts must deal with phenomena which are defined in terms of the operational or strategy selection requirements, and the prediction must be derived from methods which have been optimized with respect to the economics of the operation supported rather than in terms of some arbitrary criterion of error.

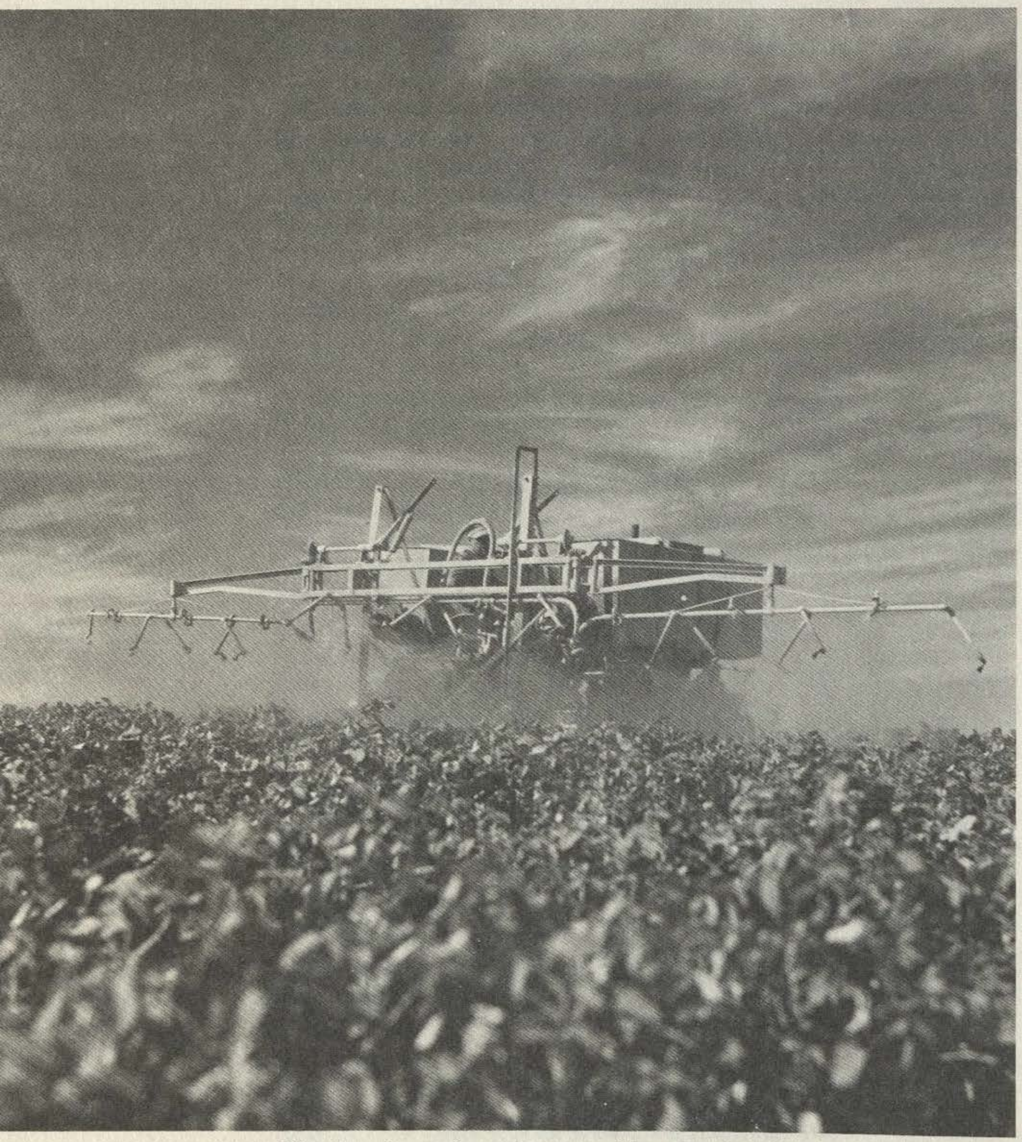
This concept generates an overriding need for an Agricultural Weather Service which is completely integrated and fully specialized in terms of its three basic components: observations, climatological analyses, and forecasts. Observations must supply the correct measurements and reports of the appropriate atmospheric elements and phenomena; climatology must organize, summarize, and present the data in proper form for planning, designing, and highlighting the forecast problem; and forecasts must supply the real-time probability functions or expectancies of the elements and phenomena required for strategy selection.

To obtain optimum value from this weather information, individual farmers or agricultural groups may seek the advice of private consulting meteorologists. Such experts in the application of meteorological information to specific operational problems can tailor National Weather Service information to individual needs and can often increase profitability of operations to such a degree that the cost of their service will be repaid many times. A list of qualified consultants can be obtained from the American Meteorological Society, 45 Beacon Street, Boston, Mass. 02108.

Because user requirements are continually changing, agricultural user groups, that is, farmers and other agriculture program decision makers, must be queried on a regular basis as to their meteorological data requirements.

The process of summarizing and presenting agricultural user requirements in concise form presents practical difficulties. The user population is very large, and the requirements of any particular segment vary, for example, as a function of the agricultural operation, geographic area concerned, segment of the growing season, presence or absence of pests and disease, air and water pollution potential, and influence of marketing factors. In developing this Plan, an attempt was made to divide the total user population into a number of categories and subcategories. For each of these groups, weather-sensitive operational decisions were identified; and for each of these decisions, the necessary weather information inputs were determined. Implicit in these determinations, of course, was the need for basic understanding of crop-weather relationships and of the practical limitations on constructive action by the user in each situation. Weather data required by each category or subcategory of user have been expressed in terms of parameters of interest, critical values if any, and forecast period required for the particular type of decision involved.

The external user population which comprises the agribusiness complex was first divided into three major categories, namely: I-Agricultural Producers; II-Supporting Services; and III-Processors, Shippers, and Marketers. Requirements of each of these categories were then examined independently.



Weather is an important consideration in planning application of chemicals to achieve desired results and reduce the risk of adverse effects. USDA Photograph.

The resultant categories and description of operational requirements (tables 1–5) provide only a general view of the total requirements of agricultural users. The activities listed represent examples and are not intended to encompass all weather-sensitive operations. Specific descriptions of quantitative limits are approximations in many cases. It is recognized that this approach tends to limit requirements to those areas where current capabilities exist for meeting requirements because the exact lower and upper thresholds of a number of weather requirements for specific operations are unavailable and in a number of cases have not been clearly defined. Research and development activities of the various private users, universities, and government agencies are constantly working toward a better understanding of these thresholds and the relationships between crops and weather. As this information becomes available, more specific user requirements will evolve.

The requirements of Category I users are generally associated with a limited geographical area and reflect the needs of specific weather-sensitive agricultural operations appropriate to the season, the product, and the stage of development. Table 1A presents a sampling of such requirements which are peculiar to the needs of certain agricultural producers; in the interest of brevity, these have been limited to five agricultural products and not all weather-sensitive operations are shown.

From similar analysis of a more extensive spectrum of products, table 1B was constructed representing a first-order consolidation of production activities, parameters, and periods of interest which are common to a number of farming operations. Such consolidation provides a basis for determination of service products which will, to the extent feasible, serve the operational needs of multiple users. The objective of the process is to limit the required output of the service to a reasonable level, but at the same time to insure that significant parameters of general interest are covered.

Category II users comprise that portion of the agribusiness complex which directly supports the operations of the Category I producers. Examples of these are commercial pest control services, farm management services, and Federal and State extension services. One of the more weather-sensitive groups is the commercial crop sprayers and dusters. Table 2 presents the summarized requirements of these users for operations incident to both aerial and ground application.

Table 1A—Agricultural Weather User Requirements

Activities	Important parameters	Operational requirement	
		Description	Forecast period
	CATEGORY I—PRODUCERS (COTTON)		
1. Planting	1. Soil moisture	Less than 80% field capacity* to 4-in. depth	Up to 2 weeks
	2. Soil temperature	Greater than 65°F.	Do.
	3. Temperature (air)	Greater than 50°F.	Up to 36 hr.
	4. Precipitation	Less than .05 in.	Up to 12 hr.
	5. Wind	Less than 25 m.p.h.	Do.
2. Defoliation	1. Soil moisture	Between 50% and 80% field capacity*	Up to 48 hr.
	2. Temperature (air)	Between 50° and 85°F.	Up to 36 hr.
	3. Precipitation	None	Up to 24 hr.
	4. Wind	Less than 10 m.p.h.	Up to 18 hr.
	5. Dew	Presence and period	Up to 12 hr.
	6. Cloudiness	Less than .7 cover	Do.
3. Harvesting	1. Soil moisture	Less than 90% field capacity* to 6-in. depth	Up to 48 hr.
	2. Temperature (air)	Variable	Up to 36 hr.
	3. Precipitation	None	Up to 12 hr.
	4. Wind	Less than 20 m.p.h.	Up to 36 hr.
	5. Humidity	Less than 70% relative humidity	Up to 12 hr.
	6. Dew	Presence and period	Up to 24 hr.
	CATEGORY I—PRODUCERS (CITRUS)		
1. Freeze protection	1. Temperature (air)	Below 28°F.	Up to 24 hr.
	2. Type freeze	Radiation-advection or combination	Do.
	3. Wind	Direction and speed	Do.
2. Forced harvest	1. Temperature (air)	Below 28°F.—without protection devices	Up to 48 hr.
		Below 20°F.—with protection devices	Do.
	2. Wind	Greater than 30 m.p.h.	Do.
	3. Precipitation	Less than .05 in.	Do.
	CATEGORY I—PRODUCERS (DAIRY AND LIVESTOCK)		
1. General feeding and shelter	1. Temperature (air)	Less than 30°F.	Up to 48 hr.
	2. Precipitation	Greater than 1 in.	Do.
	3. Wind	Greater than 40 m.p.h.	Do.

*Field capacity—The amount of water held in the soil after the excess gravitational water has drained away and after the rate of downward movement of water has materially decreased.

Table 1A—Agricultural Weather User Requirements—Continued

Activities	Important parameters	Operational requirement	
		Description	Forecast period
CATEGORY I—PRODUCERS (DAIRY AND LIVESTOCK)—Continued			
1. General feeding and shelter —Continued	4. Chill factor	Integrated index	Up to 48 hr.
	5. Blizzard	Blizzard or near blizzard	Do.
2. Lambing and calving shelter	1. Temperature (air)	Less than 40°F.	Up to 5 days
	2. Precipitation	Greater than .05 in.	Do.
	3. Wind	Greater than 20 m.p.h.	Up to 48 hr.
	4. Chill factor	Integrated index	Do.
3. Pest control	1. Temperature (air)	Variable	Up to 36 hr.
	2. Precipitation	Less than .05 in.	Do.
	3. Wind	Less than 15 m.p.h.	Do.
4. Sheep shearing	1. Temperature (air)	Greater than 40°F.	Do.
	2. Precipitation	Less than .05 in.	Do.
	3. Wind	Less than 25 m.p.h.	Do.
CATEGORY I—PRODUCERS (APPLES)			
1. Pruning	1. Temperature (air)	Variable	Up to 24 hr.
	2. Precipitation	Less than .05 in.	Do.
	3. Wind	Less than 20 m.p.h.	Do.
2. Spraying (ground)	1. Soil moisture	Less than 90% field capacity*	Up to 48 hr.
a. Thinning	2. Temperature (air)	Very critical at 10°F. increments from 40° to 80°F.	Up to 24 hr.
	3. Precipitation or dew	None	Do.
	4. Wind	Less than 10 m.p.h.	Do.
b. Pesticides	1. Soil moisture	Less than 90% field capacity*	Up to 48 hr.
	2. Temperature (air)	Between 40° and 85°F.	Up to 24 hr.
	3. Precipitation or dew	None	Do.
	4. Wind	Less than 10 m.p.h.	Do.
3. Pollination	1. Temperature (air)	Greater than 55°F.	Up to 48 hr.
	2. Precipitation	None	Do.
	3. Wind	Less than 15 m.p.h.	Do.
4. Forced harvest	1. Wind	Greater than 30 m.p.h.	Do.

*Field capacity—The amount of water held in the soil after the excess gravitational water has drained away and after the rate of downward movement of water has materially decreased.

Table 1A—Agricultural Weather User Requirements—Continued

Activities	Important parameters	Operational requirement: Description	Operational requirement: Forecast period
		CATEGORY I—PRODUCERS (GREENHOUSE OPERATOR)	
1. House heating	1. Temperature (air)	Generally less than 50°F.	Up to 36 hr.
	2. Insolation	Amount of sunlight (Langleys)	Up to 48 hr.
	3. Wind	Greater than 25 m.p.h.	Up to 36 hr.
	4. Precipitation (snow)	Greater than .5 in.	Do.
2. House ventilation	1. Temperature	Greater than 80°F.	Up to 6 hr.
	2. Humidity	Generally greater than 90%	Do.
3. Watering	1. Temperature (air)	Greater than 50°F.	Up to 36 hr.
	2. Humidity	Less than 80%	Do.
	3. Cloudiness	Less than .8 cover	Do.
4. Harvesting (timing)	1. Temperature (air)	Regulated based on growth rate	Up to 48 hr.
	2. Insolation	Amount of sunlight (Langleys)	Do.

Table 1B—Agricultural Weather User Requirements

Activities	Important parameters	Operational requirement: Description	Operational requirement: Forecast period
		CATEGORY I—PRODUCERS (GENERAL ACTIVITIES)	
1. Soil preparation	1. Soil moisture	Workable soil (generally less than 80% field capacity* to 2-ft. soil depth).	Up to 48 hr.
	2. Soil temperature	Above 32°F.	Do.
	3. Temperature (air)	Variable	Do.
	4. Precipitation	Less than .05 in.	Up to 24 hr.
	5. Wind	Less than 30 m.p.h.	Do.

*Field capacity—The amount of water held in the soil after the excess gravitational water has drained away and after the rate of downward movement of water has materially decreased.

***Table 1B—Agricultural Weather User Requirements*—Continued**

Activities	Important parameters	Operational requirement: Description	Operational requirement: Forecast period
CATEGORY I—PRODUCERS (GENERAL ACTIVITIES)—Continued			
2. Soil fumigation	1. Soil moisture	40% to 80% field capacity* to depth of 1 ft.	Up to 48 hr.
	2. Soil temperature	55° to 80°F. at 6-in. depth	Do.
	3. Precipitation	Less than .01 in.	Up to 36 hr.
	4. Wind	Less than 20 m.p.h.	Do.
3. Crop planting	1. Soil moisture	40% to 80% field capacity* to 2- to 4-in. depth	Up to 10 days
a. Seed crops	2. Soil temperature	Variable, generally above 40°F. at 4-in. depth (cotton—greater than 60°F.)	Do.
	3. Temperature (air)	Variable	Up to 36 hr.
	4. Precipitation	Less than .05 in.	Do.
	5. Wind	Less than 20 m.p.h.	Do.
4. Transplants	1. Soil moisture	60% to 90% field capacity* to 4- to 8-in. depth	Up to 48 hr.
a. Succulents	2. Soil temperature	Variable, generally above 50°F. at 4-in. depth	Do.
	3. Temperature (air)	Generally above 28°F.	Up to 1 month
	4. Precipitation	Less than .05 in.	Up to 48 hr.
	5. Wind	Less than 15 m.p.h.	Do.
b. Woody	1. Soil moisture	Greater than 80% field capacity* to 1-ft. depth	Do.
	2. Soil temperature	Generally between 32° and 50°F. to 1-ft. depth	Do.
	3. Temperature (air)	Less than 50°F.	Do.
	4. Precipitation	Less than .05 in.	Do.
	5. Wind	Less than 30 m.p.h.	Do.
5. Crop fertilization	1. Soil moisture	30% to 80% field capacity* to 6-in. depth	Do.
	2. Soil temperature	Less than 50°F. for high nitrogen level (inorganics)	Do.
	3. Temperature (air)	Variable	Up to 36 hr.
	4. Precipitation	Less than .05 in.	Do.
	5. Wind	Less than 30 m.p.h.	Do.
6. Crop cultivation	1. Soil moisture	60% to 90% field capacity* to 8-in. depth	Up to 48 hr.
	2. Temperature (air)	Variable	Up to 36 hr.
	3. Precipitation	Less than .05 in.	Do.
	4. Wind	Less than 30 m.p.h.	Do.

*Field capacity—The amount of water held in the soil after the excess gravitational water has drained away and after the rate of downward movement of water has materially decreased.

Table 1B—Agricultural Weather User Requirements—**Continued**

Activities	Important parameters	Operational requirement	
		Description	Forecast period
	CATEGORY I—PRODUCERS (GENERAL ACTIVITIES)—Continued		
7. Spraying	1. Soil moisture	Less than 90% field capacity* to 6-in. depth	Up to 48 hr.
	2. Dew	Presence and duration	Up to 36 hr.
	3. Precipitation	None	Do.
	4. Temperature (air)	Variable	Do.
	5. Wind	Less than 20 m.p.h.	Do.
8. Irrigation	1. Soil moisture	Less than 50% field capacity* in root zone	Up to 48 hr.
	2. Precipitation	None	Up to 36 hr.
	3. Temperature (air)	Daily max. and min.	Up to 24 hr.
	4. Wind	Less than 30 m.p.h.	Up to 36 hr.
	5. Evapotranspiration		
	6. Radiation		
9. Freeze protection	1. Temperature (air)	Below 32°F.	Up to 24 hr.
	2. Type freeze	Radiation, advection, or combination	Do.
	3. Wind	Direction and speed	Do.
10. Harvesting	1. Soil moisture	Less than 90% field capacity* to 6-in. depth	Up to 48 hr.
a. Moisture-sensitive	2. Temperature (air)	Variable	Up to 36 hr.
crops	3. Precipitation	None expected	Up to 72 hr.
	4. Wind	5 to 20 m.p.h.	Up to 36 hr.
	5. Humidity	Less than 75% relative humidity	Do.
	6. Sunlight	Hours/day or Langleys	Do.
	7. Dew	Presence and duration	Do.
	8. Evapotranspiration	Inches/day	Do.
	9. Drying index	Combination of some of above factors	Do.
b. Temperature-sensitive	1. Soil moisture	Less than 90% field capacity* to 6-in. depth	Up to 48 hr.
crops	2. Temperature (air)	Less than 55°F. (forced harvest), above 90°F. (increased harvest)	Up to 36 hr.
	3. Precipitation	Less than .05 in.	Up to 24 hr.
	4. Wind	Above 25 m.p.h. (forced harvest)	Up to 36 hr.
c. All hardy crops	1. Soil moisture	Less than 90% field capacity* to 6-in. depth	Up to 48 hr.
	2. Temperature (air)	Variable	Up to 36 hr.
	3. Precipitation	Less than .05 in.	Up to 24 hr.
	4. Wind	Above 25 m.p.h. (forced harvest) tree fruit	Up to 36 hr.

Table 1B—Agricultural Weather User Requirements—Continued

Activities	Important parameters	Operational requirement	
		Description	Forecast period
	CATEGORY I—PRODUCERS (GENERAL ACTIVITIES)—Continued		
11. Livestock and poultry	1. Temperature (air)	Above 85°F.—below 40°F.	Up to 36 hr.
a. Protection	2. Precipitation	Greater than .05 in.	Do.
	3. Wind	Greater than 25 m.p.h.	Do.
	4. Blizzard	Feed and shelter	Up to 48 hr.
b. Watering	1. Temperature (air)	Less than 20°F.	Up to 36 hr.
	2. Precipitation	Less than .5 in.	Do.

Table 2—Agricultural Weather User Requirements (Supporting Services)

Activities	Important parameters	Operational requirement	
		Description	Forecast period
	CATEGORY II—SUPPORTING SERVICES (SPRAYING AND DUSTING—AERIAL APPLICATION)		
1. Fertilizer application	1. Cloud ceiling	500 ft. or greater	Up to 3 hr.
	2. Visibility	1 mi. or greater	Do.
	3. Precipitation	Less than .05 in.	Up to 12 hr.
	4. Wind	Less than 20 m.p.h.	Do.
	5. Dew	None present	Do.
2. Herbicide spray	1. Cloud ceiling	500 ft. or greater	Up to 3 hr.
	2. Visibility	1 mi. or greater	Do.
	3. Low-level temperature inversion	Surface inversion desirable	Do.
	4. Temperature (air)	Variable; generally between 55° and 80°F.	Up to 36 hr.
	5. Precipitation	None	Up to 24 hr.
	6. Wind	Direction; speed less than 10 m.p.h.	Up to 3 hr.
	7. Dew	Presence and period	Do.

Table 2—Agricultural Weather User Requirements (Supporting Services)—**Continued**

Activities	Important parameters	Operational requirement	
		Description	Forecast period
		CATEGORY II—SUPPORTING SERVICES (SPRAYING AND DUSTING—AERIAL APPLICATION)—Continued	
3. Fungicide and insecticide spray and dust	1. Cloud ceiling	500 ft. or greater	Do.
	2. Visibility	1 mi. or greater	Do.
	3. Low-level temperature inversion	Surface inversion desirable	Up to 12 hr.
	4. Temperature (air)	Variable; generally less than 85°F.	Up to 36 hr.
	5. Precipitation	None	Up to 12 hr.
	6. Wind	Direction; speed less than 10 m.p.h.	Up to 3 hr.
	7. Dew	Presence and period	Up to 12 hr.
		CATEGORY II—SUPPORTING SERVICES (SPRAYING AND DUSTING—GROUND APPLICATION)	
1. Fertilizer application	1. Soil moisture	30% to 80% field capacity* to 6-in. depth	Up to 48 hr.
	2. Soil temperature	Less than 50°F. for high nitrogen level (inorganics)	Do.
	3. Temperature (air)	Variable	Up to 36 hr.
	4. Precipitation	Less than .05 in.	Do.
	5. Wind	Direction; speed less than 25 m.p.h. (granular),	Do.
		20 m.p.h. (spray), and 10 m.p.h. (dust)	Up to 48 hr.
2. Herbicide	1. Soil moisture	50% to 80% field capacity *to 6-in. depth	Up to 36 hr.
	2. Temperature (air)	Generally between 50° and 80°F.	Do.
	3. Precipitation	None	Up to 24 hr.
	4. Wind	Direction; speed less than 15 m.p.h. (spray)	Do.
	5. Dew	and 10 m.p.h. (dust)	Up to 48 hr.
3. Insecticide and fungicide application	1. Soil moisture	Presence and period	Up to 36 hr.
	2. Temperature (air)	Less than 90% field capacity*	Do.
	3. Precipitation or dew	Variable	Do.
	4. Wind	None	
		Direction; speed less than 15 m.p.h.	Do.

*Field capacity—The amount of water held in the soil after the excess gravitational water has drained away and after the rate of downward movement of water has materially decreased.

Category III users include processors, shippers, and marketers who provide the final link in the production chain to the ultimate consumer. Table 3 presents the summarized operational requirements of these users in similar fashion.

The foregoing summarizations were further consolidated as presented in table 4 which outlines the minimum generalized product requirements to meet the most significant and basic operational needs of each major user category. Examination of this table indicates that generalized operational information needed by producers can conveniently be met by an agricultural zone forecast including the listed parameters, supplemented by interpretation in agricultural terms of the 5-day and 30-day weather outlooks. Product requirements for Category II users suggest the need for a spraying and dusting forecast for agricultural areas. In addition to operational requirements, the recent national concern over pesticide residue and runoff places added significance on weather services designed to increase the efficiency of pesticide application. And finally, the product requirements of Category III users can be met by shippers' temperature forecasts and other generalized products of the Public Weather Service.

Weather-influenced agricultural decisions cover a broad spectrum of time. The agribusiness community could benefit greatly from weather forecasts covering the entire season. However, any appreciable forecasting skill that improves on long-term climatological expectancies is limited by present knowledge to a period of about a month in advance. Therefore, the operational requirements expressed in tables 1 through 3 have been restricted to those which can be reasonably well met by presently feasible forecasts. Climatological information, showing the probability of weather conditions based on past history, provides a useful input into many operational decisions and is the only useful weather information for planning decisions that have implementation more than a month in the future. Table 5 gives some examples of planning requirements for which decisions can be improved by the application of climatological information. As meterological knowledge and forecasting techniques improve through research efforts, it may be possible to relax the somewhat arbitrary distinction between operational requirements and planning requirements, and

It will take years to restore production on this orchard damaged by ice storm.

thus to further improve and refine the statements of user requirements on which plans for service are based.

The process described above leads to a convenient means of describing a product mix which would provide a minimum useful level of service to agriculture based on known user requirements. It is, however, a gross oversimplification to assume that these products are adequate to support effective and economical operations of Category I users in particular. This is true not only because there are numerous and complex crop-weather relationships which must be considered, but because the critical elements are variable as a function of time and space. The extent to which generalized product requirements, such as those of table 4, will serve the total needs of all users in even a limited geographical

Table 3—Agricultural Weather User Operational Requirements

Activities	Important parameters	Operational requirement: Description	Operational requirement: Forecast period
	CATEGORY III—SHIPPERS, PROCESSORS, AND MARKETERS (GENERAL ACTIVITIES)		
1. Scheduling of shipping and processing	1. Temperature	Expected max., mean, and min.	Up to 72 hr.
	2. Precipitation	Quantity and distribution	Do.
2. Loading	1. Temperature	Generally 50° to 80°F. optimum	Up to 48 hr.
	2. Precipitation	Less than .05 in.	Up to 36 hr.
	3. Wind	Less than 25 m.p.h.	Do.
3. Transporting and marketing	1. Temperature	Between 32° and 80°F. with no control	Up to 5 days
	2. Precipitation	Less than .05 in.—no ice or snow	Do.
	3. Wind	Less than 40 m.p.h.	Up to 72 hr.
4. Storing	1. Temperature	Greater than 32°F. and less than 60°F.	Up to 36 hr.
	2. Precipitation	Less than 1 in.	Do.
	3. Humidity	Between 30% and 70%	Do.
	4. Wind	Less than 40 m.p.h.	Do.

Table 4—Summary of Generalized Agricultural Weather Product Requirements

User category	Area of interest	Important parameters	Operational information: Required description	Operational information: Forecast period	Planning information: Required description	Planning information: Forecast period
I. Producers	Local agricultural area	Temperature	Max. and min. in °F.	0 to 48 hr.	Trend and departure from normal	3 to 30 days
		Precipitation	Type and intensity	Do.	Total amounts and periods of occurrence	Do.
		Wind	Direction and speed	Do.		
		Humidity	Amount to nearest 10%	Do.		
II. Supporting services	Local agricultural area	Cloud ceiling	≥ 500 ft.	0 to 36 hr.		
		Visibility	≥ 1 mi.	Do.		
		Precipitation	Type and intensity	Do.		
		Wind	Direction and speed	Do.		
		Dew	Occurrence and duration	Do.		
III. Processors, shippers, and marketers	Processing sites and destinations	Temperature	Max. and min. in °F.	0 to 48 hr.		
		Humidity	Amount to nearest 10%	Do.		
		Precipitation	Type and intensity	Do.		

Table 5—Agricultural Planning Requirements (Some Examples)

Activities	Important parameters	Planning requirements	
		Description	Time period
1. Site and crop selection	1. Temperature 2. Precipitation 3. Wind 4. Humidity	Means, extremes, and probabilities for each parameter based on weekly, monthly, and annual data from nearby observation stations	One month to years
2. Equipment procurement such as irrigation, snow plows, air conditioners, frost abaters, etc.	1. Temperature 2. Precipitation 3. Wind 4. Humidity	Do.	Do.
3. Building farm structures	1. Precipitation 2. Wind	Probabilities of heavy precipitation, particularly snow; maximum wind speed probabilities	Years
4. Shelter-belt location and orientation	1. Wind	Direction and speed of prevailing wind	Do.
5. Crop harvest scheduling	1. Temperature 2. Sunlight	Normal accumulation of growing degree days above appropriate base temperature; total Langleys or hours	Growing season
6. Transplanting succulents, that is, tomatoes, peppers, egg plants, etc.	1. Temperature	Freeze probabilities	One month to one year

area is therefore distinctly limited. Producers in particular require more than strictly meteorological information; they require detailed and specialized assistance in the determination of the *implications* of forecast conditions to their immediate operations.

As an example, table 1A indicates that apple growers require forecasts of probable outbreaks of apple scab to plan and execute control procedures. These forecasts require the coordinated efforts of the meteorologists and the agricultural specialists. Knowledge of the specific meteorological conditions favorable to scab occurrence is only one contributing factor. Other elements which also enter into this determination are the presence and stage of development of the causal organism, and the susceptibility of the orchard (which is in turn a function of the stage of growth and resistance characteristics of the tree variety). Table 6 indicates the type of meteorological information which must be made available for the production of such plant disease forecasts. Similar meteorological and hydrological inputs have been developed which contribute to the forecasting of additional significant indirect effects of weather on agricultural operations other than disease control; specific advisories are valuable, for example, in such operations as irrigation, harvesting, blossom thinning, defoliation, and application of special herbicides.

U.S. agriculture, a $215 billion industry in terms of assets and employing 6.5 million workers, provides the food and fiber necessary for the welfare of 205 million people domestically and for the welfare of many other nations as well. Direct weather-caused losses in crop output alone amount to between $1 and $2 billion per year. These losses are often borne by consumers in the form of higher prices for the undamaged portion of the crops or by desirable commodities not being available at all. These data suggest that the potential benefits to our society from the availability and use of better weather information in making farm management and product-processing decisions are indeed large, with many of these losses amenable to elimination or reduction. For example, the $10 million program envisaged in this Plan would need to result in only a 1-percent reduction of weather damage to crops to be economically justified. A 5-percent reduction would yield a ratio of at least 5 to 1, a rate of return greatly exceeding tangible returns on most other forms of public investment.

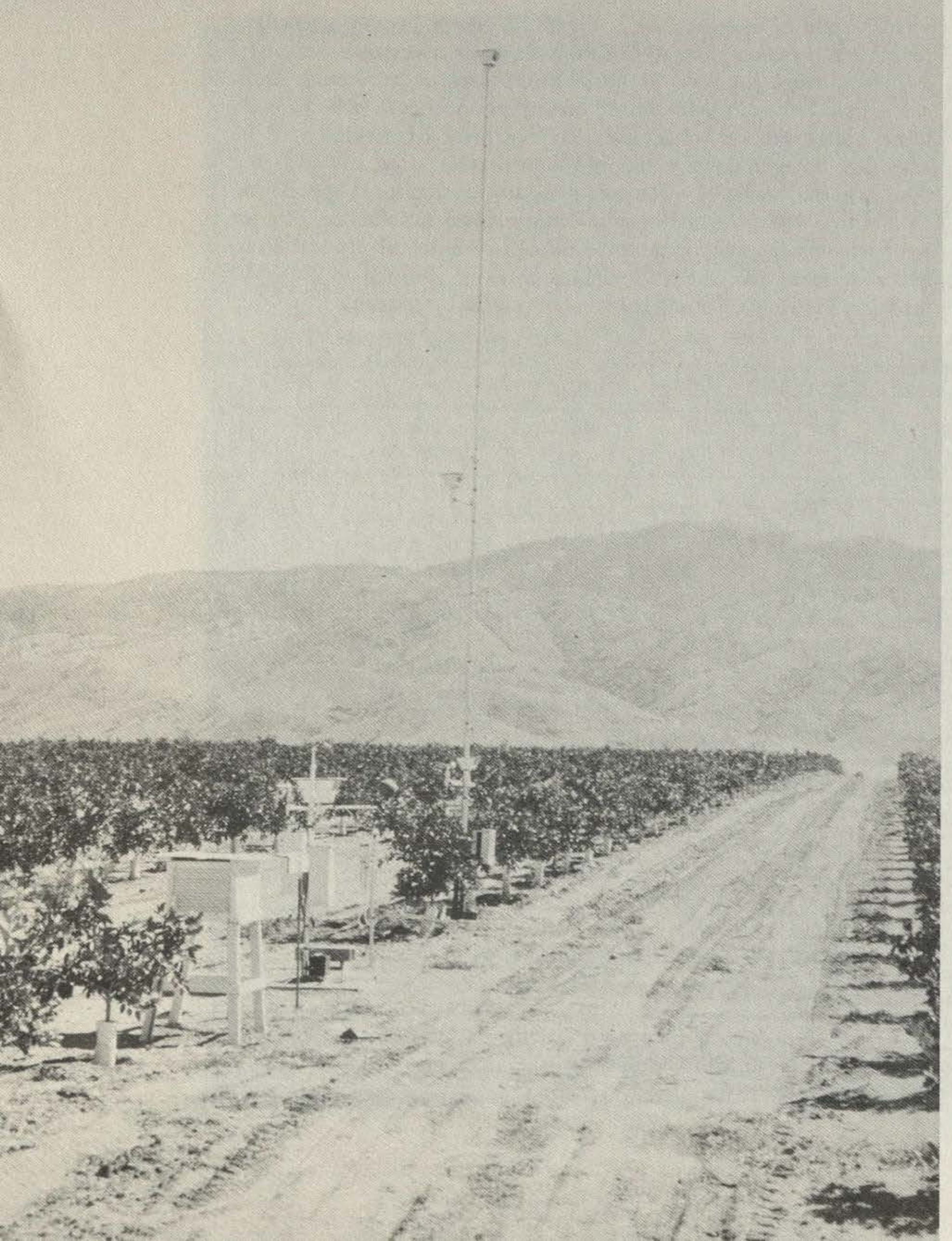
In summary, analysis of agricultural user requirements indicates that although generalized area-type products can provide some useful support, the most effective level of service will be provided through locally tailored interpretive products utilizing the integrated skills of meteorological and agricultural specialists. In addition, the potential benefit derived from satisfaction of user requirements can support an investment in service of around $5 to $10 million a year and still yield a ratio of savings to expenditures greater than most other forms of public investment.

Table 6—Specialized Agricultural Forecast Requirements

FORECAST CATEGORY—CROP DISEASES*			
Disease type	Important meteorological parameters	Critical values	Forecast period
1. Apple scab	1. Temperature	Between 45° and 80°F.	Up to 72 hr.
	2. Precipitation	Greater than .05 in.	Up to 36 hr.
	3. Humidity	Greater than 75%	Up to 72 hr.
	4. Dew	Duration and time	Up to 36 hr.
2. Late blight	1. Temperature	Between 45° and 80°F.	Up to 72 hr.
	2. Precipitation	Greater than 1 in.	Do.
	3. Humidity	Greater than 75%	Do.
	4. Dew	Duration and time	Up to 36 hr.
3. Downy mildew	1. Temperature	Between 50° and 80°F.	Up to 72 hr.
	2. Precipitation	Greater than 1 in.	Up to 36 hr.
	3. Humidity	Greater than 69° F. dew point	Up to 72 hr.
	4. Dew	Duration and time	Up to 36 hr.
4. Pecan scab	1. Temperature	Between 50° and 80°F.	Up to 72 hr.
	2. Precipitation	Greater than .05 in.	Up to 36 hr.
	3. Humidity	Greater than 75%	Up to 72 hr.
	4. Dew	Duration and time	Up to 36 hr.
5. Wheat rust	1. Temperature	Between 45° and 85° F.	Up to 72 hr.
	2. Wind	Direction and speed of winds aloft	Do.

*Crop diseases listed in this table represent a few examples of plant epidemiological research by agricultural specialists which have provided sufficiently detailed weather-dependent data to permit issuance of specific plant disease forecasts. Such forecasts are issued jointly by agricultural research or extension personnel and meteorologists.

Weather observation station in a citrus grove.



2.0 PRESENT NOAA AGRICULTURAL WEATHER SERVICE PROGRAM

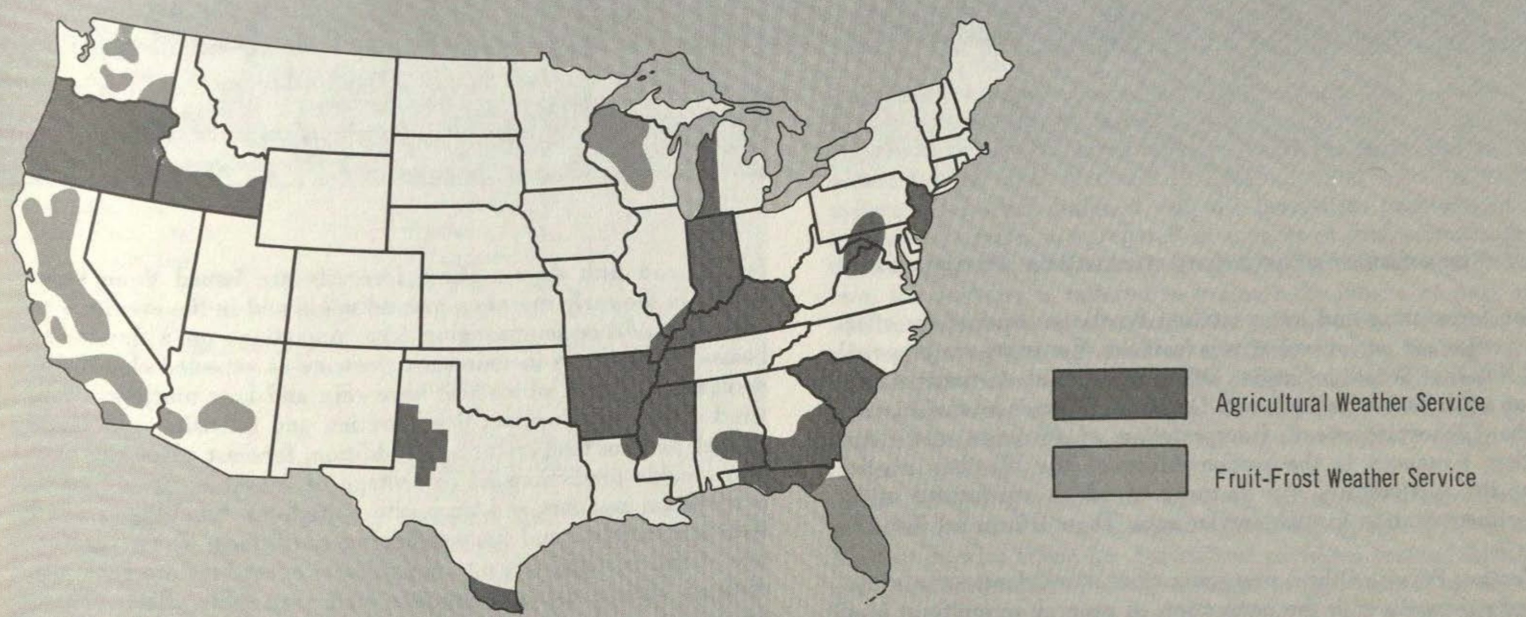
Agriculture's need for specialized forecasts and advisories has been clearly established. A pilot project to determine the best procedure for serving the interests of an important agricultural area was started in the Mississippi Delta with funds appropriated by the 85th Congress. Evaluation of this program during the 1959 crop season, as reported to the Congress, indicated that providing the tailored service saved agriculturists millions of dollars—a return of about $50 for each dollar spent. This program was expanded to eight other regions in FY 1962; a joint Survey was authorized by the Congress whereby the Department of Agriculture and the Weather Bureau, representing the Department of Commerce, determined the need for similar service in other parts of the Nation.

2.1 PRODUCTS AND SERVICES

The successful Delta experiment thus became the prototype for the present Agricultural Weather Service which is operating in a total of 12 areas of the United States where there are valuable concentrations of weather-sensitive crops. As depicted in figure 1, these are: (1) New Jersey; (2) an area including northern Virginia, northeastern West Virginia, western and central Maryland, and south central Pennsylvania; (3) South Carolina; (4) a tristate area including southern Georgia, southeastern Alabama, and northwestern Florida; (5) the Mid-South including northern Mississippi, western Tennessee, Arkansas, northeastern Louisiana, and the Boot Heel of Missouri; (6) the Lower Rio Grande Valley of Texas; (7) western Lower Michigan; (8) southern Idaho; (9) Oregon; (10) the High Plains area of Texas; (11) Indiana; and (12) Kentucky.

The Agricultural Weather Service provided in the above areas represents advanced and effective integration of available meteorological talent with that of Federal and State specialists of Colleges of Agriculture, Agricultural Experiment Stations, Extension Services, and other components of the Federal and State Departments of Agriculture to provide users with both short- and long-range planning information and certain specialized services. To accomplish this objective, the Agricultural Weather Service has developed three closely integrated programs involving forecasting and interpretation, data collection and dissemination, and more general climatological planning support; these programs are described below.

Figure 1.—Present Agricultural Weather Service Program.



Orchard protected by heaters in response to forecast of unseasonable snow.

2.1.1 Forecasting and Interpretation Program

The forecasting and interpretation functions required for effective service are performed at two facilities. Forecasts are prepared at a National Weather Service Office staffed with forecasters having an agricultural background. One such Office is located in each of the 12 service areas. Interpretation of forecasts and other weather issuances is the responsibility of the Weather Service Office for Agriculture, one or more of which are located at an Experiment Station in each service area. These Offices are listed in table 7.

Weather Service Offices preparing agricultural forecasts are concerned primarily with the generation of general agricultural forecasts covering a 2-day period (with an outlook for the third, fourth, and fifth days). These forecasts are issued three times daily—in the early morning, around noon, and in the evening—to provide guidance in managing farm operations on a day-to-day basis. The forecasts include such elements as expected cloudiness, percentage of area which will have rain and how much will fall, wind speed and direction, dew duration and intensity, and range of high and low temperatures. In addition, forecast advisories may also include predictions of percentage of sunshine, drying rates, evaporation amounts, soil temperature, high-low humidity, ground level temperature, and harvest/haying conditions. Thus, parameters of known significance to agricultural operations are generally forecast without explicitly stating their proximate effects. There are exceptions, however, in certain areas where the Weather Service Office preparing agricultural forecasts provide specific operational forecasts for which the forecast techniques are well established; these include, for example, spraying and dusting forecasts (issued twice daily) and daily drying forecasts for hay.

In producing their forecasts, Weather Service Offices preparing agricultural forecasts utilize guidance products received from the National Meteorological Center and Area or State Forecast Offices of the Basic Meteorological Service, synoptic reports, and special observations received daily from agricultural cooperative weather observers. In addition, Weather Service Offices preparing agricultural forecasts use observations from weather radars in their areas to produce advisories (as needed) which report the occurrence of significant precipitation and predict, to the extent feasible, the movement and intensity of shower activity to facilitate short-range operational decisions in agriculture.

Table 7—Agricultural Weather Service Facility Locations

WEATHER SERVICE OFFICES HAVING AGRICULTURAL FORECAST RESPONSIBILITY	
Boise, Idaho	Lubbock, Tex.
Brownsville, Tex.	Memphis, Tenn.
Columbia, S.C.	New York, N.Y.
Grand Rapids, Mich.	Portland, Oreg.
Indianapolis, Ind.	Tallahassee, Fla.
Louisville, Ky.	Washington, D.C.

WEATHER SERVICE OFFICES FOR AGRICULTURE	
Auburn, Ala.	Lexington, Ky.
Clemson, S.C.	Lubbock, Tex.
Corvallis, Oreg.	New Brunswick, N.J.
Experiment, Ga.	Portageville, Mo.
Fayetteville, Ark.	Quincy, Fla.
Jackson, Tenn.	Stoneville, Miss.
Kearneysville, W. Va.	Tifton, Ga.
Keiser, Ark.	Twin Falls, Idaho
Lafayette, Ind.	Weslaco, Tex.
Lansing, Mich.	

Weather Service Offices for Agriculture carry the interpretive (as opposed to the forecasting) function a step further, acting in collaboration with the Federal and State Agricultural Specialists. Weather Service Offices for Agriculture are staffed by National Weather Service Advisory Agricultural Meteorologists (AAM) and are generally collocated with a Federal or State Agricultural Experiment Station. This arrangement enables the AAMs to coordinate closely with the Extension Service and the other groups involved in the welfare of agricultural activities in their respective States. Through effective joint action, detailed knowledge of such factors as crop-weather relationships, life cycles of pests, and cultivation techniques is applied to produce explicit interpretive guidance to agricultural operations. For example, on a daily basis (5 days per week), a farm weather summary is issued as a supplement to the general agricultural forecast of the Weather Service Office preparing agricultural forecasts. This summary provides an evaluation of the effects of expected weather factors on agricultural operations in progress or planned for the period.

Each day, the Weather Service Office for Agriculture issues an agricultural interpretation of the 5-day outlook. Twice monthly, a similar interpretation is issued for the 30-day outlook. The foregoing products are routinely provided during the entire agricultural season for the areas involved. In addition, joint specialized agricultural advisories, designed with the immediate problems of the local area in mind, are prepared in support of such critical operations as planting, pest control, irrigation, and harvesting. In each case, the advisory is tailored to evaluate the effects of past, present, and expected weather factors on agricultural operations, permitting the agricultural user to minimize loss or damage from adverse factors or to take advantage of favorable conditions. Advisories, involving epidemiology potentials, are coordinated with those Federal and State agencies having the statutory responsibility for providing such reports.

The foregoing represents advisory functions which directly serve the interests of agriculturists. In addition, the AAM at each Weather Service Office for Agriculture performs certain functions which indirectly affect the improvement of agricultural operations. These include cooperating closely with State and Regional Climatologists and with River Forecast Centers and River District Offices

Early dissemination of blizzard and cold wave warnings assists actions to reduce livestock losses.

to make maximum use of climatological and hydrological data and services and to prevent duplication of effort. Another important service is provided by the AAMs to the Federal and State Experiment Stations, Research Centers, and Colleges of Agriculture; through close cooperation with agricultural scientists, meteorological support is provided for the pursuit of technical studies relevant to agriculture-weather relationships. These studies most frequently involve: (a) microclimate of agricultural areas; (b) growth, yield, and quality of crops; (c) agricultural pests; (d) effects of pollutants (pesticides, etc.) on the quality of the environment; (e) farm animals and, to a lesser extent, wildlife; and (f) soils.

Better understanding of these relationships resulting from technical studies not only promotes improved farming practices, but provides effective feedback to guide continuing improvement in the day-to-day operational weather support being provided to agriculturists. Where such studies are closely related to crop or livestock response studies conducted by Federal or State agricultural research agencies, consideration is given to joint publication as a means of providing a more effective and useful release of these data.

Because of the concentrated growing areas, the high per-acre value of the crops, and the extreme sensitivity of the fruit crops to frost conditions, a specialized Fruit-Frost Weather Service is currently being provided for fruit growers, primarily in Florida, California, Arizona, Washington, Oregon, and Wisconsin as part of this total Agricultural Weather Service. This Service, developed before the generalized Agricultural Weather Service, demonstrated an effectiveness which has had a strong influence on the development of expanded service to other agricultural users. The Service structure varies with the areas served as a function of local climatological factors, being centralized, for example, in Florida (at Lakeland) and decentralized in the Western States. In the West, trained forecasters from the Pomona, Calif., Weather Service Office are stationed in other California Offices close to the fruit-producing areas during the winter, moving north to Oregon and Washington with the advancing spring season. Forecasts are issued several times daily during the critical seasons for the particular crops concerned; parameters reported include minimum temperatures expected at key points, wind, cloud cover, and temperature inversions. These data have proved extremely effective in assisting growers to provide timely, economical, and effective control measures when damaging frost conditions (cold, calm, and clear) are forecast. The Fruit-Frost Weather Service is generally operated on a cooperative basis with States, counties, or local growers' organizations providing active support, such as special temperature observations required from field location.

2.1.2 Data Collection Program

One of the prime requirements of the Agricultural Weather Service is an adequate network of observing stations to provide data on elements that characterize the physical environment of the agricultural area. Parameters may include some or all of the following: temperature and humidity of the air, air-motion, sunshine and radiation, soil temperature and moisture, and hydrometeors and other water balance factors. To provide such data, the National Weather Service utilizes a number of cooperative observing stations in representative agricultural areas and within or near various crops or enterprises. Currently, there are about 20 such stations in each area being served by the Agricultural Weather Service. As far as practicable, the stations used are already integral parts of the national climatological and hydrological networks; where necessary to obtain pertinent data, additional sites are established for the specific purpose of supporting the Agricultural Weather Service. Instruments are furnished and serviced by the National Weather Service, and in most cases the observers, as part of a corps of nearly 13,000 private citizens, serve without pay. Normally, daily measurements are made of the maximum and current air and soil temperatures, amounts of rainfall, and, sometimes, evaporation.

Routine agricultural observations from these cooperative stations are taken in the early morning and are telephoned to the nearest Weather Service Office where they are placed on a teleprinter network for dissemination. These observations provide an essential supplement to the National Weather Service's overall observing network, aiding the Weather Service Office preparing agricultural forecasts and the Weather Service Office for Agriculture in the preparation and verification of forecasts and advisories, and in the evaluation of the accuracy of previous products. These observations also provide valuable data for preparing agriculture-meteorology technical studies and for developing improved forecasting techniques. Summarizations are made by the AAM for these purposes and are available to other interested local users on request.

As part of the overall agricultural weather observing program and in cooperation with agricultural scientists at Federal and State Experiment Stations, colleges, and universities, observations of the microenvironment are also obtained at each Weather Service Office for Agriculture for use in technical studies associated with agriculture-meteorology relationships. Some of the parameters being observed are:

Total radiation	Temperature of soil-air interface
Net radiation	Soil moisture
Evaporation (Evapotranspiration	Composition of the air in the biosphere
Temperature of air	Duration and amount of dew and/or leaf wetness
Temperature of soil	Wind (crop level and standard)
Temperature of foliage	Rainfall (micronetwork)
Temperature at crop level	Humidity

Automatic data loggers have been developed and are in use at three Weather Service Offices for Agriculture. This equipment records the data from the above observations on 5-level punched tape which is adaptable to computer processing. Certain of these parameters are extracted and transmitted over the communication net for use by the Weather Service Forecast Office in its forecasting procedures.

2.1.3 Dissemination Program

Beneficial results from any Agricultural Weather Service cannot be realized unless a direct link with the user is available by which weather forecasts and advisories, farm bulletins, weather observational data, and allied information can be effectively distributed. As in other weather services, the products of the Service reach the users in a variety of ways, the most common being through the news media and agricultural agencies (for example, county agents). To improve the collection and dissemination of agricultural weather information, the National Weather Service employs a group of special, local, agricultural-area, and teletypewriter networks (NOAA Weather Wire Service). The operation of these networks insures that vital weather information is made available for dissemination by the mass media with the least possible delay.

Each of the existing networks connects the area Weather Service Office preparing agricultural forecasts and the Weather Service Office(s) for Agriculture with the news media and other agricultural disseminators in the respective service area. The networks operate 24 hours a day throughout the year. Some of the networks are localized as, for example, the Lower Rio Grande Valley of Texas, southern Idaho, and western Lower Michigan networks. Others cover a single State area, such as New Jersey, South Carolina, Oregon, or a multistate area as, for example, the Mid-South networks. Routine collection and distribution schedules are arranged for and monitored by the Weather Service Forecast Office for each network.

Communication facilities in the expanding Agricultural Weather Service are provided by the National Weather Service which pays the charges of the basic circuit. In turn, mass dissemination media and other interested subscribers lease receiving machines from the appropriate communications company and pay local connection charges.

In addition to forecasts, advisories, and observations of specific interest to agriculture, these circuits also carry flood warnings, river forecasts, and weather information aimed at the general public such as warnings and advisories of severe weather.

2.1.4 Climatological Planning

While not part of the Agricultural Weather Service, State Climatologist Offices maintained by NOAA serve all States. Agricultural service is provided in proportion to its importance in each State, but one State Climatologist (and some serve more than one State) cannot provide much detailed guidance. These one-man Offices, often strengthened by university cooperation, are located as shown in table 8; appropriate Regional Climatologist locations are also given.

Climatological studies provided by the Environmental Data Service and National Weather Service, relating the long-time probabilities of the weather elements to agricultural practices, supplement the forecasting service. These studies are published and made available to farmers and county agents as a permanent reference to be used in conjunction with the forecast service. This information is useful in seasonal operations (for example, planting and defoliation) and in long-term planning such as determining the capacity required of supplementary irrigation systems.

Water use by evaporation and transpiration is calculated and related to soil water capabilities and rainfall received. State and

Table 8—Regional and State Climatologists Locations

Eastern Regional Climatologist—Garden City, N.Y.		
State Climatologists:		
Blacksburg, Va.	Columbus, Ohio	Raleigh, N.C.
Boston, Mass.	Ithaca, N.Y.	Storrs, Conn.
Clemson, S.C.	Morgantown, W. Va.	University Park, Pa.
College Park, Md.	New Brunswick, N.J.	
Southern Regional Climatologist—Fort Worth, Tex.		
State Climatologists:		
Athens, Ga.	Jackson, Miss.	Nashville, Tenn.
Austin, Tex.	Las Cruces, N. Mex.	Oklahoma City, Okla.
Baton Rouge, La.	Little Rock, Ark.	San Juan, P.R.
Gainesville, Fla.	Montgomery, Ala.	
Central Regional Climatologist—Kansas City, Mo.		
State Climatologists:		
Brookings, S. Dak.	Des Moines, Iowa	Lincoln, Nebr.
Champaign, Ill.	East Lansing, Mich.	Madison, Wis.
Cheyenne, Wyo.	Fargo, N. Dak.	Manhattan, Kans.
Columbia, Mo.	Lafayette, Ind.	St. Paul, Minn.
Denver, Colo.	Lexington, Ky.	
Western Regional Climatologist—Salt Lake City, Utah		
State Climatologists:		
Boise, Idaho	Phoenix, Ariz.	San Francisco, Calif.
Helena, Mont.	Portland, Oreg.	Seattle, Wash.
Logan, Utah	Reno, Nev.	
Alaska Regional Climatologist—Anchorage, Alaska		
Pacific Regional Climatologist—Honolulu, Hawaii		

national bulletins carry weekly tables and maps of currently available soil moisture in comparison with normal. These same bulletins also monitor progress of the season in terms of heat accumulated for crop development and actual stages of development attained. By providing normal total seasonal heat units, guidance is afforded seed suppliers and farmers in producing and planting varieties adapted to the time remaining after planting. These cumulative evaluations are part of the management process which modern scientific farming employs. It is not feasible, however, for the State Climatologist to furnish guidance for all operational decisions requiring special current observations and tailored forecasts.

In tailoring such climatological information to individual needs, a consulting meteorologist may be found highly desirable. A list of recommended consultants may be obtained from the American Meteorological Society as indicated on page 7.

2.2 AREA OF POTENTIAL IMPROVEMENT

An evaluation of user requirements was performed and the products and services necessary to meet these requirements were established. These products and services were then compared with those provided by the existing Agricultural Weather Service. This comparison indicates that in selected areas of the United States (fig. 1), the existing Agricultural Weather Service (described in Section 2.1) effectively meets the needs of agricultural interests within existing technical capabilities.

In those States for which no specialized agricultural weather programs have been authorized by Congress, the Meteorologist in Charge (MIC) of the National Weather Service Forecast Office, upon approval of National Weather Service Headquarters, will arrange for service to agriculture as a part of the general forecast service. Generally speaking, however, this arrangement does not meet the full requirement for agricultural weather services for the following reasons:

a. Public service forecasts and advisories, while frequently of general interest to agriculturists, do not cover all parameters of importance.

b. No advisories are available which interpret the forecast meteorological parameters in terms of probable effects on agricultural operations and environmental quality.

c. Special agricultural observations which are essential to the production of adequate forecasts are not available.

Because valuable and highly weather-sensitive agricultural products are cultivated throughout the United States and because livestock production is the mainstay of many areas, there is a demonstrated need to provide the products and services of the modernized Agricultural Weather Service to remaining areas of the country.

3.0 NOAA'S PLAN FOR AN IMPROVED AGRICULTURAL WEATHER SERVICE

3.1 PRODUCTS AND SERVICES

There is widespread recognition of the benefits resulting from the improved level of service now being provided in selected areas. As a result, there is increasing demand for broadening the service program's scope to meet established user requirements. A joint Department of Agriculture-Weather Bureau Survey*, authorized by the Congress, resulted in the evolution of a 10-phase plan which will allow gradual expansion of the current service into presently unserviced areas. The service improvement program consists of the introduction of the products and services described in Section 2.1 into remaining areas of the United States, and the provision of advisory services to the Department of Agriculture. This will be accomplished in accordance with phasing described in Section 5.0.

*Authorized by the Appropriations Committee of the 87th Congress, First Session, Report No. 497 (General Bill, 1962) Accompanying H.R. 7577 and Report No. 448 Accompanying H.R. 7444.

3.2 SERVICE SYSTEM CONFIGURATION

Improvement of the Agricultural Weather Service is based primarily on implementation of a phased program to provide coverage to all currently unserviced areas. This action constitutes the major change necessary in the present system configuration to meet the specific requirements of agricultural user groups. This expansion will require the assignment of agricultural weather forecasters at selected National Weather Service locations to provide forecast service in the associated agricultural areas. These forecasters will perform functions and generate products as described in Section 2.1.1. (As the program is implemented, the specialized, long-established Fruit-Frost Weather Service will continue to be reviewed to assure that the critical seasonal requirements for frost and freeze warnings are met.)

Concurrently, Weather Service Offices for Agriculture will be established to provide the agricultural users with the specialized interpretive products which are most pertinent to agricultural operations. Specifically, the AAMs at each Weather Service Office for Agriculture will have responsibility for:

a. Coordinating with MICs of National Weather Service Offices within the area, with Field Aides, and with Regional and State Climatologists in the establishment of a network of representative agricultural weather observing stations.

b. Acquainting the forecasters (through the MIC) with the requirements of agriculture for weather data and forecasts.

c. Cooperating closely with State and Regional Climatologists to make maximum use of climatological data and analyses, to prevent duplication of efforts, and to take advantage of the existing working relations already established by State Climatologists.

d. Cooperating with the MIC of the Weather Service Forecast Office in promoting the maximum distribution of weather data, forecasts, and outlooks by the various means of mass news dissemination.

e. Cooperating with River Forecast Centers and River District Offices to obtain maximum application of hydrologic services to agricultural operations and to prevent duplication of effort.

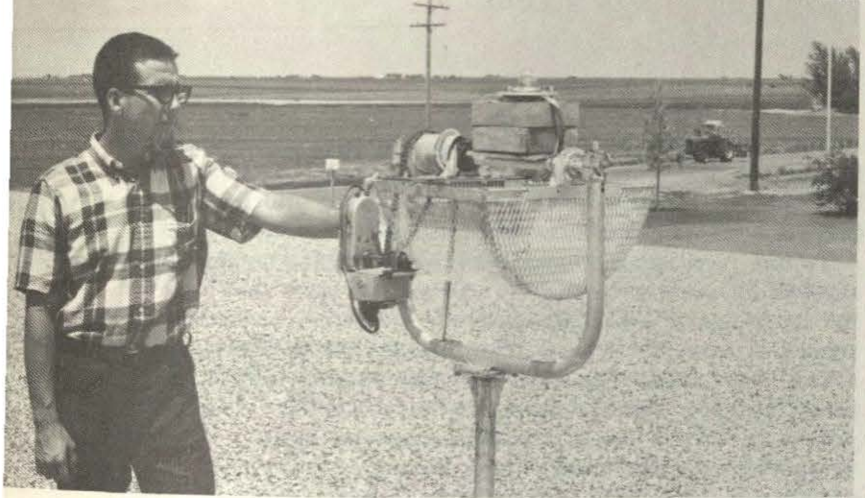
f. Issuing joint releases on agricultural interpretations of the daily and other meteorological forecasts in cooperation with State and Federal research and extension personnel.

g. Maintaining liaison with mass news disseminators and with all segments of agriculture in the area.

h. Cooperating with Federal and State Agricultural Specialists and State Climatologists on technical studies relevant to agriculture-weather relationships and on the application of these relationships to the improvement of operational Agricultural Weather Service.

The ability to provide accurate and meaningful forecasts for an agricultural area depends to a large extent on the availability of weather observations from sites which are representative of conditions in those areas. Special agricultural observing sites will be established as required to augment the existing national climatological and hydrological network, and arrangements will be made for daily reporting by telephone toll calls from the cooperative observers to the nearest Weather Service Office. The number of sites required will be a function of size of the area, topography, types of agriculture, and weather variability.

Finally, the communications required for the collection of agricultural observations and the dissemination of agricultural forecasts, advisories, summaries, and related information to mass media and other interested subscribers will be provided by the planned nationwide Weather Wire Service. Existing agricultural networks will be absorbed within the larger Network as it is implemented. Continuous radio transmission facilities provided for under other National Weather Service programs will be used where they exist to supplement mass media dissemination as required.



Pyroheliometer records solar energy received for plant growth. A hail shield automatically raises when atmospheric conditions interrupt sunlight or power.

4.0 SUPPORTING PROGRAMS

4.1 RESEARCH AND DEVELOPMENT PROGRAM, DEPARTMENT OF COMMERCE (NATIONAL WEATHER SERVICE)

Except for special agricultural observing, the functions of the Agricultural Weather Service are interpretive in nature; that is, every product is intended for and oriented toward direct use by agricultural user groups. The effective use of these Agricultural Weather Service products by any user in making operational and planning decisions depends, to a large extent, on accuracy in predicting future weather conditions. Present forecast techniques leave much to be desired in this regard. To insure effective accomplishment of the Service program, an extensive agriculture-weather research and development effort is essential. The objectives of such effort are:

a. To combine successfully knowledge obtained through interrelated studies and investigations made in the fields of agriculture, meteorology, climatology, and hydrology;
b. To apply this knowledge to the solution of practical agricultural problems;
c. To adapt general forecasts to the specific needs of agriculture;
d. To provide forecasts of increased accuracy and of longer projection into the future.

In addition to the broadscale motion of the atmosphere and its accompanying weather systems, local variations are particularly important in agriculture. Local variations of insolation; precipitation (rain, snow, hail, etc.); dew; air, soil, and foliage temperature; humidity; wind; and the presence or absence of low-level inversions, individually or collectively, are frequently the controlling factors in agricultural operations. The improvement in methods of measuring and forecasting these parameters is therefore a valid area for meteorological research. Such research is quite distinct from the technical studies that the AAM conducts in cooperation with Agricultural Specialists as a part of his operational program.

Meteorological research programs in support of Agricultural Weather Service should include improved means of describing and forecasting weather through the development of physical models. These models should allow the prediction of meteorological conditions at the macro-, meso-, and microscale levels. The models should further increase accuracy of temperature and precipitation predictions in the 5-day, 30-day, and seasonal forecasts, aid in improving accuracy of shorter range forecasts of wind, temperature, humidity, and precipitation; and promote the prediction of microscale meteorological phenomena.

Because there are many meteorological elements whose prediction is important to agricultural operations, some initial priority must be assigned to the various problem areas. First priority should be assigned to the forecasting of precipitation, its occurrence, timing, and amount. Next in importance is evaporation, including some means of accurate measurement and forecasting. Other meteorological factors in order of their general importance are: temperature, temperature inversions, wind, and dew. Table 9 lists specific technique and equipment development projects which should be pursued in support of the general problems of agriculture.

Table 9—National Weather Service Supporting Research and Development Projects

I. METEOROLOGICAL RESEARCH

A. Short-term forecasting (up to 72 hr.)
   1. Interpretation and application of radar information in predicting the intensity and movement of convective storms (up to 6 hr.).
   2. Localization (to agricultural zone level) of quantitative precipitation and probability of precipitation forecasts (up to 48 hr.).
   3. Evaluation of current methods of forecasting evapotranspiration and evaporative drying conditions, and development of standard procedure for general use (up to 72 hr.).
   4. Development of techniques for subsynoptic-scale minimum-temperature forecasting for certain agricultural districts (up to 36 hr.).
   5. Distinction of predominantly radiation freezes from advective freezes in forecasts to fruit growers with wind machines (up to 24 hr.).
   6. Exploration of methods of forecasting surface temperature inversions and low-level winds (direction and speed) for use in agricultural aviation (up to 12 hr.).
   7. Exploration of methods of forecasting occurrence and duration of leaf wetness in critical agricultural districts (up to 24 hr.).
   8. Exploration of methods of forecasting air pollution potential of significance to agriculture in certain vulnerable areas (up to 36 hr.).
   9. Exploration of methods of forecasting solar radiation on a daily basis (up to 72 hr.).

B. Intermediate-term forecasting (3 to 10 days)
   1. Refinement and expansion of 5-day outlooks to include precipitation and temperature *trends* up to 10 days.

C. Long-range forecasting (greater than 10 days)
   1. Improvement of monthly outlooks and introduction of generalized seasonal outlooks.

II. EQUIPMENT DEVELOPMENT

A. Development of an automatic station for observing parameters of agricultural significance in areas where increased frequency and/or density is required.

B. Development of low-level sounding equipment to provide temperature, dew point, and wind profiles to approximately 1,000 ft.

C. Development of improved sensors for: leaf wetness, soil temperature, soil moisture, net radiation, and spectral radiation.

The foregoing list assigns priorities in terms of general overall interest and importance to many areas. In any one area, there may be specialized problems which have a high local priority and are thus worthy of particular emphasis. Examples are listed in table 10.

To meet agricultural research and development needs, only a small effort has been carried on over several years that explored the application of new methods to the prediction of freezes and rainfall in agricultural areas. The program outlined in tables 9 and 10 will expand this effort and will provide techniques for predicting other weather factors such as humidity, local wind patterns, dew, sunshine, and combinations of weather elements which affect particular types of operation.

Table 10—Examples of Specialized Weather Problems of Research Interest in Particular Areas

Area	Factors
West Virginia	Spring precipitation and wind
South Carolina and Southeast	Winter precipitation, spring temperatures, wind, evaporation, and drying conditions
Texas—High Plains	Spring and fall temperatures, and wind
Mississippi—Mid-South area	Spring and summer precipitation, dew, soil temperature, and wind
Washington, Oregon, and Idaho	Precipitation, temperature, and wind
Carolinas, Indiana, and Kentucky	Precipitation and temperature
Southern Ohio	Humidity—drying conditions
California, Nevada, and Arizona	Temperature, frost, and inversions
Central and Northeastern Texas	Temperature and precipitation
Virginia through Northeastern United States	Temperature, precipitation, and drying conditions
North Central United States	Precipitation timing and blizzards

4.2 RESEARCH AND DEVELOPMENT PROGRAM, DEPARTMENT OF AGRICULTURE

Agricultural research programs in support of agricultural weather services include the following:

a. Detailed microclimatic studies to determine the interactions between measured meteorological parameters and specific plant, forest, and animal responses.

b. Study of energy budget relationships at the earth's surface as they affect evaporation from soil and water surfaces and transpiration from crops and forest plants, and as they influence animal responses.

c. Study of precipitation-runoff relationships and related meteorological parameters as they relate to the hydrologic responses of agricultural and forested watersheds.

d. Detailed research studies on the influence of meteorological parameters upon the incidence of plant and animal pathogens and upon the related epidemiological consequences of such infections.

e. Detailed research studies on the influence of meteorological parameters upon the incidence of insect, parasite, and fungus populations and upon the related epidemiological consequences of populations.

f. Studies of the relationship of weather parameters to problems of pre- and post-crop harvest, processing, storage, and shipment as they influence the quality of a crop and its use.

g. Studies of the relationship of meteorological parameters to the incidence and control of forest and range fires and of such other weather phenomena as frost, hail, wind, and severe storms.

4.3 EDUCATION AND TRAINING PROGRAM, DEPARTMENT OF COMMERCE (NATIONAL WEATHER SERVICE)

A factor which may limit the rate of expansion of the Agricultural Weather Service is the availability of trained personnel. In anticipation of this need, the National Weather Service in recent years (since FY 1961) has sponsored special Agricultural Meteorological Institutes at Land Grant Colleges in various parts of the country. The objective of this program has been to familiarize meteorologists with agricultural weather relationships. About 10 meteorologists have attended each of these Institutes. The curriculum extends over one semester and consists of courses in micrometeorology, microclimatology, or agricultural meteorology, and selected courses in agricultural sciences.

Although completion of such a course of study does not make an expert agricultural scientist of the meteorologist, it does provide him with a clear picture of the problems of agriculture and their relation to weather phenomena, and facilitates the exchange of ideas between meteorologists and agriculturists. The agricultural education and training program will, therefore, continue to support these Institutes as an instrument for training agricultural forecasters.

Specialized training of a different nature from the one-semester Institute is required by the prospective AAMs and the Meteorological Technicians and Field Aides who will support the agricultural service program. Proper discharge of the multiple important functions of the AAM requires detailed knowledge of crop-weather relationships. The agricultural education and training program will provide the necessary support to insure that prospective AAMs receive advanced university training in agricultural meteorology or closely related fields.

Finally, it is essential that Meteorological Technicians and Field Aides associated with the Agricultural Weather Service receive specialized training to insure most effective performance. An in-service survey seminar series will be provided for this purpose.

5.0 IMPLEMENTATION PLAN

As previously noted, a joint Department of Agriculture-Weather Bureau Survey determined that a phased plan would allow for gradual and orderly extension of the improved Agricultural Weather Service to cover the needs of the entire Nation. Further, the data supplied during this study by the Directors of Agricultural Experiment Stations provided guidelines for establishing priorities for agricultural enterprises which can be classified into two broad areas:

a. Those enterprises for which economic returns are only slightly related to associated weather factors or those of such a nature that once the farmer has committed himself, he can do relatively little to affect the outcome.

b. Those enterprises for which economic returns are closely related to weather-influenced decisions and operations of the farmer.

Clearly, more immediate benefits and more profitable application of agricultural forecasts and research can be realized in those regions where the number of weather-related options or alternative decisions are greatest, that is, where weather-sensitive agricultural production is concentrated. It is not suggested that a perfect one-to-one relationship exists between the weather sensitivity** of a crop or a type of livestock and the per-acre value of the resultant agricultural commodity. However, reflection on the contrasting cultural practices in the production of wheat versus vegetables or the production of soybeans versus fruit lends credence to a good correlation between weather sensitivity and the per-acre value of the commodity. There are, for example, a greater number of weather-related activities and decisions associated with the high per-acre value of intensely cultivated fruit and vegetable crops as contrasted with lower per-acre value of wheat or soybean production.

A rationale for providing a specialized Agricultural Weather Service to agribusiness can be based on the assumption that specialized meteorological information allows weather-related agricultural decisions to be made more expeditiously than would otherwise be the case. The importance of these decisions to the farmer, to the agribusiness community, and finally to the Nation in terms of a wholesome environment and in terms of adequate food and fiber for the total population varies over wide ranges or levels of social and economic importance. In the final analysis, the goal of an Agricultural Weather Service should be to provide the meteorological information or service needed to assure an efficient agricultural operation in a healthy and viable environment.

**For the purpose of this Plan, weather sensitivity is defined as the degree that one or more elements of the weather effects growth, disease and pest control, and production, and, for which the farmer, given an accurate forecast of unfavorable weather, can take protective, preventive, or corrective action or, given a forecast of favorable weather, can take positive action (plant, spray, or harvest).

Since a national Agricultural Weather Service can be implemented in only a few States each year, the question then arises as to how the various States should be ranked when considering expansion of the Service program.

More profitable application of agricultural weather forecasts can be realized in those regions where the number of weather-related options or alternative operational decisions is greatest, that is, where weather-sensitive agriculture (high cash receipts per acre) is concentrated. Furthermore, those States with a higher proportion of farm population would potentially profit most from valid, timely, and pertinent weather information.

Based on these points, an order for implementing the Agricultural Weather Service in the remaining States was developed by multiplying each State's per-acre cash receipts (fig. 2) by the percent of total U. S. population residing on farms in the State (fig. 3). This was used as a rating factor to aline the States 1–50. A final factor concerns local requirements. Those States with a sufficiently strong local interest will be given a higher priority for implementation, thereby responding to the demands arising from the fluctuating agricultural situation. Table 11 shows the order of proposed implementation of the Service in those States yet to be served.

Expansion of the Agricultural Weather Service program into unserviced areas is planned as outlined above and will be carried out as funds become available. Funding for such expansion will be provided by one of the following: (1) Federal Government; (2) State and local governments; or (3) combined participation by Federal, State, and local governments.

When all funds are provided through the first method, the Federal Government, they must be obtained through the regular budget process. Implementation of programs in a State, using this type of financing, is subject to unpredictable delays regardless of the State's standing in the priority list (table 11).

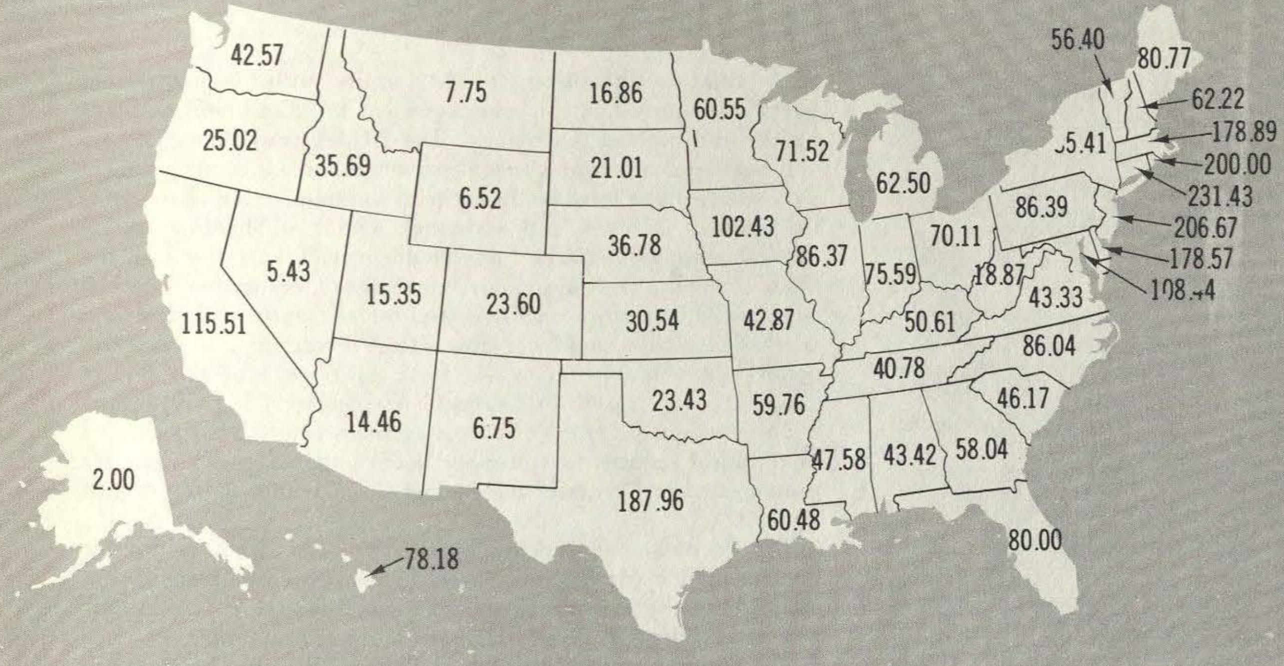


Figure 2.

Cash Receipts in Dollars per Acre of Farmland* (1968).

* COMPUTED FROM TABLE 2, FARM INCOME STATE-ESTIMATES 1949-1968. A SUPPLEMENT TO THE JULY 1969 FARM INCOME SITUATION. ERS/FIS 214 SUPPLEMENT AUGUST 1969.

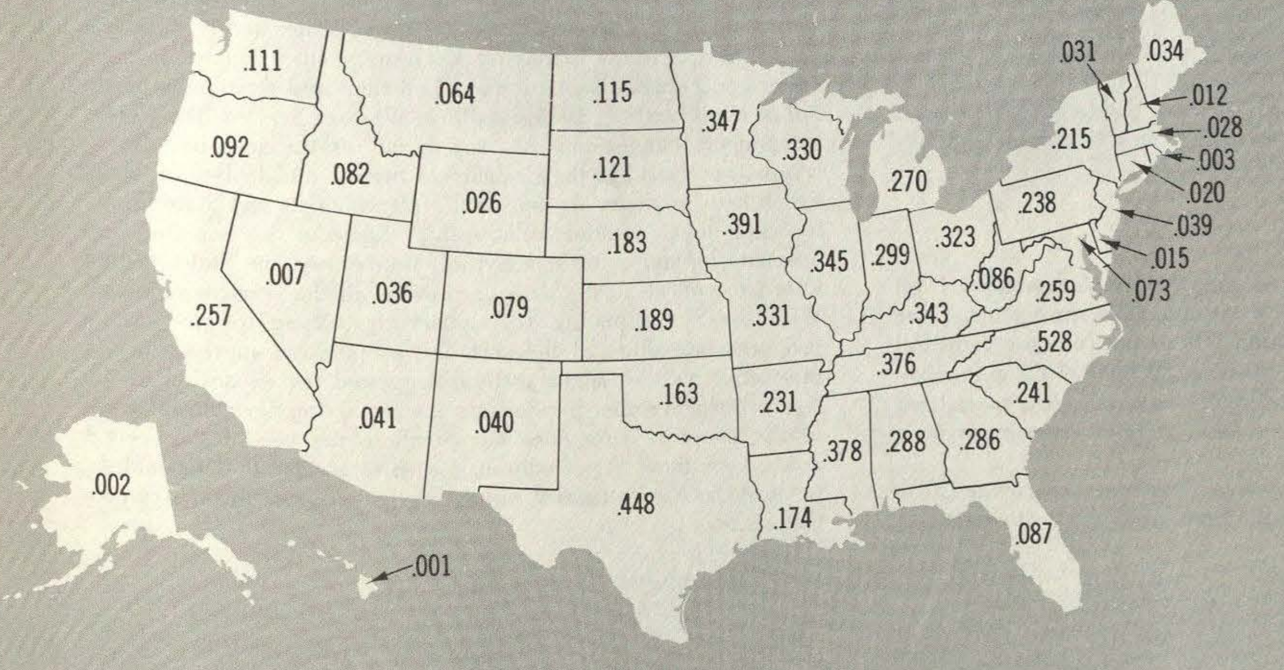


Figure 3.

State Farm Population as a Percentage of the Total U.S. Population* (1960).

* COMPUTED FROM TABLE 6, FARM POPULATION ESTIMATES FOR 1910-62. ERS-130 OCTOBER 1963.

Table 11—Agricultural Weather Service Implementation Plan

PHASE 2	PHASE 3	PHASE 4
Arizona	*Texas	Wisconsin
Ohio	North Carolina	Minnesota
New York	Iowa	*Pennsylvania
Nebraska	Illinois	*Mississippi
Montana	California	*Michigan
Wyoming		*Georgia
		*Tennessee
PHASE 5	**PHASE 6**	**PHASE 7**
*Missouri	Kansas	Maine
*Alabama	Massachusetts	Delaware
*Virginia	Washington	South Dakota
*Louisiana	Connecticut	North Dakota
*Maryland	Oklahoma	Colorado
*Florida	*Idaho	Vermont
PHASE 8	**PHASE 9**	
*West Virginia	Nevada	
New Hampshire	Rhode Island	
Hawaii	Alaska	
Utah		
New Mexico		

Note: Phase 1 consists of those States in which the Agricultural Weather Service is fully implemented. States marked with an asterisk contain partially implemented Service.

However, a different order of program implementation from that shown is possible through a reimbursable arrangement, the second method of funding. Section 302 of the Intergovernmental Cooperation Act of 1968 (P. L. 90–577; 82 Stat. 1102) authorizes Federal agencies to provide, under certain conditions, specialized or technical services to States and local units of government on a reimbursable basis.

Specialized agricultural weather services may be provided to a State or political subdivision of the State upon the written request of the chief executive of the political entity, with the proviso that payment or provision for reimbursement to NOAA will be made by the unit making the request. The NOAA provision could involve assignment of professional personnel, access to all pertinent data analyses and forecasts in national communication channels or the national archives, and assistance with a public information dissemination system. The State could provide expertise in many fields of application (agronomy, horticulture, entomology, pathology, etc.), laboratory facilities and office space, technical and clerical assistance, and local travel. Cost determination will be in accordance with the policy set forth in Bureau of the Budget Circular No. A–25, "User Charges" (September 23, 1959). Rules and regulations permitting Federal agencies to provide specialized or technical services to States and local units of government are promulgated in Bureau of the Budget Circular No. A–97 (August 29, 1969).

The third method for funding Agricultural Weather Service implementation corresponds closely to the procedure employed in establishing the existing programs (established FY 1959–1966) and is dependent upon Federal, State, and local support.

The present cooperation between National Weather Service, Environmental Data Service, and State Universitites and Agricultural Experiment Stations is making a strong weather impact on agriculture and appears to be the most efficient and economical methoid of implementing the Agricultural Weather Service. The NOAA components cannot possibly supply all of the interdisciplinary competence found in the Experiment Station and University staffs which help Advisory Agricultural Meteorologists and State Climatologists define weather relationships basic to the planning and operation of agricultural activities. Conversely, the States cannot afford to collect all the data or provide all the services required. With the States paying (or apparently willing to pay) for a proportionate share of the cost, the cooperative approach seems most effective and is the method suggested for expansion of the Agricultural Weather Service into the remaining agricultural areas of the country. This does not preclude the use of the second method for those States who may wish to accelerate the establishment of the Agricultural Weather Service program in their respective areas.

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