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ECON
INCORPORATED

A PLAN FOR APPLICATION SYSTEM VERIFICATION TESTS--THE VALUE OF IMPROVED METEOROLOGICAL INFORMATION

EXECUTIVE SUMMARY

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FINAL

A PLAN FOR APPLICATION SYSTEM VERIFICATION TESTS--THE VALUE OF IMPROVED METEOROLOGICAL INFORMATION

EXECUTIVE SUMMARY

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ABSTRACT

NASA is currently considering undertaking one or more Application Systems Verification Tests (ASVTs) concerned with demonstrating the practicality and value of improved meteorological forecasts made possible by satellite data and made available on a timely basis to decision makers. Three ASVTs are considered in this report and program outlines and plans are summarized for performing experiments to demonstrate the economic consequences of improved meteorological information. The ASVTs are concerned with the citrus crop in Florida, the cotton crop in Mississippi and a group of diverse crops in Oregon. The program outlines and plans include schedules, manpower estimates and funding requirements. These are based upon a framework which considers the impact of improved information on decision processes, the data needs to demonstrate the economic impact of the improved information, the data availability, the methodology for determining and analyzing the collected data and demonstrating the economic impact of the improved information, and the possible methods of data collection.

ACKNOWLEDGEMENTS

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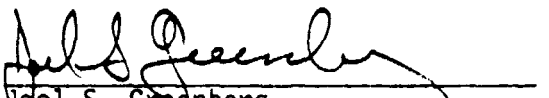

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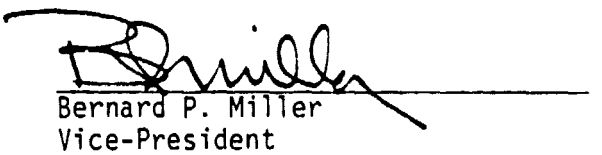

Bernard P. Miller
Vice-President

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

NASA is currently considering undertaking one or more Application Systems Verification Tests (ASVTs) concerned with demonstrating the practicality and value of improved meteorological forecasts made possible by satellite data and made available on a timely basis to decision makers. As part of these considerations, ECON, Inc. was asked to establish and develop the economic tests necessary to show (a) the economic relationships of the operations of the ASVTs to short-term weather variables, and (b) the economic relationships of the effect of improved weather information from current operational weather satellites on the ASVT operations. More specifically, ECON was asked to determine the economic elements and operation factors involved in the ASVTs to permit a further detailed economic analysis of the effects of meteorological satellite information during the actual ASVT demonstration. The ECON activities have therefore been concerned with

a. the determination of the current decision processes and related economic factors involved in each proposed ASVT,

b. the establishment of the economic data needs for both current operations and the modified operations that are expected to result from the utilization of the additional and/or improved weather information,

c. determination of the procedures and methods for obtaining the economic data identified in point (b) above,

d. establishment of a program outline and plan for the necessary data collection, evaluations and schedules for conduct of the ASVTs,

e. identification and definition of the necessary interfaces required between the various organizations (i.e., federal agencies, state and local governments and agriculture and professional organizations) which may be involved in the ASVTs, and

f. an assessment of the energy savings and environmental benefits that may result from changes in procedures, operations and/or policies as a result of the improved weather information.

ECON has therefore set out to develop the framework within which the experiments can be performed and the economic consequences of improved meteorological information demonstrated. This framework considers the impact of improved information on decision processes, the data needs to demonstrate the economic impact of the improved information, the data availability (past, present and future), the methodology for obtaining and analyzing the collected data and demonstrating the economic impact of the improved information, and the possible methods of data collection. The result is a program outline and plan for performing experiments to demonstrate the economic consequences of improved meteorological information.

The ECON analyses were primarily directed in support of demonstration or "NOWCAST" experiments being planned by Colorado State University and University of Florida. Colorado State University is planning demonstration experiments to show the practicality and value of frequent television broadcasts of SMS cloud imagery, radar images, current weather analysis, surface weather information and other weather advisories to specific agriculture user groups. It is anticipated that the SMS cloud imagery, together with the other weather information, will lead to improved scheduling decisions so as to significantly reduce weather related costs and losses. Colorado State University concluded that the television broadcasts could and should be provided to the agriculture sector in the states of Mississippi and Oregon. The University of Florida is planning a demonstration experiment to show that

frost and freeze prediction improvements are possible utilizing operational satellite information and that this information together with timely SMS temperature measurements, can affect Florida citrus grower operations and decisions so as to significantly reduce the cost of frost and freeze protection and crop losses resulting from frost and freeze.

The analyses performed by ECON were concerned with the formulation of plans for the performance of the demonstration experiments in a manner such that the economic benefits of the new and/or improved information can be reliably established. It is important to note that, to a large extent, the forecasts and information distribution methods and procedures will proceed independent of the experiment to measure the economic benefits of improved forecasting and/or new information. This has a major impact on the design and conduct of the economic portion of the experiment. Therefore, because of the limited control (from the point of view of the measurement of economic benefits) of the specific information type, format, timing and distribution methods, the economic portion of the experiment (ASVT) must be designed from the point of view of measuring the economic benefits associated with "new information" relative to "old information." Because of the control limitations, the experiment will yield the benefits of improved information without specific regard to the detailed characteristics of the information. In particular, for example, in the case of the Mississippi cotton crop ASVT, it will be possible to establish the economic benefits of the particular combination of cloud cover images, radar images, meteorological forecast interpretations, etc., being distributed in the particular

TV format. It will not be possible to explicitly measure the economic benefits associated specifically with the distribution of the cloud cover images nor with changes in the quantity, quality and timing of the distributed information. It should be noted that in the case of the cotton growers, the National Weather Service (NWS) false alarm and miss statistics are not totally relevant. What is relevant are the cotton growers perceived false alarm and miss statistics which are the result of their evaluation of the NWS forecasts in combination with the TV broadcasts of SMS cloud cover pictures plus meteorologist interpretations.

Within the above basic and important constraint, it is the objective of the experiments to measure the economic benefits which result from the distribution and use of the improved information (content, frequency, accuracy, etc.) and to extrapolate the results. Extrapolation is necessary since some form of sampling is dictated by time, budget and data source constraints. Thus the experiment must be such as to measure the economic benefits associated with a sample and then to provide the information such that the benefit data can be extrapolated to other farmers, ranchers and growers (i.e., the ultimate users of the information) in other geographic locations.

Each of the experiments necessitates the establishment of a control group and a test group and the comparison of the costs and losses associated with the two groups; the difference being the benefits from the use of the new information. The control group consists of a number of cooperating farmers, ranchers and/or growers which undertake business as usual--that is, they do not have access to the

improved information. The test group consists of a number of cooperating farmers, ranchers and/or growers which have improved information available to them. The purpose of the experiment is to measure and thence compare the costs and losses associated with these two groups. A number of basic problems are immediately evident: (a) What data should and could be collected? (b) What is the accuracy of the data? (c) What should be the populations of the control and test groups? (d) What level of confidence should be, and can realistically be, the goal of the experiment? (e) How should the control and test groups be formed (i.e., the sampling strategy)? (f) Over what duration should data be collected? These, and others, have been carefully considered in the formulation of the experiment plans.

It is important to understand the basic differences between the three experiments. The Colorado State University ASVT, actually consisting of two possible experiments (Mississippi and Oregon), requires the determination of the economic benefits of additional information (the TV pictures of cloud cover and radar data and meteorologist interpretations)--that is, the information is in addition to the NWS forecasts available to the cotton (and possibly other crops) farmers in Mississippi and farmers and orchardists in Oregon. In order to measure the economic benefits, it is necessary to establish a control group and a test group. In the case of the Mississippi experiment, the control group must consist of farmers who do not receive the new information. Since all farmers in Mississippi will have available the TV information (to be distributed via the state educational TV network), the following several options are possible, (a) the control group may consist of farmers in

Arkansas and/or Louisiana which produce similar crops, have similar growing and weather conditions, employ similar farming practices, etc., and data collected during the same time period as that of the test group in Mississippi, (b) the control group may consist of farmers in Mississippi prior to the distribution of the new information, (c) the control group may consist of farmers in Mississippi which provide historical cost, loss, activity and weather forecast and actual occurrence data, and (d) a combination of (a), (b) and (c). In no case can a control group be established in Mississippi which provides data concurrently with the test group. Because of this fact, the response to the new information will have to be observed in different geographic areas and/or in different time periods. Since different weather occurrences and different forecast capabilities will probably exist between the control group and the test group, it is necessary to perform an adjustment to the basic data which biases out these differences. Again, the reason for this is that in the Mississippi experiment it is desired to ascertain the economic benefits of the TV distributed information directly to the farmers and not the benefits arising from differences in the NWS forecast capabilities.

The current concept of the Florida experiment is to provide the SMS temperature data and related forecasts to the NWS which, in turn, will utilize this, along with other information, in improving their forecasts to the citrus growers. In this case, since the satellite data will be used directly by the NWS and will not (at least initially) be provided directly to the growers, it is desired to measure the economic benefits resulting from improvements in the NWS frost and freeze forecasts which result from the use of satellite measured temperature data.

The question of the control group arises again. In the case of the Florida experiment it does not seem possible to establish a control group by geographic segmentation. All of the citrus growers in Florida receive the current and will receive the improved NWS forecasts. Therefore, the control group will have to be based upon either or both historical data and data which could be collected during the 1976-77 frost season (assuming, of course, that the SMS temperature measurements and University of Florida forecasts are not introduced during this frost season). Indications are that a very limited amount of historical data may be available. It should be noted that data preceding the rapid rise in fossil fuel prices is suspect since grower protection decisions are influenced significantly by their fuel cost.

The Oregon experiment is a combination of the information distribution technique of the Mississippi experiment and the data gathering technique of the Florida experiment. The same type of information as that discussed for the Mississippi experiment will be distributed to the farmers and orchardists in Oregon via television. The problem of establishing a control group is similar to that of the Florida experiment. Since the TV signal will be available to most farmers and orchardists, as in the case of the Florida control group, a control group can only be established by using historical data and/or collecting data during growing seasons prior to the introduction of the new information. The major difference between the Oregon and the other two experiments is the number of different crops and divergence of farming practices in Oregon relative to Mississippi and Florida. This contributes significantly to the complexity of performing an experiment to

measure the economic benefits of the new information to the Oregon farmers and orchardists.

In summary, three experiments are considered in the following pages, namely (1) an experiment to demonstrate the use of SMS temperature measurements in citrus crop production and to measure the resulting economic benefits (the Florida Citrus Industry ASVT), (2) an experiment to demonstrate the ability of television dissemination of SMS cloud cover pictures and other data to cotton and other farmers in Mississippi and to measure the resulting economic benefits (the Mississippi Cotton Growing ASVT), and (3) an experiment to demonstrate the utility of television dissemination of SMS cloud cover pictures and other data to farmers and orchardists in Oregon and to measure the resulting economic benefits (the Oregon Mixed Crop ASVT).

Because of the great variability of weather phenomena and the variability and differences in grower decision processes, farming practices, costs and losses, great care must be exercised in the formulation and conduct of the economic experiments. If strict adherence to detail is not maintained it is likely that fallacious results will be obtained. The three experiment plans have been devised so as to establish credible measures of the benefits which may result from the new and/or improved information and have carefully considered the variability of the phenomena to be measured. The experiments have focused only on those crops and farm activities which indicate potentially large benefits which are measureable. The measurement of a number of potentially large benefit areas (for example, improved marketing decisions based on improved knowledge of actual frost occurrences across the State of Florida) have

been omitted as part of the experiments since they are not considered measureable in the time frame under consideration.

2. CITRUS INDUSTRY ASVT (FLORIDA)

The Synchronous Meteorological Satellite (SMS) currently in orbit is furnishing temperature and other data to ground receiving stations. The National Weather Service plans to receive much of this data at Ruskin, Florida. Utilizing computer and display equipment which it is planned will be installed at Ruskin (prior to the start of the 1977-78 frost season), together with temperature forecast models under development at the University of Florida, the NWS will be capable of generating high resolution spatial and temporal short-term temperature forecasts. Thus, actual temperature distributions of 4n.mi. spatial resolution and .5 degrees centigrade temperature resolution will be observed hourly across the state of Florida and incorporated into the University of Florida forecast models. These forecasts will then be utilized, in conjunction with other data available to the National Weather Service, in the determination of the meteorological forecasts provided by the National Weather Service to the citrus growers.

It is anticipated that the citrus growers will, as they have in the past, utilize the temperature forecasts in their planning and decisions pertaining to frost protection. It is further anticipated that improved temperature forecasts resulting from the use of SMS data will lead to both reduced citrus crop protection costs and reduced citrus crop losses. The reduced protection costs will arise from better decisions with regard to when frost protection is necessary, when protective action should originate and when it should be terminated. Crop loss reduction may result from improved temperature forecasts whereby frost occurrences are forecast

more accurately (i.e., the probability of not predicting a frost which in reality does occur--miss probability--is reduced) and adequate frost protection measures taken. It should be noted that crop losses may be reduced both by reducing the miss and false alarm probability and forecasting the magnitude and duration of an anticipated frost more accurately.

The SMS temperature data can also play a role in frost damage assessment by providing a current comprehensive record of temperatures which occurred throughout the State of Florida. These temperature measurements may result in improved decisions concerning the harvesting and processing of frost damaged crops. The historical temperature measurements may also play a role in marketing (harvesting and pricing) decisions whereby growers have more information on the status of other citrus growers' crops as impacted by actual temperature conditions.

The economic experiment portion of the ASVT is planned to measure the economic benefits which might result from improved frost forecasting and associated with reduced citrus crop protection costs and reduced crop losses due to frost incurred damage. The experiment should also yield estimates of crop loss reductions which may result from improved knowledge of actual temperatures which occurred and their impact on harvesting and processing decisions. The experiment, because of the very limited number of frost seasons which can realistically be considered (i.e., the sampling problem) is not being planned to provide experimental verification data of the economic benefits which may result from better knowledge of actual temperature distributions throughout the State of Florida.

In order to measure the economic benefits of improved information (i.e., the SMS temperature data), it is necessary to establish

and thence compare the costs and losses which would result with and without the improved information. This implies establishing two separate groups, namely a test group (the "haves") and a control group (the "have-nots"). Since the National Weather Service does not at this time contemplate changing the information distribution network and since current meteorologic forecasts are available to all citrus growers, it is not possible to establish control and test groups simultaneously in the State of Florida. This implies that the necessary isolation between the citrus growers comprising the control and test groups needs to be established through geographic and/or time displacement. Since geographic displacement within the State of Florida is not possible, it is theoretically possible to establish a control group outside of Florida. Serious doubt as to the credibility of a control group outside of Florida has been raised by representatives of the Florida citrus growers, the NWS, the USDA County Extension Agents and the University of Florida. Since it was deemed important to develop credible results, the idea of a control group outside the State of Florida has been ruled out. Thus it is necessary to establish the control group by time displacement. The time displacement can be either (or both) backward in time or forward in time--the former relying on historical data and the latter relying on at least a one frost season delay in the utilization of SMS data for frost forecast improvement on an operational basis.

The use of historical data for the control group appears to be possible but highly risky. Numerous discussions with citrus growers in Florida indicates that there is in general a lack of detailed data

which is necessary to establish the pertinent costs and losses. It is therefore highly desirable to establish a control group consisting of a number of growers during the 1976-77 frost season and using historical records, as appropriate, to increase the sample size. The same growers which participate as part of the control group could thence participate in the test group during the 1977-78 and other future frost seasons. Since it appears likely that the SMS temperature data will be incorporated into frost and temperature forecasts starting with the 1977-78 frost season it is mandatory (if the experiment is to be performed in Florida) that the control group be established during the 1976-77 frost season. It is felt that a minimum of two frost seasons of test group experience are required since it is likely that during the first season, the NWS will be learning how to utilize the new data and growers will be learning to adapt their decisions and actions to the improved information. Thus, it is likely that the 1977-78 frost season will be a transient with the steady-state reached by the 1978-79 frost season.

Figures 1, 2 and 3 illustrate the functional flow of the economic experiment, the schedule of events and the general areas of activity of all involved organizations, respectively. The experiment consists of six tasks namely, (1) detailed experiment design, (2) data collection, (3) data reduction, (4) economic analysis, (5) econometric modeling, and (6) reporting. The econometric modeling task is concerned with evaluating the economic benefits resulting from improved marketing decisions. Since these benefits may be large and should be evaluated, but cannot be measured within the scope of the outlined experiment, a separate task is proposed. This task (5) has been broken out separately in Table 1 which summarizes the manpower requirements and budgetary estimates.

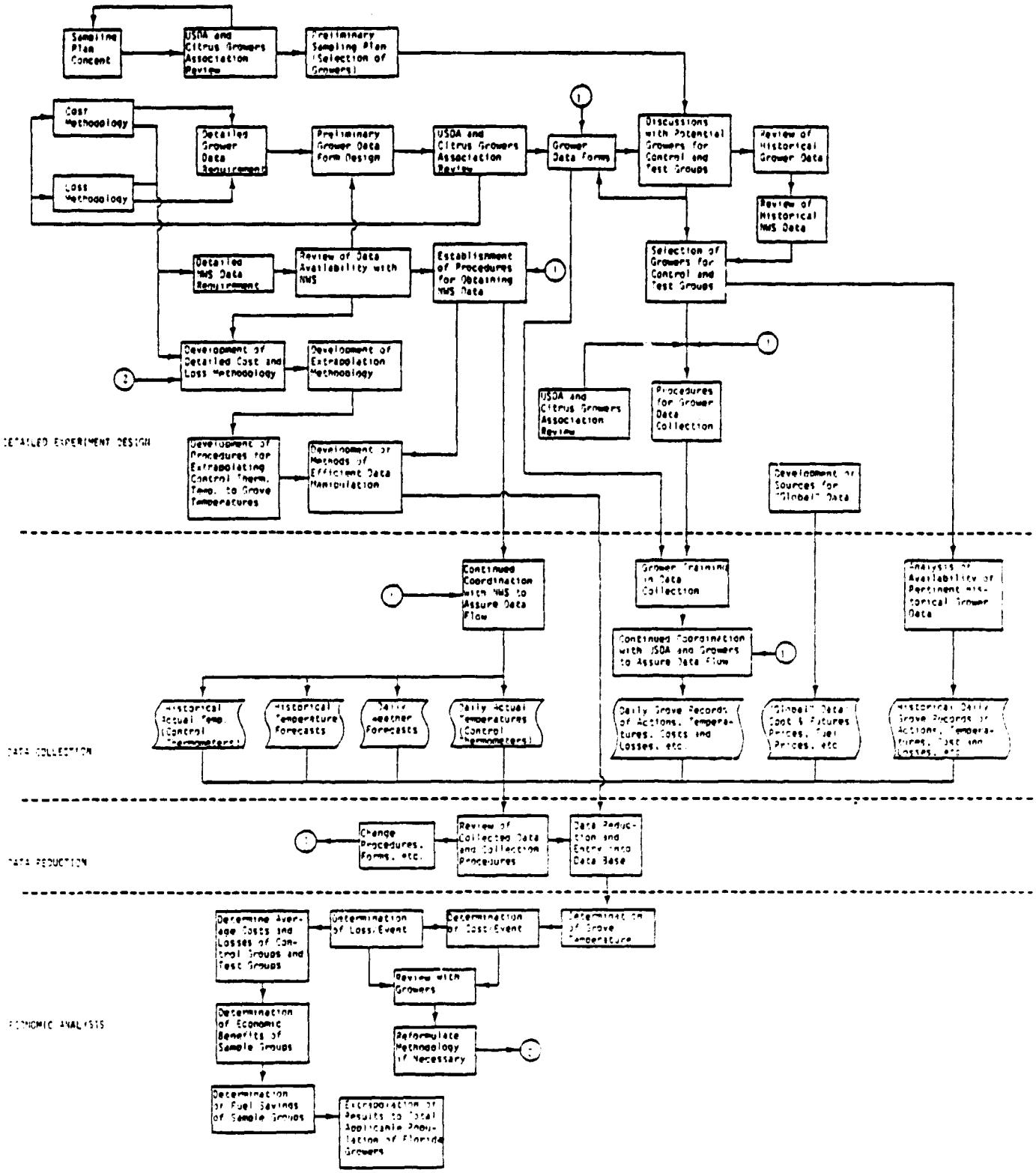

Figure 1 Functional Flow of Florida Citrus Crop ASVT (Economic Experiment)

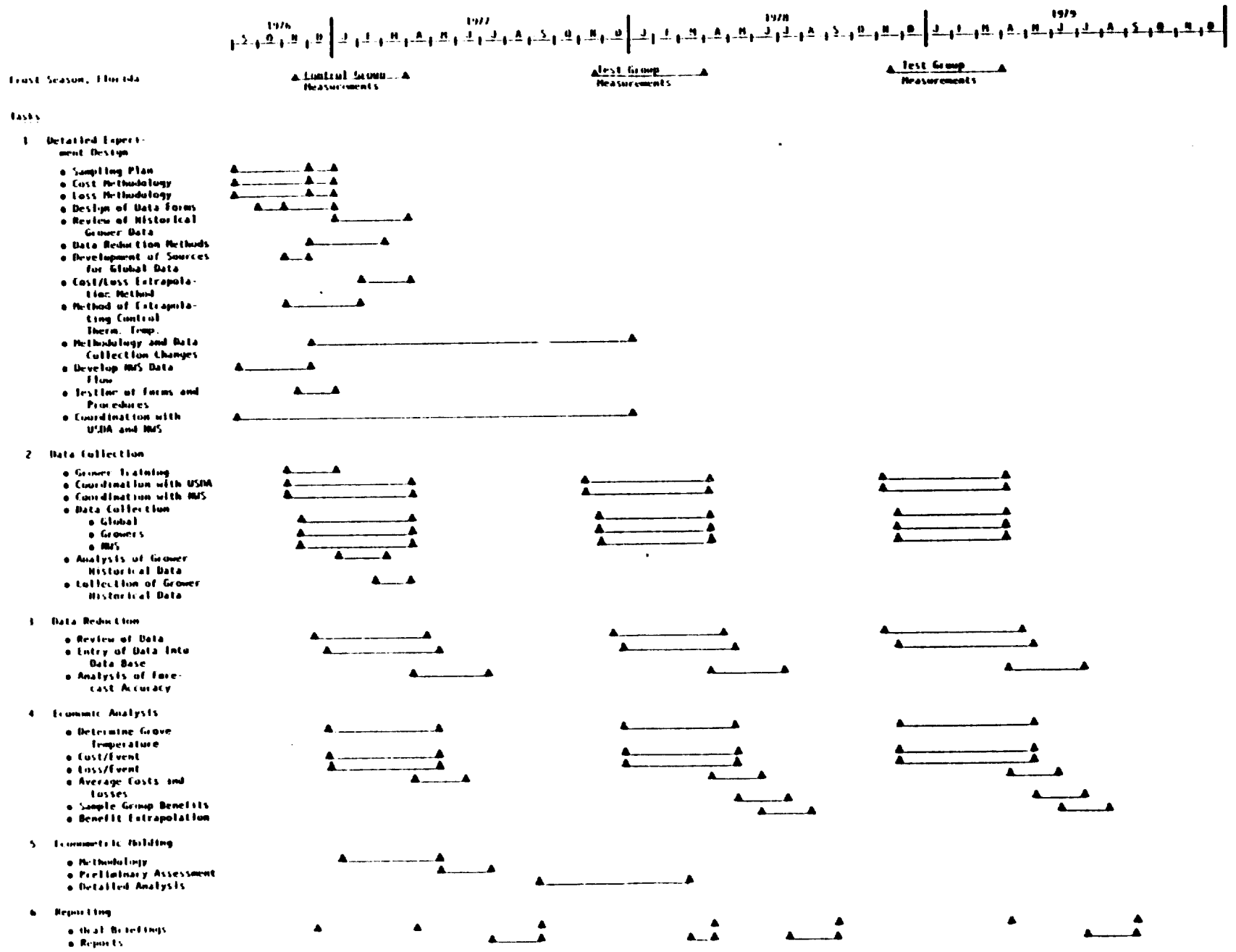

Figure 2 Schedule for Florida Citrus Crop ASVT (Economic Experiment)

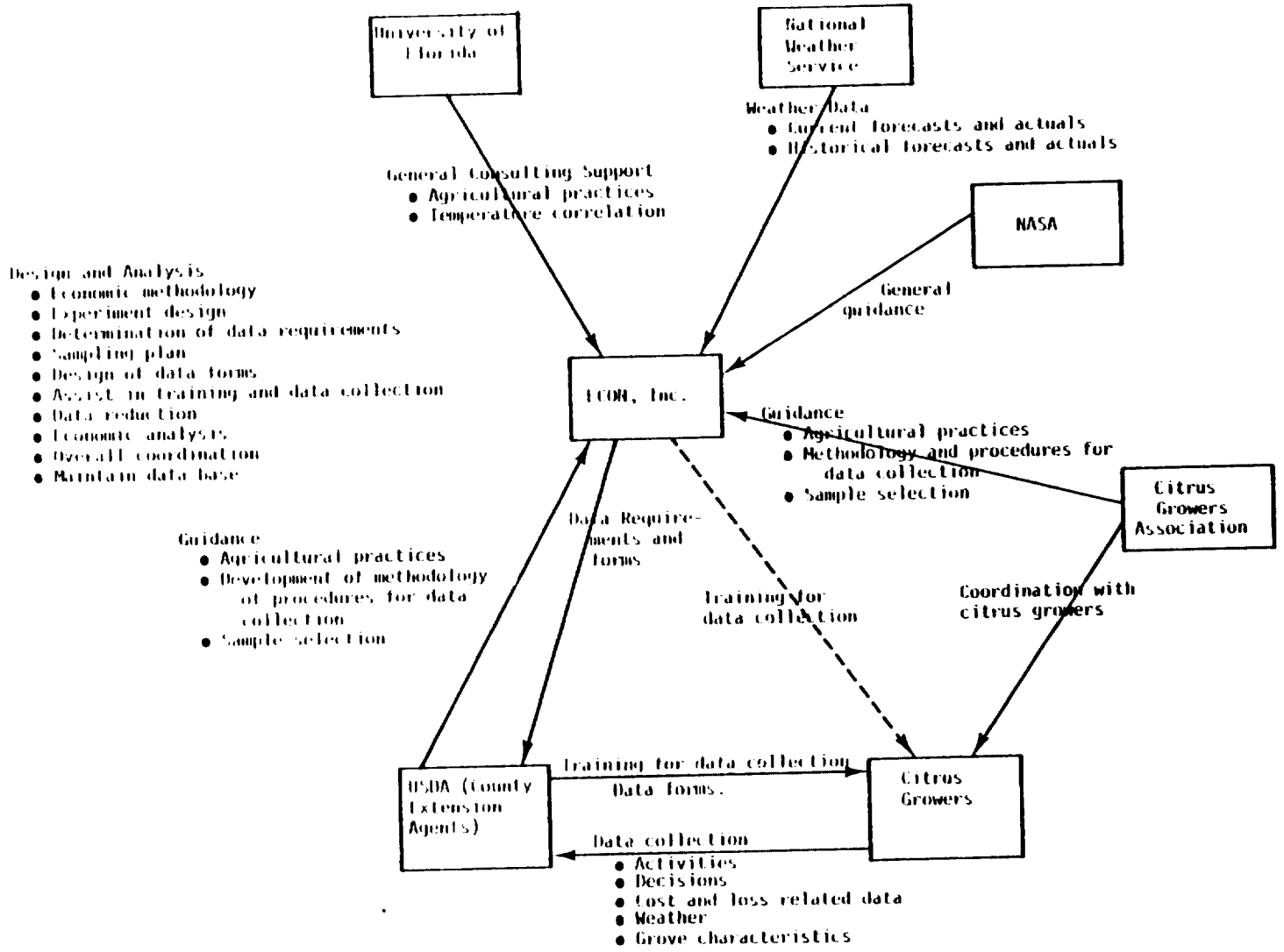

Figure 3 General Areas of Activity for Economic Benefit Experiment (Florida)

Table 1 Manpower Requirements (man-months/year) and Budgetary Estimates (K$/year) for Florida ASVT

Tasks 1, 2, 3, 4 and 6	9/76-8/77	9/77-8/78	9/78-8/79
Manpower			
Project Director	4-5	2-3	2-3
Senior O.R. Analyst	6-8	3-4	3.5-4.5
Statistician	1.5-2.5	--	--
Economist	8-10	6	6
Research Assistant	12	12	12
Programmer	3-4	--	--
Agriculture Economist	1-2	.5	--
Total (mm/year)	35.5-43.5	23.5-25.5	23.5-25.5
Budget Estimates (K$/year)	175-215	115-125	115-125
Task 5			
Manpower			
Senior Economist	3	1.5-2	--
Economist	3	3-4	--
Programmer	--	2	--
Agriculture Economist	.5-1	--	--
Total (mm/year)	6.5-7	6.5-8	--
Budget Estimates (K$/year)	40-43	36-45	--

3. COTTON GROWING ASVT (MISSISSIPPI)

Colorado State University is currently planning an experiment to demonstrate the practicality and value of frequent television broadcasts of SMS cloud imagery, radar images, current weather analysis, surface weather information and other weather advisories to specific agriculture user groups. It is anticipated that the planned information dissemination in Mississippi will effect farmer operations and decisions so as to significantly reduce crop production costs and losses due to meteorological events. Therefore, the Mississippi ASVT has as a further objective the conduct of an experiment which will monitor farmer decisions, actions costs and losses, and meteorological forecasts and actual events and allow the economic benefits of the information and distribution technique to be ascertained.

Since it is anticipated that by far the largest benefits will be achieved by the cotton growing sector of the Mississippi agricultural economy, the economic portion of the Mississippi ASVT is limited to consideration of the cotton crop.

The cotton growing ASVT is concerned with disseminating up-to-date weather information, especially including cloud cover pictures from the SMS, to cotton farmers so they can improve their short-term (12 hours or less) weather-related decision process. The weather information is to be broadcast via the Mississippi state-owned educational television network (ETV). It is anticipated that the improved weather information will materially reduce the frequency of herbicide, insecticide and defoliant washoff on cotton, thereby saving the farmers the

cost of the wasted chemicals, benefiting the environment through reduction in total application of powerful chemicals and saving fuel actually consumed in wasted spraying applications and the fuel equivalent in the petrochemicals not applied.

Since the experiment is designed to quantify the benefits of the television information dissemination system and since these benefits are expected to be most dramatic and measurable in the area of chemical spray applications, primary plans are concerned with these areas. The plan has been created to measure the reduction in materials and time brought about by the ability to more accurately determine the likelihood of certain weather occurrences within the near future. It is thought that this will involve primarily reduced loss of sprays (and their application costs and effectiveness) due to unexpected rain occurrences shortly after application.

SMS and related information distributed via television broadcasts may also have some impact on increasing yields through more accurate timing of chemical use and other management decisions but since it is felt that these effects can not be suitably measured in the experimental time frame, they are not included in the experimental design.

The experiment will consist of a comparison of the pesticide cost and loss measurements made for two groups of farmers. One in the Delta area of Mississippi where television broadcasts are received and the other in the Delta area of Arkansas where the broadcasts are not received. The similarities between the weather, soil types and farming practices in Mississippi and Arkansas create an unusual opportunity for

establishing a control group to be measured during the experimental years rather than having to rely on time-series data and the technology problems inherent in that type of experiment. However, in view of the fact that this television broadcasting will probably not be operational in Mississippi until 1978, it would be possible to collect data from the same farmers who will be in the test group later, during the 1977 growing season and to use that data as an additional control area. While this would be added insurance against biases which might exist and are not already obvious, it would also involve additional expense.

The functional flow of the Mississippi cotton crop ASVT is similar to that illustrated in Figure 1 for the citrus crop ASVT. The schedule for the cotton crop ASVT (economic experiment) is detailed in Figure 4 and encompasses a time period from February 1, 1978 through March 31, 1980. This enables data to be collected through two growing seasons, both being for control group and test group measurements. The consideration of two concurrent control/test group seasons allows for the highly likely possibility that it will not be possible to collect reliable data during the 1978 growing season because the cotton growers' decision processes will be evolving to adjust to the use of the newly available information.

The schedule is geared to the cotton growing (spraying) season and the start of the Colorado State University television distribution of weather related data. It is assumed that this will start in the Spring of 1978. If the television distribution of the weather data is delayed beyond June 1978 then the indicated schedule would be shifted to start with the 1979 (or later) growing season.

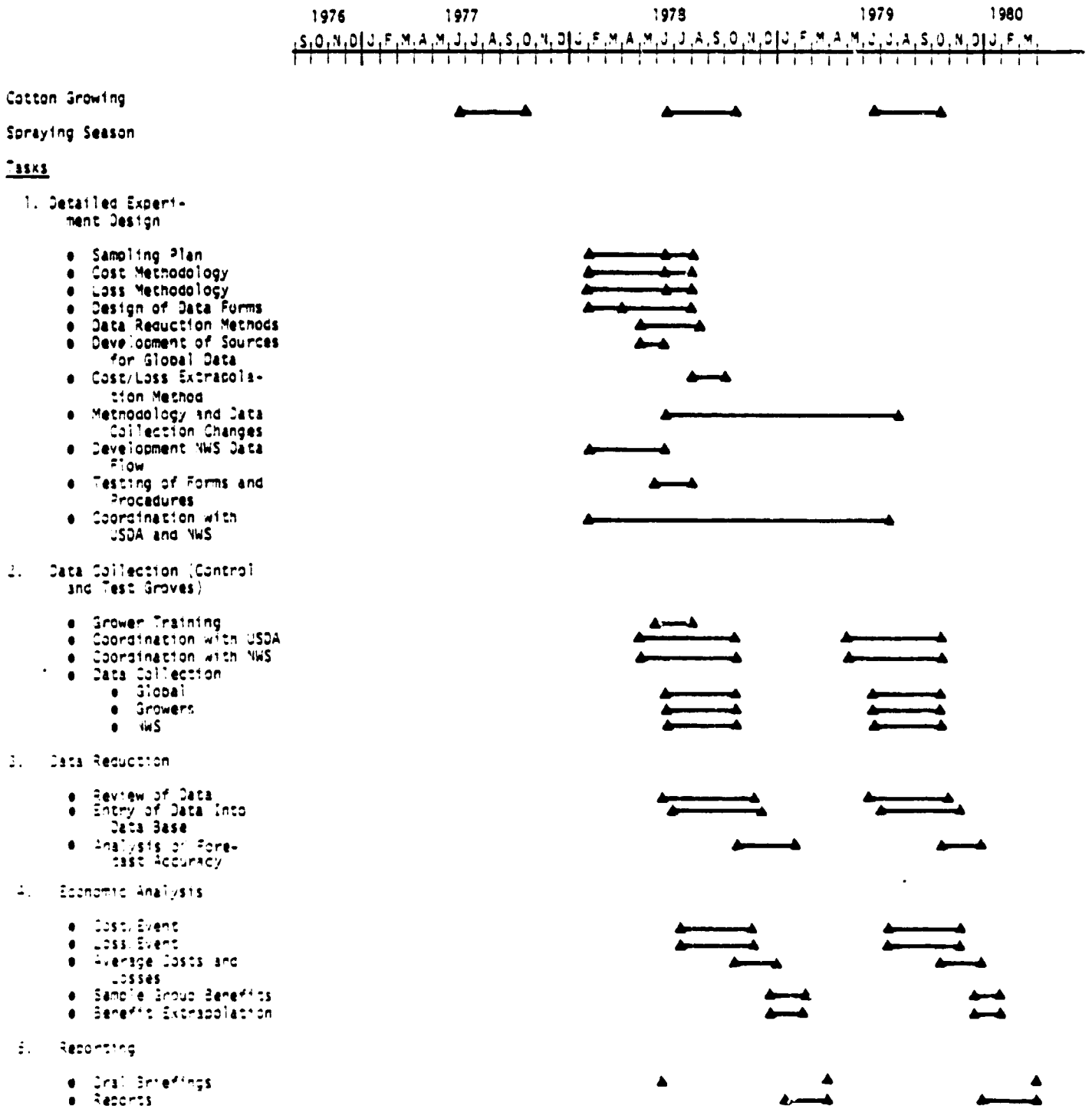

Figure 4 Schedule for Mississippi Cotton Crop ASVT (Economic Experiment)

The various organizations which will be involved in the cotton growing ASVT (economic experiment) are indicated in Figure 5 along with their general areas of activity. Table 2 presents manpower requirements for the economic portions of the experiment and budgetary estimates. These estimates are based upon the schedule illustrated in Figure 4.

Table 2 Manpower Requirements (man-months/year) and Budgetary Estimates (K$/year) for Mississippi ASVT

Manpower	9/77-8/78	9/78-8/79	9/79-8/80
Project Director	2-3	2-3	1.8-2.2
Senior O.R. Analyst	3-4	2-3	1.8-2.2
Statistician	1.5	--	--
Economist	3.5	6	3.5
Research Assistant	7	12	7
Programmer	3	--	--
Agriculture Economist	1-1.5	1	.5
Total (mm/year)	21-23.5	23-25	14.6-15.
Budget Estimates (K$/year)	100-120	100-120	64-74

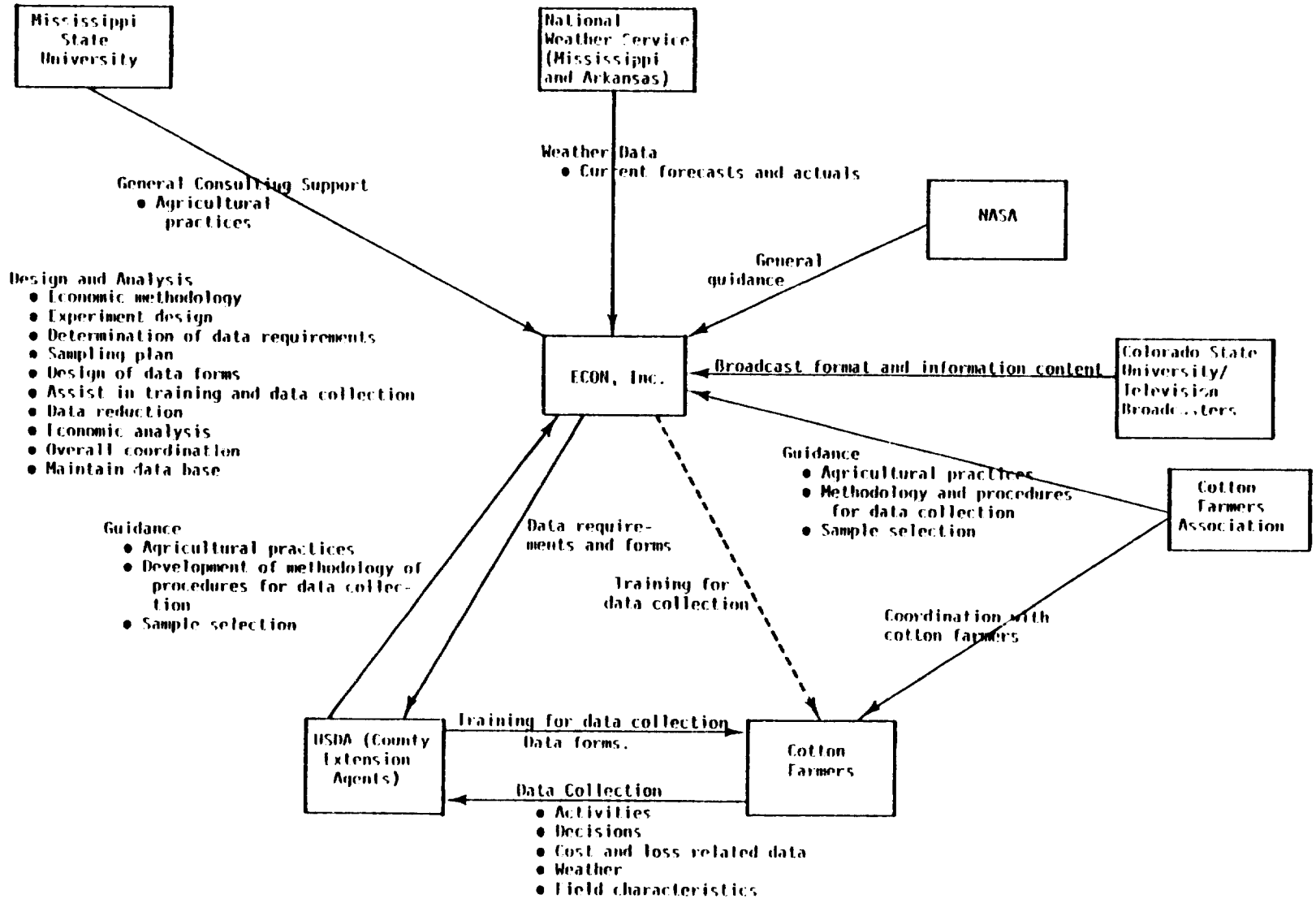

Figure 5 General Areas of Activity for Economic Benefit Experiment (Mississippi)

4. MIXED CROP ASVT (OREGON)

The Oregon ASVT will encompass essentially four different experimental areas each designed to demonstrate the benefits of improved weather information and dissemination in the production of one of the important agricultural commodities of Oregon. The first will be concerned with the chemical spraying application to potatoes, pears and possibly snap beans, the second will be concerned with frost protection of potatoes and pears, the third will be concerned with the protection of potatoes from being sheared by sanddrift, and the final area will be concerned with the field burning of grass after the harvesting of grass seed.

The chemical spraying application to potatoes, pears and snap beans is similar to the spraying of the cotton crop in Mississippi and hence the basic experimental plan is similar to that in Mississippi. The frost protection of potatoes and pears is similar in concept to that of the citrus crop in Florida and hence the basic experiment plan is similar to that in Florida. The protection of potatoes from being sheared by sanddrift is concerned with a protect-don't protect decision. The protective action is the wetting (watering) of potato fields to prevent wind blown sand particles from shearing the leaves off of the potato plants. In concept, this protect-don't protect application is similar, though somewhat less complex, than the protect-don't protect application in the state of Florida. Hence the basic experiment plan is similar to that of Florida.

The concept of the grass field burning experiment requires a special mention. Oregon produces approximately 50 percent of the U.S.

grass seed. This production is based upon certain economic advantages which the Oregon farmers have due to generally ideal weather and soil conditions. This economic advantage is being threatened by the need to significantly reduce the smoke pollution effects of burning fields of grass which is necessary to eliminate a fungus which develops after grass seed harvesting. Current legislation will significantly limit the grass burning in future years forcing either the use of expensive funguscides and/or the phasing-out of the grass seed crop. It is anticipated that improved scheduling of grass burning and the consequent reduction in smoke pollution effects may result from the timely television dissemination of SMS and related data to the grass seed industry. It is possible that the improved scheduling of grass burning could reduce the pollution effects to a more tolerable level and thereby allow the economic advantage of the Oregon grass seed industry to be maintained. Therefore an experiment will be conducted to measure the impact of the television distribution of the SMS and related data on the grass seed industry.

The grass burning experiment, together with the econometric model which must be developed, will measure both the social benefit due to decreased respiratory ailments and the benefits associated with the continuation of grass seed production at a relatively low cost. The concept of the econometric model required to forecast the future price of grass seed and of any replacements that may be grown as an alternative to grass seed is illustrated in Figure 6. Control group and test group data will be used in conjunction with the econometric model to establish the economic benefits of the television distribution of SMS and related data.

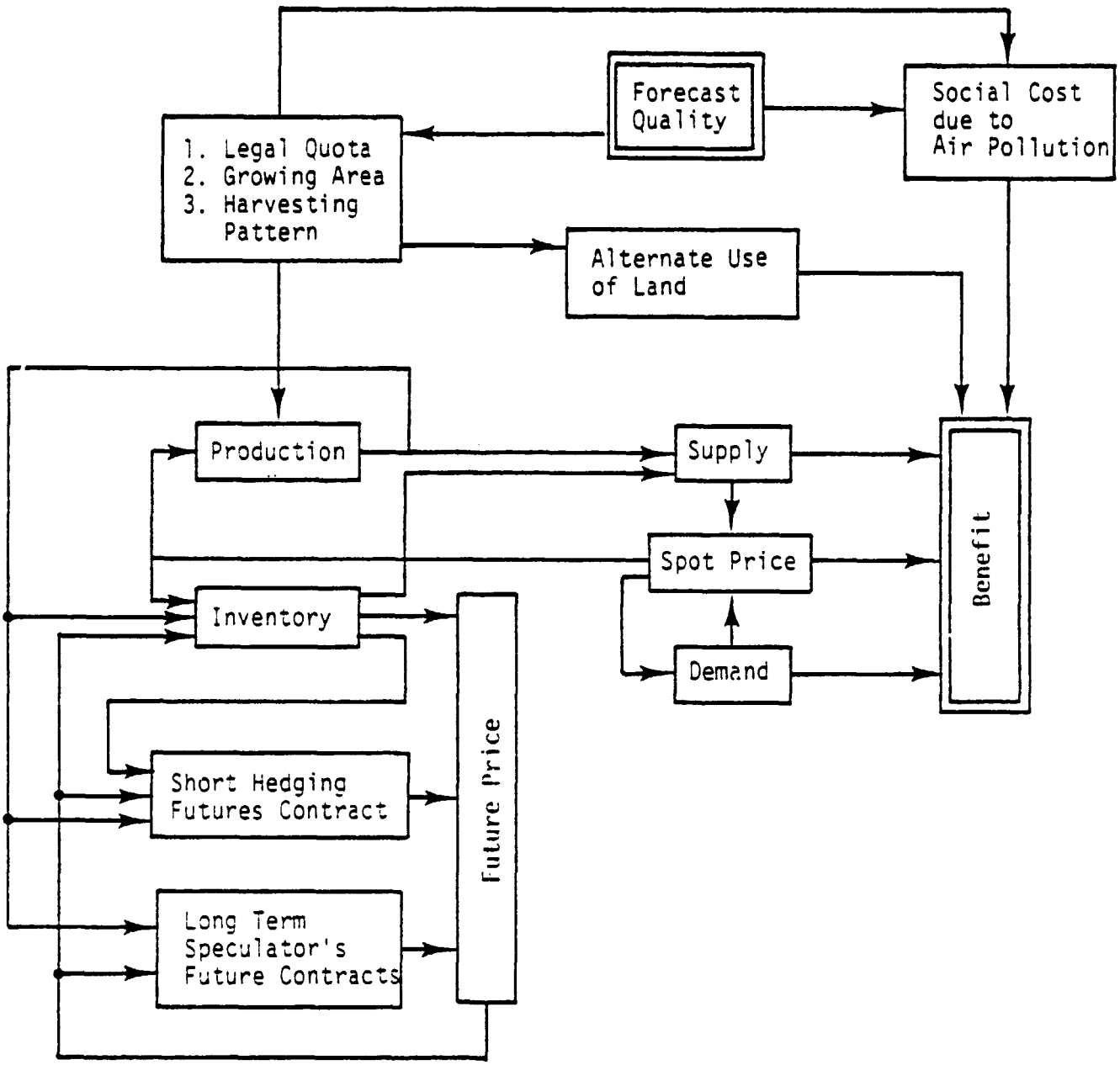

Figure 6 Econometric Model for Estimating Impact of Meteorological Forecast on Socio-Economic Consequences of Grass Seed Industry

Since it is not possible to establish a control group outside of Oregon for the grass burning experiment and it will at best be difficult if not risky to establish control groups for the other experiments outside of Oregon, the same control-test group concept will be followed as in the state of Mississippi. In other words control group data will be collected in Oregon prior to the start of the television distribution of information. If it is assumed that the new data distribution will start during 1979 then the control group data collection will take place during the 1978 growing season. The schedule for the Oregon mixed crop ASVT (economic experiment) is illustrated in Figure 7 and Table 3 presents a summary of manpower requirements and budgetary estimates. It should be noted that econometric modeling for the field burning experiment can, if desired be delayed one full year without jeopardizing the experiment.

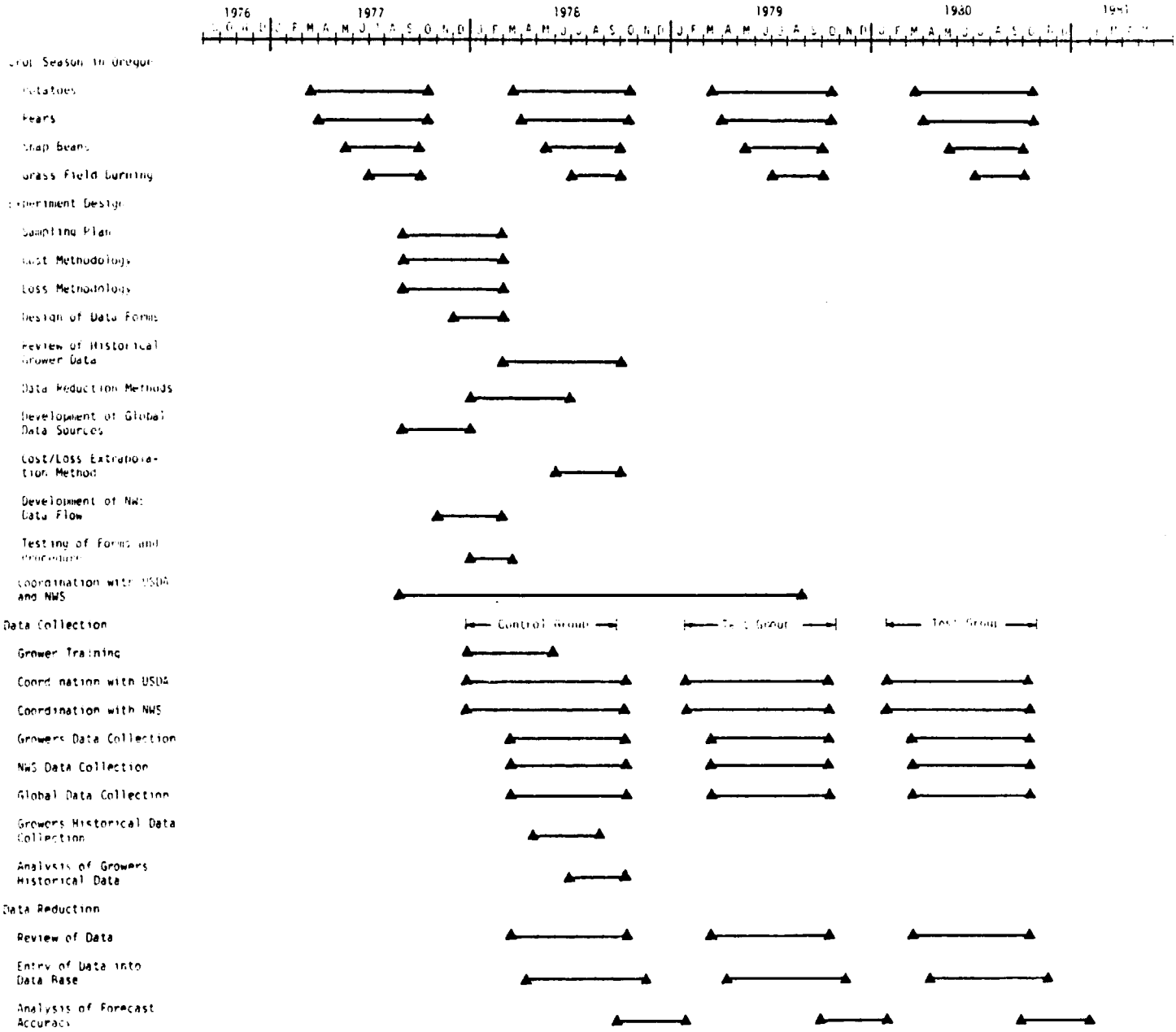

Figure 7 Schedule for Oregon Mixed Crop ASVT (Economic Experiment)

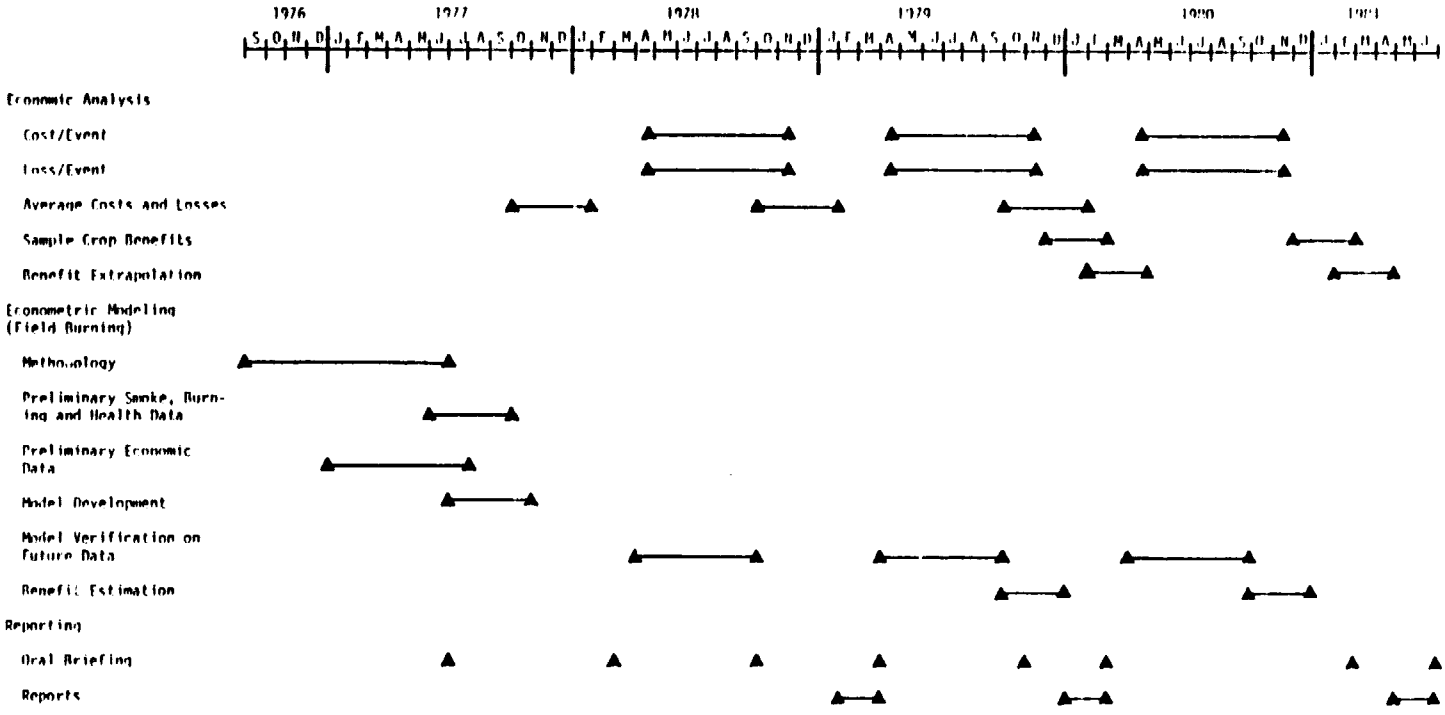

Figure 7 Schedule for Oregon Mixed Crop ASVT (Economic Experiment) (Continued)

Table 3 Manpower Requirements (man-months/year) and Budgetary Estimates (K$/year) for Oregon ASVT

Tasks 1, 2, 3, 4 & 6	9/76-8/77	9/77-8/78	9/78-8/79	9/79-8/80	9/80-8/81
Manpower					
Project Director		3.5-4.5	2-3	2-3	2-3
Senior O.R. Analyst		7-8	5-6	3-4	3.5-4
Statistician		4-5	--	--	--
Economist		8-10	5.5-6	6	5
Research Assistant		12	12	12	10
Programmer		6-8	--	--	--
Agricultural Economist		2-3	1-1.5	1-2	--
Total		42.5-50.5	25.5-28.5	24-27	20.5-22
Budget Estimates (K$/year)		200-240	120-135	110-125	95-105
Task 5					
Manpower					
Senior Economist	3.5-4.5	1-1.5	1	1-1.5	1-2
Senior O.R. Analyst	0.5-1	1	1-1.5	1	1-2
Economist	2.5-3	3-3.5	1	1	1.5
Statistician	1-2	2	1-2	0.5-1	2
Research Assistant	3	4	4	4	2.5
Programmer	1	2	1	1	1-2
Total	11.5-14.5	13-14	9-10.5	8.5-9.5	9-12
Budget Estimates (K$/year)	60-70	60-65	45-50	40-45	50-60

5. A RECOMMENDED TIME-PHASED PLAN

The scheduling of the economic experiment portion of the Florida, Mississippi and Oregon ASVTs must take into account several constraints, namely (1) the timing of pertinent crop planting, maintenance and harvesting activities, (2) the season weather patterns, and (3) the schedule for the commencement of distribution of new and/or improved weather related information. Figure 8 presents a recommended schedule for performing the Florida, Mississippi and Oregon economic experiments.* The combined timing of pertinent agricultural activities and weather events is indicated and represents the frost season in Florida (mid-November through March), the Mississippi cotton crop spraying season (mid-June through mid-October), and the frost and spraying seasons for pears (April through mid-September), the frost, spraying and crop shearing seasons for potatoes (mid-March through mid-October), the spraying season for beans (May through August), and the grass burning season (mid-July through September) in the state of Oregon.

It is anticipated that the improved temperature and frost warning information will be distributed starting with the 1977-78 frost season in Florida. This dictates that, if the Florida experiment is to be undertaken, the control group data collection must take place during the 1976-77 frost season.

The Mississippi cotton crop economic experiment is the least constrained experiment since it is possible to establish concurrent control

*Note that the methodology and modeling development of the Oregon field burning experiment may be delayed approximately one year without jeopardizing the experiment.

(Arkansas) and test (Mississippi) groups. These groups can be established and data collection started any time after the television dissemination of SMS cloud imagery and related data has been initiated. The indicated plan is based upon an assumed starting date of mid-calendar year 1978. This implies that the Colorado State University television broadcasts will commence in Mississippi some time prior to this.

The Oregon economic experiment, as in the case of the Florida experiment, must get started approximately one year prior to the initiation of the television dissemination of SMS cloud imagery and related data. This is necessary so that control group data can be collected prior to the start of the television broadcasting. The Oregon schedule is based upon the assumption that the television broadcasts will commence early in calendar year 1979.

Table 4 indicates the budget required to perform the Florida, Mississippi and Oregon economic experiments in accordance with the schedule illustrated in Figure 8. As mentioned above, the Mississippi budgets can be adjusted in time and are independent of the timing of the start of television broadcasting except that the data collection must be accomplished after the broadcasting has been initiated. Both the citrus experiment in Florida and the mixed crop experiment in Oregon are critically tied to the time of television broadcasting since each must start data collection during the growing season which precedes the initiation of the television broadcasting.

Table 4 Budget Summary for Performing the Florida, Mississippi and Oregon Economic Experiments (K$/year)

ASVT	9/76-8/77	9/77-8/78	9/78-8/79	9/79-8/80	9/80-8/81
Citrus Industry (Fla.)	175 - 215	115 - 125	115 - 125	--	--
Cotton Growing (Miss.)	--	100 - 120	100 - 120	64 - 74	--
Mixed Crop (Oregon)*	--	200 - 240	120 - 135	110 - 125	95 - 105
Total	175 - 215	415 - 485	335 - 380	174 - 199	95 - 105
Econometric Modeling (Citrus Crop--Fla.)	40 - 43	36 - 45	--	--	--
Econometric Modeling and Experiment (Grass Burning--Oregon)	60 - 70+	60 - 65	45 - 50	40 - 45	50 - 60

*Not including the Oregon grass burning econometric modeling and experiment.

+This expenditure may be delayed by one year.

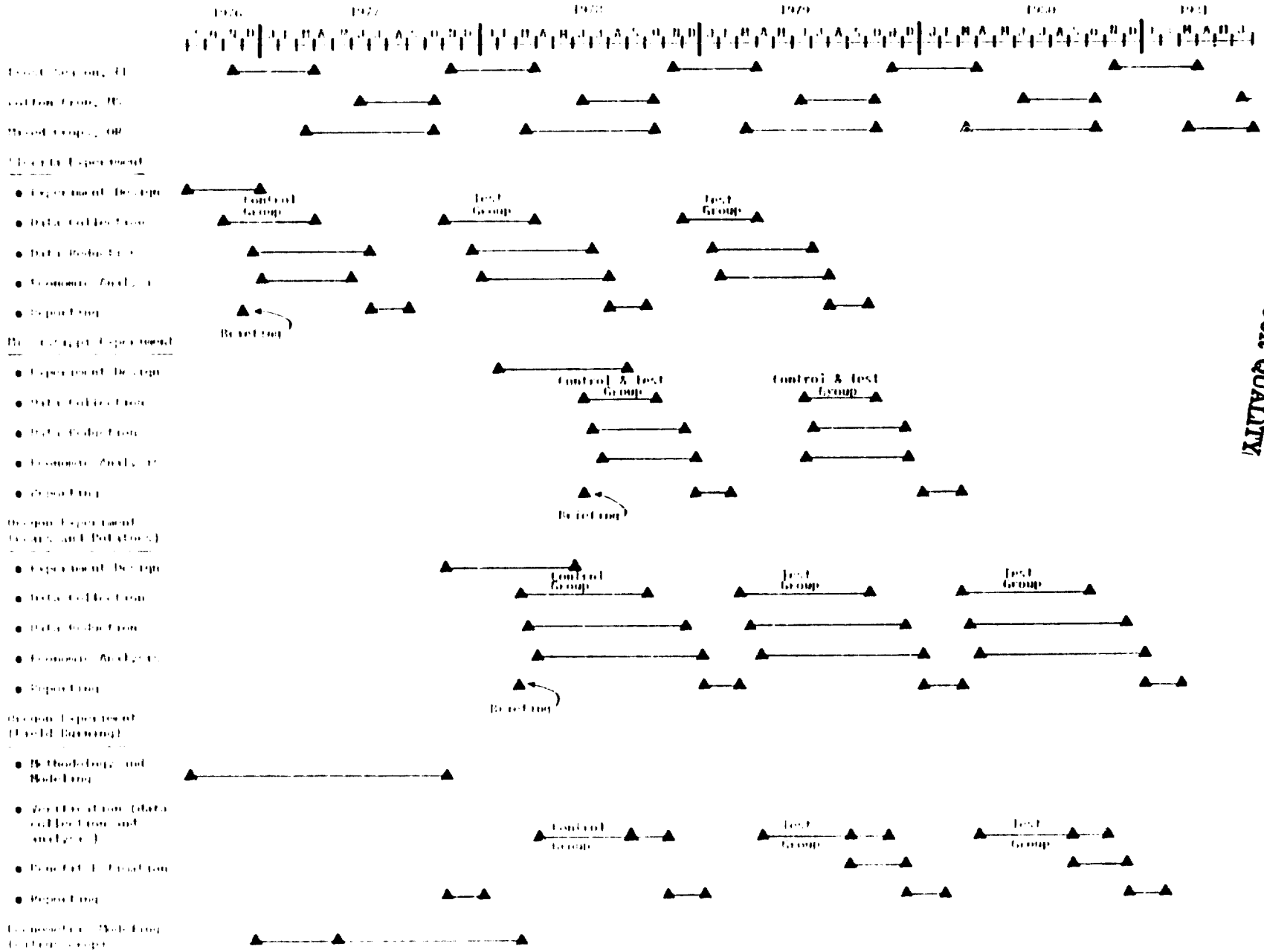

Figure 8 Recommended Schedule for Performing the Florida, Mississippi and Oregon Economic Experiments