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NOAA Technical Report NCPO 001

Use of Climate Information by U.S. Agribusiness

Peter J. Lamb, Steven T. Sonka,
and Stanley A. Changnon, Jr.

Climate and Meteorology Section,
Illinois State Water Survey

Rockville, MD
December 1985

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Climate Program Office

THE NATIONAL CLIMATE PROGRAM

Congress enacted the National Climate Program Act in 1978 to "assist the Nation and the world to understand and respond to natural and man-induced climate processes and their implications." The Act established the National Climate Program (NCP) and created the National Climate Program Office (NCPO) to coordinate a national plan for climate research and service.

Priorities in the NCP are to improve the collection, storage, and use of climate data and information; understand the impact of natural and man-induced changes of climate; and increase our ability to predict climate from one month to one season or more in advance.

U.S. participation in the World Climate Programme (WCP) of the World Meteorological Organization is coordinated through the NCP. In addition to its participation in the WCP, the United States also conducts bilateral and multilateral climate-related activities with other nations.

The NCPO publishes an annual report highlighting major activities of the NCP. This report and additional information on the NCP may be obtained from:

National Climate Program Office
National Oceanic and Atmospheric Administration
11400 Rockville Pike, Room 108
Rockville, MD 20852

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Malcolm Baldrige, Secretary
National Oceanic and Atmospheric Administration
Anthony J. Calio, Administrator
National Climate Program Office
Alan D. Hecht, Director

Copies Available from Illinois State Water Survey, 2204 Griffith Drive, Champaign, IL 61820

This investigation was conducted partially under the auspices of the North Central Regional Climate Center (NCRCC), which is located at the Illinois State Water Survey and supported by the National Climate Program Office (NOAA Contract No. NA81AA-D-00112) and the State of Illinois. The objectives of NCRCC include improving the efficiency and effectiveness of climate information dissemination at the state and regional levels. The present study contributes to that end by documenting the climate information uses and needs of United States agribusiness, particularly in the twelve north-central states served by NCRCC. It includes recommendations concerning data acquisition/assembly, scientific research, information generation and dissemination, and user education that would make the agribusiness use of climate information more efficient and effective.

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Use of Climate Information by U. S. Agribusiness

PETER J. LAMB,[1] STEVEN T. SONKA,[2]
and STANLEY A. CHANGNON, JR.[1]

ABSTRACT

This study sought to identify the climate information uses and needs of agribusiness decision makers in the United States. It was conducted in three phases: (1) a nationwide mail questionnaire survey for which usable responses were obtained from 107 individuals involved in nine types of agribusiness activity; (2) a two-day workshop at which the primary participants were 14 of the questionnaire survey respondents; and (3) individual day-long post-workshop discussions with several of the workshop attendees. Four types of climate information were considered: historical data, year-to-date accumulations, now-only conditions, and climate predictions.

Climate information is currently being used extensively by agribusiness decision makers. This usage has increased substantially in recent years and occurs in (1) design and planning of ongoing and future operations, (2) monitoring of in-season conditions, and (3) model-based prediction of crop yields. Climate information is used most by integrated pest management consultants, the grain trade, the seed production and food processing industries, and professional farm managers, and the information used involves a relatively wide range of meteorological parameters. This situation is probably little recognized by the atmospheric science community. Its implications for the United States National Climate Program, the World Climate Programme, agribusiness, and the provision of climate services are discussed.

Non-use of climate information is found to stem from reservations about the availability, utility, cost, value, and (in the case of climate predictions only) accuracy of that material. In order to remove these impediments substantial initiatives are needed in the areas of data acquisition/assembly, scientific research, information generation and dissemination, and user education. An in-depth consideration of these needs is presented. It includes an assessment of the most appropriate roles for federal and state government agencies, universities, private meteorological companies, and agribusiness itself. The potential exists for a substantial and profitable increase in the use of climate information by the private agricultural sector.

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Chapter 1. Introduction

One of the more striking science policy developments of the past decade has been the formulation and partial implementation of large, ambitious, multifaceted "climate programs" at both the national and international levels.

The United States National Climate Program (USNCP), for instance, was established by an Act of Congress (September 1978, PL 95-367) to "assist the Nation and the world to understand and respond to natural and man-induced climate processes and their implications" (Section 3). The program has three components (National Oceanic and Atmospheric Administration 1980). A *Climate Impact Assessment* effort is seeking to identify "procedures to evaluate climate's effects on society, the economy, and the environment in order to develop responses and strategies for dealing with climate fluctuations" (NOAA 1980, p. E-4). *Climate System Research* will attempt to increase the knowledge of global and regional climate and its variation through a range of empirical studies and analyses of the climate record, the development of climate simulation and prediction models, and the investigation of climate system processes (e.g., solar and terrestrial radiation, ocean heat storage and transport). The *Data, Information, and Services* component is designed to provide accurate and timely data and information products and to be responsive to government and private sector needs.

The USNCP is just one of several emerging national programs that are intended to be consistent with the larger World Climate Programme (WCP), which was formally established during 1979 by agreement among the World Meteorological Organization, the United Nations Environment Program, the International Council of Scientific Unions, and the Intergovernmental Oceanographic Commission. It will span the two decades 1980-2000 and contains subprograms that parallel the components of the USNCP. It is intended to accelerate progress by serving as a catalyst rather than by providing direct support (World Meteorological Organization 1979), a role that will involve assisting developing countries to build modern data acquisition and application systems, fostering international cooperation when it is a necessary prerequisite for research progress (e.g., on the carbon dioxide question and ocean heat storage/transport), and other similar activities.

The relatively sudden emergence of these programs is in marked contrast to the situation in the 1950s and 1960s when there was little interest in climate, its vagaries, or their effects. The programs are a response to the striking weather extremes and climatic fluctuations during the last 15 years and to the wide publicity given to the adverse socioeconomic effects of those episodes through the ever-increasing capabilities of the news media (White 1982). In particular, the Sahel drought and consequent famine of the early 1970s forced governmental and scientific communities, on an international level, to recognize that climate does vary on short time scales and that such variations can have disastrous consequences for mankind.

This new awareness has been increasingly reinforced in the 1970s and 1980s by other pronounced climatic fluctuations and their adverse impacts, such as the 1976 heat wave, drought, and water shortages in Western Europe; pronounced extremes in Indian monsoon rainfall and their associated flooding and famine; four recent very severe United States winters, including one whose excessive snowfall crippled the Chicago transportation system for many weeks; recurrent poor growing seasons in the Soviet Union; and the 1980 central United States heat wave and drought that greatly reduced crop production. For the United States, the appreciation of climate's central role in human affairs was hastened by the serious economic repercussions of the 1972-73 and 1975 grain sales to the Soviet Union that were at least partly occasioned by that nation's climate-induced crop failures (National Oceanic and Atmospheric Administration 1980).

Climate programs such as the USNCP and the WCP have been conceived and designed to broadly benefit mankind by reducing the adverse (or enhancing the beneficial) socioeconomic consequences of climatic variability, rather than to foster narrow basic research (White 1982). This is why they are dominated by efforts such as climate impact assessment, data acquisition and applications, and the provision of information and services. The climate system research they do include would very probably have been supported and pursued, for reasons of scientific curiosity, without the creation of the programs. In fact, it seems fair to assert that the existence of these elaborate, ambitious, and expensive programs is based on the assumption that a substantial reduction of the unfavorable effects (or enhancement of the beneficial effects) of climatic variability is attainable. Whether this is the case has never really been demonstrated, as is clearly acknowledged by the previously quoted objectives for the USNCP Climate Impact Assessment effort. There is no doubt that the second of these goals (the development of "responses and strategies for dealing with climatic fluctuations") will be much more difficult to achieve than its necessary forerunner (the identification of "procedures to evaluate climate's effects on society, the economy, and the environment").

Our contention is that the management strategies necessary to substantially change the socioeconomic consequences of climatic variation are largely unknown. If this assessment is correct, the climate programs constitute something of a risk. However, we believe that this risk is justified, and that the emergence of ambitious climate programs is a desirable development that has considerable potential and that offers a challenge to a broad range of specialists, including atmospheric, agricultural, and social scientists, and economists. Clearly, atmospheric scientists will need the assistance of these other people in tackling the problem. However, the other side of the coin is that an inadequate response to this situation will be to the considerable detriment of the atmospheric sciences' reputation among the wider scientific and governmental communities for their ability to "deliver." The fact that early optimism relating to weather modification (Changnon 1975, 1980) and numerical weather prediction (White 1982) has so far not been matched by actual achievement underlines the atmospheric sciences' need for the climate programs to be at least modestly successful. In contrast, since social and agricultural scientists and economists did not initiate the climate programs, they presumably have little to lose (and much to gain) from being actively involved in these endeavors.

In order for the climate programs to ultimately alter the socioeconomic effects of climatic variability and hence come to be regarded as successful, considerable initial effort must be devoted to understanding the climate information needs of decision makers (National Research Council 1981). It is only from this foundation of appropriate knowledge that the required management strategies can be developed and deployed. The study reported here sought to identify such information needs for one important group of economic activities — those constituting the United States private agricultural sector. Climatic variability probably affects agriculture more than any other broad economic sector (National Research Council 1976, 1982). In recognition of the need for this type of work to be interdisciplinary, the present project was a fully collaborative undertaking between two atmospheric scientists and an agricultural economist.

Chapter 2. The Present Study: Investigation of Climate Information Uses by the U.S. Private Agricultural Sector

Background

While climatic fluctuations impact all economic sectors to some degree, the production of food and fiber is perhaps the activity most sensitive to these vagaries of nature (National Research Council 1976, 1982). Most of the recent pronounced climatic variations listed previously, for instance, substantially reduced agricultural outputs. Thus one of the best starting points for investigating the extent to which the adverse socioeconomic consequences of climatic variability could be reduced (or benefits enhanced) is the consideration of the world's most productive agricultural system — that of the United States and particularly its midwestern heart.

This agricultural system consists of not only the actual producer (grower, farmer, rancher), but also the large and complex support structure that has evolved to serve the producer. This support structure includes the development, production, and distribution of seeds, fertilizers, pesticides, and farm machinery; the provision of rural insurance, financial, farm management, and integrated pest management services; the food processing and brokerage industries; the grain trade; and several other activities. This combination of the producer and the non-farm support firms constitutes the private agricultural (or "agribusiness") sector. The present inquiry deals with this entire sector. In contrast, most prior efforts, including a recent National Research Council inquiry into the use of weather information by United States agriculture, were limited to on-farm decision making (National Research Council 1980a).

There are several reasons why the climate information needs of the United States private agricultural sector were selected for this study. The first is simply the size of this sector and its importance to the United States and world economies (National Research Council 1980b; National Defense University 1983). The value of the nation's agricultural production in 1981 was $167 billion (United States Department of Agriculture 1982a). In that same year, sales by input suppliers to agricultural producers totaled approximately $40-45 billion (Midwest Association of State Departments of Agriculture 1981), while agricultural exports earned $43 billion (United States Department of Agriculture 1982b). Exports from this sector typically include approximately 70 and 40%, respectively, of the world's total corn and wheat exports (Cramer and Heid 1983) and about 70% of the world's soybean meal-equivalent (Sisson 1981). Despite its size and importance, the agribusiness sector can be severely impacted by climatic fluctuations, as the enormous crop yield fluctuations of 1979-83 readily attest. Improvements to this sector's efficiency would therefore substantially benefit the consumers of food and fiber in the United States and throughout the world.

The second reason to investigate this sector stems from its very nature. This overwhelmingly private (and hence initiative rewarding) enterprise is endowed with highly fertile soil; generally abundant moisture; extensive scientific and technological support in the fields of plant breeding, chemical development, pest management, and machinery design; and educated operators who function within the motivating (succeed or perish!) environment of the "farm firm." If the present level of use of climate information by this highly developed sector could be clearly established, and the benefits ascertained, there could be guidelines for the adoption of such practices by less developed agricultural systems.This is a goal of the World Climate Programme (WCP). In addition, the attributes of the sector suggest that it may possess the structural and human flexibility that is necessary to provide a demonstration of the potential for improved management strategies to deal with the socioeconomic effects of climatic variation.

The diversity and complexity of this sector provide further justification for its study. Because of the differing sizes and functions of the sector's firms, the characteristics of the climate information needed by agribusiness are likely to be quite varied. This hypothesis is offered despite the fact that, for a given commodity, the climatic vagaries that have the greatest effect on production generally are the same whether the climate information user is an input supplier, a producer, or an output processor. What is likely to vary substantially across the sector are the types of climate information needed, the times at which such material is required, and the decision maker's ability to interpret and use individual information items. This likelihood that the characteristics of the climate information needed by each component of the sector may be very different is significant, for it offers an opportunity to assess the potential scope and complexity of the general problem of providing appropriate data and information products to the private sector. As indicated in the introduction, the latter task is an important component of the United States National Climate Program (USNCP).

The final reason that this study deals exclusively with the United States private agricultural sector is that this sector was surprisingly neglected in, and hence had little or no input to, the development of the USNCP. For example, it was not represented at either of two meetings that were an important part of this development process: (1) the April 1980 "Workshop on the Methodology of Economic Impact Analysis for Climatic Changes," sponsored by Resources for the Future (RFF) and the National Climate Program Office (NCPO), which had 43 participants (Resources for the Future 1980; Smith 1982); and (2) the June 1981 "Climate Users' Conference" of the Climate Analysis Center (CAC) that was part of the USNCP (National Oceanic and Atmospheric Administration 1980), which had 50 attendees (Climate Analysis Center 1981). The agricultural perspectives, positions, and interests at these gatherings were instead offered solely by government (federal and state) and academic economists and scientists — people with limited practical involvement in the United States agricultural system.

While this constitutes an undesirable situation, it is understandable for at least two reasons. First, atmospheric and other environmental scientists have hitherto shown little interest in applications of their broad disciplines to agribusiness. Only 10% of the papers (14 out of 141) presented at three recent and highly relevant American Meteorological Society meetings dealt with the private agricultural sector. Furthermore, this treatment generally lacked extensive depth. These meetings were the August 1980 "Conference on Climatic Impacts and Societal Response" at Milwaukee (American Meteorological Society 1980a), the San Diego "Symposium on the Economic and Social Value of Weather and Climate Information" in January 1981 (American Meteorological Society 1980b), and the "Sixteenth Conference on Agriculture and Forest Meteorology" held in Fort Collins, Colorado, in April 1983 (American Meteorological Society 1983). Even important interdisciplinary conferences and workshops on topics such as the likely environmental and societal consequences of climatic change (United States Department of Energy 1980) and the use of climate information in decision making (Pocinki et al. 1980) have given scant attention to the climate information needs of the United States private agricultural sector, despite its importance for the global food supply.

The second probable reason this sector was neglected in the development of the USNCP is that its actual use of climate information was little known. This seems to have occurred because (1) the climate information suppliers to agribusiness are typically private meteorological consulting firms for whom report writing and conference participation have extremely low priorities; (2) individual agribusiness concerns have a need to protect their own operating procedures; and (3) some agribusiness companies have not realized, or have not had the resources to exploit, the "gold mine" of information they have accumulated (e.g., many years of field trial and operations results obtained under different climatic conditions).

It seems clear that the further shaping and implementation of the USNCP as the program enters its critical second five years would benefit from increased exposure to and input from this nation's private agricultural sector. The research project reported here was conceived as an initial contribution to this end and to the others discussed above.

Objectives of the Study

As noted previously, the motivating force for the recent initiation of several major climate programs was a belief that at least some of the adverse socioeconomic effects of climatic variability can be reduced (or favorable effects enhanced) through an improved use of climate information. Although this information is generated by atmospheric scientists and other specialists, these people are seldom involved in decisions regarding the information's actual use within the private sector. Such decisions tend to be made by the professionals in the sector concerned and are influenced by a variety of economic, political, and social forces in addition to climatic considerations.

The present study therefore focuses on United States agribusiness decision makers with the fundamental goal of understanding the factors that determine their use of climate information. It has the following three specific objectives:

(1) To describe the present level, types, and methods of use of climate information by this sector.

(2) To identify the potentials for and impediments to a fuller use of climate information in the future.

(3) To specify the scientific research and data acquisition/information dissemination developments necessary before the level of present use can be increased to the maximum possible, thus enabling decision makers to attempt to reduce the unfavorable effects of climate fluctuations.

Components of the Study

This project was conducted in three phases. The first involved a nationwide mail questionnaire survey of agribusiness decision makers. Usable responses were obtained from 107 individuals. The second phase was an intensive two-day workshop at which the primary participants were 14 of the respondents to the mail survey, selected because they were users of climate information and had indicated an advanced interest in this topic in their questionnaire responses. The third phase consisted of individual day-long post-workshop discussions with several of these workshop attendees.

Questionnaire Survey

The questionnaire was prepared and mailed in the spring of 1982, and its results were analyzed during the rest of that year. It focused strongly on the present use of climate information, with historical data, year-to-date accumulations, and climate predictions treated separately. (The fourth type of climate information considered in the study — now-only information — was treated at the workshop but not in the questionnaire.) A copy of the survey instrument appears as Appendix A of this report. The survey was designed by the agricultural economist among us (S. Sonka), and underwent developmental testing within the College of Agriculture at the University of Illinois. It was sent to 125 agribusiness decision makers after they had agreed by telephone to participate in the survey. Where necessary, further telephone contact was used to ensure the return of completed questionnaires. This time-consuming procedure proved worthwhile, since it produced an extremely high (86%) response rate — 107 usable responses.

Table 1 indicates the components of the private agricultural sector that were represented in the survey responses and the number of respondents in each component; Appendix B gives the title, company, and location of each respondent. That material documents both the generally nationwide character of the survey (except for producers, as explained below) and the types of professionals from whom we sought information. The latter is important because the information obtained from a given company may not be independent of the role (e.g., marketing versus product development) of the respondent. Appendix B may also provide useful contacts for other researchers wishing to pursue this and related subjects.

The components of the private agricultural sector identified in Table 1 have vastly differing characteristics. They represent industries as diverse as farm production, with its several million individual operators, and grain merchandising and pesticide manufacture, which are dominated by a relatively small number of multinational companies. In the case of integrated pest management, the industry is relatively new and the definition of its population is accordingly difficult. For this reason, and because of the extremely large size of the private agricultural sector, no attempt was made to conduct a fully comprehensive statistical survey. Instead, the role of the questionnaire survey in the total effort (which itself was of an exploratory nature) was to obtain background knowledge on the present use of climate information, as well as initial insight into the potentials for or impediments to fuller use of this material in the future. This information provided a starting point for the more specific investigation of the same topics at the subsequent workshop.

The names of potential survey respondents were assembled through what may be best termed an "informed judgment" approach. For each component

Table 1. — Components of Private Agricultural Sector Represented in Questionnaire Survey Responses, and Number of Respondents from Each Component

Component	Number of respondents
Agricultural chemical manufacturers	5
Agricultural finance companies	12
Food processing/canning industry	8
Grain trade (merchandisers, brokers, consultants)	19
Integrated pest management consultants	12
Producers	27
Professional farm managers	13
Rural insurance industry	6
Seed production companies	5
TOTAL	107

of the sector (Table 1), a key individual was identified and asked to name those persons whose present positions and performances qualified them to provide the information we sought. These key "nominating" individuals were chosen by the authors because of their prominence as agribusiness leaders (e.g., in trade associations) or, in the case of the production component, because of their involvement with the Cooperative Extension Service. The non-production nominators, who also consented to participate in the survey themselves, tended to name people from among their peers in other companies. The Extension Agents were asked to nominate producers they considered to be among the most innovative of the many with whom they had contact. In addition, we were able to supplement the list of potential respondents from our own prior contacts in this sector.

A strong effort was made to obtain survey responses from throughout the nation. For some of the agribusiness components, this goal was attainable because many of the respondents work for national and multinational concerns (Appendix B). Their responses therefore reflected an exposure to the agribusiness practices of a broad geographical area. The production component was an exception to this desired nationwide character of the survey. To make its treatment both manageable and informative, respondents were sought from only two, highly contrasting regions: unirrigated portions of the humid Upper Midwest and of the much drier west Texas. The Midwest respondents were overwhelmingly Illinois cash grain producers, while those from Texas raised cotton and beef. Irrigated production was excluded because most of the humid Upper Midwest does not use irrigation. Since the use of irrigation could be expected to alter an operator's use of climate information, it seemed desirable that the second and contrasting production system studied also be unirrigated. Texas dryland farming was chosen as the second system; unfortunately, however, both the quantity and quality of the responses obtained from this region were disappointing.

We believe that the size and scope of the questionnaire survey were adequate for the task at hand.

Workshop

The second phase of our study took place at an intensive two-day workshop in Door County, Wisconsin, in August 1982. Although it included some further inquiry into the present use of climate information, it primarily involved in-depth considerations of (a) potentials for and impediments to a fuller use of climate information by agribusiness in the future, and (b) scientific research and data acquisition/information dissemination development efforts that are necessary before the level of present use can be increased to the maximum possible. The workshop thus sought to exploit and build on the foundation of knowledge about the agribusiness use of climate information that was acquired from the earlier questionnaire survey.

The primary workshop participants were 14 of the 107 questionnaire respondents, with one or two chosen to represent each component of the private agricultural sector (Table 1). They were selected because their questionnaire responses exhibited both an interest in the issue of improved climate information availability and the insight needed to anticipate possible future needs. Other workshop attendees included three people from federal agencies (United States Department of Agriculture [USDA], National Science Foundation [NSF], and National Climate Program Office [NCPO]); a market analyst from the Illinois Agricultural Association (IAA, i.e., the Farm Bureau); and five Illinois State Water Survey/University of Illinois personnel. The federal agency and IAA participants were representatives of some of the financial sponsors of the project (see acknowledgments and Appendix C). The NCPO person's attendance was also desired because of the study's relevance to the National Climate Program, as outlined in the introduction to this report. A complete list of the workshop attendees and a copy of the agenda that was followed appear as Appendix C.

The group discussions at the workshop focused on three topics: present uses of climate information, major impediments to a fuller use of climate information, and climate prediction needs for the future (Appendix C). For each topic, the participants were divided into the same three discussion groups of seven individuals. Each group included five agribusiness personnel from different components of the sector (one of whom acted as group leader and gave oral summary reports to the entire group at the end of each discussion session), one federal government representative, and one Illinois person who was the guide and rapporteur for the discussions. The two remaining Illinois participants, who later became the senior authors of this report (P. Lamb and S. Sonka), directed the workshop. In this role they provided introductory "lectures," chaired plenary sessions, and observed as much of the group discussions as possible.

For the purpose of the group discussions, the participants from the USDA's Federal Crop Insurance Corporation (FCIC) and the IAA were considered to be from the private sector, based on the IAA's advisory role to private sector clients and the FCIC's substantial interaction with private insurance companies. Because of the latter circumstance, the FCIC representative had also been one of the questionnaire respondents.

Post-Workshop Discussions

The third phase of the project consisted of post-workshop discussions with several workshop participants from the private sector. These were conducted on an individual (as opposed to group) basis, were generally day-long, and occurred at both the Illinois State Water Survey and private company locations. The discussions concentrated particularly on the third objective of this study: specification of the scientific research and data acquisition/information dissemination development thrusts needed to maximize use of climate information by the agribusiness sector. The agribusiness personnel involved in these discussions were chosen because of the potential importance of climate information to their companies, and because their contributions to the earlier workshop discussions suggested that they could be of further help.

These interactions proved immensely valuable to the authors in formulating this report. Insights from them are not listed separately, however. Instead they are woven into the interpretations of the survey and workshop results presented in the following chapters.

Types of Climate Information Treated

Four types of climate information were considered in this investigation.The questionnaire survey dealt with three of these: historical data, year-to-date accumulations, and climate predictions. These information categories were also treated at the workshop, along with the fourth type (now-only conditions). Our use of the term "climate information" thus includes climate data, a practice that has not always been followed recently (e.g., National Research Council 1981, 1982). The contrasting nature of these climate information types needs to be clearly established before the results can be discussed in detail and appreciated fully.

Historical Climate Data

The term historical climate data refers to the very large bank of all instrumental measurements (such as those for temperature and precipitation) made since the inception of such observations, between 30 and 100 years ago at many locations in the United States. These point data are available as averages (as in the case of temperature) and totals (as in the case of precipitation) for individual years, seasons, months, and shorter time periods, and can also yield important information on the past variability of climate (e.g., frequency of occurrence of extreme daily and monthly values). It is from these data that the well known standard climatic "normals" (monthly means for the most recent three-decadal period, currently 1951-80) are computed, and from which alternative shorter-period normals (Lamb and Changnon 1981) and a wide range of other information, including some that is highly user-specific, can readily be obtained.

Year-to-Date Accumulations

Year-to-date accumulations consist of summations of the daily values of actual weather parameters (such as precipitation) and derived quantities (e.g., growing degree days, which are obtained from temperature records) through any point in a given year. While such accumulations are generally made and used in a near real-time operational mode for the present year, this use could reasonably involve a comparison with counterpart values for earlier years, or averages for longer periods (e.g., the 1951-80 normal). The latter would of course be derived from the bank of historical data discussed above. Year-to-date accumulations thus provide integral-type measures of relevant aspects of the climate of a given year.

Now-Only Conditions

Year-to-date accumulations contribute, usually on a collective rather than an individual basis, to agriculturally important now-only conditions such as (for the Midwest) late-April soil temperature and mid-July soil moisture. For the case of mid-July soil moisture, the more important controlling factors include year-to-date precipitation (the moisture input) and year-to-date solar radiation, growing degree days, and wind run (all of which influence the drying of soil). A subtle difference therefore exists between year-to-date accumulations and now-only conditions.

Climate Predictions

A climate prediction is a statement of the expected general character of the weather for a period in the future whose length may be a part of a season (one or two months), a season, a year, a decade, or even longer. One month is the shortest period for which a climate prediction should be made. The present investigation is concerned only with the shorter-term climate predictions (those for one-month to one-year periods) that could potentially be incorporated into the agricultural decision process. Longer-term climate predictions are much less likely to have such utility in the foreseeable future.

The short-term predictions are generally made only for the mean temperature and total precipitation for the prediction period, and tend to be expressed in qualitative terms such as "above normal," "near normal," and "below normal," as well as "indeterminate" for temperature and "heavy," "moderate," and "light" for precipitation. A prediction period (e.g., July-August) can be somewhat ahead of the date the prediction is issued (e.g., 1 May). This time difference is termed the "lead time" of the prediction. While longer lead times (3-6 months) presumably offer the greatest potential for the use of short-term climate predictions as planning instruments, this is presently offset because such predictions are less reliable than those with shorter lead times.

Short-term climate predictions are in pronounced contrast to the short-period weather forecasts for up to 1-2 days into the future with which most people are familiar. The latter have lead times of only 0-1 day and cover a wider range of parameters in a much more quantitative manner (e.g., daily maximum and minimum temperatures, probability of occurrence of precipitation, wind speed and direction, sky cover, etc.). It is unlikely that such detail will ever appear in short-term climate predictions.

Chapter 3. Results of Questionnaire Survey

Background

The questionnaire survey was the means by which the overall project was launched and by which we began to acquire information. Since previous work in this field was meager, we started from a position for which there was minimal available guidance. The role of the questionnaire survey was therefore to provide quantitative background knowledge on the present general use of climate information by the United States private agricultural sector. It was intended to form the foundation for the subsequent and more specific components of the study. Accordingly, the first results summarize the valuable information obtained from the analysis of the questionnaire survey responses.

Extent of Use of Climate Information

Probably the single most important finding of the entire survey is that climate information is now being used extensively by agribusiness decision makers in the United States. This situation is documented in Tables 2-8, in which the three types of climate information treated in the questionnaire — historical data, year-to-date accumulations, and climate predictions — are dealt with separately. Table 2 indicates that almost three-quarters of the respondents use historical precipitation data and that nearly as many use historical temperature records. A smaller percentage, but still a majority, use year-to-date accumulations and climate predictions. The aggregation of the results across the entire private agricultural sector in Table 2, while providing an informative starting point for this discussion, masks the considerable and highly important intrasectoral variation in the use of climate information. This variation is revealed in Tables 3 to 8.

Table 2. — Summary of Extent of Present Use of Climate Information by Entire Private Agricultural Sector

Type of climate information	Percent of respondents who use each type of information: Precipitation	Temperature
Historical climate data	74	70
Year-to-date accumulations	64	51
Climate predictions	64	60

Historical Climate Data

Table 3 shows that producers, agricultural finance companies, and the rural insurance industry are relatively low users of both historical temperature and historical precipitation data. At the other extreme, pest management consultants, the chemical, seed, and grain industries, and (to a lesser degree) farm managers use this type of climate information to a very considerable extent. The specific uses involved are summarized in Table 4. This information is offered here primarily as background material. The specific uses of all types of climate information were investigated more fully at the workshop and are treated in greatest detail in Chapter 4. Table 4, however, shows that agribusiness entities use historical climate data primarily in pre-season planning.

Table 3 indicates that the canning industry makes substantial use of historical temperature data but has less interest in historical precipitation records. This industry's statements about the types of specific decisions influenced by historical climate data (Table 4) shed light on this discrepancy, even though our question did not differentiate between the uses of temperature and precipitation information. We found that historical climate data are primarily used by canning companies in their pre-season locating and planning (as opposed to in-season direction) of contract production. Since these pre-season activities involve decisions that are obviously strongly influenced by temperature — decisions on site selection, expected planting and harvesting dates, assessment of spring and fall frost risk, and choice of seed variety, which is contingent upon all of the foregoing — it is probably not surprising that the canning industry uses

Table 3. — Intrasectoral Variation in Extent of Use of Historical Climate Data

Component of sector (Number of respondents in parentheses)	Percent of respondents who use this type of information	
	Precipitation	Temperature
Agricultural chemical manufacturers (5)	100	100
Agricultural finance companies (12)	50	25
Food processing/canning industry (8)	63	88
Grain trade (19)	100	95
Integrated pest management consultants (12)	100	100
Producers (27)	44	37
Professional farm managers (13)	85	77
Rural insurance industry (6)	67	50
Seed production companies (5)	100	80
Average for entire sector (107)	74	70

historical temperature data more than precipitation data.

It seems likely, however, that some historical precipitation information is implicitly "factored" into decision making by the canning industry, at least to the extent that particular crops (or varieties of crops) are grown in only those areas for which the decision maker's experience suggests that the moisture supply is usually adequate. This assumption is reinforced by the fact that the seed production companies, which evidently use historical climate data in a very similar manner to the canning industry (Table 4), reported a much greater dependence on this type of precipitation information (Table 3).

Table 3 indicates that farm managers use historical climate data much more extensively than do producers. This result is rather surprising, given that these two groups make similar production and marketing decisions (Table 4). Both groups stated that they use historical climate data in pre-season planning decisions concerning crop and variety selection; the estimation of likely planting, pollination, and harvesting times and desirable planting densities; the assessment of in-season climatic risk probabilities, likely pest control, and land requirements (work, rent, etc.); and the scheduling of financial borrowing/investing, land purchases, and commodity marketing.

It can be hypothesized that the substantially greater use of historical climate data by farm managers results from the larger scale of their operations. Since farm managers tend to direct the operation of several farms that may be in quite disparate locations, they likely need to use historical climate data (among other information) to gain a full understanding of the production potentials and problems of the tracts of land under their control. The individual producer, on the other hand, is usually quite familiar with his own land base, especially if he or his family has worked it for many years, and thus may have little need for historical climate data. A continuation of the current trend away from the relatively small family farm to larger production units that are managed professionally from remote locations (Schertz 1979) may therefore be accompanied by an increased need for and use of historical climate data.

Year-to-Date Accumulations

Table 5 documents the intrasectoral variation in use of year-to-date accumulations, while Table 6 shows specific uses of this type of climate information. The uses presented in Table 6 are offered here primarily as background material and will be discussed more fully in Chapter 4.

Table 5 indicates that the variations in use of year-to-date accumulations are at least as pronounced as, and in many cases are very similar to, those in the use of historical data. However, the results on specific uses of these two information categories (Table 6) include some interesting differences. Agribusiness activities use year-to-date accumulations largely for in-season operational decisions, in contrast to their use of historical data in pre-season planning.

Table 4. — Intrasectoral Variation in Types of Specific Uses of Historical Climate Data, as Revealed by Responses to Question 3 of Questionnaire Survey (Appendix A)*

Component of sector	Types of specific use
Agricultural chemical manufacturers	Design of application instructions on product labels; *a posteriori* litigation over alleged product liability; pre-season location and post-season evaluation of product trials; development of marketing strategies; study of pesticide residues in soil.
Agricultural finance companies	Derivation of basis of loan volume predictions (from July and August rainfall); establishment of framework for feedlot performance projections (temperature).
Food processing/canning industry	Pre-season general decisions relating to the location, planning, and scheduling of contract production from planting to harvesting; assessment of spring and autumn frost risks.
Grain trade	Development of basis of analog approach to crop yield estimation (identifies and uses earlier years with similar climate to present year); construction and refinement of quantitative crop yield models; analysis of supply-demand relationships; development of general marketing, trading, and hedging strategies and recommendations (including aforementioned analog method); quantification of effects of past extreme climatic fluctuations.
Integrated pest management consultants	Pre-season general recommendations of crop planting dates and densities and hybrid selections; estimation of timing/length of pollination periods at planting; general planning of scouting for insect presence/damage and probable pesticide and herbicide application schedules; pre-season decisions on fertility goals and fertilizer type and application rate; scheduling of autumn application of nitrogen fertilizer; planning of consultants' own field activities.
Producers	Pre-season general planning of planting schedules and herbicide applications; anticipation of timing of possible insect infestations (degree-day correlation); planting-time projection of first autumn freeze; estimation of harvest dates and final yields.
Professional farm managers	Pre-season consideration of crop and variety options; preliminary estimation of planting and harvesting times and plant populations; assessment of in-season climatic risk probabilities, and probable pest control and land requirements; general scheduling of borrowing/investing, land purchases, and commodity marketing.
Rural insurance industry	Promulgation and verification of rates; analysis of prior yield fluctuations; claim analysis for past years.
Seed production companies	Pre-season choice of seed production areas; calculation of likely hybrid maturity times for those areas; general crop planning for coming season — estimation of probable planting dates, desirable plant population levels, autumn freeze likelihoods, and facilities needed to harvest seed crop.

* This question did not differentiate between uses of precipitation and temperature data.

Note: This table is simply a listing, and makes no attempt to indicate how frequently a particular use was cited.

The heaviest users of both year-to-date rainfall and temperature accumulations are pest management consultants and the seed and canning industries (Table 5). All three of these components of the private agricultural sector are required to make production decisions during the growing season. Their monitoring of the evolution of the present year's climate through year-to-date accumulations apparently enables them to better anticipate the growth processes of the crops and the possibility of insect infestations (Table 6). A comparison of Tables 3 and 5 shows that the seed industry uses year-to-date results to the same extent as historical climate data and that pest management consultants use year-to-date results to almost as great an extent as historical data. Interestingly, the results for the canning industry show that whereas this industry's use of historical temperature data (primarily for pre-season planning purposes,

Table 5. — Intrasectoral Variation in Extent of Use of Year-to-Date Accumulations

Component of sector (Number of respondents in parentheses)	Percent of respondents who use this type of information	
	Precipitation	Temperature
Agricultural chemical manufacturers (5)	40	40
Agricultural finance companies (12)	50	25
Food processing/canning industry (8)	75	88
Grain trade (19/16)*	74	50
Integrated pest management consultants (9/11)*	88	91
Producers (27)	52	33
Professional farm managers (13)	85	69
Rural insurance industry (6/5)*	17	0
Seed production companies (5)	100	80
Average for entire sector (104/102)*	64	51

* The first number in parentheses indicates the number of respondents replying about their use of precipitation data; the second number indicates the number replying about use of temperature data. Note that a very small number of respondents did not supply information (see Table 1).

Table 4) was more extensive than its use of historical precipitation data (Table 3), there is not as large a discrepancy between its use of year-to-date temperature and precipitation data. Once the growing season has commenced, the canning companies evidently find the guidance to production decision making (Table 6) offered by that year's cumulative precipitation to be almost as valuable as that provided by temperature-based accumulations such as growing degree days.

The other agribusiness activities that use year-to-date accumulations extensively are farm managing and grain merchandising (Table 5), both of which were also found to be heavy users of historical climate data (Table 3). However, in contrast to their use of historical data, they make far greater use of year-to-date precipitation data than year-to-date temperature data. This is particularly true for the grain trade. Since these users find year-to-date accumulations valuable when making in-season assessments of both the yield potentials of diverse areas and their market implications (Table 6), it is likely that growing season precipitation is perceived to be the most critical determinant of the likely production of major crops such as corn, soybeans, and wheat. While this perception probably holds true for most years, it may not be true for all. It is distinctly possible that a detailed analysis of climate-crop interactions during the disastrous 1983 Midwestern growing season (Illinois State Water Survey 1985) will show that prolonged excessive temperature played a more important role in this calamity than did deficient moisture. Such a finding would provide a timely reminder of the need for full cognizance of temperature conditions. Table 5 also suggests that the grain trade uses year-to-date information far less than it uses historical climate data (Table 3). This difference is surprising and would seem to be to the disadvantage of that industry.

The same difference is even more characteristic of the chemical industry results in Tables 3 and 5. Whereas all the survey respondents in the chemical industry make use of historical climate data, fewer than half use year-to-date accumulations. This implies that chemical manufacturers are less concerned with making in-season adjustments to their field trials in response to the evolving climate (Table 6) than with both the pre-season planning of these trials and the post-season evaluation of product performance in relation to the overall growing season climate (Table 4). Such evaluations may involve the intercomparison of several years of trial/climate data, which in turn could well include the retrospective use of year-to-date accumulations. In this case, however, the year-to-date information would be drawn from the histor-

Table 6. — Intrasectoral Variation in Types of Specific Uses of Year-to-Date Accumulations, as Revealed by Responses to Question 16 of Questionnaire Survey (Appendix A)*

Component of sector	Types of specific use
Agricultural chemical manufacturers	Final decisions on planting options (crop, variety) and in-season decisions on pesticide applications for product trials; following in-season performance of product trials; field research testing; study of pesticide residues in soil.
Agricultural finance companies	Loan volume predictions (from July and August rainfall) and feedlot performance projections (from temperature) for present year.
Food processing/canning industry	Finalizing of planting schedules; in-season forecasting of insect control needs, spray dates, and likely harvesting times for specific crops and varieties.
Grain trade	Pre-season projection of subsoil moisture for next crop (autumn and winter) and in-season assessment of growing conditions (spring and summer); in-season estimation of likely crop production over wide areas and resultant crop prices and marketing patterns (especially timing of latter); assessment of possible future climate-induced crop and market conditions; development of current year marketing, hedging, inventory, and transportation decisions and strategies.
Integrated pest management consultants	Final decisions on crop planting dates, hybrid selection, and population rates; scheduling of in-season scouting for specific insect pests and development of predictions for outbreaks of their occurrence; timing of in-season applications of herbicides, insecticides, and supplemental fertilizers; in-season projections of crop development (including recovery from hail, wind, and frost damage), maturation and harvest times, and yield potentials; marketing and hedging advice; pesticide carry-over risk evaluations.
Producers	Final decisions on crop planting dates, hybrid selection, and population rates; in-season projections of pollination periods, harvest times, crop yields, and marketing options; in-season assessment of likely timing of insect infestations; real-time decisions on livestock numbers and associated acquisition/shipping considerations.
Professional farm managers	Finalizing of crop and variety choices and planting times and densities; in-season scheduling of pesticide spraying; in-season projections of crop development, maturation and harvest times, and yield potentials; planning for subsequent crops; farm valuation and investment analyses; development of marketing strategies.
Rural insurance industry	In-season estimation of insurance losses; investment guidance.
Seed production companies	Final decision on planting date; in-season prediction of detasseling periods (corn); monitoring of crop progress and formulation of production decisions/ recommendations; in-season prediction of effects of extremes (e.g., of high temperatures on pollination and of freeze damage on yields).

* This question did not differentiate between uses of precipitation and temperature data.

Note: This table is simply a listing, and makes no attempt to indicate how frequently a particular use was cited.

ical data bank. Since the chemical industry's interest in yield maximization is limited to the *future* contribution of its own products to that end, which is in strong contrast to the dominating real-time concern with yield maximization that is characteristic of most of the other activities being considered (Table 6), its limited use of year-to-date accumulations is understandable.

Table 5 indicates that producers, agricultural finance companies, and in particular the rural insurance industry are low users of year-to-date accumulations of both precipitation and temperature. These agribusiness activities were also found to use historical climate data the least (Table 3). However, while producers and finance companies use year-to-date data to about the same extent that they use historical data, the insurance industry uses year-to-date information far less than historical data. In fact, Table 5 suggests that this industry makes little, if any, use of year-to-date temperature accumulations. At the present time, insurance companies clearly do very little in-season monitoring of their likely losses (Table 6) from this type of climate information. Such knowledge is instead acquired largely through field scouting of affected areas, the locations of which may be at least partly identified from now-only climate information (defined in Chapter 2). However, the present trend towards "all-weather peril" insurance (as opposed to solely hail insurance) could make this industry more reliant on year-to-date information.

Finally, it should be noted that the much lower usage of year-to-date accumulations by producers than by professional farm managers (Table 5) parallels the situation identified for historical climate data (Table 3). It may be hypothesized that this difference has at least partly the same origin as that suggested for the historical data case. Whereas remotely located farm managers probably need formal year-to-date accumulations to make in-season production and marketing decisions (Table 6), on-site producers are much more likely to have assimilated the year's climate into their own experience. In addition, economies of scale in information acquisition and interpretation may be working against producers' use of this information type. Because professional farm management concerns (along with seed and grain companies) are larger entities, they probably can better justify the cost of acquiring this derived-type information, and/or of hiring specialists to perform (sometimes internally) the necessary data reduction and interpretation, than can individual producers. If the efficiency of food and fiber production by individual operators would be enhanced by improved access to year-to-date accumulations, there is a need for an infrastructure that will deliver an interpretive treatment of this derived information at reasonable costs. This situation is considered further in Chapter 5.

Climate Predictions

Intrasectoral variation in the extent of use of climate predictions is summarized in Table 7. This type of climate information is used to about the same extent as year-to-date accumulations, and somewhat less extensively than historical data. The results in Table 7 include both interesting similarities to and differences from those for the two other types of climate information (Tables 3 and 5).

Table 7 is supplemented by Table 8, which summarizes the specific uses of climate predictions by the private agricultural sector. This table is offered here primarily as background material. More in-depth dis-

Table 7. — Intrasectoral Variation in Extent of Use of Climate Predictions

Component of sector (Number of respondents in parentheses)	Percent of respondents who use this type of information	
	Precipitation	Temperature
Agricultural chemical manufacturers (5)	40	40
Agricultural finance companies (12)	33	25
Food processing/canning industry (7)	43	43
Grain trade (19/18)*	89	89
Integrated pest management consultants (12/11)*	75	73
Producers (27/25)*	63	60
Professional farm managers (13/12)*	77	67
Rural insurance industry (5)	60	60
Seed production companies (5)	40	40
Average for sector (105/100)*	64	60

* The first number in parentheses indicates the number of respondents replying about their use of precipitation data; the second number indicates the number replying about use of temperature data. Note that a very small number of respondents did not supply information (see Table 1).

Table 8. — Intrasectoral Variation in Types of Specific Uses of Climate Predictions, as Revealed by Responses to Question 31 of Questionnaire Survey (Appendix A)*

Component of sector	Types of specific use
Agricultural chemical manufacturers	Estimation of potential sales and production requirements; capital investment considerations; general planning of field research; plant growth regulator applications.
Agricultural finance companies	Loan volume forecasting and general business planning; extension of credit (risk management) considerations.
Food processing/canning industry	Tentative general planning of planting, spraying, and harvesting schedules; harvest prediction.
Grain trade	Preliminary estimation of crop planting times and yields; marketing, hedging, inventory, and transportation decisions.
Integrated pest management consultants	Tentative general planning of crop production advice — crop/variety types and acreages, pesticide choices and application rates and timing, scheduling of particular field activities; preparation of marketing and hedging advice.
Producers	Tentative general planning and design of crop production activities such as cultivation, crop and variety mix selection, pesticide applications, and harvesting; estimation of labor requirements; preparation of marketing strategies.
Professional farm managers	Tentative general planning and design of crop production activities such as planting, crop and variety choices, pesticide applications, and harvesting; preliminary estimation of crop yields; planning of marketing strategies.
Rural insurance industry	Establishment of coverages and rates; investment planning; estimation of likely insurance experience for coming season.
Seed production companies	Tentative general planning of planting, spraying, and harvesting schedules and strategies.

* This question did not differentiate between uses of precipitation and temperature data.

Note: This table is simply a listing, and makes no attempt to indicate how frequently a particular use was cited.

cussions of climate prediction uses and needs appear in Chapters 4 and 5. An inspection of Table 8, however, clearly reveals that the agribusiness sector uses climate predictions in general planning, both before and during the actual growing season.

Climate predictions are used most extensively by the grain trade, pest management consultants, and farm managers (Table 7). All of these groups show a similar interest in temperature and precipitation predictions, apparently because of their need to plan production schedules (or, in the case of the grain trade, anticipate them) and develop marketing strategies (Table 8). These components of the private agricultural sector are also heavy or relatively heavy users of historical climate data and year-to-date accumulations (Tables 3 and 5). One rather surprising finding is that the grain trade uses climate predictions (particularly temperature predictions) more extensively than year-to-date accumulations, and almost as much as historical data. This pattern was not found for either farm managers or pest management consultants (Tables 3, 5, and 7).

Producers and the insurance industry use climate predictions to a moderate extent (Table 7). Both groups evidently consider this type of climate information to be of similar value to, or more valuable than, either historical data or year-to-date accumulations (Tables 3, 5, and 7). The insurance industry's increased use of climate predictions relative to its minimal use of year-to-date accumulations is especially marked. This suggests that general planning may be of more concern to insurance companies (Table 8) than the monitoring of in-season developments (Table 6), at least to the extent that the latter is based on formal climate information.

Producers use climate predictions more, and at a level closer to that of farm managers, than was the case for the other information types. The specific uses of the information are once again highly similar for these two groups — in this case the planning of production and marketing (Table 8). Two hypotheses may be advanced to explain producers' greater use of climate predictions: (a) a climate prediction is not part of a producer's experience in the way that information in historical data and year-to-date accumulations may be, and (b) climate predictions are more readily available and in an easier-to-use format than the other climate information types (they appear in a small brochure published twice monthly by the National Weather Service, and in many newspapers).

Perhaps the most striking feature of the climate prediction results in Table 7 is the rather limited use of this information type by the chemical, seed, and canning industries. In contrast, all these groups are heavily dependent on historical data (Table 3), and only the chemical manufacturers do not use year-to-date accumulations extensively (Table 5). Clearly, these groups do not consider climate predictions to be particularly valuable to the general planning of their operations (Table 8). Given the extreme vulnerability of these operations to climatic fluctuations, it would seem that predictions of such vagaries, if considered to be in a usable format and of sufficient reliability, ought to be one of the more important management tools they use. The fact that this is not the case suggests that climate predictions are poorly regarded. This hypothesis was discussed in depth at the workshop, and the results and implications are reported in Chapters 4 and 5.

Finally, it should be noted that the use of climate predictions among agricultural finance companies is even less widespread than in the canning, chemical, and seed industries (Table 7). The type of planning undertaken by finance companies, some of which is summarized in Table 8, is at present apparently not thought to greatly need or benefit from the available information on the likely future climate. This component of the private agricultural sector was also found to be a low user of historical data and year-to-date accumulations.

Some Characteristics of Uses of Climate Information

The questionnaire respondents who indicated that they/their company used climate information were asked several subsequent questions designed to reveal some of the characteristics of that use (see Appendix A). Some of the results have been presented in Tables 4, 6, and 8. Other results are discussed below.

Specificity of Use

Respondents were asked to indicate whether they used climate information as general background information, for specific decisions, or both. Table 9 clearly indicates that the need for guidance of a general background type is a motivation for almost all agribusiness users of climate information. This result varies little either across the sector or between information types. Interestingly, although agribusiness as a whole uses historical data more than year-to-date accumulations or climate predictions (Table 2), the actual users of the information rely on year-to-date accumulations and climate predictions as general background essentially as much as they rely on historical data as general background (Table 9).

Table 9. — Percentage of Respondents Using Climate Information as General Background and for Specific Decisions

Component of sector (Number of respondents for each information type in parentheses)	Climate information type: Historical data		Year-to-date accumulations		Climate predictions	
	GB	SD	GB	SD	GB	SD
Agricultural chemical manufacturers (5,2,2)	100	80	100	100	50	100
Agricultural finance companies (6,6,4)	100	17	100	17	100	50
Food processing/canning industry (7,7,3)	86	43	86	86	100	67
Grain trade (19,14,17)	100	53	100	43	100	53
Integrated pest management consultants (12,10,9)	100	75	90	90	100	67
Producers (12,14,17)	100	42	100	43	88	82
Professional farm managers (11,11,10)	100	64	100	55	90	80
Rural insurance industry (4,1,3)	75	100	100	100	100	100
Seed production companies (5,5,2)	100	60	100	60	100	50
Average for entire sector (81,70,67)	98	57	97	57	94	70

Note: GB = general background; SD = specific decisions.

Table 9 also identifies the percentage of climate information users for whom this use occurs during the making of specific decisions. Fewer users make use of the information for this purpose than for general background. Only 57% use historical data and year-to-date accumulations in making specific decisions, while 70% use climate predictions in this way.

The specific decision results in Table 9 contain much greater intrasectoral variation than those pertaining to the use of climate information as general background. The rural insurance industry, agricultural chemical manufacturers, and integrated pest management consultants make the greatest use of climate information, and agricultural finance companies make the least use of it, during specific decision making. Although the remaining agribusiness activities are, on the average, only moderately dependent on climate information when making specific decisions, some clearly find one information type to be more helpful in that context than the other types. Information categories of particular value to individual components of the sector in making specific decisions are year-to-date accumulations for the food canning industry and pest management consultants, and climate predictions for producers and professional farm managers. The grain trade's relatively low incorporation of climate information into its decision making process is one of the most surprising results in Table 9. A comparison of Tables 3, 5, 7, and 9 reveals no clear relation between the extent of an agribusiness activity's overall recourse to climate information and the degree of exploitation of this material during the making of specific decisions by the activity's actual users.

Respondents whose decision making is influenced by climate information were asked to list the types of specific decisions involved (Appendix A). The results of this question have already been presented in Tables 4, 6, and 8. Brief discussions of these tables were given previously; in summary, they show that historical data are used largely in pre-season planning, that year to-date accumulations tend to be used during in-season operations, and that climate predictions are used for tentative general planning purposes. As already indicated, the main discussion of the specific agribusiness uses of climate information appears in Chapter 4.

The survey also investigated the extent to which climate information is inserted into mathematical equations and formulae that aid decision making. The results (Table 10) indicate that little more than one-third of climate information users presently use historical data and year-to-date accumulations in this way, while only 22% do so for climate predictions. A comparison of Tables 9 and 10 establishes that much of the agribusiness dependence on climate information during the making of specific decisions does not include introducing this material into mathematical equations or formulae. This is especially true of the use of climate predictions.

Of the agribusiness activities studied, pest management consulting makes the greatest use of climate information in mathematical equations and formulae

Table 10. — Percentage of Respondents Using Climate Information Who Use Such Information in Mathematical Equations or Formulae That Aid Decision Making

Component of sector (Number of respondents for each information type in parentheses)	Climate information type		
	Historical data	Year-to-date accumulations	Climate predictions
Agricultural chemical manufacturers (5,2,2)	40	50	0
Agricultural finance companies (6,6,4)	17	17	25
Food processing/canning industry (7,7,3)	43	57	33
Grain trade (19,14,17)	26	21	24
Integrated pest management consultants (12,10,9)	58	70	44
Producers (12,14,17)	33	43	18
Professional farm managers (11,11,10)	27	18	10
Rural insurance industry (4,1,3)	75	0	33
Seed production companies (5,5,2)	40	40	0
Average for entire sector (81,70,67)	38	37	22

(Table 10). This result is probably not surprising, given that this group emerged as a consistently strong utilizer of climate information throughout the study (Tables 3, 5, 7, and 9). The food canning, agricultural chemical, and seed production industries use historical climate data and year-to-date accumulations in mathematical equations and formulae to a moderate extent, while rural insurance companies apparently frequently use historical data in this way. Other notable results in Table 10 include the relatively low mathematical use of climate information by the grain trade, the greater use by producers than professional farm managers, and the very low use by agricultural finance companies.

Focus, Resolution, and Source of Information

Survey respondents were asked which seasons and sizes of area they used climate information for, the lengths of the prediction or data summary periods used (daily, weekly, monthly, seasonal, annual), whether or not information for regions outside the United States was used, and the source(s) of their information. Table 11 provides the results for the private agricultural sector as a whole, listed according to type of climate information. While the original data analysis for Table 11 differentiated betweeen the responses of individual agribusiness activities, the variation that emerged was considered insufficient to warrant the cumbersome display needed to convey that information. However, the most notable aspects of this variation are mentioned in the ensuing discussion.

Table 11 shows that climate information for the spring and summer seasons is used much more than that for the other half year, particularly winter. Very similar results were obtained for all three information types. The only moderate anomalies in this regard are the greater use of autumn climate predictions than autumn information of the other two types, and the lower use of spring and summer historical data than spring/summer information of the other types.

The results for pest management consultants, producers, and farm managers conform very closely to

Table 11. — Seasons of the Year, Data Period Lengths, and Region Sizes for Which Climate Information Is Used by Respondents, and Sources of Respondents' Climate Information, Listed by Percentages of Respondents

Characteristic	Climate information type: Historical data (81 respondents)	Year-to-date accumulations (70 respondents)	Climate predictions (67 respondents)
Season			
Spring	72	91	97
Summer	73	91	97
Autumn	49	53	70
Winter	22	31	33
Data summary/prediction period length			
Daily	52	—	73
Weekly	47	—	72
Monthly	63	—	48
Annual	28	—	22
Region size			
Smaller than a county	28	24	22
County	51	56	58
Crop reporting district	42	41	37
State	38	38	45
Larger than a state	21	16	27
Part of foreign country	27	29	30
Information source			
Directly from National Weather Service	62	61	78
Other government agency	54	61	40
Private consultant	28	29	46
Other	28	36	43

the pattern depicted in Table 11 for the entire sector, but those for the other agribusiness activities include some interesting departures from that pattern (not shown). For example, while the chemical and canning industries apparently make no use of winter climate information, the grain trade is very dependent on winter information. This is also true of the agricultural finance companies that use climate information. One possible explanation for this is that the operations, and hence cognizance of climatic influences, of these two agribusiness activities are year-round.

The seed industry was found to be an especially strong user of autumn climate information. This is consistent with that activity's paramount need to bring in an undamaged harvest. The same finding was not obtained for the canning companies, despite the fact that most of the other seed and canning results are very similar (Tables 3-10). It is possible that this difference in use of autumn climate information by the two groups stems from the fact that the canning industry is dominated by crops that generally mature faster than those grown for the seed companies.

For the sector as a whole, monthly historical data are used more than historical data for other time scales (Table 11). While daily and, to a lesser extent, weekly historical data are used moderately, annual historical data are apparently considered to be of little value. Analysis of the use characteristics of individual agribusiness activities revealed that the grain trade and seed industry make particularly extensive use of daily, weekly, and monthly historical data, and that the canning industry is heavily dependent on daily historical data (not shown). The canning industry makes little use of weekly and (especially) monthly information of this type.

The questionnaire survey (Appendix A) did not ask the time scale for which year-to-date accumulations are used, since by definition this time scale needs to be daily. However, the survey did ask the lengths of the periods for which climate and (for comparative purposes) weather predictions are used. Table 11 shows that of the respondents who use climate information, almost three-fourths use daily and weekly climate predictions, 48% use monthly climate predictions, and only 22% use annual climate predictions. While the grain trade, pest management consultants, and professional farm managers all make moderate use of monthly climate predictions, only the insurance industry uses annual predictions to a significant extent (not shown).

Table 11 reveals that the county is the United States areal unit for which climate information is most frequently compiled and used. The level of use of both historical data and year-to-date accumulations declines as the unit size increases from county to crop reporting district to state. These two types of information are seldom compiled and used for areas that are either smaller than a county or larger than a state. The results obtained for climate predictions differed from the above only slightly — in this case, the state is apparently a more useful unit than the crop reporting district. While the canning and seed industries, chemical manufacturers, and pest management consultants emerged as the heaviest users of climate information compiled for counties, the grain trade showed the strongest interest in information for the larger spatial units (not shown). The grain trade is also the greatest user by far of climate information pertaining to countries outside the United States (not shown). Its use of this information approaches its use of domestic climate information (not shown). For the sector as a whole, however, the use of foreign climate information is rather restricted (Table 11).

It is clear from Table 11 that a majority of the climate information currently used by agribusiness is obtained directly from the National Weather Service (or other National Oceanic and Atmospheric Administration agencies). This is particularly true of climate predictions. For historical data and (especially) year-to-date accumulations, other government agencies are collectively of equal or almost equal importance in this regard. Private consultants play a much greater role in provision of climate predictions than in provision of the two other information types. The most prominent intrasectoral variation in the source of information results was the strong dependence of the grain trade on private consultants (not shown). In addition, the canning, chemical, and insurance industries were found to be very reliant on information supplied by the National Weather Service, while farm managers and pest management consultants are similarly dependent on other government agencies.

General Reasons for Non-Use of Climate Information

The questionnaire respondents who indicated that they/their company did not currently use climate information were asked to choose among several possible reasons for this non-use (Appendix A). A slightly different set of possible reasons was offered for each type of information. It should be noted that these reasons were, by design, rather general. This portion of the questionnaire was intended only to furnish the background knowledge needed to focus the in-depth discussion of the same topic at the subsequent workshop, the findings of which are fully detailed in Chapter 4. It should also be emphasized that the questionnaire responses obtained on this subject are in fact largely perceptions, and that such views may be at variance with reality, sometimes considerably so. The extent and significance of this discrepancy will be fully treated in the two remaining chapters, for they are highly germane to the third objective of this study: the determination of how the present use of climate information can be increased to the maximum possible.

Table 12 presents the questionnaire results on non-use for the entire sector, listed according to information type. As with the data analysis for Table 11, the original data analysis for Table 12 differentiated between the reasons for non-use offered by individual agribusiness activities. While the sample sizes involved and intrasectoral variation detected were considered insufficient to warrant inclusion of the total data in Table 12, the most prominent aspects of the variation are mentioned below.

The two most cited reasons for the non-use of historical data are the perceptions that this information is not available and that it has no value even when believed to be available (Table 12). By comparison, relatively few respondents considered data processing costs to be high enough to dissuade them from using this information type. Agricultural finance companies in particular doubt the value of historical data to their operations, while producers were found to be the strongest believers that this information was not available (not shown).

The results for year-to-date accumulations in Table 12 are very similar to those for historical data. Again, reservations about the availability and utility of the information emerge as the major impediments to its greater use. In addition, a sizeable fraction of the respondents who believe that year-to-date accumulations become available in due course do not consider this process to occur quickly enough for the information to be useful. Approximately half of the entire set of questionnaire respondents indicated (question 26, Appendix A) that year-to-date accumulations need to be updated on a weekly basis to have real utility; much smaller percentages favored daily or monthly updating (not shown). The belief that this type of climate information is not available or not available when needed was found to be strongest among producers and agricultural finance companies that do not use climate information (not shown). The latter group, along with representatives of the grain trade and chemical industry, was also found to be among the agribusiness personnel most influenced by the notion that year-to-date accumulations have little value (not shown).

The principal reason for the non-use of climate predictions is doubt about their accuracy (Table 12). This concern was found to be widespread throughout the sector (not shown). These findings help to explain

Table 12. — Reasons Given by Survey Respondents for Non-Use of Climate Information

Type of information	Reason for non-use	Percent
Historical data (26 respondents)	Data have no value	42
	Data not available	65
	Too costly to convert data to a usable form	19
	Other	12
Year-to-date accumulations (37 respondents)	No need for it	54
	Not available	43
	Too costly	8
	Not available when needed	27
	Other	0
Climate predictions (40 respondents)	No need for information	28
	Present forecasts are not sufficiently accurate	73
	Present forecasts are not available soon enough	13

Note: Some respondents gave more than one reason for their non-use of a particular information type.

the non-use of climate predictions by many survey respondents, as discussed earlier in this chapter. (In this regard, it is of interest to note that three-quarters of the questionnaire survey respondents [question 45, Appendix A] indicated that climate predictions would "have to be approximately correct" 70-80% of the time before they would incorporate them into their decision making process.) In contrast, there seems to be much less concern about the zero or very short lead times (defined at the end of Chapter 2) that presently characterize most of these predictions (Table 12). Furthermore, only 28% of the respondents who do not use climate predictions said they are non-users because they have no need for this type of information. This is much smaller than the percentages of non-users of historical data (42%) and year-to-date accumulations (54%) who said they are non-users because the information has no value or they have no need for it (Table 12). Only among agricultural finance and chemical companies is there any real tendency to avoid using climate predictions because of doubts on this score (not shown).

Chapter 4. Results of Workshop

Background

The workshop held as part of this study sought to exploit and build on the knowledge about agribusiness use of climate information that was acquired from the questionnaire survey. In particular, it attempted to provide the detail, specificity, and clarity concerning the climate information uses and needs of this sector that can not be obtained from a survey. Although the workshop (Appendix C) was concerned primarily with the second and third of the three study objectives — those dealing with possible future information needs and opportunities, in which regard it constituted an extension of the questionnaire survey — some time was also spent reviewing the survey's results on the present agribusiness use of climate information. This effort represented both a confirmation and an extension of the questionnaire survey.

Although the organizational aspects of the workshop are detailed elsewhere (Chapter 2 and Appendix C), some comment on the rationale for certain organizational features is in order here. The decision to include people from five different components of the private agricultural sector in each discussion group, as opposed to clustering participants from the same and closely related agribusiness activities, was made in the hope that contrasting backgrounds and perspectives would produce a "cross-fertilization" of ideas on the subject at hand, and so make the discussions more productive. This goal was largely realized. This type of organization was prompted by the questionnaire survey results revealing that some components of the sector had potentially similar climate information uses/needs (e.g., the seed and canning industries) and that others currently exhibited a surprisingly low level of use of some information types (e.g., chemical manufacturers, grain trade). The holding of plenary sessions at which groups summarized their discussions was similarly motivated and equally successful. One of the principal reasons for the success achieved was the participants' ability to accept our "charge," issued early in the workshop, to think and speak not just for themselves or their company but for the entire agribusiness activity they had been chosen to represent.

The following three sections deal, in turn, with the three topics considered in the group discussions (Appendix C): present uses of climate information, major impediments to fuller use of climate information, and climate prediction needs for the future. In contrast to the quantitative nature of the results in Chapter 3, this new material is necessarily qualitative. It is primarily the product of a summary and synthesis of the formal reports on the group discussions prepared by their rapporteurs from the Illinois State Water Survey and the University of Illinois (see Chapter 2, "Workshop" section). However, it also reflects the responses to the qualitative-type questions in the questionnaire survey (questions 11-13, 23-25, and 40-44, Appendix A) that were not considered in Chapter 3.

Present Uses of Climate Information

One of the principal reasons for holding group discussions on present uses of climate information was the hope that they would permit the identification of broad categories of climate information use. This approach offered the chance to focus on the nature of climate information use, as opposed to focusing on the different types of climate information. The summary of the questionnaire results in Chapter 3 was organized by climate information type and, as such, was almost completely limited to the identification of the extent and characteristics of the use of each of the three varieties of information by individual agribusiness activities. A sector-wide synthesis was not attempted there, whereas it is in this section.

Our distillation of the reports on the group discussions identified several major and somewhat overlapping categories of current application of climate information within the private agricultural sector. This not only strongly confirmed the questionnaire survey results, but also yielded considerable insight into the genesis, context, present limitations, and probable future characteristics of the various types of use. Details follow.

Design and Planning of Operations

One especially important agribusiness use of climate information that emerged from the group discussions is in the design and planning of ongoing and future operations. This particularly involves the use of climate information in the scheduling of field efforts (tillage, fertilizer and pesticide application, planting, harvesting, etc.) by producers, professional farm managers, chemical manufacturers, food processing organizations, pest management consultants, and seed producers. Furthermore, both the agricultural finance companies that provide capital for borrowing and the agribusiness activities that depend on this service (most of those listed above) utilize climate information during their financial decision making. In the cases of the seed and food processing firms, the planning also involves the climate-based selection of sites for contract production, while for the chemical industry climate information plays a role in locating the field trials as part of the product development process.

The above information confirms many of the questionnaire results in Table 4 (for historical data) and some of those in Tables 6 (year-to-date accumulations) and 8 (climate prediction). Even more important, however, is the fact that the workshop setting permitted a full appreciation of the widespread reliance on climate information in the design and planning of operations. Such use extends across a considerable fraction of the sector and is clearly an integral and important part of the decision making processes of the agribusiness activities concerned. Furthermore, there seems to be potential for the future enhancement of this type of use of climate information. This theme is developed in Chapter 5.

Crop Yield Modeling

The second prominent category of agribusiness use of climate information that emerged from the workshop discussions involves the input of this material into the predictive crop yield models that are run routinely during the growing season by some grain merchandisers, commodity brokers, and their consultants. While this activity is not a practice throughout the entire sector, it was selected for treatment here because of its considerable influence on the nation's financial markets and because of its reliance on climate information. The use of climate information for crop yield modeling has important implications that extend beyond this activity; they will be developed further in Chapter 5. In addition, since the yields that are predicted reflect the efforts and possible uses of climate information by many other agribusiness activities (e.g., use of year-to-date accumulations to guide pest management, dependence on climate predictions for seed variety selection), they represent a sector-wide integration of sorts. The following discussion substantially extends the questionnaire-based information on crop yield modeling given in Tables 4 and 6. Again, the workshop setting permitted the needed in-depth treatment.

The crop yield models currently in use are diverse in their formulations. They range from those that have a sufficiently strong physiological basis to require the input of daily meteorological data (but which are run at intervals of at least a week) to the more traditional statistical (e.g., multiple regression) models that use monthly information. Irrespective of the type of model used, however, these operational crop yield prediction efforts depend on two separate sets of climate information: actual data for the entire growing period or year prior to the time of the model run, and assumptions about the climatic character of the remainder of the growing season.

In some cases, the information of the first type that is currently being fed into the models is interpolated to a much finer spatial resolution (e.g., down to the county scale) than the material from which it is derived. The latter is often limited to reports from only the "first-order" National Weather Service (NWS) stations, of which there are presently a very limited number (only five in Illinois, for example). Unfortunately, the NWS "cooperative substation" data that are recorded at many more locations (approximately 200 in Illinois) and therefore have considerable potential utility in this context are currently not disseminated to agribusiness with the required speed. The time lag involved tends to be several months, whereas delays of a few days to a week are probably the longest that most of this modeling can tolerate. The larger issue of which this situation is part — the question of the design of an appropriate climate information "delivery system" for agribusiness — is considered fully both later in this chapter and in the next one.

This data availability problem raises two fundamental questions that pertain to a modeling endeavor of this type. The first question concerns the number of versions of a given type of model (the versions may differ from one another only slightly) that are required to adequately treat agricultural areas as large as the North American Great Plains, the Midwestern United States, and the portion of southern Brazil that is increasingly being used for soybean production, all of which are currently of great interest to grain merchandisers and commodity brokers in the United States. These groups require a regionalization of such areas into smaller units that are statistically coherent with respect to the basic characteristics and objectives of a given model type. While these regionalizations should be developed from historical climate data, they have to be consistent with the present availability of climate information for the current year in the required real-time operational mode outlined above.

The second question stemming from the data availability problem relates to the number and locations of the stations from which climate information is used in operational crop yield prediction. Juxtaposed against the obvious need for economy is the need for the design of the station network to be consistent with a regionalization of the type advocated above. The workshop discussions suggested that the grain trade's crop yield prediction modelers are quite cognizant of the two foregoing problems. The solution to these problems would seem to require considerable basic research into the variability of growing season climates in both space and time. An example of the type of work that should prove helpful in this regard is given in the next chapter.

The need for the delineation of climatic regions also pertains to the second of the two previously mentioned sets of climate information used in operational crop yield prediction efforts: assumptions about the climatic character of the rest of the growing season beyond the time of a given model run. Such assumptions are, in effect, climate predictions. The alternatives currently in use include regarding the standard 30-year normals as predictors, doing likewise with some shorter period normals (e.g., Lamb and Changnon 1981), making conditional probability predictions that are derived from the historical climate data (e.g., there is X% chance August will be Y because July was Z), and adopting the more physically-based 30- and 90-day forecasts of the National Weather Service. Not surprisingly, therefore, the people involved in operational crop yield prediction are very much aware of the considerable potential value to them of accurate climate predictions. They are also rather skeptical of the quality of the climate predictions presently available. Balanced against this somewhat harsh opinion, however, is a realization that the prediction of climate is not easy.

Monitoring of In-Season Conditions

A further category of substantial climate information use by the private agricultural sector is in the monitoring of in-season conditions. This occurs quite extensively among many of the agribusiness activities considered: canning industry, seed production companies, pest management consultants, professional farm managers, and, to a lesser extent, grain merchandising companies. It permits timely and productive adjustments to operating practices that are needed because of prior climatic developments. This monitoring also leads to revised estimations of the procedures that should be used during the rest of the season and their likely outcomes (including yields). Particularly prominent in this regard are decisions relating to seed variety and planting rate, pesticide type and application, and harvesting/processing arrangements.

This category of climate information use involves not only the year-to-date accumulations whose treatment constituted an important part of the questionnaire survey (see Chapter 3), but also the "now-only" conditions (e.g., mid-July soil moisture, late April soil temperature) that are typically contributed to by year-to-date accumulations for several meteorological parameters. Now-only conditions were not considered in the questionnaire survey, but one of the most valuable findings of the workshop was its identification of the strong dependence of many agribusiness activities on now-only climate information for the monitoring of in-season conditions.

Finally, the workshop discussions also revealed that historical climate data yield a range of probability estimates (e.g., of spring and fall frost dates, planting dates, high temperature extremes) that are frequently used as background information for this in-season monitoring.

Types of Information Used

As the foregoing discussion implies, the present application of climate information within the private agricultural sector involves a relatively wide range of meteorological parameters. For some of the parameters, the types of information being used are also quite varied.

In the case of temperature, for instance, the use includes the entire historical data bank on seasonal, monthly, and shorter time scales; daily values for the present season; temporal integrations of interpretive quantities derived from these daily data (e.g., year-to-date accumulations such as growing degree days and other heat units); and information on runs of daily extremes. Precipitation data are used in broadly similar forms. With regard to temperature and precipitation, the workshop was thus able to expand on the information obtained from the questionnaire survey.

The workshop discussions revealed the use and potential value of information on several meteorological parameters that were not treated in the questionnaire survey. For example, many workshop participants stressed that information on cloud amount/sunshine duration/solar irradiance is considered very useful for photosynthetic and soil moisture considerations, especially when extensive cloudiness persists during important crop growth periods. Interestingly, the participants' appreciation of the potential value of such information was heightened by the fact that considerable cloud cover occurred over the upper Midwest during the middle third of the 1982 growing season (in the six weeks or so immediately prior to the workshop) and caused plant development there to lag considerably behind the stage implied by the accumulated growing degree days. However, as is discussed later in this chapter, the much needed cloud/sunshine/radiation data are not readily available. The other parameters for which climate information is presently being used include wind (relevant to insect pest problems), soil temperature (planting), soil moisture (crop maturation and nitrogen application), and frost occurrence (seed variety selection and overall scheduling). The availability of this information is also considerably less than optimum.

Workshop participants expressed the belief that there is presently a relatively high level of climate information use by their sector. This confirmed the similar result yielded by the questionnaire survey. The workshop discussions also suggested that the major innovative and intensive climate information users are pest management consultants, the highly controlled seed and food canning industries, and some grain and brokerage companies. Their use particularly involves in-season dependence on year-to-date accumulations and now-only information. The grain trade's workshop participants were found to be more dependent on these information types than some of the questionnaire respondents from that activity. This difference suggests that the potential exists for a greater use of climate information by this important component of the sector.

The situation outlined above — the high overall level of use, and the especially strong dependence of some activities on year-to-date accumulations and now-only information — is probably little recognized by the atmospheric science community. Furthermore, it appears that there has been a rapid growth in this utilization in recent years. The workshop discussions left us with the impression that such enhanced use has occurred in response to several developments: increased financial pressures felt by agribusiness, a perception that such use could provide a company with an economic advantage over its competitors, the dramatic improvement in the sector's modeling and information management capabilities that has resulted from greatly enhanced computer technology, and the financial consequences of the 1972-73 and 1975 grain sales to the Soviet Union, which are perceived to have been at least partly climate-induced.

Major Impediments to a Fuller Use of Climate Information

A minor objective of the questionnaire survey (Appendix A) was to obtain a preliminary indication of the reasons for non-use of climate information. The results were reported in Chapter 3 and reflect the very general level of that inquiry. The subsequent workshop group discussions attempted to elicit informative details regarding the questionnaire survey's finding that the agribusiness use of climate information is currently most curtailed by reservations about the availability, utility, and (for climate predictions) accuracy of that information. As in the rest of the workshop, a sector-wide synthesis was sought. The results obtained are summarized below.

Lack of Delivery System

A principal reason for non-use of climate information is the lack of an appropriate delivery system for material that exists, is known to exist, and is desired. This particularly limits use of year-to-date accumulations and now-only information, for which preceding discussion noted a substantial need. It is much less applicable to the other information types.

An excellent example of this problem is provided by the NWS cooperative substation data that were mentioned during the discussion of crop yield modeling earlier in this chapter. This data set contains daily precipitation totals and (to a lesser extent) daily maximum and minimum temperatures for a large number of locations (e.g., approximately 200 in Illinois for rainfall). It is data of this type and resolution that are needed to reliably compute year-to-date accumulations, help identify now-only conditions, and ascertain the important spatial variations of such information. The recordings are made on a daily basis. If they could be transmitted to potential agribusiness users with some urgency (say, within 3 to 5 days), these observations could have value for the monitoring of in-season conditions.

However, the current NWS procedures relating to these data delay their availability much longer than can be tolerated by the agribusiness community. These procedures require station observers to mail a given month's handwritten records to the National Climate Data Center (NCDC, Asheville, North Carolina) at the end of the month concerned. NCDC then per-forms a quality control of the huge mass of acquired data and archives the resulting sanitized sets, after which the latter are published for each state in the series of National Oceanic and Atmospheric Administration (NOAA) pamphlets entitled *Climatological Data.* Only at the end of this process, which takes from 2 to 4 months depending on the time of year, are cooperative substation data available to agribusiness, by which time they are of no use for in-season monitoring. Chapter 5 provides an example of the type of initiative that is needed to remove this delay.

In the absence of the delivery system needed to provide the most appropriate climate information (e.g., data from the national cooperative substation network discussed above), the agribusiness community is forced to use its own measurements, qualitative field reports of climatic conditions and indicators, data from a less appropriate but more accessible national network such as the NWS first-order stations, various other estimates, experience, and instinctive reactions.

Perceived Complexity of Problem

A second major impediment to a fuller use of climate information by agribusiness is the perceived complexity of the decision maker's problem of which climate is but one part. There is wide recognition that the complicated decision making and modeling processes characteristic of this sector have other equally or more important inputs (e.g., economic, social, and political considerations) that are not easily quantified or whose dimensions are imperfectly known. In the face of this situation, there has been a distinct tendency for some agribusiness personnel to see little dividend in the sophisticated use of climate information.

It is important to stress that this view is presently but a perception, and that it may be at variance with reality. It is possible that the current situation exists because the benefits to be obtained from the use of climate information have generally not yet been adequately demonstrated, because there is uncertainty about how this needed demonstration can be accomplished, and probably also because there are nagging doubts about the sector's ultimate ability to mitigate adverse climate impacts or enhance beneficial ones. Clearly, all of these issues need to be addressed in the very near future. We believe that this task would best be pursued via economic modeling that includes the effects of climate fluctuations, and that is rigorous and quantitative in nature. This approach, which probably should commence by dealing with individual components of the sector (e.g., the operation of the farm firm), would open new and professionally rewarding fields for agricultural scholars. If we are to achieve the much needed involvement of specialists other than atmospheric scientists, the work will have to be professionally beneficial for all participants. The section on research needs in Chapter 5 discusses a developing interdisciplinary study that is being patterned along the lines just advocated, which deals with the possible use of climate predictions by Midwestern row crop producers. This study was motivated partly by the results of the present study.

In conclusion, we wish to emphasize that while the relatively qualitative and survey-type approach adopted throughout this study and also by Glantz (1977, 1979) constitutes an informative way to initiate research into the use of climate information, such efforts are insufficient to address the important issues listed above. As already indicated, future progress would seem to require the use of quantitative economic models.

Deliberate Non-Use

There is also deliberate non-use of climate information that is known to be available. Either such material is perceived to be of little use, or else it is thought that its utility has not yet been demonstrated. The difference between this type of non-use and that discussed immediately above is one of attitude — in this case the non-user definitely believes that the information concerned is of questionable utility and does not consider the issue to be clouded by "complexity of the problem" type arguments.

An excellent example of this type of non-use concerns the monthly and seasonal climate predictions issued by the Climate Analysis Center (CAC) of the NWS. The availability of these predictions, both in many newspapers and by subscription, is apparently very widely known within the agribusiness community. Furthermore, relatively few of those in agribusiness question the potential value of climate predictions — the workshop discussions confirmed this result of the questionnaire survey. The neglect of the CAC predictions by a large majority of agribusiness personnel stems instead from a perception that they are too unreliable to be useful (also see Table 12). In addition, the workshop discussions suggested that the zero lead time, coarse spatial resolution, and open distribution (which gives no individual or company an "edge" over competitors) of these predictions further militate against their use. While the climate predictions that are being increasingly issued by private meteorological consultants do not have the latter disadvantages, the workshop discussions indicated that their perceived credibility is at least as low as that of the CAC predictions.

It is our belief that the foregoing agribusiness standpoint may not be entirely appropriate. Even though climate predictions have yet to consistently achieve the accuracy levels that most people (including both atmospheric scientists and potential prediction users) think is desirable, they nevertheless may already be reliable enough to be of some economic value to agribusiness. This has proven to be the case for crop-hail insurance (Changnon and Fosse 1981). There is thus a definite need for a quantitative investigation of the above possibility. As already indicated, Chapter 5 describes a developing study that has these objectives with respect to the use of climate predictions by Midwestern row crop producers.

The same general comments and research needs apply to some (but not all) of the other deliberate non-use of climate information. It does seem to us, however, that a reasonable fraction of this non-use is based on rational grounds.

Exploitation Difficulties

The private agricultural sector is sometimes unable to fully exploit the climate information currently available. In some cases the limitations are conceptual — for example, the appropriate models do not exist or are thought not to exist. If modeling work of the type advocated above can be developed to at least a moderate extent during the next decade, this type of impediment should gradually be removed. This process would be accelerated, particularly for the smaller agribusiness concerns (pest management consultants, professional farm managers, producers), by an improved diffusion through the sector of information about innovations in the above regard.

In other instances, the present use of climate information is limited by physical constraints, including lack of the requisite organizational support, computational facilities, appropriately trained staff, and financial resources. However, the growing trend towards the provision of electronically generated and transmitted agribusiness information by some large organizations, such as grain and brokerage companies and farm organizations, should help overcome these limitations. There is considerable potential for the inclusion of climate information in this supply. The situation should be further eased by the guidance on accessing and use of electronic information that is becoming available to smaller agribusiness concerns (Sonka 1983).

Other Impediments

The workshop discussions revealed several other reasons why the present use of climate information is not as great as possible. These include simple unawareness of the material that is available; the nonexistence/paucity/inaccessibility of some highly desirable information, such as that on cloud/sunshine/radiation, wind, soil moisture, and soil temperature, as previously discussed; communication problems between scientists and lay users (e.g., the question of what probability predictions mean); the apparently inappropriate formats of some of the present information publications and data tapes; and the notion that the cost incurred in acquiring and processing the information is not justified by the resulting benefits (real or perceived). The implications of some of these findings for the future agribusiness use of climate information are considered in Chapter 5.

Climate Prediction Needs for the Future

There were several reasons for holding group discussions on climate prediction needs for the future. First, the questionnaire treatment of the subject was either very cursory or did not yield definitive results. For example, in indicating the climate events for which they most desire predictions (question 40, Appendix A), many respondents offered general statements such as "precipitation, temperature," "drought and extreme wet periods," and "early or late frost." We therefore felt a need to capitalize on the flexibility of the workshop setting to explore the above topic in as much depth as possible. This decision was further prompted by our belief that the achievement of a really substantial reduction of the adverse consequences of climatic variation (or enhancement of the favorable consequences) would seem to require an effective use of skillful climate predictions. The potential benefits to be derived from a fuller utilization of other forms of climate information are inherently more modest.

The workshop group discussions on this subject were prefaced by an introductory lecture on climate prediction that sought to provide participants with the background needed to address the issues to be considered. This lecture began with a review of relevant terminology, such as climate-versus-weather prediction, lead time, and prediction period. It also sought to differentiate between three additional and potentially confusing terms used in relation to climate prediction: "resolution" (whether predictions are expressed in such extremely qualitative terms as "above normal" and "near normal," or something more precise), "accuracy" (the absolute difference between a predicted value and what actually occurs), and "skill" (the extent to which a given prediction method is more successful than would be achieved by chance or some other standard of comparison that does not require meteorological expertise to produce). The lecture concluded with an outline of the current procedures, format, and skill levels of the NWS CAC climate predictions. It was partially based on discussions by Harnack (1981a,b). The participants were then charged with discussing the future climate prediction needs of the agribusiness activity they represented (as opposed to only their own company) with respect to applications, lead times, desired length and timing of prediction periods, weather elements to be treated, resolution, accuracy, and skill.

In general, the workshop participants found this assignment extremely difficult, and these group discussions were decidedly less successful than the others, at least in the sense of providing definitive results. It was clear that the participants had never before given this particular subject the serious and rigorous consideration that it apparently requires. The same factor presumably also accounts for the undefinitive questionnaire responses obtained on the same topic.

The foregoing situation was deemed useful in a "negative" sense, however, for it provided real-world support for Lamb's (1979, 1981) earlier and somewhat abstract contention that considerable interdisciplinary research is needed to assess whether, where, how, and what type of climate predictions could/should be used. He argued that the use of climate predictions to minimize the adverse socioeconomic consequences of climatic variation has three demanding and reasonably sequential prerequisites: (1) identification of the human activities most severely impacted by such variations (according to geographical region, time of year, and weather parameters responsible); (2) determination of which of the most affected regional economies possess the flexibility to adjust or change to an extent that would permit them to capitalize substantially on the availability of skillful climate predictions; and (3) development of accordingly focused prediction schemes for the cases for which some skill seems attainable. The study of the possible value of climate predictions for Midwestern row crop producers (alluded to previously and discussed in Chapter 5) is being substantially shaped by the workshop findings.

Despite the participants' general difficulty in dealing with this subject, their efforts did yield three positive (if rather general) conclusions. The first was that, for many agribusiness applications, a prediction of the likely general character of late spring and summer conditions would be useful if it was made available during the preceding January-March period (certainly no later than April 10). For example, the forecasting of late May and June climate with this lead time could potentially influence preplanting decisions on fertilizer use, insecticide and herbicide choices, and production/sales questions. The important meteorological parameters appear to be temperature, sunshine, and rainfall. Since the early-July through mid-August period is the most critical one for crop growth, a demonstrated capability to successfully anticipate its climatic character six months ahead would affect numerous decisions made during the intervening time. A particularly important issue in this regard is the likelihood of July-August climatic extremes such as the 1980 and 1983 Midwestern heat waves/droughts and their antitheses. Highly favorable growing conditions affected Illinois (and also some surrounding states) during its record 1979, 1981, and 1982 growing seasons.

The second important positive conclusion to emerge from these group discussions was that the private agricultural sector would welcome attempts to predict September and early October conditions with some lead time. It is particularly interested in the likelihood of an early frost that would damage crops, and of an extended wet and cool period that would delay harvesting and thereby expose the crop to a range of yield-reducing threats. It appears that predictions of these phenomena would be needed by mid-August to influence late-season decisions. These decisions, which of course vary somewhat across the sector, in general relate to harvest scheduling and preparations, yield expectations, grain storage considerations, financial planning, and the development of marketing strategies. Because of the time of year in question, few of these decisions materially affect production. Predictions of autumn conditions with much longer lead times would be needed to influence production; this would occur through the selection of seed variety which, in turn, determines maturation time. These September-October climate prediction needs were only weakly recognized by the questionnaire respondents (questions 40-44, Appendix A). Furthermore, the atmospheric science community has probably greatly underestimated this interest in the prediction of autumn conditions.

Finally, the workshop group discussions strongly confirmed the questionnaire finding that the agribusiness community thinks climate predictions will need to be "highly accurate" before they take them seriously. Some of the consequences and implications of this workshop result have already been treated earlier in this chapter, in the section on deliberate non-use of climate information; the comments made there have equal application in the current context.

For instance, our earlier contention that the above agribusiness standpoint may not be entirely appropriate is supported by the fact that workshop participants had considerable difficulty dealing with the concepts of skill, accuracy, and resolution. Furthermore, they readily agreed that considerable research and user education will be necessary before an individual or company can properly assess the potential benefits and likely risks involved in using climate predictions, including those expressed in probabilistic terms. This sentiment is also consistent with the earlier ideas of Lamb (1979, 1981).

Chapter 5. Conclusions, Implications, and Recommendations

Summary of Motivation and Scope of Study

This study has sought to identify the climate information uses and needs of the groups that constitute the United States private agricultural sector.

The study was undertaken in the belief that it could contribute to the refinement of a recent important atmospheric science policy development: the formulation and partial implementation of large, ambitious, multifaceted, national and international "climate programs" (e.g., United States National Climate Program, World Climate Programme) that are intended to broadly benefit mankind by reducing the adverse socioeconomic consequences (and increasing the beneficial consequences) of climatic variability. While these climate programs (World Meteorological Organization 1979; National Oceanic and Atmospheric Administration 1980) are predicated on the assumption that such a goal is attainable, the validity of this assumption has never been demonstrated. We contended at the outset that the required management strategies are largely unknown, and that their development awaits substantial investigation of the climate information needs of decision makers (National Research Council 1981). It was in this context that we decided that the United States private agricultural sector merited comprehensive investigation.

This viewpoint was prompted by the many and varied characteristics of that sector. First, not only is agriculture the broad economic activity most affected by climatic variation (National Research Council 1976, 1982), but the private enterprise production system that has evolved in the United States is the most developed in the world and is of great importance to the United States and world economies. It is very large, diverse, complex, and technology-based, encompassing the actual producers (growers, farmers, ranchers); the elaborate support structure that provides producers with high quality materials (fertilizers, seeds, pesticides, machinery) and services (insurance, financing, farm and pest management); and the grain trade and the food processing and brokerage industries that are concerned with the ultimate outputs of the system. The sector is also endowed with highly fertile soil, generally abundant moisture, research and development related to the materials listed above, and educated operators who function within the initiative-rewarding environment of the "farm firm." However, despite these great strengths, the sector can be severely impacted by climatic fluctuations, as the enormous crop yield variations during 1979-83 readily attest.

An equally important motivation for this study was the dearth of prior knowledge of the climate information uses and needs of the agribusiness sector. We argued initially that the redressing of this deficiency would likely have several benefits in the "climate programs" context: (1) Identification of the present level of use and its value might increase the exploitation of such material within less developed agricultural systems. (2) The diversity and complexity of the system implied that its uses and needs would be varied and therefore offer an indication of the scope and difficulty of providing appropriate climate information products to the United States private sector in general. (3) The system's considerable structural and human flexibility might provide the possibility for a greatly enhanced use in the future, which would in turn offer an agricultural demonstration of the ultimate potential for improved management strategies to mitigate the unfavorable socioeconomic consequences (and enhance the beneficial consequences) of climatic variation. (4) Such management strategies would improve the sector's efficiency and thus benefit the consumer of food and fiber both in the United States and throughout the world.

The fundamental goal of the present study has therefore been to obtain an understanding of the factors that determine the use of climate information by agribusiness decision makers in the United States. It has had the following three specific objectives: (1) to describe the present level, types, and methods of utilization; (2) to identify the potentials for and impediments to a fuller use in the future; and (3) to specify the scientific research and data acquisition/

information dissemination development thrusts that are necessary before the level of present use can be increased to the maximum possible.

The project was conducted in three distinct phases. The first involved a nationwide mail questionnaire survey of agribusiness decision makers, from which 107 usable responses were obtained (86% response rate). This effort concentrated strongly on the present use of climate information. We believe that the size and scope of the questionnaire survey were adequate for the task at hand. The second phase was an intensive two-day workshop at which the primary participants were 14 of the respondents to the mail survey, selected because they were already users of climate information and had indicated an advanced interest in this topic in their questionnaire responses. Although the workshop made some further inquiry into the present use of climate information, it was dominated by in-depth consideration of how the sector's profitable use of climate information might be increased in the future. Furthermore, the workshop sought the detail, specificity, and clarity that could not be obtained from a survey. The third phase of the project consisted of day-long post-workshop discussions with several workshop participants from the private sector. These interactions concentrated particularly on the scientific research and data acquisition/dissemination development that are needed to enhance the agribusiness use of climate information (i.e., the third of the study objectives).

All phases of the project have thus been totally dominated by the extraction of information and opinions from active members of the private agricultural sector. As such, this study has not been at all influenced by atmospheric scientists' perceptions of the climate information uses and needs of that sector. While a study with the latter basis would likely have been easier to undertake, it would also have been of less value.

Four types of climate information have been considered. The questionnaire survey dealt with three of these: *historical data* (the very large bank of instrumental measurements made since the inception of such observations), *year-to-date accumulations* (summations of the daily values of actual weather parameters and derived quantities through any point in a given year), and *climate predictions* (statements of the expected general character of the weather for future periods of at least one month in length). These three information categories were also treated at the workshop, along with a fourth type, *now-only conditions*, such as mid-July soil moisture, which are the product of year-to-date accumulations for a range of parameters.

Summary and Implications of Present Use of Climate Information

The present extent and types of use of climate information were treated in Chapters 3 (questionnaire survey results) and 4 (workshop results). We here attempt to summarize the many, detailed, and somewhat disparate findings reported in those chapters. Table 13 provides a synopsis of the quantitative/explicit material in Tables 2 through 8 as well as the qualitative workshop information contained in Chapter 4. It gives a general indication of both the extent and type of use, listed according to information category and agribusiness component. Although the year-to-date and now-only columns of Table 13 contain identical information, we have resisted the temptation to combine them. By keeping them separate we seek to emphasize that, because of the insight obtained from the workshop discussions, our investigation came to include now-only conditions in addition to the three other information types considered from the outset.

Extent of Use

One of the most important findings of the entire study is that climate information is now being used extensively by agribusiness decision makers in the United States, and that this usage has increased substantially in recent years. For example, almost three-quarters of the questionnaire survey respondents were found to use historical temperature and precipitation data (Table 2). A smaller percentage of those respondents, but still a majority, indicated that they/their company use year-to-date accumulations and climate predictions for the same parameters. Furthermore, the workshop findings suggested that the recourse to information on now-only conditions is similar to that for year to-date accumulations. In addition, as indicated in Table 13, both the questionnaire survey and the workshop revealed considerable intrasectoral variation in dependence on all of the climate information types considered.

The heaviest users of historical data were found to be pest management consultants, the chemical, seed, and grain industries, and to a lesser extent farm managers. At the other extreme, producers, agricultural finance companies, and the rural insurance industry make relatively little recourse to this type of climate information. Two especially interesting results were the canning industry's much greater dependence on temperature than precipitation data (presumably because of the more obvious thermal implications for

Table 13. — Summary of Intrasectoral Variation in Present Use of Climate Information on a 5-Category Basis (Very Considerable, Considerable, Moderate, Little, Very Little), and Synopsis of the Types of Uses Involved

	Climate information type				
Component of sector	Historical data	Year-to-date accumulations	Now-only conditions	Climate predictions	Average of extent of use across all information types
Agricultural chemical manufacturers	VERY CONSIDERABLE Varied (esp. understanding product performance)	LITTLE Monitoring (Adjusting) in-season conditions (operations)	LITTLE Monitoring (Adjusting) in-season conditions (operations)	LITTLE Varied planning (production, sales, investment, trials)	MODERATE
Agricultural finance companies	LITTLE Formulation of operating infrastructure	LITTLE Monitoring of in-season conditions for loan volume predictions	LITTLE Monitoring of in-season conditions for loan volume predictions	LITTLE General planning (esp. loan volume predictions)	LITTLE
Food processing/canning industry	CONSIDERABLE Pre-season operations planning	CONSIDERABLE Monitoring (Adjusting) in-season conditions (operations)	CONSIDERABLE Monitoring (Adjusting) in-season conditions (operations)	LITTLE Tentative general operations planning	CONSIDERABLE/ MODERATE
Grain trade	VERY CONSIDERABLE Development of crop yield models and operating strategies	MODERATE Monitoring (Adjusting) in-season conditions (operations)	MODERATE Monitoring (Adjusting) in-season conditions (operations)	VERY CONSIDERABLE Anticipation of growing conditions and operations planning	CONSIDERABLE
Integrated pest management consultants	VERY CONSIDERABLE Pre-season operations planning	VERY CONSIDERABLE Monitoring (Adjusting) in-season conditions (operations)	VERY CONSIDERABLE Monitoring (Adjusting) in-season conditions (operations)	CONSIDERABLE Tentative general operations planning	VERY CONSIDERABLE
Producers	LITTLE Pre-season operations planning	LITTLE Monitoring (Adjusting) in-season conditions (operations)	LITTLE Monitoring (Adjusting) in-season conditions (operations)	MODERATE Tentative general operations planning	LITTLE
Professional farm managers	CONSIDERABLE Pre-season operations planning	CONSIDERABLE Monitoring (Adjusting) in-season conditions (operations)	CONSIDERABLE Monitoring (Adjusting) in-season conditions (operations)	CONSIDERABLE Tentative general operations planning	CONSIDERABLE
Rural insurance industry	MODERATE Insurance history and rate analyses	VERY LITTLE Monitoring of in-season conditions	VERY LITTLE Monitoring of in-season conditions	MODERATE Varied planning (rates, investment) and prediction (insurance experience)	LITTLE
Seed production companies	VERY CONSIDERABLE Pre-season operations planning	VERY CONSIDERABLE Monitoring (Adjusting) in-season conditions (operations)	VERY CONSIDERABLE Monitoring (Adjusting) in-season conditions (operations)	LITTLE Tentative general operations planning	CONSIDERABLE
Average for entire sector	CONSIDERABLE Pre-season operations planning	MODERATE Monitoring (Adjusting) in-season conditions (operations)	MODERATE Monitoring (Adjusting) in-season conditions (operations)	MODERATE Varied (often tentative) planning (esp. operations)	CONSIDERABLE/ MODERATE

planning) and the clear evidence that the use of historical data is more extensive among farm managers than producers (discussed further below).

The extent of use of year-to-date accumulations and now-only information was found to have both similarities to and differences from the use of historical data (Table 13).The seed industry and pest management consultants were again heavy users, while producers, agricultural finance companies, and (especially) the rural insurance industry were once more found to be at the opposite end of the extent-of-use spectrum. Agricultural chemical manufacturers also fall into the latter category, in pronounced contrast to their strong use of historical data. Other interesting differences from the historical data results include the canning industry's more extensive use of precipitation information in year-to-date form, and the grain trade's lesser use of year-to-date temperature accumulations. Finally, as in the case of historical data, farm managers were found to be more dependent on year-to-date accumulations and now-only information than are producers.

The intrasectoral variation in the extent of use of climate predictions showed both interesting similarities to and differences from that for the other climate information categories considered (Table 13). Climate predictions are utilized most extensively by the grain trade, pest management consultants, and farm managers. For the grain trade, the dependence is (surprisingly) much greater than on year-to-date accumulations and now-only information. The moderate users of climate predictions (producers and the insurance industry) also use this information type more than or to the same degree as the other types. Furthermore, it is only for climate predictions that the extent of use by producers approaches that of farm managers. A particularly striking feature of the climate prediction results was the limited use identified for the chemical, seed, and canning industries, groups that were found to be generally heavily dependent on the other types of climate information. The low use of climate predictions by agricultural finance companies, on the other hand, parallels this group's use of historical data, year-to-date accumulations, and now-only conditions.

Characteristics of Use

The questionnaire respondents who indicated that they or their company use climate information were asked several subsequent questions designed to reveal some of the characteristics of that use. The results (Tables 4, 6, 8, 9, 10, and 11) were confirmed by the workshop discussions and are summarized next. First, it is very clear that one motivation for almost all agribusiness users of climate information is the need for guidance of a general background type. The dependence on climate information during the making of specific decisions is, on the other hand, less prevalent. Furthermore, no clear relation was found to exist between the extent of an agribusiness activity's overall recourse to climate information and the degree of use of this material for specific decision making by the actual users. Apparently, too, much of the agribusiness use of climate information in specific decision making does not yet extend to the quantitative extreme of inserting that information into mathematical equations and formulae.

Both the questionnaire survey and the workshop clearly established that historical data are used primarily in pre-season planning of operations (Table 13). This is rather intriguing given the difficulty of justifying the value of planning (well planned decisions can still turn out to be less than optimum!). Despite the latter circumstance, however, many agribusiness decision makers clearly find this mode of utilization of historical data to be particularly helpful. The major alternative uses of this information type (Tables 4 and 13) occur among agricultural chemical manufacturers (in product label design, litigation over alleged product liability, and post-season evaluation of trials) and grain merchandisers (in the important formulation of crop yield estimation procedures).

The questionnaire survey results strongly suggested that year-to-date accumulations are used largely during in-season operational activities that often build on pre-season planning formulated with the aid of historical data. This finding was firmly supported by the workshop discussions, which also established that now-only information is exploited in the same manner (Table 13). This use of year-to-date accumulations and now-only information primarily involves the monitoring of the evolution of in-season conditions. It permits timely and productive adjustments to operating practices that are needed because of prior climatic developments, and it also leads to revised estimations of the procedures that should be used during the rest of the season and their likely outcomes (including yields). Particularly prominent in the latter regard is the use of these two information types in the predictive crop yield modeling efforts that are routinely conducted during the growing season by some grain merchandisers, commodity brokers, and their consultants (Table 6).

The present agribusiness use of climate predictions generally occurs during planning (Table 13), both in and out of the growing season. However, because decision makers frequently have strong reservations about the current reliability (but not potential value) of such predictions, this use is often somewhat tentative. One of the most important — and probably least obvious — specific applications of this type of climate information to emerge from our study is in the predictive crop yield modeling efforts undertaken by/for the grain trade (Chapter 4). This modeling requires assumptions about the climatic character of the growing season beyond the time of a given model run. Such assumptions are climate predictions. Their use in this context also can influence the nation's financial markets.

Our inquiry into the characteristics of the agribusiness use of climate information also yielded considerable insight into the focus, resolution, and source of the material being used. For example, it is very clear that climate information (all types) pertaining to the spring and summer seasons is currently being used much more than that for the other half-year, particularly winter. Furthermore, the spring and summer use in particular involves a wide range of meteorological parameters: temperature and precipitation information from each of the four categories expressed in a broad variety of forms, as well as information on wind, soil moisture, soil temperature, and (where available) cloud amount/sunshine/solar irradiance.

Monthly historical data are used more by the sector as a whole than historical data with longer or shorter time scales. However, some agribusiness activities (grain trade, seed and canning industries) depend heavily on daily and weekly historical data. Calendar months and 30- to 31-day intervals running from the middle of one month to the middle of the next are the periods for which climate predictions are now most frequently used.

Concerning the spatial resolution of the information presently being exploited, the county is the preferred United States areal unit. The grain trade makes by far the greatest use of climate information for countries outside of the United States, a use apparently approaching its use of domestic climate information. Finally, it is clear that a majority of the climate information currently used by agribusiness is obtained directly from the National Weather Service or other agencies of the National Oceanic and Atmospheric Administration.

The extensive current use of climate information by the United States private agricultural sector that has been summarized above has diverse and important implications, which are discussed in the following sections.

Implications for Climate Programs

The results of this study offer considerable support for the basis and goals of the United States National Climate Program (USNCP). The relatively high use of climate information suggests that agricultural decision makers believe that the adverse socioeconomic consequences of climatic variability can indeed be reduced (and the beneficial consequences increased) by the incorporation of climate information into management strategies. This circumstance, in turn, provides encouragement for the long-run success of the USNCP. Furthermore, as noted previously, it appears that there has been a rapid growth in this use in recent years. This entire situation is probably little recognized by the atmospheric science community. Greater appreciation of it would surely improve the quality of the (proportionately large) atmospheric sciences' input into the refinement and continued development of the USNCP as it enters the crucial second five years of its existence. Furthermore, the results suggest that counterpart investigations for other climate-affected sectors of the United States economy (e.g., transportation, energy, water resources, government) would be helpful.

The very positive nature of the present-use results obtained here also suggests that this research effort could be profitably "duplicated" for several foreign countries. The motivation for and objectives of this study would seem to be quite transferable. An obvious starting point would be to consider the use of climate information by some of the more developed private agricultural sectors, such as those of Western Europe, Canada, Argentina, Australia, New Zealand, and South Africa. However, the most productive state-controlled agricultural systems also invite investigation in this context. Such systems would ideally be drawn not only from the Eastern European and Soviet republics, but also from the People's Republic of China. Perhaps this potential research thrust could be developed under the auspices of the World Climate Programme (WCP). Certainly, it is the WCP that must take the lead in the much more difficult task of determining how to pursue this line of inquiry in the developing nations.

Implications for Agribusiness

The present-use results also have ramifications for the people whose decisions affect agricultural production in both the United States and a number of foreign countries. For the United States, individuals/companies whose current use of climate information is noticeably below the level identified here for their agribusiness activities may have much to gain by increasing their recourse to such material. This comment particularly applies to pest management consultants, seed companies, farm managers, and those in the grain trade who make little use of climate information.The study results showed a surprisingly limited level of use of year-to-date accumulations and now-only information by some grain traders, especially when making specific in-season decisions.

The results should also provide considerable guidance to decision makers in the foreign private agricultural sectors listed above.

Implications for Climate Services

The considerable intrasectoral variation in the extent and type of use of climate information that has been identified for the United States private agricultural sector confirmed our initial hypothesis that the climate information needs of this complex sector were likely to be quite diverse. This was particularly exemplified by the far greater use of climate information by remotely located professional farm managers than by on-site producers. Apparently farm managers have both a greater need for such material (because of the difficulty of assimilating the climate history of several disparate and possibly contrasting units into their own experience) and stronger present acquisition capabilities (being larger concerns they can better justify the costs involved). The case of the private agricultural system has thus yielded the desired demonstration of the scope and difficulty of providing appropriate climate information products to the United States private sector in general. Recognition of this circumstance should assist state and federal governments in the formulation and implementation of the needed national system of climate services.

Initiatives Needed to Maximize Use of Climate Information

The questionnaire survey included a preliminary investigation of reasons for non-use of climate information, the results of which were reported in Chapter 3. That inquiry was intended to furnish the background knowledge needed to focus the in-depth discussions of this topic at the subsequent workshop. Table 14 summarizes the present reasons for the non-use of climate information. It is readily seen that this non-use stems from reservations about the availability, utility, cost, value, and (in the case of climate predictions only) accuracy of the information.

Table 14. — Summary of Present Reasons for the Non-Use of Climate Information and the Initiatives Needed to Remove Those Impediments

Type of information	Reasons for non-use	Research/technological initiatives needed
Historical data	Perceived to be unavailable	Improve awareness, accessibility, and delivery of existing data. Improve present data collection networks (especially density). Develop new networks to measure additional parameters.
	Perceived to have little value	Develop methods (especially economic models) to define value. Demonstrate potential to provide background guidance for the design and use of other climate information types. Communicate above utility and proof of value to users. Improve capabilities to exploit data (models, hardware, personnel).
	Considered to be too costly to convert to usable form	Establish (e.g., through modeling) most cost efficient modes of utilization. Identify cost/benefit ratios. Develop relatively cheap methods of furnishing useful information (e.g., by private consultants).
Year-to-date accumulations	Perceived to be unavailable (especially in the required near real-time)	Improve present data collection networks (especially density). Develop new networks to measure additional parameters. Establish procedures to rapidly assemble the raw observational data, process them into the most desirable forms of information, and deliver that information to users in near real-time.
	Perceived to be unnecessary	Perform research (climatological, agrometeorological) on historical data to establish the most appropriate formats for this information. Develop methods (especially economic models) to define value. Communicate most appropriate formats and proof of value to users. Improve capabilities to utilize this information (models, hardware, personnel). Make cost of information supply as low as possible (through private consultants).

Table 14 also points out the types of data acquisition, scientific research, data assembly/processing, information delivery, and related initiatives that are needed before the agribusiness use of climate information can be maximized. We conclude this report by offering an in-depth consideration of those needs.

Data Acquisition

Clearly, the provision of the best possible climate information to the private agricultural sector has, as its first prerequisite, the acquisition of high quality meteorological data. We have several specific recommendations regarding that important requirement.

The first recommendation concerns the "cooperative substation" network of the National Weather Service (NWS) that was discussed in the "Crop Yield Modeling" and "Lack of Delivery System" sections of Chapter 4. This network, which is manned by volunteer observers, records the daily precipitation totals and (to a lesser extent) daily maximum and minimum temperatures for a large number of locations (for example, approximately 200 in Illinois for rainfall). As such, it makes the primary contribution to the nation's ever-expanding bank of historical climate data. In addition, this network has the potential to provide the accurate and timely year-to-date and now-only information desired for the monitoring of in-season conditions. It also seems possible for this potential to be realized (see below).

Since this network is clearly the basis for much of the climate information currently being supplied to agribusiness, and since it is likely to remain so, the preservation and (preferably) enhancement of its integrity deserve to be high priorities. For example,

Table 14. — Concluded

Type of information	Reasons for non-use	Research/technological initiatives needed
Now-only information	Perceived to be unavailable (especially in the required near real-time)	Improve present data collection networks (especially density).
		Develop new networks to measure additional parameters.
		Establish procedures to rapidly assemble the raw observational data, process them into the most desirable forms of information, and deliver that information to users in near real-time.
	Perceived to be unnecessary	Perform research (climatological, agrometeorological) on historical data to establish the most appropriate formats for this information.
		Develop methods (especially economic models) to define value.
		Communicate most appropriate formats and proof of value to users.
		Improve capabilities to utilize this information (models, hardware, personnel).
		Make cost of information supply as low as possible (through private consultants).
Climate predictions	Perceived to be insufficiently accurate	Establish (e.g., through modeling) how accurate predictions need to be to have economic value.
		Improve accuracy of predictions.
	Considered to have inappropriate designs	Perform research to ascertain the optimum prediction designs (prediction period, lead time, weather parameters treated, resolution, etc.) for key agricultural areas.
		Improve capability to predict (1) late spring-summer conditions prior to mid-April and (2) autumn conditions by August 15.
	Perceived to be of restricted value	Develop procedures (e.g., economic models) to establish economic value.
		Educate users about all aspects of predictions.

there should be no further reduction in the station density that has occurred in recent years (see National Research Council 1982). Strenuous efforts should be made to identify and retain the oldest stations with the most reliable records, a research task now being initiated by Griffiths (1983). In addition, attempts should be made to (a) standardize the observation time (see Schaal and Dale [1977] and Nelson et al. [1979] concerning the problems caused by varying observation times); (b) increase the number of parameters monitored; and (c) improve the accuracy of the measurements. While NWS has obvious responsibilities in this regard, the issues concerned are also of great relevance to the United States National Climate Program (USNCP). The latter could become a leading advocate for the maintenance and improvement of this important network.

NWS has reduced the number of its "first-order" stations in recent years. Although this trend may be arrested, it is unlikely to be reversed. This development is unfortunate because, from the agricultural standpoint, the observations made at these scattered stations (there are presently five in Illinois) usefully complement those acquired by the cooperative substation network. Not only do first-order stations monitor a much wider range of agriculturally relevant parameters than cooperative substations (including cloud cover, weather, humidity, and wind speed and direction, in addition to temperature and precipitation), but the measurements are made on an hourly or continuous basis. Furthermore, the latter circumstance facilitates interpretation of and extrapolation from the cooperative substation daily temperature and precipitation observations.

We therefore recommend that there be as much compensation as possible for the decline in the NWS first-order station network. It appears that the states will have to take the initiative in this regard. If they accept this challenge, they will have the opportunity to construct networks that not only complement the aforementioned NWS one, but also have agricultural considerations firmly embedded in their design. Such considerations would include the location and spacing of the stations, and the parameters to be monitored. A relatively even spatial distribution of stations, with at least one sited in each agriculturally important area, such as a crop reporting district, would seem appropriate. Chapter 4 showed that solar radiation, soil temperature and moisture, screen height temperature and humidity, and wind speed and direction should be measured on a continuous or (in the case of soil moisture) frequent basis in order to serve agribusiness needs. Figure 1 provides information on one state (Illinois) climate network that is being established in accordance with the above suggestions, and whose development is now receiving guidance from the results of this investigation. Further details on this network appear in Hendrie (1983). Nebraska (Hubbard et al. 1983) and Ohio are other agriculturally important states that have established state weather networks to monitor such parameters.

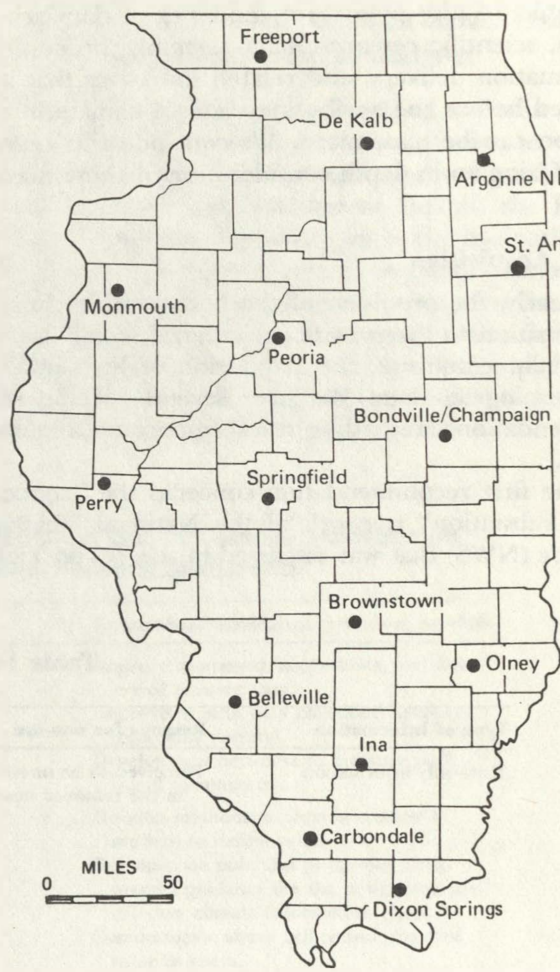

Figure 1. — Location of Illinois Climate Network stations. The stations continuously monitor the total flux of solar radiation (direct plus diffuse) on a horizontal surface; wind speed and direction at 10 m; and screen height air temperature and relative humidity, precipitation, and soil temperature at 10, 20, and 40 cm. In addition, neutron-probe estimates of the soil moisture content of 20-cm layers between 0 - 2 m are obtained on a weekly, bimonthly, or monthly basis depending on the time of year.

Two notes of caution should be issued at this point. First, the installation and operation of such a network are very resource demanding. For example, the "set-up" costs of the Illinois network will total close to $500,000, while the annual operating expenses will be in the vicinity of $80,000. In addition, it is imperative that the staffing of such networks include one or two individuals with electronics expertise. Clearly, such a network cannot be established without a substantial and ongoing commitment from state government, through either a state agency or a university.

Our second caution relates to the need for coordination among the state networks that might evolve in a given agricultural region. In order for their data to become the basis for climate information that is of the greatest possible utility to agribusiness, such networks will have to be reasonably consistent with respect to the sensors used, parameters monitored, and time periods over which integrations are made. Consistency is needed because the private agricultural sector's climate information needs tend to occur on a regional rather than state basis. It seems that network coordination would be an ideal function for USNCP's developing Regional Climate Centers (National Oceanic and Atmospheric Administration 1983; Hill 1983), the first two of which have already been established (north-central and north-east regions). In fact, the North Central Regional Climate Center has already initiated a project to assemble and manage the state network data from that 12-state region.

Conspicuously absent from the above discussion is the suggestion that any part of the acquisition of meteorological data be performed by private (non-government) agencies. A principal conclusion of our second workshop plenary session, which dealt with the question of the relative roles of the public and private sectors in providing climate information for agribusiness (Appendix C), was that data collection should remain the responsibility of federal and state government organizations. The participants felt strongly that this was the best way to ensure that the observation procedures continue to be consistent, that the resulting data are accurate and credible, and that permanent archiving is performed by a "neutral" body. The need for meteorological data to have widespread credibility is a particular concern of agricultural chemical manufacturers, who must use that material in litigation over alleged product liability.

Research Needs

The second step towards providing agribusiness with the best possible supply of climate information involves ascertaining what might be very simply and generally termed the "most appropriate formats" for that information. This will require considerable research. It is a potentially complex and open-ended task that has many dimensions. We attempt here to indicate some of the ways progress might be achieved in this regard.

• *First, it seems that the quality of this information supply would benefit from a concerted basic research effort in climatology that seeks to better understand the patterns and relationships in the historical data for important agricultural regions.*

A concerted research effort would greatly improve our knowledge of the climate of the areas concerned (including its spatial and temporal variability), and accordingly would constitute valuable background for decisions concerning the provision of climate information to agribusiness. The atmospheric science community has been slow to exploit the by now large bank of historical data to this end. In particular, most of the work that has been undertaken has used these data in the time-averaged forms (e.g., monthly and seasonal means, both for individual years and longer periods) that are relatively easy to access and compact to process and analyze. Furthermore, the fine spatial resolution inherent in the cooperative substation data has seldom been fully realized; too many studies have used only the much sparser network of first-order stations. Because (a) growing season rainfall over much of the United States is convective and therefore highly variable in space and time, and (b) crop development is particularly affected by runs of days of extreme temperatures, it is imperative that this research be performed on data that have rather fine temporal and spatial resolutions.

Figure 2 provides an example of the type of product that can emerge from the above line of inquiry. This display divides the important agricultural region between the Rocky and Appalachian mountains into subareas within which weekly rainfall during the growing season tends to be spatially coherent. Separate patterns are given for the entire season and its constituent months. They result from an advanced statistical treatment (VARIMAX-rotated Principal Component Analysis) of 32 years of rainfall data for 402 cooperative substations that form an approximately rectangular grid. Full details on the computational procedures employed, along with a complete discussion of the results, appear in Lamb and Richman (1983a,b) and Richman and Lamb (1985). Here, however, we can only point out the potential of products such as Figure 2 to improve the use of climate information by agribusiness.

The section on crop yield modeling in Chapter 4 stressed that the grain trade's operational crop yield prediction modelers are uncertain about the number and morphology of the regions for which individual models should be used, and also about the spatial representativeness of the observations currently input into the models. Because these observations have to be very recent, they are presently restricted to ob-

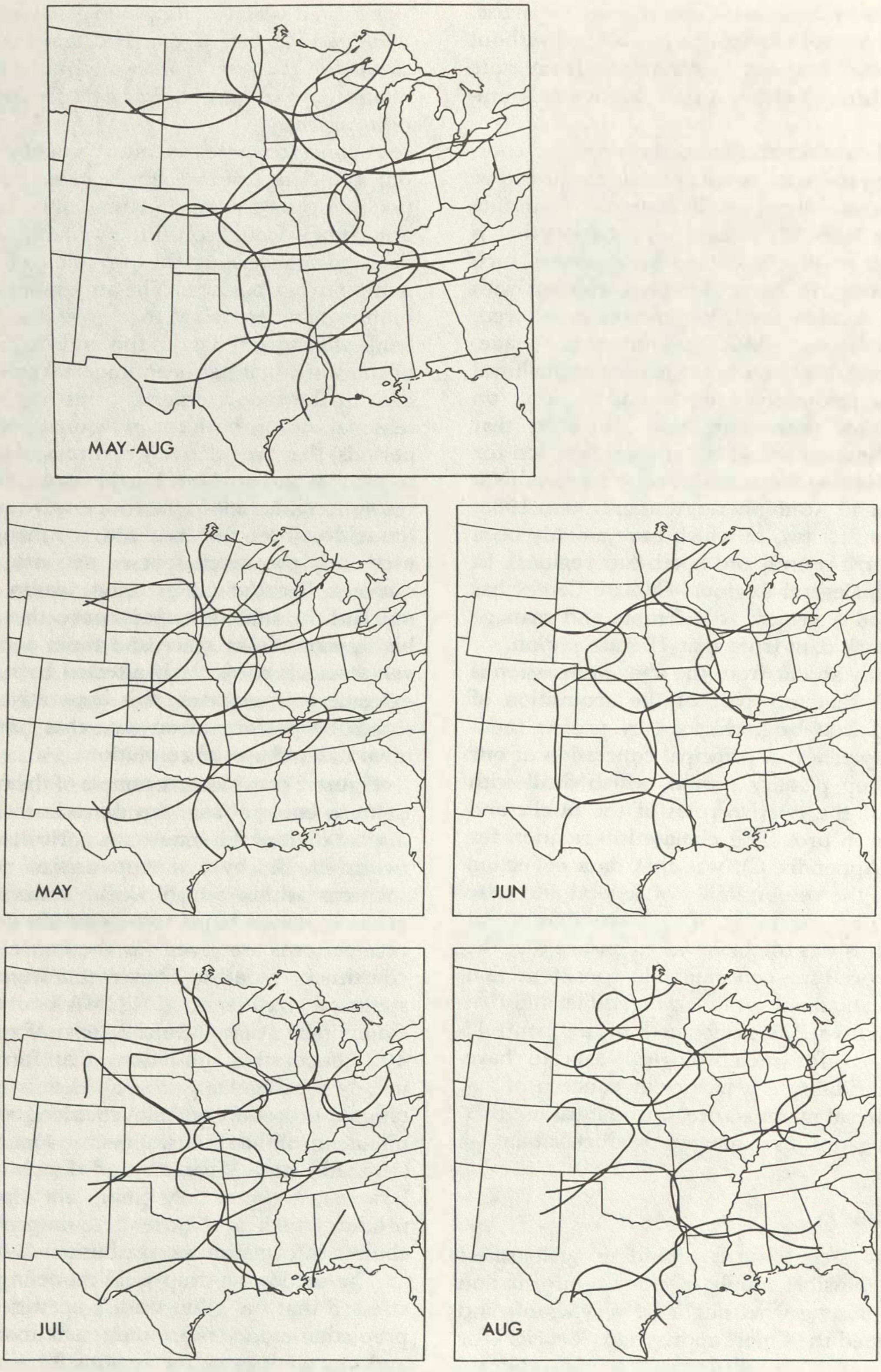

Figure 2. — Regionalization of the central United States for weekly summer rainfall on the basis of the patterns for the first 10 VARIMAX orthogonally rotated Principal Components (PCs). The regional boundaries are the +0.4 loading isopleths for each PC; they enclose areas for which at least 16% of the station variance is accounted for by that PC.

servations from the sparse network of first-order stations, which is the only network for which daily updating is routinely possible. We believe that the patterns contained in Figure 2 can substantially reduce the two above sources of uncertainty, since their weekly time scale coincides with the interval between many of the model runs. These patterns also suggest that intraseasonal variations should not be ignored. Counterpart analyses for temperature would be of further assistance in this crop modeling context.

To summarize, we have seen here an illustration of the potential for basic research using historical data to improve the agribusiness use of year-to-date and now-only information, as well as climate predictions. Furthermore, similar research using data for longer time periods, examples of which appear in Lamb and Richman (1983b, 1985), could assist the location and planning of field trials and contract production by the chemical, seed, and canning companies.

Other analyses of the historical data base would benefit agribusiness. For instance, a comprehensive investigation of the variability of climate using daily observations would provide useful background for many activities, not the least of which is the ongoing development of plant growth regulators (PGRs) by chemical companies. This development process will in time require the assessment of the likely response of these products to a wide range of possible environmental (largely climatic) conditions and extremes. This situation will in turn demand a more detailed documentation of past climatic variation than is presently available.

It would also be useful to establish the extent to which entire medium-to-large states (e.g., Montana, Illinois, Texas) experience the same climate anomalies (e.g., "above normal" temperature, etc.) for individual months and seasons. Since NWS's present monthly and seasonal climate predictions frequently place entire states or even regions in the same prediction category (e.g., "above normal" temperature, etc.) — the coarse spatial resolution that was disliked by the workshop participants — such research could improve the utility of those predictions.

Many other challenging basic research opportunities that could ultimately assist agribusiness exist for climatologists within the historical data base. A final example, taken from Changnon (1984), appears in Figure 3. It provides an informative historical perspective on recent Illinois growing season rainfall fluctuations, and in particular shows that 1954-73 was highly favorable for agriculture.

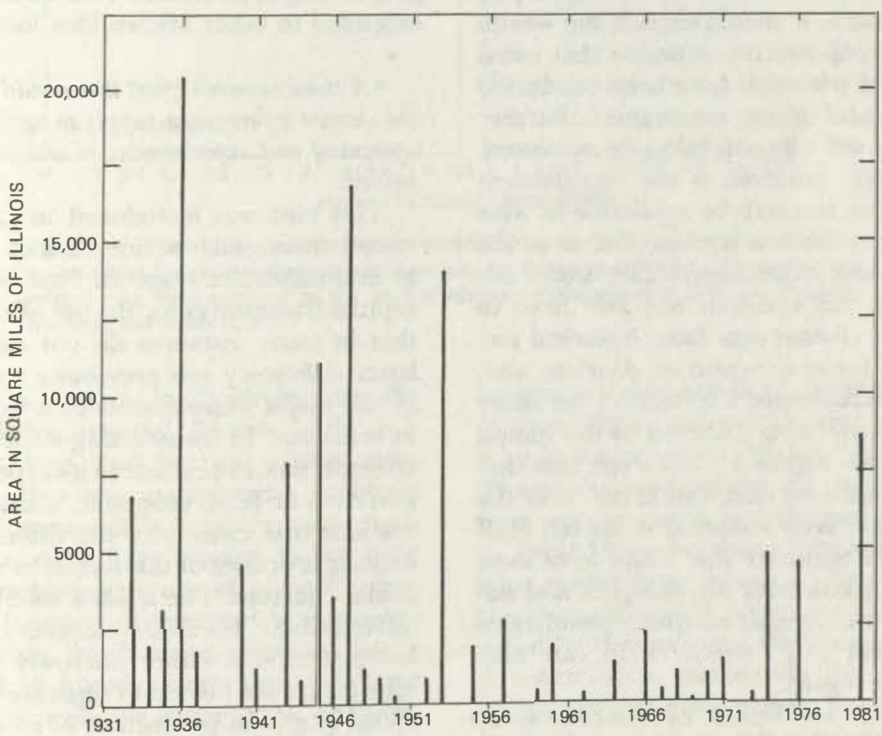

Figure 3. — Interannual variation of area within Illinois (total area = 55,748 square miles) that received less than 50% of normal July - August rainfall during 1931-81. The computations used data from a dense network of cooperative substations.

• *A second way the climate information supply to agribusiness can be made more appropriate is through agrometeorological research designed to improve our understanding of the response of crops to climatic fluctuations.*

We need to clearly identify — as functions of region, time of year, and crop type and variety — the weather conditions that most influence crop development and yield. Since it is highly probable that such conditions will involve the coincidence of particular values of more than one meteorological element (e.g., cool temperatures and excess precipitation, hot temperatures and low relative humidity), this research will have to provide for a wide range of possible outcomes. For example, it was previously suggested that the incorporation of solar radiation information into the purely temperature-based growing degree day accumulation statistic would enhance the latter's correlation with crop development. In short, there is an urgent need for the continued improvement of crop models and agroclimatic indices. This must occur before the agribusiness monitoring of in-season conditions, which is both important and increasing, can be performed using the most appropriate year-to-date accumulations and now-only information.

The accomplishment of the above research task will not be easy. It will require a wide range of inputs. First, since the research will need the strongest possible physiological basis, it should exploit the wealth of information on crop-weather relations that exists within the records of trials that have been conducted previously at the land grant universities. Further experimental work will also doubtless be necessary. Of equal importance, however, is the requirement that the results of this research be applicable to wide areas. They must not be too site specific, as is the case with at least some experimental plot work. Because of this need, the research will also have to utilize the historical climate data base, historical records of crop yields for crop reporting districts, and, where available, microclimate information for many locations such as is now being gathered by the Illinois Climate Network (see Figure 1). However, this necessary recourse to historical data should not force the research into an excessively statistical mode (cf. Huff and Neill 1982). The approach that seems to be most appropriate would utilize both physiological and statistical methods. It is likely that computer simulations of crop development (e.g., Reetz 1976) can help substantially in that regard.

Figure 4 gives the key results of a recent study (Hollinger and Hoeft 1985) that had the above objectives. It utilized six years of land grant university crop trial records and historical climate data to investigate the well known large year-to-year variation in the yield response of corn to anhydrous ammonia fertilization for the case of east-central Illinois. The goals were to determine which normally measured and predicted weather parameters have the greatest impact on this year-to-year variability, and to suggest a growing season climate prediction design that would permit the most efficient use of anhydrous ammonia.

A regression analysis indicated that the corn yield response to this fertilizer is most strongly related to the precipitation/evaporation (P/E) ratio for the June 11-July 15 period, which corresponds to the stage of rapid vegetative development (Figure 4). When P/E is less than optimum (<0.6), water is limiting and the plant is unable to use the applied nitrogen efficiently. When P/E is greater than optimum, nitrogen is lost through denitrification and/or leaching and is unavailable to the plant. This relationship was much weaker for July 16-31 and nonexistent for May 16-June 10 and August 1-September 30 (Figure 4). Before climate predictions can be used to guide fertilizer application in east-central Illinois, they will therefore need to deal with the likely evaporation as well as precipitation for June 10 through July 15 or 31. A lead time of two to four weeks would make such predictions useful for side-dressing, while one of six to eight weeks would permit them to influence preplanting applications. This work is currently being extended to other Midwestern locations.

• *A third research effort that would substantially benefit the climate information supply to agribusiness is the development of and experimentation with appropriate economic models.*

This idea was introduced in Chapter 4. As intimated there, such a line of inquiry would help in several important respects. First, it can provide conceptual frameworks for the use of climate information that in many instances do not currently exist. The latter deficiency was previously suggested to be one of the major impediments to a fuller use of climate information. In constructing such models, strenuous attempts should be made to incorporate the important non-climatic (e.g., economic, social, political) considerations that enter into the often complex decision making processes of this sector, as well as the relevant climatic factors. The models should be rigorous and quantitative. Their development probably should commence with rather narrowly focused individual efforts that are limited to separate components of the sector (e.g., the production of row crops).

If the above structure can be achieved, the models will have the capability to quantitatively demonstrate the economic value of climate information for the

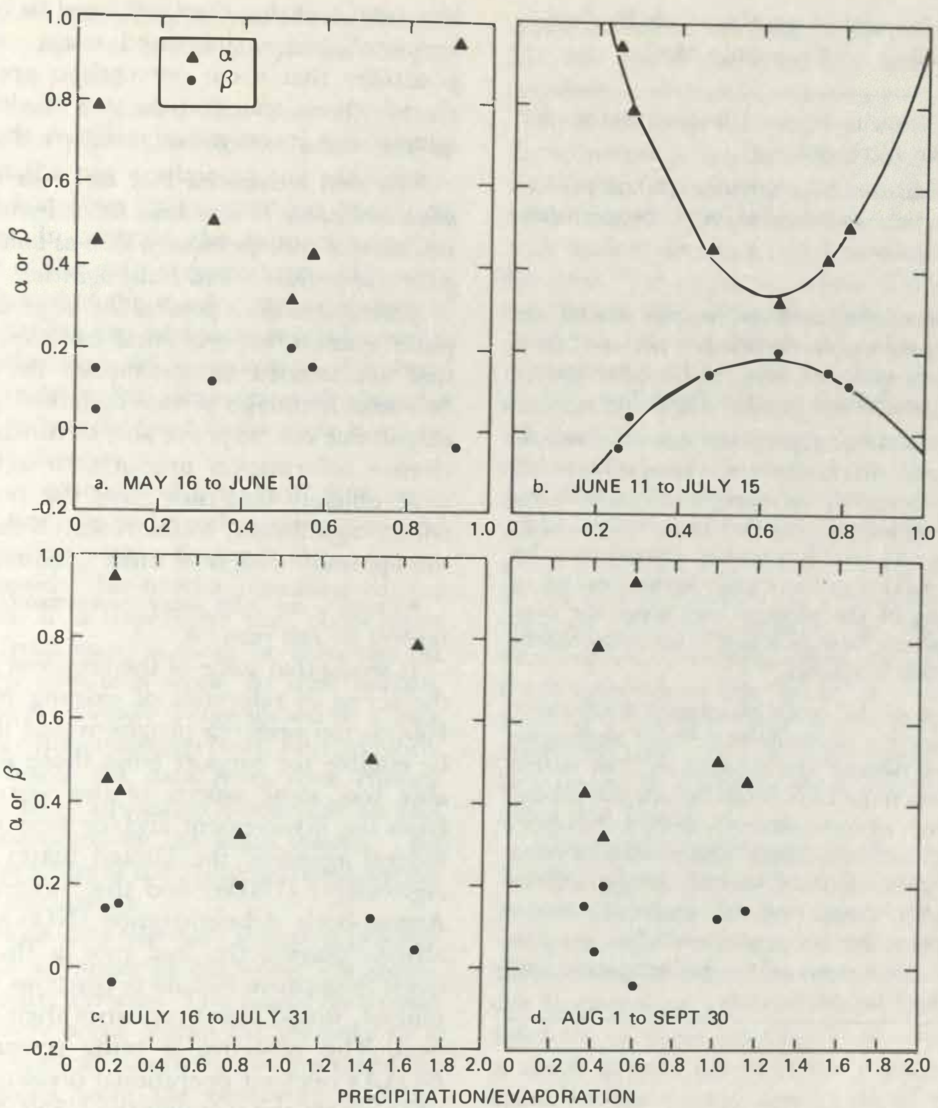

Figure 4. – Plots of quadratic regression coefficients α and β versus precipitation/evaporation ratios for various growing season periods for east-central Illinois. The coefficients related corn yield response to the level of nitrogen fertilization. Full details appear in Hollinger and Hoeft (1985).

activity concerned. This, in turn, should increase the agribusiness use of that material. Because of the lack of such demonstrations, and because of the widespread perception that the management problems involving climate are especially complex, some agribusiness decision makers have tended to see little dividend in the sophisticated use of climate information. The development of appropriate economic models would permit much more rigorous future assessments of such dividends, which may well prove to be larger than is presently thought. In addition, experimentation with operational models would likely identify the most desirable formats for the needed climate information. The flexibility of the modeling approach would permit the estimation and intercomparison of the economic benefits to be obtained from a wide range of alternative "information designs." The products ultimately delivered to agribusiness (see next section) could be fashioned accordingly.

Table 15 summarizes a developing economic modeling research project that is being patterned along the lines advocated above, and that was partly motivated by the results of the present study. The effort is restricted to considering the use of one type of climate information (climate predictions) by a single agribusiness activity (Midwestern row crop production), a focus that was encouraged by the pilot study of Sonka et al. (1982). Central to this endeavor is the

Table 15. — Information on Research Project That Is Using an Economic Model

TITLE:	Design of Growing Season Climate Forecasts for Midwestern Agriculture
GOAL:	To establish the characteristics climate predictions must have to be useful for Midwestern row crop production
COMPONENTS:	
(1)	Estimation of the interrelationships among climatic fluctuations, production practices, and crop yields. This seeks to isolate a farm operator's potential production practice flexibility.
(2)	Development of an appropriate quantitative economic model that can be used to assess the value of alternative prediction designs and capabilities. This will include the relationships established in (1) above, and must be capable of simulating the decision making processes of a farm operator in the setting of the physical and economic constraints on the farm firm and in an environment of uncertain outcomes.
(3)	Utilization of the model developed in (2) above to estimate the probable benefits of alternative prediction designs and capabilities. The design parameters to be considered include the prediction period, weather elements treated, lead time, and prediction resolution. The benefits of using climate predictions of various design will be estimated by comparing the results of running the model with "no prediction," "perfect prediction," and a range of "imperfect prediction" assumptions for prior years.

construction of an economic model that can simulate the decision making processes of a farm operator in the setting of the physical and economic constraints on the "farm firm" and in an environment of uncertain outcomes. The economic benefits of using climate predictions will then be quantitatively estimated by comparing the results of running the model with "no prediction," "perfect prediction," and a range of "imperfect prediction" assumptions. The experimentation will also include variations in prediction period, lead time, meteorological parameters treated, and resolution.

We expect that this research will begin to provide concrete information on such important issues as the optimum prediction design and accuracy that must be attained before economic benefits accrue. The results of the present study indicated that many agribusiness decision makers believe that the climate predictions currently available are too unreliable to be useful and that they will need to become "highly accurate" before increased usage can occur. The possibility that these perceptions are incorrect has already been mentioned; they invite the type of quantitative investigation outlined above.

• *We next recommend that the three types of research advocated above be conducted in environments with strong traditions of scientific inquiry, such as universities and some government (federal and state) agencies.*

Such institutions possess the large data bases, computer systems, experimental facilities, and personnel that are needed to accomplish the complex tasks involved. Although private meteorological companies may in due course prove able to furnish some routine climate information products to agribusiness, it is most unlikely that they have the resources to contribute significantly to the research that will ascertain the optimum design of those products.

• *Finally, we also have recommendations concerning support for this research.*

It seems that some of the required work lies within the terms of reference of existing National Science Foundation research programs and therefore should be eligible for support from those sources. Presumably, too, some aspects of this work would benefit from the involvement and/or support of two other federal agencies: the United States Department of Agriculture (USDA) and the National Oceanic and Atmospheric Administration (NOAA). The latter is already playing the lead role in the research-based quest to improve climate predictions which, if accomplished, would clearly enhance their use by agribusiness. This objective is being pursued both within NOAA's relevant operational division (Climate Analysis Center) and through the USNCP's Experimental Climate Forecast Center program (National Oceanic and Atmospheric Administration 1980, 1983) that NOAA sponsors. Some extension of this type of effort into the areas outlined above, by both NOAA and the USDA, would be helpful. Furthermore, given the obvious potential utility of this research to agribusiness, it seems appropriate that some of the work be supported from private sources.

Data Assembly/Processing and Information Delivery

The next stage in improving the supply of climate information to agribusiness has three separate steps: assembly of the raw observational data, processing of those data into the most desirable forms of information, and delivery of that information to agribusiness users. We have specific recommendations concerning each of these activities.

• *In the case of the assembly of the raw observations, the most important requirement is that this function be performed as quickly as possible.*

It was previously reported that the only NWS surface network for which the data are assembled in near real-time is the one containing the widely separated first-order stations that record on hourly or continuous bases. In contrast, the national assembly and distribution of the daily temperature and precipitation data gathered at the much denser network of cooperative substations can take up to several months. Furthermore, although weekly summaries of substation data are available for some states during the growing season, relatively few locations are involved (e.g., about 20 in Illinois).

Given the great potential of this network to serve as the basis for accurate and timely year-to-date and now-only information with a fine spatial resolution, and given the considerable need agribusiness has for such information, it is imperative that cooperative substation data from many stations be assembled at intervals of a few days to a week. At least initially, this task would be most easily accomplished on a state or regional (rather than national) basis. Furthermore, it would be desirable for data from state climate networks of the type advocated previously in this chapter to be assembled by the same system. This would increase the utility of the cooperative substation data (see earlier discussion).

Such an ambitious data assembly system is possible because of recent advances in electronic communications and computer systems. The actual data compilation would likely occur within the memory of a reasonably large central computer programmed to receive transmissions from the observing stations. Such transmissions could emanate either directly from the more sophisticated of the recording instruments or, in the case of the traditional cooperative substation measurements, from the volunteer observers themselves via touchtone telephone linkages. The availability of touchtone telephones substantially eases the digitization process and also facilitates quality control. The latter should be an integral feature of any future climate data assembly system.

The feasibility of establishing a data assembly system of the foregoing type is illustrated by recent developments in Illinois. Daily observations of maximum and minimum temperature and total precipitation from 35 cooperative substations in that state are now transmitted each morning to an Illinois State Water Survey computer via touchtone telephone. This initiative, which has been partly shaped by the results of the present project, cost $100,000 to implement (further details appear in Changnon et al. 1984). The system's annual operating costs are expected to total $30,000. Data assembly, like data acquisition, thus requires a substantial investment.

It is unlikely that either NWS or the National Environmental Satellite, Data, and Information Service (NESDIS) will organize and fund the nationwide establishment of near real-time data assembly systems with station densities equal to those desired by agribusiness. For example, while NWS has begun the installation (in the Central Region, CR) of a computerized system for the real time acquisition of cooperative substation data that may eventually become nationwide, it is including only 15 to 20 stations per CR state (Friday 1983; Vogel et al. 1984). This means that the bulk of the support for the "setting up" of more dense such systems will have to come from the states. The USNCP's Regional Climate Center program should be encouraged to fund these initiatives to the extent possible. At a minimum, however, that regional program ought to be responsible for the vital regional coordination of such efforts. Farm and trade associations may be other potential sources of funding for the establishment of these systems. Their operating costs, on the other hand, could probably be covered by charging users who acquire data from them (see below).

The routine operation of the systems would be most consistent and reliable if placed in the hands of government agencies or regional organizations with whom the former are affiliated, rather than private meteorological (or other) companies. Such companies are furthermore unlikely to contribute to the establishment of these systems. There would seem to be a much greater potential for private sector involvement in the second and third of the steps being considered in this section.

• *The second step involves transforming the assembled raw data into the information forms most desired by agribusiness.*

Where year-to-date and now-only information are required, this process would occur routinely. In the case of information to be extracted from historical data, on the other hand, it would likely take place on a more individual basis. The determination of the nature of such information products should draw heavily on research of the type advocated in the previous section. It will also need to be guided by an intimate appreciation of each user's needs, which will vary substantially as a function of agribusiness activity. For example, while very small agribusiness concerns such as pest management consultants will likely require sophisticated information, larger organizations such as grain traders may have the capability and desire to do much of the analysis themselves using raw data.

Such a role is made possible by recent developments in the computer and communications fields. The organizations involved in this work will need to possess computer systems that are capable of quickly performing the required calculations, contain all relevant historical data, and are linked with both the source(s) of the raw observational data and the users of the generated information. Relevant data sources would include the state/regional assembly systems of the type advocated above, and probably also the National Climatic Data Center (NCDC) in Asheville, North Carolina.

It is likely that this climate information generation could be satisfactorily performed by private meteorological companies; they would purchase the raw data and sell the information products. There is already some limited but competent activity along these lines. The expansion of such efforts could produce, through the resulting economies of scale, the needed relatively cheap method of providing agribusiness with useful climate information. One of the findings of this study was that the sector is sensitive to the cost of this material. This information generation role could also be assumed by state agencies with the requisite expertise and by the USNCP's developing regional climate centers. However, both types of institution would have to be permitted to charge for such services. Given agribusiness' need for regional scale information, the development of regional climate information centers would seem especially appropriate.

• *The final step to be considered is the actual delivery to agribusiness users of climate information products that have the foregoing genesis.*

As already intimated, this would ideally occur via computer linkages and would be performed best by the organizations who generate those products. It may prove possible for trade and farm associations to partially support the establishment of the needed information dissemination networks. While the USNCP's Regional Climate Center Program should assume a coordinating role in this context, as well as in the others considered above, any further involvement by that program would probably be outside its area of responsibility.

The above type of distribution system would obviously require the user to maintain some kind of computer facility, one that is not necessarily limited to a terminal for the receipt of the climate information. This is unlikely to be a problem for larger agribusiness organizations. It should also be within the reach of the smaller concerns, given the increasing availability and decreasing cost of computer hardware, and the accessibility of guidance on the use of that equipment (e.g., Sonka 1983). By receiving climate information in this way, users would have the flexibility of subjecting it to any further processing their experience might recommend.

User Education

The final prerequisite for maximizing the use of climate information by the private agricultural sector is user education. This should seek to give potential users the best possible appreciation of the availability, utility, cost, and value of such information, and thus render them able to make informed decisions about the extent of their utilization. Decisions of that type are not always possible at present. We have several specific recommendations on this subject.

First, there is a clear need for many agribusiness decision makers to become better acquainted with the range of climate information that is presently available. This is evidenced by the fact that approximately 20% of the questionnaire respondents perceived historical climate data to be unavailable (Tables 2 and 12). Such an education effort should be sufficiently broad-based to encompass the sources and alternative formats (pamphlets, magnetic tape, etc.) of the information, the typical costs and time delays involved in its acquisition, and the explanatory material that would facilitate its use. The latter would likely be especially valuable for climate predictions. An initiative of this type should remove at least some of the impediments listed previously. It could logically emanate from state or regional climate centers, and could include instructional publications in trade journals and the conducting of workshops for potential users. The USNCP's Regional Climate Center Program should, at a minimum, encourage and coordinate such efforts. In addition, there would seem to be a clear role for trade and farm organizations to play in facilitating and funding this educational initiative, given that it will be to the benefit of their members. When the initiative is directed at producers, the Cooperative Extension Service should be involved.

There is also a need for agribusiness decision makers to be routinely updated on new climate information products that become available. This applies particularly to information shaped by or emanating from relevant research, such as that advocated earlier in this chapter. It is imperative that this educational effort include demonstrations of the utility and value of new information, especially the most innovative and novel. One way to accomplish this would be through "closed demonstration projects," in which the use by a limited number of selected participants (for little or no cost) is very closely guided and monitored for an appropriate period of time. This could provide the basis for the final design of an information product, documentation of its likely utility and value, and instructions for its use. The latter material could be communicated to potential users via the trade journal articles and workshops mentioned above. We believe that this procedure would hasten the profitable use of new climate information products by agribusiness. To be of the utmost success, it would require the professional expertise of state and regional climate centers, coordination by the USNCP's Regional Climate Center Program, the involvement of the Cooperative Extension Service, and financial and logistical support from agribusiness itself.

Ultimately, it will not be possible to provide agribusiness with the best possible climate information without the appreciable involvement and assistance of that sector.

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APPENDIX A

Questionnaire Survey Administered by Mail to Agribusiness Decision Makers during the Spring of 1982

Section I

1. Does your firm (farm) currently use records of historical rainfall amounts or temperature levels?

    RAINFALL: YES____ NO____

    TEMPERATURE: YES____ NO____

    (If NO to both, please skip to question 10)

2. Are these data used as general background information, or are they required for specific decisions?

    GENERAL BACKGROUND: YES____ NO____

    SPECIFIC DECISIONS: YES____ NO____

3. If used in specific decisions, for what types of decisions are they used?

    a. ____________________

    b. ____________________

    c. ____________________

    d. ____________________

4. Are these data used in any type of mathematical equation or formula in helping your firm (farm) make decisions:

    YES____ NO____

5. Is this data summarized only on an annual basis?

    YES____ NO____

    (If yes go to 7)

6a. For what seasons are the data summarized?

    SPRING ____ FALL ____

    SUMMER ____ WINTER ____

6b. What type of data do you use?

    DAILY ____ MONTHLY ____

    WEEKLY ____ ANNUAL ____

7. For what geographic area are the data compiled?

    SMALLER THAN A COUNTY ____ COUNTY____ STATE____

    CROP REPORTING DISTRICT____ LARGER THAN A STATE____

8. Do these data relate to the United States and/or foreign countries?

UNITED STATES: YES____ NO____

FOREIGN: YES____ NO____

9. How do you acquire these data?

DIRECTLY FROM NATIONAL WEATHER SERVICE ____

FROM OTHER GOVERNMENT AGENCIES ____

FROM PRIVATE CONSULTANTS ____

FROM OTHER SOURCES ____

10. Why do you presently not use such data? (Check those statements in a-c with which you agree.)

a. DATA HAVE NO VALUE TO US____

b. DATA NOT AVAILABLE____

c. TOO COSTLY TO CONVERT DATA TO A USABLE FORM____

d. OTHER (please specify)________________________

11. If you could receive data on historic precipitation and/or temperature levels at no cost to you, what weather events would you like to know about? (Please describe as to time and location of these events.)

Weather event Time period Area

a. ____

b. ____

c. ____

12. If more than one weather event is listed in 11, which would be most useful in making business decisions?

____

13. What business decisions does that event affect?

a. ____

b. ____

c. ____

Section II

14. Does your firm (farm) currently use data on "year-to-date" precipitation amounts or temperature levels?

PRECIPITATION: YES____ NO____

TEMPERATURE: YES____ NO____
(If NO to both, please skip to question 22)

15. Are these data used as general background information, or are they required for specific decisions?

GENERAL BACKGROUND: YES____ NO____

SPECIFIC DECISIONS: YES____ NO____

16. If used in specific decisions, for what types of decisions are they used?

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

17. Are these data used in any type of mathematical equations or formula in helping your firm (farm) make decisions?

YES____ NO____

18. During what seasons do you use this data?

WINTER ____ SPRING ____

SUMMER ____ FALL ____

19. For what geographic area are the data compiled?

SMALLER THAN A COUNTY ____ COUNTY____ STATE____

CROP REPORTING DISTRICT____ LARGER THAN A STATE____

20. Do these data relate to the United States and/or foreign countries?

UNITED STATES: YES____ NO____

FOREIGN: YES____ NO____

21. How do you acquire these data?

DIRECTLY FROM NATIONAL WEATHER SERVICE____

FROM OTHER GOVERNMENT AGENCIES____

FROM PRIVATE CONSULTANTS____

FROM OTHER SOURCES____

22. Why do you not use this type of data? (Check those statements in a-d with which you agree.)

a. NO NEED FOR IT____

b. NOT AVAILABLE____

c. TOO COSTLY____

d. NOT AVAILABLE WHEN I NEED IT____

e. OTHER (Please specify)______________________________

23. If you could receive data on "year-to-date" precipitation and/or temperature levels at no cost to you, what weather events would you like to know about? (Please describe as to time and location of these events.)

Weather event	Time period	Area
a.		
b.		
c.		

24. If more than one weather event is listed in 23, which would be most useful in making business decisions?

____

25. What business decisions does that event affect?

a. ______________________________

b. ______________________________

c. ______________________________

26. When you are using such data, how current does it have to be to be useful? (CIRCLE ONE)

AS OF: YESTERDAY: ____

PREVIOUS WEEK: ____

PREVIOUS MONTH: ____

OTHER: ______________
(Explain)

27. How much would you pay (per year) for such information?

$__________

Section III

28a. Does your firm (farm) use short-term weather forecasts such as given by local radio or TV stations:

YES____ NO____

28b. If YES, are these the only forecasts your firm (farm) uses?

YES____ NO____

29. Does your firm (farm) currently use longer-term forecasts of future precipitation or temperature levels?

PRECIPITATION:	YES____	NO____
TEMPERATURE:	YES____	NO____

(If NO to both, please skip to question 39)

30. Are these forecasts used as general background information or are they required for specific decisions?

GENERAL BACKGROUND:	YES____	NO____
SPECIFIC DECISIONS:	YES____	NO____

31. If used in specific decisions, for what decisions are they used?

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

32. Are these data used in any type of mathematical equation in helping your firm (farm) make decisions?

YES____ NO____

33. For what length of period do these forecasts relate:

DAILY ____ WEEKLY ____

MONTHLY ____ ANNUALLY____

34. For what season are your forecasts?

WINTER ____ SPRING ____

SUMMER ____ FALL ____

35. For what geographic area are the forecasts required?

SMALLER THAN A COUNTY ____ COUNTY____ STATE____

CROP REPORTING DISTRICT____ LARGER THAN A STATE____

36. Do the forecasts relate to United States and/or foreign countries?

UNITED STATES: YES____ NO____

FOREIGN: YES____ NO____

37. How do you acquire these forecasts?

DIRECTLY FROM NATIONAL WEATHER SERVICE ____

FROM OTHER GOVERNMENT AGENCIES ____

PRIVATE FORECAST SERVICES ____

FROM OTHER SOURCES ____

38. How far in advance of the weather event do you receive these forecasts?

ONE DAY ____ ONE WEEK ____

ONE MONTH____ TWO MONTHS ____

MORE THAN TWO MONTHS ____

Please skip to 40

39. Why do you presently not use long-term forecasts of precipitation or temperature in your firm?

NO NEED FOR INFORMATION ____

PRESENT FORECASTS ARE NOT SUFFICIENTLY ACCURATE ____

PRESENT FORECASTS ARE NOT AVAILABLE SOON ENOUGH ____

40. If you could receive long-term forecasts of future precipitation or temperature events, what events would you want to know about?

a. ______________________________

b. ______________________________

c. ______________________________

41. Of the events listed in 39 above, which would be most helpful to you in making business decisions?

____

42. What types of decisions does the event cited in 40 affect?

____

____

____

(use additional space as necessary)

43. How far in advance of that event would you like to have the forecast?

____

44. What is the minimum lead time with which the forecast could have been made and still have been useful to you?

____

45. How many years out of ten would the forecast have to be approximately correct before it would affect your decision?

1__2__3__4__5__6__7__8__9__10__

46. How much would you pay per year for such a forecast?

$__________

47. Please comment as to additional needs of your business for weather related information. Please be specific as to how you could use such information.

APPENDIX B

Title, Company, and Location of Each Respondent to the Nationwide Mail Questionnaire Survey Reproduced in Appendix A

Agricultural Chemical Manufacturers (5)

Vice President (Research and Development), Agricultural Division, Ciba-Geigy Corporation, Greensboro, North Carolina.

Manager (Environmental Regulatory Activities, Water), Dow Chemical Company, Midland, Michigan.

Head (Plant Physiology Research), Lilly Research Laboratories (Division of Elanco Products), Greenfield, Indiana.

Director (Product Development), Monsanto Agricultural Products, St. Louis, Missouri.

Manager (Field Development and Technical Services), Shell Development Company, Houston, Texas.

Agricultural Finance Companies (12)

Vice President and Farm Loan Officer, Clinton County Bank and Trust Company, Frankfort, Indiana.

President, Citizens' State Bank of Norwood, Norwood, Minnesota.

County Supervisor, Farmers' Home Administration, Jackson, North Carolina.

Vice President (Credit), Federal Land Bank of Wichita, Wichita, Kansas.

President, First Central State Bank, DeWitt, Iowa.

Senior Vice President, First Farmers' State Bank of Minier, Minier, Illinois.

Vice President, First National Bank of DeKalb, DeKalb, Illinois.

President, Fox Valley Production Credit Association, Morris, Illinois.

President, Production Credit Association-Lincoln, Lincoln, Nebraska.

President, Production Credit Association of Madison, Madison, Wisconsin.

Vice President, Rockingham National Bank, Harrisonburg, Virginia.

Vice President (Agribusiness Affairs), Wells Fargo Bank National Association, San Francisco, California.

Food Processing/Canning Industry (8)

Agricultural Research Manager (Eastern Production), Del Monte Corporation, Rochelle, Illinois.

General Manager, Dutch Valley Growers, South Holland, Illinois.

Agricultural Manager (Midwest), Heinz USA, Fremont, Ohio.

President, Joan of Arc Company, Peoria, Illinois.

District Manager (Contract Agriculture), Libby, McNeill, and Libby Inc., Morton, Illinois.

Agricultural Supervisor, Pillsbury Green Giant Company, Belvidere, Illinois.

Agricultural Research Manager, Stokely-Van Camp, Indianapolis, Indiana.

Vice President (Agriculture), Viasic Foods Inc., Detroit, Michigan.

Grain Trade (19)

Manager, Anderson's Grain Company, Champaign, Illinois.

Assistant Vice President, A. G. Becker Inc., Chicago, Illinois.

Commodity Broker, Blunt, Ellis and Loewi, Decatur, Illinois.

District Manager, Bunge Corporation, Cairo, Illinois.

Research Analyst, Clayton Brokerage Company, St. Louis, Missouri.

Economic Analyst, Con Agra Inc., Omaha, Nebraska.

Vice President (Commodity Research), Continental Grain, New York, New York.

Research Data Analyst, Continental Grain, Chicago, Illinois.

Senior Agricultural Meteorologist and Crop Analyst, Control Data Corporation, Minneapolis, Minnesota.

Manager (Product Systems Research), Deere and Company, Moline, Illinois.

Manager, Farmers' Grain and Livestock Corporation, West Des Moines, Iowa.

Staff Economist, *Farm Journal,* West Lafayette, Indiana.

Grain Division Manager, Gelderman and Company Inc., Chicago, Illinois.

Chief Economist and Research Director, Heinold Commodities, Chicago, Illinois.

Chief Meteorologist and Assistant Vice President, E. F. Hutton and Company, Milwaukee, Wisconsin.

Account Executive, E. F. Hutton and Company, St. Charles, Missouri.

Senior Manager (Commodity Development), M and M/Mars, Hackettstown, New Jersey.

Vice President, Schnittker Associates, Washington, D. C.

Corporate Economist, A. E. Staley Manufacturing Company, Decatur, Illinois.

Integrated Pest Management Consultants (12)

Nematologist, Agri-Growth Research Inc., Hollandale, Minnesota.

Consultant, Ag. Service of Texas, Wharton, Texas.

Owner, Ascheman Associates, Des Moines, Iowa.

Crop Consultant, Spencer, Iowa.

Owner, Crop Pro-Man Inc., Glenwood, Iowa.

President, Crop Tech. Services Inc., Cedar Rapids, Iowa.

Owner/Agronomist, Eck-Cel Crop Production Consultation, Sioux City, Iowa.

Manager (Crop Monitoring Service), Laverty Sprayers Inc., Indianola, Iowa.

Owner, Nissen Crop Advising Service, Clear Lake, Iowa.

Owner/Entomologist, Pest Management Consultants Inc., Lincoln, Nebraska.

Consultant, Prairie Crop Pro-Tech, Waterloo, Iowa.

Owner, Schaaf Consulting, Ames, Iowa.

Producers (27) (types specified were taken from questionnaire responses)

Farmer (corn, soybeans, cattle feeding), Altona, Illinois.

Farmer (cash grain; Past President of Corn Growers Association), Altona, Illinois.

Fruit Grower (apples, peaches), Belleville, Illinois.

Farmer (Christmas trees), Champaign, Illinois.

Fruit and Vegetable Grower (general), Chester, Illinois.

County Extension Advisor, Geff, Illinois.

County Executive Director (USDA Agricultural Stabilization Board), Geff, Illinois.

Fruit Grower (apples, peaches), Grafton, Illinois.

Fruit Grower (apples), Griggsville, Illinois.

Farmer (cash grain), Harvard, Illinois.

Farmer (cash grain), Ogden, Illinois.

Farmer (cash grain), Ogden, Illinois.

Farmer (cash grain), Ohio, Illinois.

Farmer (corn, beans, swine), Oneida, Illinois.

Fruit Grower (apples), Poplar Grove, Illinois.

Farmer (cash grain), Seymour, Illinois.

Farmer (cash grain), Sims, Illinois.

Fruit Grower (apples), Speer, Illinois.

Farmer (cash grain), Spring Valley, Illinois.

Farmer (cash grain), Walnut, Illinois.

Farmer (cash grain, livestock), Woodhull, Illinois.

Farmer and Farm Manager (corn, soybeans), Lewisville, Minnesota.

Rancher (livestock feeder), Fort Stockton, Texas.

Rancher (beef), Fort Stockton, Texas.

Farmer (cotton), Knott, Texas.

Farmer (cotton), Midkiff, Texas.

Farmer (cotton), Midland, Texas.

Professional Farm Managers (13)

Owner/Farm Manager, J. Blackburn Farm Management Company, Fresno, California.

Farm Managers, Doane Western Management Company, Phoenix, Arizona.

Vice President/Farm Manager, Farmcraft Service Inc., Logansport, Indiana.

District Farm Manager, Halderman Farm Management Service Inc., Lafayette, Indiana.

Vice President/Farm Manager, Hertz Farm Management Inc., Monticello, Illinois.

Board Chairman/Farm Manager, Hertz Farm Management Inc., Nevada, Iowa.

President/Farm Manager and Rural Appraiser, Hoysler Real Estate Service, Faribault, Minnesota.

Vice President/Farm Manager, Hutchinson National Bank and Trust, Hutchinson, Kansas.

Farm Manager, Jensen and Associates Farm Management Service, Dubuque, Iowa.

Sole Owner, Larson Farm Management, Princeton, Illinois.

Senior Vice President and Trust Officer/Farm Manager and Rural Appraiser, National Bank of Bloomington, Bloomington, Illinois.

Farm Manager, J. Sawyer Company, London, Ohio.

President/Farm Manager, Stalcup Agricultural Service, Storm Lake, Iowa.

Rural Insurance Industry (6)

Executive Secretary and Manager, Crop-Hail Insurance Actuarial Association, Chicago, Illinois.

Director (Actuarial Division), Federal Crop Insurance Corporation, United States Department of Agriculture, Kansas City, Missouri.

Assistant Manager, Insurance Services Office, New York, New York.

Assistant General Manager, Crop Insurance Research Bureau, National Association of Mutual Insurance Companies, Indianapolis, Indiana.

President, Reinsurance Association of America, Washington, D. C.

Director (Natural Hazards Program, Corporate Research Division), Travellers' Insurance Company, Hartford, Connecticut.

Seed Production Companies (5)

General Manager (U. S. Agronomics), Asgrow Seed Company, Kalamazoo, Michigan.

Manager (Agronomic Services), DeKalb Ag Research, DeKalb, Illinois.

President, Funk Seed International, Bloomington, Illinois.

Directors (Plant Breeding and Biotechnological Research Divisions), Hi-Bred International Inc., Johnston, Iowa.

Research Coordinator, North American Plant Breeders, Ames, Iowa.

APPENDIX C

Agenda and Participants, "Workshop to Assess the Present and Potential Use of Climate Information by the United States Private Agricultural Sector," Sturgeon Bay, Wisconsin, 8-9 August 1982

Arranged by: Illinois State Water Survey, Champaign

Sponsored by: National Science Foundation
United States Department of Agriculture
National Climate Program Office
Country Companies
Growmark
Crop-Hail Insurance Actuarial Association
State of Illinois

Agenda

(1) Sunday 8 August (evening, 6-9 p.m.)

(a) Welcome, Introductions, Dinner

(b) "Why are we here?" — an attempt to place the Workshop in the context of international and U. S. Atmospheric Science policy developments that have resulted from the climatic fluctuations experienced during the last 10-15 years.
(Speaker: Peter J. Lamb)

(c) Review of the results of the earlier questionnaire survey and statement of the hypotheses they suggest. This material will provide the basis for much of Monday's effort.
(Speaker: Steven T. Sonka)

(2) Monday 9 August (morning, 8 a.m.-12 noon)

(a) Group Discussions: Participants' reactions to the results of the questionnaire survey, especially those dealing with the present use of climate information.

(b) "How can we serve agribusiness?" — a survey of the extent to which a government agency such as the Illinois State Water Survey (which deals with water and atmospheric resources) could assist the agribusiness community, and the facilities and support that would be needed . . . from the present perspective of the Chief of the Illinois State Water Survey. This will set the stage for the rest of the Workshop . . . which will seek to establish the industry's perspective on the matter.
(Speaker: Stanley A. Changnon, Jr.)

(c) Brief review of the present availability of climate information (excluding predictions). Written materials on this topic will be distributed.
(Speaker: Wayne M. Wendland)

COFFEE BREAK

(d) Group Discussions: Participants' views on the major impediments to a fuller present use of climate information by this sector.

(3) Monday 9 August (afternoon, 1-4 p.m.)

(a) Plenary Session: Review of morning discussions.
(Chairman: Steven T. Sonka)

(b) "An introduction to climate prediction" — a brief review of relevant terminology (e.g., climate-versus-weather prediction, lead time, prediction period, resolution, accuracy, skill, etc.) and the current procedure, format, and skill levels of National Weather Service climate predictions.
(Speaker: Peter J. Lamb)

(c) Group Discussions: Participants' views on the major future climate prediction needs by this sector.

(d) Plenary Session: The question of the relative roles of the public and private sectors in providing climate information for agribusiness.
(Chairman: Steven T. Sonka)

(e) Closing

Participants

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Dr. Don Collins
Director, Product Development
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Agricultural Finance Company

K. Kirk Jamison, President
Production Credit Association-Lincoln
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Food Processing/Canning Industry

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Stokely-Van Camp
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