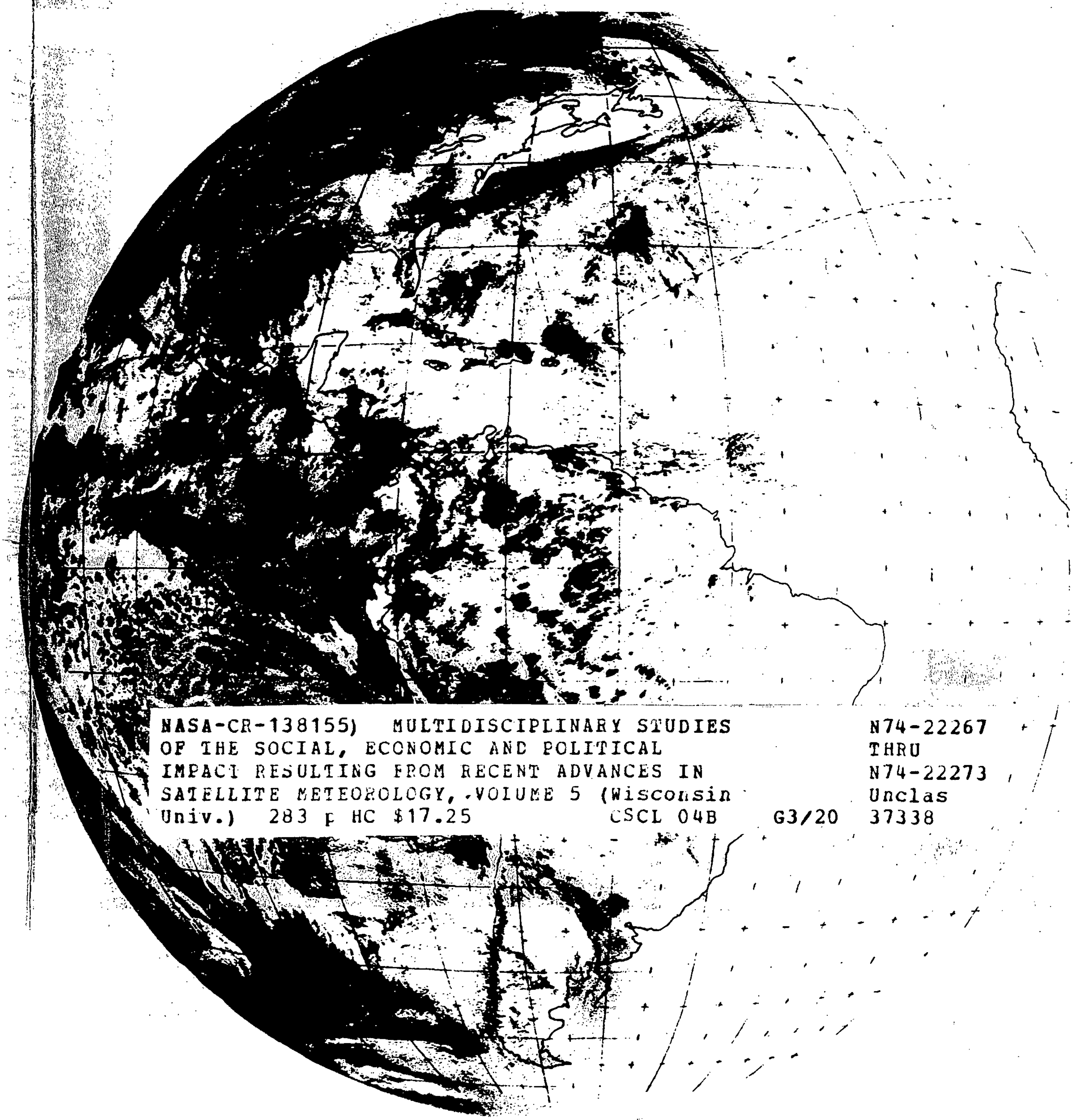
multidisiplinary studies of the social, economic, and political impact resulting from recent advances in satellite meteorology

an interim report

volumn five

space science and engineering center
the university of wisconsin
madison, wisconsin



NASA-CR-138155) MULTIDISCIPLINARY STUDIES OF THE SOCIAL, ECONOMIC AND POLITICAL IMPACT RESULTING FROM RECENT ADVANCES IN SATELLITE METEOROLOGY, VOLUME 5 (Wisconsin Univ.) 283 p HC $17.25 CSCL 04B G3/20
N74-22267 THRU N74-22273 Unclas 37338

Space Science and Engineering Center
The University of Wisconsin
Madison, Wisconsin

MULTIDISCIPLINARY STUDIES OF THE SOCIAL, ECONOMIC AND POLITICAL IMPACT RESULTING FROM RECENT ADVANCES IN SATELLITE METEOROLOGY

Interim Report on

NGL 50-002-114

Volume V

The research in this document has been supported by the National Aeronautics and Space Administration

November 1973

PREFACE

This is the fifth volume of a series of reports produced by the Space Science and Engineering Center addressing the impact of meteorological satellite programs on a broad range of activities. The four previous reports (totalling 1341 pages) explored the ways in which people obtained and used weather information and the role meteorological satellites played in meeting their needs. This report focuses more sharply on the area which our previous studies indicated was one of the greatest public need, and where the greatest opportunity for direct application of meteorological satellite data lies. We call this "NOWCASTING" because of the emphasis on current weather and how it will change in the near future. Actually a more technically correct term would be "Mesoscale weather monitoring, analysis, and information dissemination".

The studies in this report treat certain specific aspects of NOWCASTING which are of particular interest in developing a NOWCASTING Service. The study by Dancer and Tibbitts establishes the cost-effectiveness of NOWCASTING in agriculture, and Kuhn's examines the dollar return of NOWCASTING in the asphalt road building industry. These two areas were selected because they typify weather sensitive activities examined in previous studies. The other four studies treat weather information dissemination aspects and provide background information for a NOWCASTING development program.

I am grateful for the continuing NASA support and for the participation of all those who have contributed to these studies.

Verner E. Suomi

MULTIDISCIPLINARY STUDIES OF THE SOCIAL, ECONOMIC AND POLITICAL IMPACT RESULTING FROM RECENT ADVANCES IN SATELLITE METEOROLOGY

SUMMARY TABLE OF CONTENTS

MULTIDISCIPLINARY STUDIES OF THE SOCIAL, ECONOMIC AND POLITICAL IMPACT RESULTING FROM RECENT ADVANCES IN SATELLITE METEOROLOGY

VOLUME V — Page

Detailed Table of Contents

List of Tables

List of Tables

List of Figures

List of Tables

List of Figures

List of Tables

List of Figures

N 74-22268

IMPACT OF NOWCASTING ON THE PRODUCTION AND PROCESSING OF AGRICULTURAL CROPS

by W. S. Dancer
and T. W. Tibbitts

INTRODUCTION

The purpose of this study was to determine the value of improved weather information and weather forecasting to farmers, growers, and agricultural processing industries in the United States. The study was undertaken to identify the production and processing operations that could be improved with accurate and timely information on changing weather patterns. Estimates were then made of the potential savings that could be realized with accurate information about the prevailing weather and short term forecasts for up to 12 hours. This weather information has been termed "nowcasting."

The growing, marketing, and processing operations of the twenty most valuable crops in the United States were studied to determine those operations that are sensitive to short-term weather forecasting. Agricultural extension specialists, research scientists, growers, and representatives of processing industries were consulted and interviewed. The value of the crops included in this survey and their production levels are given in Table 1. Statistics from the U.S.D.A. Crop Reporting Board (1) show that the farm value for crops produced in the United States was more than 26 billion dollars in 1971. The total value for crops surveyed in this report exceeds 24 billion dollars and represents more than 92 percent of total U.S. crop value.

Table 1. Production value and the principal growing areas for the major economic crops grown in the United States. 1970-1971 growing season.

Crop	Production (millions of tons)	Value (millions of dollars)	Growing Area (principal states)
Field corn	155.0	5890	Iowa, Ill., Ind.
Soybeans	35.1	3465	Ill., Iowa, Ind.
Hay	131.0	3333	Cal., Wis., N.Y.
Wheat	49.2	2168	Kan., Daks., Wash.
Cotton	7.0	1679	Cal., Texas, Miss.
Tobacco	0.9	1368	N. Car., Ky., S. Car.
Sorghum grain	25.1	926	Texas, Kan., Nebr.
*Citrus	11.3	670	Fla., Cal., Texas
Potatoes	15.8	626	Idaho, Cal., Maine
Oats	14.0	638	Minn., Daks., Wis.
Tomatoes	5.8	444	Cal., Ohio, Ind.
Barley	11.1	443	Daks., Minn., Cal.
Rice	4.2	440	Texas, Ark., La.
Sugar beets	26.9	414	Cal., Idaho, Colo.
Peanuts	1.5	406	Ga., Ala., N. Car.
Grapes	4.0	372	Cal., N.Y., Mich.
Apples	3.1	308	Wash., N.Y., Mich.
Lettuce	2.3	272	Cal., Ariz., N.M.
Peaches	1.4	173	Cal., S. Car., Ga.
**Processed Vegetables	3.2	161	Wis., Ore., Minn.
Total	507.8	24,096	

* Includes oranges, grapefruit, and lemons.

** Includes green peas, snap beans, and sweet corn.

A special detailed study was made of the operations in the production and processing of vegetable crops to obtain precise estimates of the value of nowcasting information. The producers of vegetable crops have traditionally been interested and very willing to cooperate in programs to increase the accuracy of short-term weather forecasts for their operations. These carefully developed estimates were then used as a basis for estimating the value of nowcasting information for related operations in the production of the other crops included in this survey.

Vegetable processing industries of the North Central Region (Wisconsin and Minnesota) were contacted through the Wisconsin Canners and Freezers Association and a special weathercasting subcommittee was established to evaluate the impact of nowcasting on the production and processing of green peas, snap beans and sweet corn. Two meetings were held with industry personnel representing six large processors in these states to determine aspects of their operations that could be improved with precise nowcasting information and to develop procedures for estimating the value that this information would have. The company representatives utilized their field and processing plant records to determine losses resulting from unfavorable weather and to provide estimates of the savings that could have been realized with accurate "now" weather information. The form shown in Table 2 was completed by these representatives.

Table 2. Wisconsin Canners and Freezers Association estimates of 1971 costs or losses which could have been avoided with accurate 6-hour weather information.

	Peas	Snap Beans	Sweet Corn
1. Planted Acreage (1971) represented by this report	______	______	______
2. Pesticide Applications - losses resulting from applications that were ineffective or were repeated because of unpredicted weather			
a. Number of acres where such losses occurred	______	______	______
b. Total cost of such applications	$ ______	$ ______	$ ______
3. Labor Costs that could have been avoided			
a. Field operations--call-in pay and idle time	$ ______	$ ______	$ ______
b. Plant operations--call-in pay and idle time	$ ______	$ ______	$ ______
4. Other Costs that could have been avoided, e.g. inter-plant hauling	$ ______	$ ______	$ ______
5. Crop Losses that could have been avoided			
a. Number of unharvested acres that could have been saved	$ ______	$ ______	$ ______
b. Loss per acre of fields not harvested (include seed, rent or guarantee, labor, pesticide application, etc.)	$ ______	$ ______	$ ______
6. Decreased Value of Finished Product-quality loss due to unexpected weather conditions			
a. Percent of pack affected	______ %	______ %	______ %
b. Decreased value resulting	$ ______	$ ______	$ ______

Chapter One

IMPACT OF NOWCASTING INFORMATION

Vegetable Crops in the North Central and Northeastern States

A number of vegetable crops in the United States are produced almost entirely for processing, and 3 of the 6 most valuable vegetables, green peas, snap beans, and sweet corn are grown largely to produce canned and frozen products. The farm value for canned and frozen green peas, snap beans, and sweet corn in the United States was well over 161 million dollars in 1971 (3). Most of these canned and frozen vegetables are grown in the North Central and Northeastern States. In these states 60, 65 and 74 percent of the green pea, snap bean, and sweet corn acreage, respectively, were planted in 1971. Wisconsin leads these states in the packing of these three crops.

The estimates obtained from the Wisconsin Canning and Freezing Association (WCFA) were utilized to develop estimates for the total production in the North Central and Northeastern States. It was estimated that the value of nowcasting for vegetable crop production and processing in these states would exceed 4.5 million dollars. Estimates were developed for each aspect of these operations for which savings could be realized.

Summer rains wash off pesticide applications before pest control can be realized. The most important pesticide spraying operations used on these vegetable crops are (a) herbicide spraying programs to control thistles and other weeds in pea fields, (b) fungicide spraying to control blight disease on snap beans, and (c) insecticide spraying for corn earworm and corn borer control. Unsuccessful herbicide applications on peas, resulting from unfavorable weather conditions, increase significantly the labor and fuel costs for the harvest and cultivation of this crop.

Ineffective fungicide applications on snapbeans decrease both yield and quality of beans. Insecticides are applied weekly to control corn earworms and stalk borers, and these insecticides must be reapplied if they are washed off by rain within 6 hours after application. Unexpected winds increase the drift of pesticides away from target areas and make spraying operations more difficult and costly. Any increase in the accuracy of weather forecasts would enable vegetable growers to improve the effectiveness of their pesticide spraying programs. It is estimated that accurate nowcasting for wind and moisture would significantly reduce the amounts of pesticides in current use.

After reviewing past field records of pesticide spraying operations, the 5 major vegetable packing companies in Wisconsin estimated that accurate nowcasts on wind and rain would decrease the annual cost of pesticide spraying operations by an average of 15, 88, and 27 cents per acre for green peas, snap beans, and sweet corn, respectively. More than 273,000 acres of green peas, 163,000 acres of snap beans and 443,000 acres of sweet corn were grown in the North Central and Northeast States in 1971 where summer rains interfered with pesticide spraying operations. With these per acre savings, the annual value of nowcasts would be more than 304 thousand dollars as shown in Table 2. This dollar saving does not include the effect that efficient spraying has upon minimizing the danger to non-target crops and to domestic animals and humans in adjacent areas, nor does it include the importance of efficient spraying in minimizing the problems resulting from pesticide pollution in our environment.

Rainfall and heavy dew disrupt the harvest of vegetable crops in the

North Central and Northeast States. Rain and heavy dew wet crop foliage, and mud clogs the sieves of mobile pea and bean viners. Heavy machinery is used to harvest vegetable crops; tractors weigh about 10,000 pounds and field viners weigh about 16,000 pounds, and it is difficult to operate this heavy machinery under muddy field conditions. When heavy rains or heavy dew occurs at harvest, the rate of harvest decreases and more breakdowns are experienced because of the increased strain on the equipment. Fluctuations in the amount of vegetables harvested results in fluctuations in the supply of vegetables to the processing plant which results in inefficient utilization of labor, equipment and supplies at the plant.

Rain and heavy dew result in higher labor and material costs for harvesting and processing. Packing companies will transport vegetables considerable distance from drier areas to keep processing plants running smoothly and efficiently. Accurate nowcasts for moisture would allow field supervisors to shift harvest operations to drier areas and would permit plant managers to plan and maintain more efficient processing operations. The results from the WCFA survey show that accurate 6-hour forecasts on moisture would reduce overhead harvest and processing costs by an average of 55, 49, and 30 cents per acre of green peas, snap beans, and sweet corn respectively. This represents an annual savings of 363 thousand dollars to vegetable freezers and canners in North Central and Northeast States. (Table 3)

The quality of vegetable products is also reduced by the interference of rain or heavy dew at harvest. Vegetable crops must be harvested at a particular stage of maturity to produce a packaged product of high quality. This is especially true for green peas (4). Overmature peas are hard, starchy, and unpalatable. Only a narrow range in maturity is acceptable for processing and peas progress rapidly through this range. If the weather is cool and the ground moist, green peas mature more slowly and harvesting may take place over a 2 to 4-day period. If temperatures are high and the soil dry, maturation is very rapid and harvesting must take place within 12 hours. Decisions as to which fields to harvest and when to harvest them are made daily and even hourly during the harvest season. Significant increases in the quality and value of vegetable products would be realized with nowcasts for temperature and moisture because harvesting and processing operations would be more efficient and more vegetables could be harvested when they are at the optimum stage of maturity. Freezers and canners in Wisconsin estimate that the value of green pea, snap bean, and sweet corn products would increase by an average of 1.14, 1.84, and 1.57 dollars per acre, respectively, with accurate nowcasting information. This increase in produce value represents more than 1.3 million dollars to vegetable processors in the North Central and Northeast States (Table 3).

Considerable vegetable acreage is abandoned each year because heavy rains prevent harvest when vegetables are at the acceptable range of maturity. More than 14,400 acres of green peas, 18,800 acres of snap beans, and 133,000 acres of sweet corn were abandoned in the North Central and Northeast States in 1971 (3). Accurate 6-hour forecasts for temperature, rain, and heavy dew would permit harvest of some of the vegetable acreage that is now being abandoned. Representatives of the WCFA estimate that the abandoned acreage for green peas, snap beans, and

Table 3. Vegetable packing operations sensitive to nowcasting information and the value of accurate nowcasts of precipitation, temperature, and wind to freezing and canning industries in Wisconsin.

Operations	Value of Nowcasts			
	Peas	Snap beans	Sweet Corn	All Crops Total Dollars for all Acres
	- - - - - dollars per acre - - - - -			
Spraying Operations Savings from avoiding ineffective pesticide applications	$0.15	$0.88	$0.27	$ 304,000
Harvest and Processing Operations Savings in labor costs for call-in-pay and for idle time, and costs for inter-plant hauling	0.55	0.49	0.30	363,000
Increased Value of Product Savings in crop value and quality gained by more efficient harvesting and processing operations	1.14	1.84	1.57	1,306,000
Acreage Reduction Savings from a reduction in planted acreage because harvesting operations are more efficient	2.07	3.25	3.28	2,548,000
Total per-acre value of nowcasts	$3.91	$6.46	$5.42	
Vegetable acreage in North Central and Northeast States	273,000	163,000	443,000	
Total value of nowcasting in North Central and Northeast States	$1,067,000	$1,053,000	$2,401,000	$4,521,000

sweet corn in 1971 could have been reduced by 30.6, 33.2 and 4.6 percent, respectively, with accurate nowcasts for temperature, rain, and dew. The average costs for planting and maintaining an acre of green peas, snap beans, and sweet corn in 1971 was 128, 85, and 71 dollars, respectively. A reduction of the abandoned acreage of green peas, snap beans and sweet corn would save vegetable packing companies in the North Central and Northeast states an average of 2.07, 3.25 and 3.28 dollars per acre respectively equalling 2.55 million dollars each year (Table 3).

The total estimated value of nowcasting information for the processing vegetable crops of green peas, snap beans, and sweet corn is 3.91, 6.46 and 5.42 dollars per acre, respectively, With the 1971 acreages of 273,000, 163,000 and 443,000 for each of these crops, the total dollar savings would be about 4.5 million dollars each year (Table 3).

The Major Economic Crops in the United States

The impact of nowcasting on each of the major agricultural crops grown in the United States is detailed in Table 4. The crops are listed in order of their dollar value in our economy. Specific operations that would be sensitive to nowcasting have been identified and it has been determined which operations would be altered with more precise weather information. The costs of these altered operations were determined and estimates were made of the savings that could be realized both in reduced operational costs and in increased crop productivity with accurate nowcasting weather information.

Field corn

No significant estimate of dollar savings from nowcasting information for field corn production could be obtained. Nowcasting information would have importance during the period of harvest to avoid leaving crops in the fields when heavy snowstorms or rainstorms occur late in the fall and prevent harvest. This would mean a savings in both total yield and quality of the corn. However, the irregular occurrence of these late storms in different areas make a reliable estimate of savings from improved weather information impossible.

Indications were found that accurate nowcasting information would reduce storage losses by improving precision in the ventilation of the seed after harvest. However, the increasing use of automated systems for the control of ventilation reduces greatly the need for forecast information and the total dollar savings would not be large.

Soybeans

The significance of nowcasting information for soybean production was similar to the conclusions obtained for field corn. No significant direct savings were established.

Hay

The harvesting operations for hay crops are controlled to a large extent by the probabilities of satisfactory weather for proper harvesting and drying before storage. Extensive study has demonstrated that the significant dollar davings that can be quantified are for 2 to 3-day forecasts and thus are not included in these shorter term forecasting estimates. Nonetheless, it is recognized that nowcasting information would be utilized in the hour-by-hour decisions that are required in the hay harvesting operation even though no dollar savings can be determined for this use.

The preservation of hay as silage could be improved with accurate short term weather forecasts and affect savings by improving the quality of the silage and preventing losses from silo fires. Hay stored in silos should be at 40-70% moisture which is obtained by permitting the green-cut hay (at 75-80% moisture) to dry partially before hauling to the silo. With insufficient drying, as the silage ferments undesirable microorganisms predominate and the silage will turn sour. Excess moisture will also cause valuable nutrients to leach from the silage. With excessive drying, the silage feed value is reduced or lost completely if it ignites spontaneously.

The loss in nutrient value from souring and heating is of consider-

Table 4. Crop Sensitivity of Nowcasting information and the value of nowcasting to major crop growers and processors in the United States.

Major United States Crops	Operation	Weather Factor	Benefit from Nowcasts	Nowcasting Value (Thousands of Dollars)
Field corn	(No significant direct savings from nowcasting information could be established.)			
Soybeans	(No significant direct savings from nowcasting information could be established.)			
Hay	Harvesting for silage	Temperature, humidity and wind velocity	Reduction in silo fires with proper hay drying	200
Wheat	(No significant direct savings from nowcasting information could be established.)			
Cotton	Spraying operations (insecticides)	Precipitation, time and duration. Wind velocity and direction.	Reduction in the amounts of insecticides required to control insect pests. Savings in labor and material costs for insecticide spraying operations. Less contamination of environment with hazardous biocides.	25,000
Tobacco	Spraying operations (fungicides & hormones), growth regulating materials.	Precipitation, time and duration. Wind velocity and direction.	Reduction in labor and materials needed to control plant diseases & suckers. Lower amounts of environmental contamination with chemicals ($2,270)	3,130
	Protection of crops from low temperature extremes	Critical low temperature, time and duration. Wind velocity and direction. Dew point. Cloud cover.	More efficient frost protection operations. Lower labor & fuel costs for frost protection. Lower crop damage and yield losses from freezing temperatures. ($860)	

Table 4 con't.

Major United States Crops	Operation	Weather Factor	Benefit from Nowcasts	Nowcasting Value (Thousands of Dollars)
Grain Sorghum	Spraying operations (insecticides)	(See cotton above)	(See cotton above.)	1,900
Citrus	Protection of crop from low temperature extremes	(See tobacco above)	(See tobacco above.) ($10,000)	15,000
	Spraying operations (insecticides)	(See cotton and tobacco above.)	(See cotton and tobacco above.) (5,500)	
Potatoes	Spraying operations (fungicides)	(See tobacco above.)	(See tobacco above.)	2,040
Oats	(No significant direct savings from nowcasting information could be established.)			
Tomatoes	Spraying operations (fungicides)	(See tobacco above)	(See tobacco above.)	540
Barley	(No significant direct savings from nowcasting information could be established.)			
Rice	Seed bed preparation and planting	Precipitation intensity and duration. Wind direction and velocity.	Safety in airplane seeding operation. Avoid seed drift. Better rice stands and higher rice yields. Better weed control. ($500)	3,500
	Harvest and combining	Wind direction and velocity. Precipitation intensity.	Decrease cost of combining rice by avoiding lodging. ($500)	
	Disease control	Wind direction and velocity. Fog.	Increased burning for disease control and higher yields. ($2,500)	

Table 4 con't.

Major United States Crops	Operation	Weather Factor	Benefit from Nowcasts	Nowcasting Value (Thousands of Dollars)
Sugar Beets	Harvest and processing	Precipitation, time and duration. Dew point temperature.	More efficient harvest and processing operations. Higher crop yields and higher produce quality and value.	400
Peanuts	Spraying operations (fungicides)	(See tobacco above.)	Higher crop yields and value. Better disease control.	686
Grapes	Protection of crop from sudden temperature extremes.	Critical temperatures. Rate & time of temperature change.	Less crop damage and yield loss from temperature extremes.	5,500
Apples	Protection of crop from low temperature extremes.	(See citrus above.)	(See citrus above.) ($7,400)	10,000
	Spraying operations (fungicides)	(See tobacco above.)	(See tobacco above.) ($3,000)	
Lettuce	Seed bed preparation and planting	Precipitation intensity & duration.	Less abandoned acreage. Reduction in planted acreage. Avoid replanting ($97)	947
	Spraying operations (insecticides)	(See cotton above.)	(See cotton above.) ($850)	
Peaches	(No significant savings from nowcasting)			

Table 4 con't.

Major United States Crops	Operation	Weather Factor	Benefit from Nowcasts	Nowcasting Value (Thousands of Dollars)
Processed vegetables (Green Peas, Snap Beans, Sweet Corn)	Planting	(See lettuce above.)	(See lettuce above.) ($2,548)	
	Spraying operations (insecticides, fungicides & herbicides)	(See cotton and tobacco above.)	(See cotton and tobacco above.) ($304)	4,521
	Harvest and processing	(See sugar beets above.)	(See sugar beets above.) ($1,669)	
	TOTAL VALUE OF NOWCASTING			74,264

able significance, but no dollar value could be estimated for this loss. The loss from fires was estimated from data collected by the University of Wisconsin Agricultural Engineering Department, indicating that there are 22 silo fires in Wisconsin annually, resulting in an average loss of $5,000 for each fire. If we estimate that the frequency of silo fires is the same in all of the other states in the Middle West and East, and that 50 percent of these could be saved by utilizing accurate nowcasting information to determine the time for drying precisely, the average annual savings would be approximately 200 thousand dollars.

Wheat

No significant dollar savings resulting from nowcasting weather information was established for wheat production.

Cotton

Insect pests are an important problem in all cotton growing areas and all cotton acreage is sprayed several times annually with insecticides. Unexpected precipitation interferes with insecticide spraying operations in many southern areas. The insecticide must remain on the cotton foliage for several hours for effective insect control. Insecticides must be reapplied when rain washes the application off within 3 to 4 hours after application. The average cotton planting in North Carolina is sprayed nine times annually with insecticides to control boll weevil and other insect pests (7), and cotton research scientists at North Carolina State University (8) estimate that at least one reapplication due to rain could be eliminated each year with accurate nowcasting information. In

Texas and Oklahoma, the boll worm is a more important insect pest than the boll weevil, and twenty insecticide applications per season are commonly used on the high plains of Texas to control boll worm and other insect pests. Most of the precipitation in Texas and Oklahoma falls during the cotton growing season, and cotton research scientists and extension specialists at Texas A and M University (9) estimate that at least one reapplication of insecticide would be avoided with accurate nowcasts on the high plains of Texas and two or three applications would be avoided in gulf coastal areas where tropical rainstorms occur quite frequently during the latter part of the cotton season. Little rainfall occurs during the cotton growing season in Southern California and Arizona and precipitation rarely interferes with pesticide spraying operations in these states.

The cost of applying insecticides to cotton varies with the region and the method of application. A survey of cotton production costs for Georgia in 1958 and 1960 (10) showed that the average cost per acre was 2.60 or 2.78 dollars depending upon the kind of insecticide used. Scientists at North Carolina State and Texas A and M University (8, 9) estimate that an average insecticide application costs about 2.50 dollars per acre. In 1971 more than 10 million acres of cotton were harvested in Texas, Oklahoma, and the southeastern states. Since it costs about 2.50 dollars per acre to apply an insecticide to cotton, nowcasts would save the cotton growing industry 25 million dollars annually if the reapplication of one insecticide treatment could be avoided.

Tobacco

Early summer and spring rains interfere with the control of blue mold (Peronospora tabacina), a disease in the tobacco seedling beds in southeastern states. Fungicides are applied twice weekly to control this disease and the fungicide must remain on the tobacco foliage for several hours to be effective. Fungicide applications that are washed off within a few hours after application have to be repeated, and tobacco extension specialists at North Carolina State University (11) estimate that an average of two fungicide applications are washed off each year by rains that occur three or four hours after treatment. Accurate 6-hour forecasts for precipitation would allow tobacco growers to avoid reapplying fungicides by covering the tobacco bed with tarpaulins to shed rain or by readjusting fungicide spraying schedules. The average cost for one application of fungicide is 1.25 dollars for each acre of tobacco transplanted into the field (11). Ninety-one percent of the tobacco in the United States, about 766,000 acres in 1971, is grown in southeastern states where blue mold occurs and the elimination of three fungicide applications per season by nowcasting would save tobacco growers 2 million dollars each year.

In these same states, chemicals are utilized for the control of suckers (branches) on the plants. These chemicals should remain on the plants a minimum of 12 hours for effective sucker control. It is estimated that 5% of the applications are washed off by rains, most of which could be avoided with accurate nowcasts. At the approximate cost of seven dollars per acre for sucker control, treatment savings would amount to approximately 270 thousand dollars.

Freezing temperatures are a problem in northern states where tobacco is air cured. Tobacco buyers in Wisconsin (12, 13) estimate an annual loss of 1 to 5% due to the freezing of tobacco before it can cure out. It is estimated that a 1% loss in tobacco due to frost could be prevented with accurate nowcasting in an average year for Wisconsin. Air-cured tobacco in the North Central and Eastern States was valued at 86 million dollars in 1971, and a 1% increase in yield would represent 860 thousand dollars to the tobacco growing industry. Nowcasts for temperature and moisture would help increase the quality of air-cured tobacco. The amount of moisture in the tobacco curing shed must be maintained at a proper level to air-cure tobacco properly. The moisture inside the tobacco shed is controlled by opening and closing the doors and vents of the shed. When more moisture is required the vents are opened during rainy or foggy weather, and when the tobacco is to be dried the vents are opened during hot dry days. Charcoal fires are built in the shed to increase air temperature and increase the rate of curing. Nowcasts for air temperature and moisture could help tobacco growers air-cure their tobacco. However, it was found to be impossible to evaluate the impact of nowcasts in terms of dollars. The value of nowcasts for helping growers cure tobacco is largely one of convenience, and it is questionable whether tobacco growers would utilize nowcasts to alter their present tobacco curing operations.

Significant losses in tobacco curing occur in the occassional wet year when rain or high humidity prevails for a week or more during curing or when unusually dry conditions persist throughout the curing period (12, 13). In such years, accurate weekly forecasts for moisture and temperature would be required to reduce losses in tobacco quality.

Grain sorghum

In 1971 more than one third of the sorghum used for grain was produced in Texas where the sorghum midge (Contarina sorghicola) is a serious insect pest. Sorghum grain losses resulting from sorghum midge damage in Texas have exceeded 10 million dollars annually in several years since 1950 (14) and yield losses for late plantings range from 20 to 100 percent annually. From one to three timely insecticide applications are required to control the sorghum midge when serious infestations occur. Wind and rain reduce the effectiveness of insecticide applications in Texas, especially on the Gulf Coast, where tropical wind and rain storms are common (15, 16). Sorghum research scientists at Texas A and M University (15) estimate that grain sorghum on the high plains of Texas is sprayed an average of twice yearly with insecticides which combat sorghum midge. Two-thirds of the grain sorghum in Texas, an estimated 3.9 million acres, is grown on the high plains. Each insecticide application costs about 2.50 dollars per acre, and the spraying program used to control sorghum midge on the high plains costs sorghum growers about 19 million dollars a year. Observations on cotton (7, 8) suggest that nowcasts for moisture would reduce the amount of pesticide needed for insect control by 10% in the southeast. A 10% reduction in insecticide spraying for sorghum on the high plains of Texas would save sorghum growers about 1.9 million dollars each year.

It is indicated that accurate nowcasting information would reduce storage losses by improving precision in the ventilation of the seed after harvest. However, the increasing use of automated systems for control of ventilation (36) greatly reduces the need for forecast information and the total dollar savings is not large.

Citrus

More than 70 percent of the citrus crop in the United States is grown in Florida. In 1962, a severe frost during two successive nights caused losses amounting to almost 500 million dollars in that state (17, 18). Approximately 15 million of the state's 52 million trees were killed and 50 million boxes of fruit were lost. Major freezes, like the one in 1962, with temperatures of 20° F or lower, occur about every 10 years in Florida, Texas, and California. Minor freezes, with temperatures of 25° to 29° F, occur over a fairly large area 10 to 25 nights a year in California, about once every two years in Florida, and about once every three years in Texas. Frost protection is minimal in Texas (19) and the three major freezes which occurred in the Lower Rio Grande Valley during the last fifteen years killed or damaged most of the fruit bearing trees in the valley. Large citrus growing areas of Florida, Southern California, and Arizona are carefully protected from low temperatures by permanent wind machines, by orchard heaters, and by flood and furrow irrigation (23, 24). In these states heaters are kept in the orchard for the entire frost season. The heaters, wind machines, and irrigation treatments must keep orchard temperatures from dropping below a critical level, about 26-27° F, to prevent damage. Accurate short-term forecasts for critical temperature levels and their duration are needed to minimize the cost of frost protection and to provide maximum protection to citrus from low temperature extremes.

Citrus extension specialists at the University of Florida (19, 20) estimate that 20% of the labor and fuel expended for frost protection is used when protection is unnecessary. Orchard heaters must be fired and wind machines turned on before critical low temperatures occur, which is a very time-consuming and expensive process. Because the low temperature for the night occurs in the early morning hours and the orchard heaters will burn only about 7 hours, the firing of the heaters must be delayed as long as possible to conserve fuel and heat for the early morning hours when the coldest temperatures will occur. For each 5 to 10 acres of citrus, one man is required to fire and maintain the orchard heaters. Not all heaters are fired at first and more will be added during the early morning hours as temperatures continue to drop. Records from citrus growers in Florida (21) show that the average annual cost for protecting an acre of citrus over a ten-year period was 41.25 dollars. There are more than 850 thousand acres of oranges and grapefruit in Florida (28), and the average annual cost for frost protection of citrus in Florida is estimated to be about 35 million dollars. If nowcasts could eliminate 20 percent of these costs by accurately predicting the time and duration of critical low temepratures, it would save the citrus growing industry in Florida about 7.0 million dollars annually. If we assume that nowcasts would have a similar value for citrus growers in other states, which produce the remaining 30% of the crop (25), then nowcasts would have an annual value of 10.0 million dollars nationwide.

Citrus research scientists and researchers (19, 20, 22) believe that accurate short-term weather forecasts for critical low temperatures would promote the establishment of sound frost protection operations in areas where there is little or no protection at present, such as the Lower Rio Grande Valley of Texas, and there is good reason to believe that accurate nowcasts would decrease citrus yield losses due to low temperature extremes.

Pesticides are applied to citrus for control of both diseases and insects. Fungicides and scalicides must cover all leaf and fruit surfaces in order to be effective and rain and heavy dew often cause the wash-off of these pesticides before the disease is controlled. Temperature is important because most summer scalicides are oil based and the use of oil sprays is not recommended when temperatures are above 90° F because of the possibility of damage to fruit and foliage. It is clear that accurate nowcasts for moisture and temperature would help citrus growers plan more effective insect and disease control programs. The average cost for citrus pesticide spraying programs in Florida is about 65 dollars per acre (26). Since there are more than 850 thousand acres of citrus in Florida (27), the pesticide spraying program for citrus costs growers in excess of 55 million dollars a year. It is estimated by entomologists in Florida (48), that accurate nowcasts would reduce the cost of pesticide spraying for citrus in Florida by 10 percent. Thus nowcasts would save citrus growers more than 5.5 million dollars each year.

Potatoes

Early blight (*Nacrosporium solani*) and late blight (Phytophthora infestand) can seriously affect potatoes grown in humid areas. In Wisconsin, potatoes are treated weekly with fungicide sprays for 4 to 8 weeks during the growing season to control early and late blight. Vegetable crop extension specialists at the University of Wisconsin (29) estimate that the average annual cost for blight control in the North Central States is 16 to 36 dollars per acre. More than 640,000 acres of potatoes were harvested in the North Central and Northeast states in

1971. Assuming that blight control costs a minimum of 16 dollars per acre in these states, then the cost to potato growers in these states would be about 10.2 million dollars annually. At present, the blight control programs are largely prophylactic and the amount of spraying could be significantly reduced if blight epidemics could be forecast. Serious blight losses occur when cool wet nights occur in combination with warm, moist days. Vegetable extension specialists at the University of Wisconsin (30) estimate that 20 percent of the fungicide applications could be eliminated with accurate six-hour forecasts for temperature and moisture. Such a reduction in fungicide spraying would save potato growers in North Central and Northeast States 2 million dollars a year.

Oats

Oats are primarily harvested by combine either as standing grain or cut and windrowed to encourage drying before being picked up by the combine. Rainfall on the windrowed oats causes loss of yield as oats shell out and also reduce the quality of the oats that are harvested later. Accurate nowcasting information would minimize the amount of oats that would be in windrows when rains occur. An estimate of savings was not made for this loss because of the irregular use of windrowing in separate areas in different years.

Tomatoes

More than 395,000 acres of tomatoes were harvested in the United States in 1971 (3, 31). About 38% of the acreage was grown in Eastern States where several diseases, e.g., anthracnose, early blight, late blight, and leaf spot, are a serious problem to tomato growers (32). U.S.D.A. Economists estimate that pesticide spraying programs in Michigan cost tomato growers about 18 dollars per acre each year. About 152,000 acres of tomatoes were harvested in eastern states in 1971, and it is estimated that pesticide spraying programs cost tomato growers in eastern states 2.7 million dollars annually. Early blight and gray leaf spot disease are brought on by warm rainy weather. Late blight is one of the most destuuctive and widespread of all plant diseases and can destroy entire fields of tomatoes in a week of cool rainy weather. Anthracnose disease develops most rapidly in warm damp weather with temperatures near 80° F. Accurate weather forecasts should allow plant pathologists to predict when disease epidemics will occur and enable them to realize more effective disease control programs. One timely fungicide application is as effective as several sprays after the disease has already become established. Utilizing estimates from spraying operations for potato blight control, a 20 percent reduction in spraying costs should be possible for tomato production. A 20 percent reduction in fungicide spraying would save tomato growers in eastern states alone more than 540,000 dollars each year.

Barley

Barley is grown in many of the same areas as oats and the harvesting procedures are similar. Thus accurate nowcasting information would minimize losses in barley that is windrowed before combining. However, as with oats, no estimate of the savings was made.

Rice

About 20 percent of the rice in the United States is produced on 330,000 acres in California with a 275,000 acre concentration in the Sacramento Valley (34). Airplanes are used to plant rice and apply herbicides and fertilizers. Accurate nowcasts for wind velocity and direction would reduce the threats to environmental quality from these operations and reduce labor and material costs for seeding rice and applying herbicides and fertilizers.

Heavy spring rains frequently are a problem at seedbed and planting time in California and they can delay all stand establishment operations. Rice farmers must plow and harrow when the fields are drained and the soil is dry enough to prepare for the spring planting. Heavy spring rains flood the paddies and delay seedbed preparations and rice planting. Thus the rice farmers are equipped with large tractors and harrows so that the seedbeds can be prepared during the short period when the paddy soils are the driest and most easily worked.

A delay in rice planting from May 1st to June 1st can reduce rice yields by 1,000 pounds per acre (35) and rice growers would benefit from accurate short-term forecasts for rain and winds in the spring so that seedbeds can be prepared as soon as possible. Rice growers have tractors equipped with flood lights and will work all night to complete seedbed preparations if heavy rains are predicted. It is estimated that half of the planting in the Sacramento Valley is delayed for 15 to 30 days during wet years that occur once in every 7 years. A yield reduction of 1,000 pounds per acre represents a 20 percent loss or about $50 per acre of rice. A loss of $50 per acre for half the rice acreage in the Sacramento Valley would amount to a total loss of 7 million dollars for the 7-year period, or about 1 million dollars each year. Rice extension specialists at the University of California-Davis estimate (35) that some of these losses could be avoided with accurate 12-hour forecasts for rain and wind. If accurate 6-hour forecasts or nowcasts eliminated half of these losses, it would save rice growers in the Sacramento Vallay an average of 1/2 million dollars per year.

Heavy rains accompanied by high winds can be a serious and costly problem at rice harvest in the Sacramento Valley. Such storms cause serious lodging and the combining of lodged rice approximately doubles the harvesting cost. Rice extension specialists at the University of California-Davis (35) estimate that about 20,000 acres of rice are lodged by rain in the average year which increases costs by 50 cents per cwt acre. An average machine can combine 10 acres of rice in 6 hours and accurate nowcasts for wind and precipitation would allow rice growers to reduce combining costs by working longer hours ahead of a storm and/or by hiring extra labor and harvesting machinery. At least some of the losses due to rain-induced lodging could be avoided, and an estimated reduction of harvesting costs of $25 per acre would save rice growers in the Sacramento Valley about $500,000 in the average year.

With the public concern over air pollution, rice growers in California are in urgent need of more effective weather forecasting so that they can burn rice fields for stem rot control during periods when it will not cause significant pollution. If fields cannot be burned, a minimum of $50 per acre is lost in the following crop due to disease injury. Weather nowcasting would help reduce this loss by enabling growers to make better use of fire as a residue-disease tool of sanitation. This could increase California rice income by $2.5 million annually.

Sugar Beets

Over 30% of the sugar beets are produced in California, and 8.2 million tons of sugar beets were harvested there in 1971 (36). Heavy rains interfere with the harvest of sugar beets in California, and harvest operations may be delayed until the following spring. Sugar beets store well in the field if they must be left over the winter. However, harvest interruptions make labor and processing operations in the sugar factories inefficient (37). Accurate nowcasts for rain would help managers of sugar processing plants schedule processing operations more efficiently and reduce overhead costs resulting from paying labor overtime and idle time. Precipitation also delays the harvest of sugar beets in North Central States (36). The case study on the vegetable processing industry in North Central States (Table 2) with sweet corn, peas and snap beans showed that accurate nowcasts for moisture would reduce processing costs by 30 to 55 cents per acre depending upon the crop. More than 1.3 million acres of sugar beets were harvested in 1971, and a 30 cent reduction in operating costs per acre of sugar beets would save the sugar industry about 400 thousand dollars in the average year.

Peanuts

Leaf spot disease is an important pest on peanuts grown in Southeastern States, and fungicides are applied to peanuts five to seven times during the growing season. Rain occasionally washes off these fungicide applications before they can be effective. Fungicide applications are seldom reapplied when they are washed off by rain, but accurate nowcasts for rain would promote more efficient leaf spot control programs and reduce yield losses due to this disease. The fungicide spraying program for peanuts in the Southeast is similar to the fungicide spraying program for the control of blight diseases on snap beans in the north central states, and the WCFA survey found that accurate nowcasts on wind and rain would save snap bean growers an average of 88 cents per acre in spraying costs. More than 780,000 acres of peanuts were harvested in the Southeast in 1971 (36), and a savings of 88 cents per acre for spraying costs would save peanut growers about 686 thousand dollars in the average year.

Grapes

About 88 percent of the grapes produced in the United States are grown in California. Spring frosts have caused significant grape losses during five of the last eleven years (39). April is the most critical month for frost damage, which is most extensive with a sudden freeze during a warm and early spring. Extension specialists at the University of California in Davis (39) estimate losses of grapes from spring frosts to be as much as 300 thousand tons. Also, early fall frosts cause significant losses to the grape industry once in every twenty to twenty-five years. Most grapes are harvested before fall frosts occur and yield losses due to fall frosts rarely exceed 30,000 tons even in unusual years. In 1971, grapes had a value ranging form 64 to 136 dollars per ton, depending upon the variety and the locality (1). The annual loss of grapes due to spring and fall frosts has been as high as 30 million dollars with an average annual loss estimated to be 6 million dollars. Grapes are protected from cold temperature extremes by wind machines, heaters, and by furrow or sprinkler irrigation. Extension viticulturists in California (39) suggest that accurate nowcasts for low temperature extremes may promote more effective frost control programs in California. Grape growers in the interior valleys of California have inadequate facilities for frost protection and are dependent upon furrow irrigation and soil management practices. Most of the grapes protected by wind machines, heaters, and sprinkler irrigation are the high quality wine grapes which are grown in the coastal valleys where frosts are more common. Accurate nowcasts would enable the growers of grapes in these areas to protect their grapes from spring frosts (39). Since 25 percent of the grapes in California are grown in the coastal valleys, it is estimated that accurate nowcasts for temperature, moisture and wind would save California grape growers about 1.5 million dollars each year.

Grapes are plagued by powdery mildew disease (Unicinula necator) and sulphur is applied to grapes as a fungicide throughout the growing season from April through August. Serious deterioration of grape foliage and fruit occurs when hot dry weather immediately follows the application of sulphur. Losses due to the heat damage associated with sulphur treatments are estimated to be about 2.5 percent of the annual grape yield (39) in California, or about 8 million dollars annually. The extension specialists at the University of California predict that half of this damage (4 million dollars) could be prevented with accurate nowcasts because sulphur applications could be avoided when hot dry weather is predicted and sprinkler irrigation could be used to cool the fruit and the grape foliage.

Apples

Apples are grown in all northern states and as far south as Arkansas and South Carolina. More apples are produced in the State of Washington than any other state, and 25 percent of the total apple crop was harvested in Washington in 1971 (36). Frost protection is a major concern of apple growers in Washington (32). Freezing temperatures just before and during blossoming kill and damage buds and blossoms, thus reducing apple yields. Apple orchards are protected from frost by orchard heaters, fires, wind machines and irrigation (44). Accurate nowcasts of low temperatures would decrease labor and fuel costs for frost protection and minimize field losses due to freezing temperatures. As with citrus, orchard heaters and the major device used for frost protection expecially when frosts are severe. Washington apple growers use from 20 to 40 orchard heaters per acre depending upon the orchard site, while citrus growers use an average of 35 heaters per acre (23, 24). Accurate nowcasts for temperature, dew point, moisture, and wind velocity would help apple growers plan more effective frost protection operations. Our analyses of the citrus industry showed that nowcasting would save growers about 8.25 dollars per acre by reducing the cost of frost protection operations. It is reasonable to assume that apple growers in Washington State and Oregon would save a similar amount per acre with accurate nowcasts. Apple yields in the Northwest have been very constant since the early 1900's (45, 46) and the average yield per acre is about 472 bushels or 20 thousand pounds. Production levels of 1.8 billion pounds have been projected for the mid-seventies by economists at Washington State University (47). If we assume an average yield of 20 thousand pounds of apples per acre, then 900 thousand acres of orchard would be required to produce 1.8 billion pounds of apples in the seventies. Assuming savings due to nowcasting of 8.25 dollars per acre and an acreage of 900,000, then nowcasts would save apple growers in Washington and Oregon more than 7.4 million dollars each year.

Apple orchards in eastern states are seldom protected f om frosts although damage from frost does occur. Apple scab is the most serious problem to apple growers in these states but is never a problem in western states. Extension specialists at the University of Wisconsin (40) estimate that 13 to 15 fungicide sprays are applied to apple orchards in eastern states to control this disease. These applications must be reapplied when they are washed by rain, and it is estimated that accurate nowcasts for rain would eliminate the need for at least one fungicide treatment each year. Production analyses (41) show that a fungicide application costs about 3 cents for each bushel of apples produced in the eastern states. More than 100 million bushels of apples were produced in these states in 1971, and it is estimated that accurate nowcasts on rainfall would save the eastern apple growers 3 million dollars annually.

Lettuce

Most of the lettuce grown for winter market is produced in the desert valleys of Arizona and Southern California. Thundershowers occur in these desert valleys in late fall and early winter and cause a thick crust to form at the surface of the clay soils common to these areas. This crust prevents young lettuce from emerging after germination. Vegetable extension specialists at the University of California in Riverside (42) estimate that 4 thousand acres of lettuce are abandoned or replanted every third year when serious crusting occurs. Accurate nowcasts for thundershowers would allow lettuce growers to bring in sprinkler irrigation equipment to keep the soil surface wet so that crusts cannot form. Dry soil conditions are necessary for crust formation and rain sinks into the soil more rapidly when the soil surface is wet. Seeding operations could be delayed without any significant yield loss. A survey conducted in Imperial County, California (43) shows that it costs about 73 dollars to plant and establish an acre of lectuce. If all the lettuce seedling losses due to crusting could be eliminated with accurate nowcasts, it would save the California lettuce industry 97 thousand dollars each year.

Five to eight insecticides are applied to lettuce between the time of emergence and thinning to protect the lettuce seedlings from cabbage loopers, leafminers, and other insect pests. Insecticides washed off by rain must be reapplied and extension specialists in California (42) estimate that at least one reapplication could be avoided with accurate nowcasts for rain for late fall and winter grown lettuce in California. Surveys conducted in Imperial County (43) show that it costs about six dollars to treat an acre of lettuce with an insecticide. Over 140,000 acres of lettuce are grown in the desert areas of California, Arizona, and New Mexico during the winter (31), and the elimination of one insecticide application would save lettuce growers more than 850 thousand dollars each year.

Peaches

Our survey indicates that nowcasting would not have a significant impact on the peach growing industry.

Chapter Two

SUMMARIZATION BY PRODUCTION AND PROCESSING OPERATIONS

There are four major production and processing operations involving one or several of the major crops that are sensitive to nowcasting information. These operations, in order of occurrence during the growing season, are (a) planting and land preparation, (b) spraying operations for controlling pests and crop growth, (c) operations used to protect crops from extremes in temperature, and (d) harvest and processing operations. Summarization of the nowcasting value for each of these operations is shown in Table 5.

Seedbed preparation and planting operations are influenced particularly by unexpected precipitation and strong winds. With the exception of the irrigated valleys of the southwestern states, unexpected precipitation interferes with land preparation and planting operations in most areas in the United States. Such delays result in lower plant populations and yields. Crops with a high per-acre value are often replanted, while crops having a low per-acre value are usually abandoned and plowed under. Crops requiring a long season to mature, i.e., cotton or rice, must be planted early in the spring to maximize yields. Strong winds are a problem in the Sacramento Valley of California where 275,000 acres of rice are planted with airplanes. Nowcasts on wind velocity and direction would allow the airplane crews to schedule planting operations around adverse weather to minimize labor and material costs. When processing operations are involved, delays in planting will interfere with harvest and processing operations at the end of the growing season. Vegetable packing industries in Wisconsin carefully schedule the planting

Table 5. Operations Sensitive to Nowcasting Information and Value of Nowcasts in the United States

Operation	Weather Factor	Benefit from Nowcasts	Crop	Nowcasting Value (Thousands of Dollars)
Seed bed preparation and planting	Precipitation intensity and duration. Wind direction and velocity.	Safety in airplane seeding operation. Avoid seed drift. Better rice stands and higher rice yields. Better weed control.	Rice	500
		Less abandoned acreage. Reduction in planted acreage. Avoid replanting	Lettuce, Green peas, Snap beans, Sweet corn	2,645
Protection of crops from temperature extremes	Critical low temperature, time and duration. Wind velocity and direction. Cloud cover. Dew point.	More efficient frost protection operations. Lower labor and fuel costs for frost protection. Lower crop damage and yield losses from freezing temperatures	Citrus, Grapes, Apples, Tobacco	19,760
	Critical high temperature. Rate & time of temperature change.	Less crop damage and yield loss from high temperature extremes.	Grapes	4,000
Spraying operations (fungicides)	Precipitation, time and duration. Wind velocity & direction.	Reduction in labor and materials needed to control plant diseases. Lower amounts of environmental contamination with pesticides.	Potatoes, Tomatoes, Tobacco, Peanuts, Snap beans, Apples Rice	10,909
Spraying operations (insecticides)	Precipitation, time & duration. Wind velocity & direction.	Reduction in the amounts of insecticides required to control insect pests. Savings in labor and material costs for insecticide spraying operations. Less contamination of environment with hazardous biocides.	Cotton, Citrus Sorghum, Lettuce Sweet corn	33,370

Table 5 con't.

Operation	Weather Factor	Benefit from Nowcasts	Crop	Nowcasting Value (Thou ands of Dollars)
Spraying operations (herbicides & growth regulating materials)	Precipitation, time & duration. Wind velocity and direction.	Higher yields and higher crop quality and value with better weed control.	Green peas Tobacco	311
Harvest and processing	Precipitation, time & duration. Dew point. Temperature.	More efficient harvest & processing operations. Higher crop yields and higher product quality and value.	Green peas, Snap beans, Sweet corn, Rice, Sugar beet	2,769
		TOTAL VALUE OF NOWCASTING IN THE UNITED STATES		74,264

of different crop varieties to stretch the harvest period. Delays at planting caused by unfavorable weather are reflected at harvest in costly losses in product quality and by increased overhead costs for processing operations. It is estimated that nowcasts would have a value of more than 3 million dollars a year to crop growers by improving efficiency in these land preparation and planting operations.

Agricultural sprays are applied annually to millions of acres to protect crops from insects or diseases and to facilitate production and harvest operations. Precipitation is the most important weather factor influencing spraying operations. Fungicides, insecticides, and many herbicides must cover the crop or weed foliage for effective pest control, and precipitation interferes with spraying operations by washing pesticides off the foliage before adequate pest control is obtained. Wind also interferes with spraying operations by promoting the drift of pesticides away from the target area and preventing good coverage on the crop or weeds. Wind is especially important in western areas of the United States where large acreages are sprayed with the use of airplanes. The drift of insecticides into non-target areas can damage adjacent cropland or ornamental plants and represents a pollution hazard to nearby livestock, wildlife, and man. Temperature is an important factor when sprays are applied to regulate crop growth and to facilitate harvest operations. Important examples are the chemical sprays used to thin apples, to control sucker growth on tobacco, and to prevent sprouting of potato tubers. It is estimated that accurate nowcasts for moisture, temperature and wind would reduce the cost of pesticide spraying by 44 million dollars in an average year.

The protection of crops from extremes in temperatures, both high and low temperatures, is a common practice with many high value fruit and vegetable crops. Freezing temperatures represent a potential hazard to crops grown in the United States for the winter market. The citrus fruits and winter vegetables grown in southern California, Arizona, New Mexico, southern Texas and Florida represent the most valuable crops subject to damage from low temperatures during the winter. A certain number of northern crops, i.e., apples and grapes, must be protected from freezing weather that occurs during the spring and summer. Fruit crops are protected by wind machines, irrigation, and by orchard heaters, while the protective measures for vegetable crops are usually limited to sprinkler, flood or furrow irrigation. The irrigation water gives off heat if it is warmer than the air and releases latent heat of fusion when ice is formed. Growers must maintain temperatures above critical levels to avoid damage. Accurate "now" weather information on temperature and moisture with projections up to six hours would allow growers to schedule frost protection operations more efficiently and reduce the labor, fuel, and material costs for frost protection.

Crops grown in dry irrigation areas of the West are subject to heat damage from rapid increases in temperature accompanied by air containing very low amounts of moisture. Nowcasts for temperature and moisture would allow growers in dry areas to use irrigation to protect crops from this damage. Heat damage to grapes grown in the coastal and San Joaquin Valleys of California results from the combination of sulphur fungicide treatments and hot dry winds. The heat damage on grapes could be minimized through the use of sprinkler irrigation and the avoidance of sulphur applications when hot dry weather is predicted. It is estimated that accurate nowcasts would save fruit growers nearly 23 million dollars a year by making frost protection operations more efficient and by reducing crop damage from temperature extremes.

Precipitation disrupts harvest schedules of sugar beets and lettuce in California, cotton and peanuts in southern states, and vegetable crops in the north central and northeastern states. Interruptions at harvests are most serious when the crop must be harvested and/or processed within a very narrow range of maturity to obtain maximum quality. In Wisconsin, garden peas must be harvested for processing within a twelve hour period during hot dry weather and within a three or four day period during cool, moist conditions. Harvest delays also interfere with processing operations and result in inefficient use of labor and higher operating costs for processing plants. Accurate nowcasts would aid supervisors to plan more efficient harvest and processing operations so that product quality can be increased and overhead costs minimized. About 5 million dollars could be saved through accurate nowcasting information for these operations.

Chapter Three

CONCLUSIONS

This survey of agricultural crops has indicated that accurate nowcasts would save crop growers and processors 74 million dollars each year. Nowcasts are of particular value for crops which yield perishable products and which require production practices which have to be very precise in order to insure a marketable product.

The production of these crops tends to involve a large number of specialized operations to protect the plants from climatic and biotic stresses, such as temperature and moisture extremes and various insect and disease infestations. Thus weather information is utilized constantly to maximize the effectiveness of particular operations. Production of the principal feed crops of field corn, soybeans, wheat, grain, sorghum, oats and barley were not sound to benefit directly from nowcasting information. The production of these crops involves a minimum of specialized operations during the season and little or no effort is made to protect these crops from climatic or biotic stresses during the growing period.

The results of this study should not preclude the possibility that other operations in the production of these crops may benefit from nowcasts. The data were taken from the principal growing areas for each crop and taken for those operations that appeared to provide a significant total dollar benefit. Thus, in different areas of the country, the benefits might be more or less, depending upon the specific operations required for the local production of the crop. It should be recognized also that each individual producer will be likely to vary in the use of the weather information so that savings will not be the same on each farm.

Several crops that would benefit from nowcasting information, such as cranberries, avocados and peppers, have not been included in this survey because the total dollar value of these crops in the United States is not large. Nonetheless, growers of these crops would utilize nowcasting information, for these crops are subject to serious losses under particular weather conditions, protection against which could be provided with accurate weather information. The cranberry industry, for example, annually supports a special cooperative program with ESSA on weather information crucial to the industry.

The value of nowcasting information will increase each year as competition forces growers to become more specialized and develop larger producing units. Growers will have to make each operation in the production of a particular crop as efficient as possible in order to maintain a profitable crop producing unit. The net effect of more accurate forecasts will be more efficient production and lower cost for the consuming public.

NOTES

1. U.S.D.A., 1972. Crop values 1970-71 season average prices received by farmers and value of production. Statistical Report Service. Cr Pr 2-1-1, 36 p.

2. Wisconsin Canners and Freezers Association Bulletin, June 9, 1972, Madison, Wisconsin.

3. U.S.D.A., 1971. Vegetables--processing 1971 Annual Summary. Statistical Report Service. Vg 3-2, 25 p.

4. Gritton, Earl, 1971. A case study to determine the impact on the growing of peas (Pisium Sativium L.) and the operations of the pea canning and freezing industry resulting from recent advances in satellite meteorology. Multidisciplinary studies of the social, economic, and political impact resulting from recent advances in satellite meteorology. Interim Report, Volume 2.

5. Merich, Austen, General Manager, Continental Grain and Cargo Co., Milwaukee, Wisconsin. Personal Interview, August, 1972.

6. Sorenson, J.W., Professor, Department of Agricultural Engineering, Texas A & M University, College Station, Texas. Personal Interview June, 1972.

7. Robertson, Robert 1971. Proposal for a three year cotton pest management project for North Carolina--1972-75. North Carolina State University.

8. Lee, Joshua A. and Robert Robertson, Professors of Cotton Genetics and Extension Entomologists, North Carolina State University, Raleigh, Personal Interview, June, 1972.

9. Elliott, F.C. and T. R. Richmond, Cotton Extension Specialists, and Professor of Cotton Genetics, respectively. Texas A & M University, College Station. Personal Interviews, August and June 1972, respectively.

10. Brooks, O. L. and C. E. Perry, 1961. Cotton production at S.E. Georgia Branch Experiment Station. Georgia Agr. Exp. Sta. Circ. 22.

11. Woltz, W. G., Professor of Soil Science, North Carolina State University, Raleigh. Personal Interview, June 1972.

12. Nettum, George, Manager of Northern Tobacco Pool, Coop., Viroqua, Wisconsin, Personal Interview, July, 1972.

13. Rutline Robert, Tobacco Buyer and Warehouse Management, Liggett & Myers, Inc., Stoughton, Wisconsin, Personal Interview, July, 1972.

14. Thomas, J. G., 1969. Extension Entomologist. The sorghum midge and its control. Texas Agricultural Extension Fact Sheet, L-842.

15. Schertz, Kieth, F., Crop Geneticist, Department of Soil and Crop Science, Texas A & M University, College Station, Personal Interview, June, 1972.

16. Sorenson, J. W., G. L. Kline, L. M. Redlinger, M. G. Davenport and W. H. Aldred, 1957. Farm drying and storage of sorghum grain. Texas Agr. Expt. Sta. Bulletin 885, 23 p.

17. Cooper, W. C., R. H. Young, and F. M. Turrell, 1964. Microclimate and physiology of citrus: their relation to cold protection, Agr. Sci. Rev. (4), 3-4.

18. Hulse, F. E., J. R. Meitin, and H. G. Hamilton, 1966. Pooling by Florida Citrus Cooperative following the 1962 Freeze. U.S.D.A. Farm Coop. Service Market Res. Rept., 764.

19. Rabtholic, J. F., Associate Professor Climatology, Department of Fruit Crops, University of Florida, Ganesville, Personal Interview, June, 1972.

20. Lawrence, F. P., Citrus Extension Specialist. University of Florida, Ganesville, Florida, Personal Interview, June, 1972.

21. Clemmons, W. E., 1963. Grove Heating--A Method of Protecting Florida Citrus. The Citrus Industry 44:18-24.

22. Platt, R. G., Citrus Extension Specialist, University of California, Riverside. Personal Interview, June, 1972.

23. Puffer, R. E. and F. M. Turrell, 1967. Frost Protection in Citrus. California Agricultural Extension Bulletin ATT-108 (Rev.) 8 p.

24. Gerber, J. F. and J. D. Martsolf, 1966. Protecting Citrus from Cold Damage. Florida Agricultural Extension Circ. 287. 29 p.

25. U.S.D.A., 1971, Crop Production. Annual Summary. Statistical Rep. Service. Cr Pr 2-1. 56 p.

26. Brooke, D. L., 1971. Citrus production costs and returns in Florida Season 1969-70 with comparisons. Florida Agr. Ext. Ag. Econ. Rept. 29. 19 p.

27. U.S.D.A., 1972. Statistics of fruits, tree nuts, and horticulture specialities. in Agricultural Statistics, 1971. Statistical Reporting Service.

28. Greene, R. E. L., G. N. Rose, and D. L. Brooke, 1969. Location of Agricultural production in Florida. Florida Agricultural Extension Bulletin 733.

29. Schoenemann, John A., 1969. Typical average potato production costs--medium to large-sized potato farms in Central Wisconsin. Mimeograph sheet University of Wisconsin, Horticulture Department.

30. Schoenemann, John A. Vegetable Extension Specialist, Horticulture Department, University of Wisconsin. Personal Interview, August, 1972.

31. U.S.D.A., 1971. Vegetables--fresh market 1971 Annual Summary. Statistical Reporting Service, Cr Vg 2-2. 61 p.

32. Tibbitts, T. W. and N. A. Meyer, 1969. The significance of accurate weather predictions to the management of certain horticultural crops. Mimeograph Sheet, Horticulture Department, University of Wisconsin.

33. U.S.D.A., 1960. Truck Crop Practices, Farm Production Economics Division, Economic Research Service, ERS-206.

34. U.S.D.A., 1967. Rice in the United States; varieties and production 1966. Agricultural Research Service., Agricultural Handbook No. 289, 124 p.

35. Miller, M. D., Extension Agronomist, Department of Agronomy, University of California, Davis, Personal Interview, June, 1972.

36. Person, Nat K., J. W. Sorenson, Jr., W. E. McCline and Price Hobgood, 1967. The Use of Conditioned Air for Maintaining Quality of Stored Sorghum Grain. Texas Agr. Ext. Stat. Bul. B-1066. 27 p.

37. Hill, F. J., Extension Agronomist, University of California, Davis, Personal Interview, June, 1972.

38. Bonnen, C. A. and W. C. Cunningham, 1964. Selected operating costs for storage of sorghum grain, Texas Agr. Ext. Bul. B-1009.

39. Kasimatis, Armid, Extension Vitologist, Department of Viticulture, University of California, Davis, Personal Interview, June, 1972.

40. Klingbeil, G. C., Extension Pomologist, Horticulture Department, University of Wisconsin, Personal Interview, July, 1972.

41. Klingbeil, G. C. Apple production expenses, Mimeograph Sheet, Horticulture Department, University of Wisconsin.

42. Johnson, Hunter, Vegetable Crop, Extension Specialist, University of California, Davis, Personal Interview, June, 1972.

43. University of California Agricultural Extension Service, 1970. Lettuce sample costs and production. Cost Data Sheet. No. 15. 4 p. Imperial County Court House, El Centro, California.

44. Ballord, J. K. and E. L. Proebsting, 1972. Frost and Frost Control in Washington Orchards. Washington Agr. Ext. Bul. 634.

45. Luroske, C. H., 1962. Washington apple production costs and labor requirements--1960 and earlier years. Washington Agr. Ext. Sta. Bul. 644.

46. Luroske, C. H., 1968. Apple production costs and returns. Washington Agr. Ext. Sta. Bul. 696.

47. O'Rourke, A. D., W. S. Greig, A. H. Harrington, 1972. Apple marketing research in the seventies. Washington Agr. Ext. Sta. Bul. 754.

48. Brooks, R. F., Professor (Entomologist) University of Florida, Lake Alford Agricultural Research and Education Center. Personal Interview. December, 1972.

N 74-22269

BROADCAST MEDIA AND THE DISSEMINATION OF WEATHER INFORMATION

by James Byrnes

SUMMARY

Although television is the public's most preferred source of weather information, it fails to provide weather reports to those groups who seek the information early in the day and during the day. The result is that many people most often use radio as a source of information, yet preferring the medium of television. Radio tends to give less information, but at a much greater frequency than TV, and television stations give significantly less coverage to weather information on weekends, when public interest in the information increases.

The public actively seeks weather information from both radio and TV stations, usually seeking information on current conditions and short range forecasts.

Nearly all broadcast stations surveyed in this study were eager to air severe weather bulletins quickly and often.

Interest in Nowcasting was high among radio and TV broadcasters, with a significant portion indicating a willingness to pay something for the service. However, interest among TV stations in increasing the number of daily reports was small.

INTRODUCTION

Weather information reaches the public through many channels, but none so popular and ubiquitous as the broadcast media of radio and television. Surveys have shown these two to be the most liked and used sources for weather information by the general public,[1] and specific user groups.[2]

There has been a notable lack of study in the past on weather information dissemination practices in radio and television. The following survey of Wisconsin TV and radio stations, then, was approached as an exploratory study to find out what weather information these media broadcast; when and from where this information is obtained, and related factors as they apply to one midwestern state.

METHODOLOGY

The data gathering instrument used was an interview schedule (hereafter called a questionnaire), administered by telephone.[3] The questionnaire[4] used for the survey was drawn up after extended interviews with one TV and one radio news director, and a weather station director. After numerous revisions and a pretest on one TV station and two radio stations, the questionnaire was put into its final form.

The total population of Wisconsin TV stations (19) was surveyed, as well as 50 radio stations, which constitute roughly one-third of the radio stations in Wisconsin (the total is 165 which includes approximately 30 duplicated broadcast stations). The radio sample was chosen at random after first deleting the FM half of any station which duplicates broadcasts on both AM and FM.

Of the 19 TV stations, the three public broadcasting stations did not broadcast weather information, and hence were not interviewed. Of the original 50 radio stations in the sample, there were three non-responses, two of which were public stations, owned and operated by regional universities, and closed down for the summer. The third was a private station which declined to be interviewed. Three additional stations were then randomly selected from the population to replace these non-responses. One station of the 50, which was completely automated, did not broadcast weather information, so that the final radio sample numbered 49.

Interviews with TV stations were completed during the period from April 28 to May 5, 1972, and the period May 22 to May 30, 1972 was used to interview radio station personnel. Interviews were held with news directors, or, if the news director was not available, any member of the news or weather staff. Callbacks were used extensively to preserve as closely as possible the original sample characteristics.

RESULTS - TELEVISION

QUESTION 3: In the usual broadcast day, how many scheduled weather reports does your station give?

The range of responses for TV stations is from one to eight scheduled reports. The modal response is three (half of the 16 stations broadcast this many weather reports).

The number of scheduled weather reports does not appear to be significantly affected by station size or by geographic location.

Table 1 shows that there is no apparent relationship between station size and number of scheduled weather reports. While the small stations have the entire range from one to eight and the medium and large stations are grouped more closely around the mode of three, the numbers are too small to be significant.*

Table 1

Number of Reports by Size of Television Station

Number of Reports	TV Station Size Small	Medium	Large	Total
1	1	1		2
2	2			2
3	3	3	2	8
4			1	1
5		1		1
6	1			1
7				0
8	1			1
Total	8	5	3	16

Station size is defined by cost for one minute of advertising, one time, during prime time (fixed positions, non-preemptible, if applicable). Small stations, $0-199/min., medium stations, $200-499/min., large stations, $500 +/min.

* Author's note: The small station which gave eight weather reports per day has recently ceased broadcasting, so that at the present, six reports per day is the maximum in the state.

Table 2 shows that there is little apparent difference between the south-urban stations and the upstate stations. The two cases of more than five reports per day occur, however, in upstate stations with their more rural audiences. But, the mode for both groups is still three.

Table 2

Number of Reports by Geographic Location of Station

Number of Reports	Location of TV Station South-Urban	Upstate	Total
1	1		1
2	1	2	3
3	3	5	8
4	1		1
5	1		1
6		1	1
7			0
8		1	1
Total	7	9	16

South-urban stations are Madison and Milwaukee based, Upstate stations are all others.

Table 3 shows the frequency of reports for different hours of the day, comparing south-urban stations with upstate stations.

Table 3

Number of Reports for Each Hour of the Broadcast Day

	6	7	8	9	12 noon	5	6	10	11	12 midnight
Upstate	2	4	3	1	5	2	7	8		1
South		1			4	1	7	6	1	2

Four stations give weather reports before noon, and three of those are upstate stations. Thus a large segment of the audience in the state is not able to receive local or state weather forecasts from its local station in the morning. However, they may get fragmentary information from a national report carried on a morning network show such as NBC's Today show.

These results suggest that television does not now play a very important role as a source of immediate local or statewide weather information for people during their working days. TV supplies weather information mainly in the evening.

QUESTION 5: Do these reports differ in length?

The range of responses is from one to six minutes, with the mean of times being 3.5 minutes, the mode being 5 minutes. The northern stations not only give slightly more reports, but also give longer reports on average. The mean for the upstate stations' reports is 3.8 minutes, while the mean for the south-urban stations' is 3.1.

QUESTION 6: Does this format change on weekends? How does it change?

All stations change their formats on weekends, 14 of the 16 stations give fewer reports on Saturday (the remaining two have the same format for Saturday), and 15 of the 16 stations give fewer reports on Sunday (the remaining station having the same format as on weekdays). Some stations gave no reports at all on Sunday, and most greatly reduced the number of reports given.

QUESTION 7: At any time in the year does your station give any forecasts which would be directed to any special interest group?

Seven stations do, nine do not.

(Continued) Who are they? (The interest groups)

Five stations gave forecasts relating to sport or recreation (snowmobilers, skiers, boaters, fishermen), three gave forecasts for cranberry growers, and one station gave a forecast for aviators.

QUESTION 8: (List of things that are included in a weather report)

The results in Table 4 show a noticeable similarity among the stations, south-urban and upstate, in what is and is not included in their weather reports. There appears to be a small difference when the content is broken down by station size (Table 5). The larger stations appear to include slightly more information.

Table 4

Location of TV Station and Completeness of Weather Reports

	South-Urban			Upstate		
	Always	Sometimes	Never	Always	Sometimes	Never
Current temperature	7			9		
Forecast temperature	7			9		
Current sky conditions	5	2		6	3	
Forecast sky conditions	6	1		7	2	
Precipitation prob.	4	2	1	6	3	
Amount of previous precipitation (24 hrs)	4	3		4	4	1
Wind direction	7			8	1	
Wind velocity	7			8	1	
Humidity	7			8	1	
Pollen index (when in season)	3	1	3	2	2	5
Pollution index	-	1	6			9
Barometric reading	7			8	1	
Local forecast	7			9		
Regional forecast	4	2	1	8	1	
National forecast	2	1	4	4	2	3

QUESTION 9: Do you have a special person assigned to prepare your weather reports for broadcasting?

All but four stations have a special person assigned to prepare

Table 5

Size of TV Station and Completeness of Weather Reports

	Large & Medium (8)			Small (8)		
	Always	Sometimes	Never	Always	Sometimes	Never
Current temperature	8			8		
Forecast temperature	8			8		
Current sky conditions	7	1		4	4	
Forecast sky conditions	7	1		6	2	
Precipitation prob.	5	2	1	5	3	
Amount of previous precipitation (24 hrs)	6	1	1	2	6	
Wind direction	8			7	1	
Wind velocity	8			7	1	
Humidity	8			6	1	1
Pollen index (when in season	5		3		3	5
Pollution index			8		1	7
Barometric reading	8			7	1	
Local forecast	8			8		
Regional forecast	6	1	1	6	2	
National forecast	4	2	2	2	1	5

their weather reports. Some of the persons assigned to prepare the reports also have other duties. The four that do not are all small stations, and whoever is on duty at the time prepares the weather reports.

9a. Has he had any meteorological training?
9b. What kind of training?

Six of the stations have a person with meteorological training of some sort, two have degrees in meteorology, three have had experience with the Weather Bureau, and one has had pilot training.

QUESTION 10: Do you have a policy regarding the rewording of weather forecasts?

Table 6 shows the very even distribution of stations from slight freedom to complete freedom in changing the wording of weather forecasts.

Table 6

Editing Policy on Changing Forecast Wording

	Use as Given	Slight freedom to change	Complete freedom to change
Number of Stations	5	6	5

QUESTION 11: Where does your station get its weather information?

Table 7

Size of TV Station and Sources of Weather Information

	Station Size		
	Large	Small	Total
NOAA weather wire	6	2	8
A local weather station	4	3	7
A news service wire	3	6	9
A private meteorologist	0	1	1
Other	0	1	1
Total			26

Note that a majority of stations use more than one source. Nine stations give two sources of weather information, the usual combination of sources being a news service wire and a local weather station (4), followed by a news service wire and the NOAA weather wire (3).

QUESTION 12: How satisfied are you with (name the source) as a source?

Only four of the nine stations using a news service wire for weather information expressed themselves as "very satisfied" with it. Four were "somewhat satisfied," and one was "dissatisfied." Six of the eight stations using the NOAA weather wire expressed themselves as "very satisfied," the remaining two described themselves as "somewhat satisfied." All but one of the seven stations using a local weather station as a source were "very satisfied." The remaining station was "somewhat satisfied."

Thus, the NOAA wire and the local weather stations have very good acceptance generally among the TV stations, while the news service wire information is apparently less well accepted. Reasons for dissatisfaction with the wire services were:

- Too slow (mentioned twice)
- Not enough local information (mentioned twice)
- Not frequent enough (mentioned once)

QUESTION 13: How often during the broadcast day does (the source mentioned) supply updated information to you?

Table 8

Source of Weather Information by Frequency of Updating

Number of Updates	NOAA Wire	Local Weather Station	News Service Wire	Private Meteorologist	Other
1					
2		2	2		
3		1	1		
4	1	2	4		
5					
6	1				
7					
8				1	
9 or more	6	2	2		

This question is of uncertain value in regard to the wire services, the NOAA weather wire as well as the Associated Press and United Press news service wires, since the times for routine updating of forecasts are fairly stable. In general the respondents seemed unsure of the frequency of updates of forecasts and other information. At best, the results might be used as a rough gauge of the respondents' familiarity with their sources' practices, which seems to range from complete familiarity to uncertainty.[5]

QUESTION 14: How often during the broadcast day does your staff consult your source(s) to update your weather reports?

Fifteen responses were obtained for this question, ranging from one time to hourly. The modal response was three times (9 of 15), one station consulted its source (UPI) once daily for weather information, about 40 minutes before their only weather report. Two stations consulted twice a day, one four times daily, one eight times daily, and one hourly. Generally, stations consult their sources only before the scheduled weather reports, which is usually three times per day (Table 9).

Table 9

Number of Times Sources are Consulted

Times Stations Consult Sources	Frequency of Stations
B*	1
1	1
2	2
3	9
4	1
5	0
6	0
7	0
8	1
9	1

*B = non-response

QUESTION 15: What would you estimate to be the average time between when you get weather information and when you put it on the air?

The range of responses for time taken to air the weather information is spread quite evenly over a period up to one hour (Table 10). There was some hesitancy from many respondents in answering this question, which may indicate that the estimates are of uncertain value.

Table 10

Time Lag between Information Reception and Broadcasting

Time Taken to Air Information	Number of Respondents
0-14 min.	4
15-29 min.	2
30-44 min.	4
45-59 min.	4
60+ min.	1
	15

QUESTION 16: Have you ever received any feedback from your audience about your weather reports?

Ten of the 16 stations have received feedback of some sort, nine receiving favorable feedback, seven receiving critical feedback.

The most frequently mentioned items for favorable feedback were:

> The presentation of or the personality giving the weather reports (7 mentions).
>
> Accuracy was mentioned three times as what the public liked about the weather reports.
>
> Detail or thoroughness of report was mentioned three times.
>
> Brevity was mentioned once.

Of the seven stations that said they received critical feedback:

> Three mentioned that the public wanted more information.
>
> One mentioned that the public wanted less detail on the national weather, more local details.
>
> One mentioned that some of the public disliked the personality giving the report.
>
> One mentioned complaints when the reports were inaccurate.

QUESTION 17: Do members of the public ever call your station for weather information?

All of the TV stations interviewed received calls from the public for weather information, and for the 14 stations that estimated the number of calls they received from the public for weather information, the average is 23 calls per week. The greatest number of calls received was 75 per week; the least 3 per week (Table 11). Most of the respondents emphasized the unpredictability of the number of calls from day to day. In general, they said that the number of calls increased with bad weather and with sporting events or other public functions.

Table 11

Number of Calls per week	Number of Stations
b*	3
5-9	2
10-14	4
15-19	2
20-24	0
25-29	0
30-34	0
35-39	2
40-44	1
45-49	0
50-54	1
55-59	0
60-64	0
65-69	0
70-74	0
75-79	1
	16

*b = non-response

The number of calls per week is not affected by station size or geographic location.

QUESTION 17b: What information do they usually ask for?

Over half of the calls were for short range local forecasts and travelling conditions (Table 12).

Table 12
Information Sought When Calling Station

Type of Information Asked for	Number of Responses
Travel Conditions	6
Recreation/Sports	3
Local forecast, short range	7
Local forecast, long range	3
Non-local forecast, short range	0
Non-local forecast, long range	0
Local current conditions	3
Current conditions, elsewhere	1
	23

Note the interest in short-range forecasts and current conditions. This interest does not appear to be served adequately by the television reports alone, since the majority are in the evening and few in number.

QUESTION 18: Does your station have a special procedure for broadcasting severe weather?

All stations answered yes, and mentioned different sources from which they get the severe weather notices. Some got notices from more than one source, such as the weather bureau, police, NOAA weather wire or a news service wire. Most stations interrupted normal programming for severe weather warnings, and waited for a normal break in programming to air severe weather watches.

Three stations mentioned an automatic audio feed from a weather station, four mentioned only the NOAA weather wire as their source of warnings, and one mentioned UPI as its only primary source. This station, after receiving a warning from UPI, would check with the local weather station for an update of the warning. One station gives a warning aimed at the deaf audience, and one station gives radar pictures from their own radar facility.

Overall, the TV stations said they put the warnings on the air as soon as possible after they received them (the usual estimate being around 30 seconds to one minute), and mentioned a multiplicity of sources, with no preference expressed for any source as superior to any other.

After hearing a short description of Nowcasting (Question 19, on questionnaire), the respondents were told that to use Nowcasting information, it would probably entail some additional time and effort on the part of their staff. This is not necessarily the case, but was included in an attempt to get a more realistic assessment of genuine interest in using Nowcasting information and willingness to pay for this information. The results seem to indicate a high degree of interest among TV stations in Nowcasting (Table 13).

QUESTION 19: Would you be interested in using Nowcasting information in your reports?

QUESTION 19a: Would you be willing to pay for this service?

There is a little difference in interest in using Nowcasting by station size. Comparing the 8 largest stations to the 8 smallest:

Table 13
Interest in Nowcasting by Station Size

	Interested in Using Nowcasting			Willing to Pay for Nowcasting		
	Large	Small	Total	Large	Small	Total
Definitely Would be	2	6	8	1	5	6
Probably Would be	3	0	3	3	0	3
Don't Know	3	1	4	4	2	6
Probably Wouldn't be	0	1	1	0	1	1
Definitely Wouldn't be	0	0	0	0	0	0
			16			16

The larger stations seem to be more hesitant to commit themselves with a strong expression of interest or disinterest, but the direction towards interest in Nowcasting is the same for both large and small stations.

QUESTION 20: Any comments?

"The only thing we could use that we don't have now is a visual service, something to show the audience about what is happening to the weather."

"I think the weather bureau could improve on advance warning of severe weather. We have a wider area of service than they use for notifying us."

"We just try to get the basics across, no more,...only what the public wants, no more." (Or, another, similar:) "We believe in keeping terms simple for the public."

"I would like more time on the air for adequate reporting of the weather, including weather features, education programs...."

"We run a special tornado program (educational) twice in the spring to tell the viewers what to do if one strikes."

"It's working out rather well for us with professional meteorologists broadcasting the weather shows."

"Would like more accuracy, of course...." (commented twice)

RESULTS - RADIO

The number of scheduled weather reports for radio stations varied from three to over one hundred. The mean for responses is 33.6 reports per day, and the mode, when the responses are grouped into intervals of five, is between 20 and 24, (16% of the sample), with over half of the sample (55%) giving more reports ranging to over one hundred.

Table 14

Radio Stations by Number of Reports

Number of Reports	under 5	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85 & over
Number of Stations	5	3	0	6	8	4	4	3	4	0	1	3	2	0	1	2	2	1

Larger stations tend to give more reports than smaller stations, the product moment correlation between size and number of reports being .291, significant statistically at $p < .05$ level, where size is determined *by the cost of one minute, one time, of advertising during prime time.*

Table 15

Frequency of Radio Stations Giving 1-6 Reports by Hour of Day

Hours (a.m.)	Number of Reports 1	2	3	4	5	6	Average Number of Reports
24:00	6	4	0	3	0	1	2.33
01:00	4	3	1	0	0	1	1.50
02:00	4	3	1	0	0	0	1.33
03:00	3	3	1	0	0	0	1.16
04:00	3	3	1	0	0	0	1.16
05:00	12	6	2	3	1	1	4.16
06:00	16	13	6	8	1	1	7.50
07:00	11	12	9	10	3	1	7.66
08:00	11	17	5	8	1	1	7.16
09:00	14	10	6	8	0	1	6.50
10:00	15	12	4	8	0	1	6.66
11:00	17	13	5	8	0	1	7.33
Hours (a.m.)	Number of Reports 1	2	3	4	5	6	Average Number of Reports
12:00	13	16	5	10	0	1	7.50
13:00	16	12	5	8	0	1	7.00
14:00	15	10	6	8	0	1	6.66
15:00	15	12	6	8	0	1	7.00
16:00	14	13	7	8	0	1	7.16
17:00	14	14	6	9	0	1	7.33
18:00	16	13	4	9	0	1	7.16
19:00	14	12	4	8	0	1	6.50
20:00	16	9	3	2	0	1	5.16
21:00	11	6	3	2	0	1	3.86
22:00	13	6	3	2	0	1	4.16
23:00	8	5	3	2	0	1	3.16

The average number of reports when computed from the listing of times given in question 4 is 34.9 per day, slightly higher than the average for question 3 (33.6), the respondents' estimates. This indicates a light underestimation of the number of reports on the part of the respondents before they list the individual reports by their times.

The average length of reports is 1.7 minutes, with a standard deviation of 1.5. The range of report lengths was from 15 seconds to 10 minutes.

According to one previous study, the most popular times for seeking forecasts are 10 p.m., 7 a.m., 11 p.m. and 8 a.m., in that order,[6] but with great variance according to different age groups. While television stations give reports most often at 10 p.m., radio is the only available source at other peak periods of public demand (Table 15).

Weekend Format Changes

Twenty-two stations (45% of the sample) said that the number of scheduled reports changed during the weekend, 13 had fewer reports on Saturday while 21 had fewer on Sunday (Table 16). Only one respondent said his station had more reports on the weedend. Those took the form of short unscheduled reports during disc jockey shows.

Table 16

Scheduled Reports During Weekends

Saturday	Number of Stations	Percent of Stations	Sunday	Number of Stations	Percent of Stations
No change	24	55.1	No change	27	55.1
Fewer reports	13	26.5	Fewer reports	21	42.9
More reports	1	2.0	More reports	1	2.0
No change	8	16.3	No change	0	0.0

Special Forecasts

31 (63%) of the stations said they gave special forecasts directed to

special interest groups. Of these, over half (55%) gave special forecasts related to sport and recreation, over one third (39%) gave special forecasts related to agriculture (the predominant response here was special forecasts for cranberry growers), one station gave special travel forecasts, and one gave flood warning forecasts as well as recreational forecasts.

Content of Reports

Content of reports is not related to the size of the station, its geographic location, or city size.

Table 17
Content of Reports

	Always	Sometimes	Never
Current temperature	48	0	1
Forecast temperature	42	7	0
Current sky conditions	24	20	5
Forecast sky conditions	33	14	2
Precipitation probability	33	14	2
Amount of previous precipitation (24 hrs.)	2	31	16
Wind direction	27	18	4
Wind velocity	26	20	3
Humidity	11	21	17
Pollen index (when in season)	3	16	30
Pollution index	0	8	41
Barometric reading	18	22	9
Local forecast	48	1	0
Regional forecast	20	27	2
National forecast	3	29	17

Staff Training

Four of the 49 stations have special persons assigned to prepare the weather reports; none of the individuals have had meteorological training of any kind.

Editing Policies

The majority of stations said they read the weather forecasts slightly modified or as given by their source (Table 18). Only one sixth of the respondents said that they were free to change or interpret the forecasts freely.[7]

Table 18

Radio Stations with Freedom to Change Forecasts

Use as given	22	45%
Slight freedom to change	19	39%
Complete freedom to change	8	16%
	49	100%

Sources

By far the most popular source for weather information for radio stations is a news service wire, followed by "other" sources. Most of the "other" sources were local reporting stations, such as a local airport or sewage treatment facility, which was consulted for current conditions, amount of rainfall, and weather statistics, but not a forecast.

Table 19

Sources Used for Weather Information

	Number of Stations	Percent of Stations
NOAA weather wire	12	25%
A local weather wire	9	18%
A news service wire	38	78%
A private meteorologist	6	12%
Other	27	55%

Fifteen stations used only one source:

6 NOAA weather wire

2 A local weather station

7 A news service wire

Twenty-seven stations use two sources, most of these (19) a news service wire and an "other", usually a local reporting station for current conditions. The next most common combination is a news service wire and a local weather station (3). Five stations use three sources, and two stations use four sources.

Satisfaction with Sources of Information

The greatest degree of dissatisfaction with sources comes from those who use a news service wire (Table 20). The most common complaint is that their information is not sufficiently locally oriented (33% of reasons given), followed by the complaint that the wire service is too slow (28% of reasons given) (Table 21).

Table 20

Satisfaction with Sources Used

Source	Very Satisfied	Somewhat	Dissatisfied
NOAA wire	9	2	0
Local weather station	5	2	2
News service wire	14	18	5
Private meteorologist	5	1	0
Other	19	5	1

Table 21

Reasons for Dissatisfaction with Source

News Service Wires	No. of Stations	% of Stations
Too slow	5	28%
Not accurate enough	3	17%
Not frequent enough	3	17%
Not enough local information	6	33%
Poor weekend service	1	5%
Local Weather Station		
Not accurate enough	1	
Not enough local information	1	

Other	No. of Stations	% of Stations
Not accurate enough	1[a]	
Poor weekend service	1[b]	

[a]The radio station's own instruments.

[b]State owned public network weather round-up, does not broadcast Saturday and Sunday.

Currency of Reports

Again, the results of Question 13 are of uncertain value, although there is less variance in radio responses than in television.

Table 22

Source of Weather Information by Frequency of Updating

Number of Updates	NOAA Wire	Local Weather Station	News Service Wire	Private Meteorologist	Other
1	0	1	0	0	3
2	0	0	0	0	0
3	0	1	10	2	1
4	3	2	15	2	1
5	1	0	5	0	0
6	0	0	0	0	2
7	0	0	1	0	0
8	0	0	0	0	0
9 or more	6	1	2	0	5

The results of Question 14 for radio stations are probably not very meaningful, since the nine or more row is inflated by "constantly" or "almost constantly" responses for the wire services, their own instruments, or other sources (Table 23).

Table 23

Number of Times Sources Consulted for Updates

Times Stations Consult Sources	Number of Stations
3	6
4	9
5	1
6	1
7	2
8	0
9 or more	30

In order to get more specific information on this subject, more specificity in the questions would be needed for both sources and type of information sought.

Length of Weather Forecasting Programs

Seventy percent of radio stations estimated the time taken to air weather information to be less than 15 minutes (Table 24). This estimate seems to have face validity, in view of radio's more frequent reporting of the weather and less preparation prior to airing the information. The amount of time taken to air weather information is not related to the frequency of consulting sources for information.

Table 24

Time Taken to Air Information

	Number of Stations
0-14 min.	35
15-29 min.	6
30-44 min.	5
45-59 min.	1
60 + min.	2

Public Feedback

Fifty-nine percent of the sample received feedback of some sort, and of those, more than half received favorable feedback. Feedback did not appear to be related to station size (Tables 25 and 26).

Table 25

Unfavorable Feedback to Radio Stations

Item disliked	Number of Stations	% of Stations
Not enough information	5	24%
Not accurate enough	13	61%
Too frequent	0	0%
Too complex	1	5%
Not understandable	2	9%

Table 26
Favorable Feedback to Radio Stations

Item Liked	Number of Stations	% of Stations
Frequency	2	15%
Thoroughness	3	23%
Accuracy	3	23%
Other	5	38%

The five "other" responses for favorable feedback were noncommittal (Table 26); the respondents merely said that the public liked their weather reports without stating what they liked about them. Lack of accuracy was the main complaint, and was mentioned 13 times (Table 25).

Stations in the northern part of the state seemed to have received more feedback than those in the southern part (Table 27).

Table 27
Having Received Feedback by Station Location

Received Feedback	South	North
Yes	10	19
No	9	11

Calls from the Public for Weather Information

Only one station received no calls from the public for weather information. Nearly one-third had under five calls per week or were unaware of the amount they received (Table 28). If the eight stations which were unaware of the amount of calls they received were excluded, then the average for all stations would be 18.5 calls per week.

Most callers seemed to be interested in what the weather was at that moment or would be in the near future (Table 29). Note the strong interest in local forecasts, short range and local current conditions. It would seem that the frequency and content of most radio reports would presently make the medium of radio more useful than television in filling the public's desire for this type of information.

Table 28
Number of Calls from the Public for Weather Information

Number of Calls per week	Number of Stations
no estimate	8
0	6
5	7
10	9
15	4
20	5
25	2
30	2
35	1
40	1
45	0
50	2
55	1
60	0
65	0
70	1
	49

Table 29
Information Sought by the Public

Type of Information Asked for	Number of Responses	% of Responses
Travelling conditions	11	13%
Recreation/sports	5	6%
Local forecast, short range	29	34%
Local forecast, long range	11	13%
Non-local forecast, short range	2	2%
Non-local forecast, long range	1	1%
Current conditions, local	25	29%
Current conditions, elsewhere (includes multiple answers)	2	2%

Special Procedure for Severe Weather

Four of the (STET) stations said they had no special procedure for broadcasting severe weather. Of those that did have a special procedure, nearly all included immediate interruption of programming, and most had a set form to read or a recording to play. The sources mentioned specifically most often for severe weather information were the news service wires (9), followed by local weather bureaus (8), and by police (6). The usual estimate for the amount of time taken to get a warning on the air is 30 seconds.

Nowcasting

While the interest in using Nowcasting information was high among respondents at radio stations, the willingness to pay for this information was much lower (Table 30). Size of station does not appear to be related to interest in using Nowcasting information (r = -.065), and appeared to make only a slight difference in willingness to pay for Nowcasting information (r = .108).

Table 30
Interest in Nowcasting

	Interested in Using Nowcasting		Willing to Pay for Nowcasting	
Definitely would be	36	74%	6	12%
Probably would be	9	18%	14	29%
Don't know	2	4%	22	45%
Probably wouldn't be	1	2%	3	6%
Definitely wouldn't be	1	2%	4	8%

Interest in using Nowcasting information is not clearly related to the amount of time spent on weather (total minutes spent per day on weather reports: r = -.123), nor is it related to the amount of information given in reports (r = -.015), nor the number of sources presently used (r = .183). Willingness to pay for Nowcasting is not related to any of these variables either.

Radio Station Comments (elicited from Question 20)

"We especially like our local connection with the airport (Arrowhead) for local information."

"We would like to be able to give more accurate forecasts."

"We would like more stations around the area where we could call for information about the weather and highway conditions."

"More specific road conditions information really is needed."

"We put on as much weather information as possible, try to keep the public informed. We think that's our job."

"We carry WHA's (a state owned station) state weather roundup, and people like it."

"We would like to see better weather forecasting from UPI, we use the 'Twin Cities' forecast instead, and find it's more accurate."

"Regional division of weather areas aren't necessarily relevant; we're located near the state line, and the weather information for adjacent area is sometimes more appropriate than what we actually get."

"One complaint -- We're in the northern part of the state, so we can't get the NOAA weather wire. The state can pay millions for the state radio stations, but nothing to extend the weather wire northward."

"Weather is such a local phenomenon -- crops, recreation ... all rely on weather."

"UP zones leave this area 'out in left field' -- we're on the border of three zones."

"Coverage (forecasts) seems to be getting more accurate with time, but we would like more localized forecasts, that's why we went to a private meteorologist."

"We have a recorded weather tape that people can dial for weather information."

COMPARISON OF RESULTS - RADIO AND TV

Radio stations tend to give more reports of shorter length than television stations, with less information in the reports and with more emphasis on local and regional forecasts (Tables 31 and 32).

Table 31
Number and Length of Reports by Medium

	Radio	Television
Average Number of Reports	34.9	3.4
Average Length of Reports	1.7 min.	3.5 min.

Table 32
Content of Reports by Medium

	Radio			Television		
	Always	Sometimes	Never	Always	Sometimes	Never
Current temperature	98	0	2	100	0	0
Forecast temperature	86	14	0	100	0	0
Current sky cond.	49	41	10	69	31	0
Forecast sky cond.	67	29	4	81	19	0
Precipitation prob.	67	29	4	63	31	6
Amount of previous precip. (24 hrs)	4	63	33	50	44	6
Wind direction	55	37	8	94	6	0
Wind velocity	53	41	6	94	6	0
Humidity	22	43	35	88	6	6
Pollen index (when in season)	6	33	61	31	25	44
Pollution index	0	16	84	0	13	88
Barometric reading	37	45	18	94	6	0
Local forecast	98	2	0	100	0	0
Regional forecast	41	55	4	75	19	6
National forecast	6	59	35	38	19	44

TV stations tend to have a special person assigned to the preparation of their reports, and while none of those assigned by radio stations in the sample had any meteorological training, half of those assigned by TV stations have some sort of meteorological training (Table 33).

Table 33
Special Staff for Weather Reports

	Radio		Television	
Special person assigned	Yes	8%	Yes	75%
	No	92%	No	25%
Any meteorological training	Yes	0%	Yes	50%
	No	100%	No	50%

While all of the television stations gave fewer weather reports on the weekends, only half of the radio stations sampled gave fewer reports.

Table 34
Weekend Changes in Reports

	Radio	Television
Fewer weekend reports	43%	100%
No change	55%	0%
More weekend reports	2%	0%

This decrease in weather information during the weekend is notable in light of the results of a survey of Wisconsin residents,[9] which showed an increase in interest in the weather for the weekend. The public was asked: "Do you look more to the weather reports for weekends or weekdays?" Nearly 40% of respondents showed more interest in weekend weather reports than weekday reports. Only 21% looked more for weekday forecasts.

Special forecasts are given by a greater proportion of radio stations than television, but the majority of special forecasts on both media are directed to audiences interested in sports or recreation (Table 35).

Table 35
Special Forecasts by Medium

Special Forecasts Given	Radio	Television
Yes	63%	44%
No	37%	56%

Radio stations seem to use less freedom in changing the wording of forecasts than television stations, although the difference is not great (Table 36).

Table 36
Forecast Editing Policies

	Radio	Television
Use as given	45%	31%
Slight freedom to change	39%	38%
Complete freedom to change	16%	31%

Radio stations seem to have less of a time lag between getting weather information and putting it on the air. Their greater frequency of reports and lack of need for visual representation enables radio stations to put updated information on the air with a minimum of delay (Table 37).

Table 37
Time Before Airing Information

	Radio	Television
No estimate	0%	6%
0 to 14 min.	71%	25%
15 to 29 min.	12%	13%
30 to 44 min.	10%	25%
45 to 59 min.	2%	25%
60 min. and over	4%	6%
	99%*	100%

*1% lost in rounding

Television stations seem to have received more favorable feedback than radio stations (Table 38). The main topics of favorable television feedback were compliments on a station's presentation, thoroughness, and accuracy, while the main topics of favorable radio feedback were thoroughness and accuracy.

Table 38
Feedback by Medium

Critical Feedback	Radio	TV	Favorable Feedback	Radio	TV
No feedback	41%	37%	No feedback	41%	38%
Critical feedback	33%	44%	Favorable feedback	31%	56%
No critical feedback	16%	19%	No favorable feedback	28%	6%

While the interest in using Nowcasting information is higher among radio stations than among television stations, the willingness to pay for Nowcasting is lower among radio stations than television stations, (Table 39). This might be accounted for by TV stations' larger budgets and the visual potential of Nowcasting reports.

Table 39
Interest in Nowcasting

	Use Nowcasting		Pay for Nowcasting	
	Radio	TV	Radio	TV
Definitely would	74%	50%	12%	31%
Probably would	18%	19%	29%	25%
Don't know	4%	25%	45%	38%
Probably wouldn't	2%	6%	6%	6%
Definitely wouldn't	2%	0%	8%	0%

DISCUSSION

Television stations tie their weather reports in with news and sports, usually giving three reports per day. Two of these reports are usually in the evening hours, at six and ten o'clock, with the third report sometimes at noon. The vast majority of the state's population cannot get access to timely, locally oriented weather information through television except at these times.

While TV stations usually have multiple and better sources for obtaining the weather information they use, the information's timeliness is lost because of the few number of reports given and the time lag between receiving the information and broadcasting it. Radio stations, on the other hand, tend to have less efficient and reliable sources, yet give more reports, so that they are disseminating less information more often. The result is that their weather reports are short and concise, but often obsolete.

The northern, more rural oriented TV stations tend to give slightly more and longer weather reports than do the south-urban stations. This may be accounted for by a greater interest in the weather by their more rural audiences. However, this does not carry through to radio stations, where the larger (and more urban oriented) stations tend to give slightly more and longer reports.

Weekend coverage of weather is poor on television due to the greatly decreased number of reports. Radio stations also decreased weekend coverage, but to a lesser extent and with less net impact due to the greater number of reports per day.

Radio stations usually air weather information sooner upon receiving it than do TV stations; however, they also tend to receive less information from fewer sources. The public tends to actively seek weather information more from TV stations than radio stations, which may be due to a greater credibility in TV weather reports. Nevertheless, most callers to both radio and TV stations wanted to know current conditions and short range forecasts, often related to specific activities.

Regarding severe weather reports, nearly all stations interviewed were eager to put on severe weather bulletins as quickly as possible. The problems most often expressed were: receiving bulletins too late, and bulletins worded in a confusing manner.

Interest in Nowcasting appeared to be high in both media, with a significant number of stations willing to bear part of the expenses of such an operation. However, TV stations seemed less willing to increase the frequency of their reports. Weather information might best be provided by cable television companies which would be able to devote one of their many channels to weather information exclusively. Although the number of persons in the state presently being served by cable television is very small, it is expected to increase significantly in the near future.

It appears that the broadcast stations act primarily as one-way transmitters of weather information, from the Weather Bureau to the public, with almost no feedback from the public getting back to the Weather Bureau through the stations or from the stations concerning weather report content and format.

The results indicate that radio stations change weather reports little from the form in which they are received. TV stations tend to change the form of reports received to a greater degree. Changes that were made were usually an attempt to increase clarity and reduce vagueness.

Comparing the needs the public has expressed in other studies and the extent to which it actively seeks weather information to what the media are providing, indicates that improvement is needed in providing visual, easily accessible, frequently updated and useable reports, with greater weekend coverage.

APPENDIX A

Cover Sheet

Interviewer:____________________ Sample No.__________________

Date:__________________________

____

____

Hello, I'm _____________from the University of Wisconsin Space Science Center. May I speak with your news director?
I'm_____________from the University of Wisconsin Space Science Center. We are doing research on the broadcasting of weather information. I would like to ask you a few questions about your station's weather broadcasting.

Interviewee's name__________________________ and title____________________

Call Box

Call no.	date	hour	to whom did you speak	result of call

Best time to call:

Interview schedule   Sample no.________

Radio only: I want you to think only in terms of station_________, even if you are also associated with another station.

1. To begin with, what type of programming does your station broadcast according to NAB classification?

__ Middle-of-the-road	__ Religious
__ Popular	__ Classical
__ Top 40	__ Old Time
__ Country and Western	__ Black
__ Variety	__ General
__ Educational	__ Other (specify)
__ Contemporary	

2. Does your station broadcast weather information?

Yes (GO TO Q 3)   No 2a, Why not? ______________________________

____

________________ TERMINATE INTERVIEW

3. In the usual broadcast day, how many scheduled weather reports does your station give?

______

4. At what regular times does your station give weather reports?
LIST TIMES VERTICALLY BY HR:MIN

TIMES   LENGTH

5. Do these reports differ in length?
LIST LENGTH AFTER TIMES

6. Does this format change on weekends?

YES   NO (GO TO Q 7)

6a. How does it change? ______________________________

____

____

7. At any time in the year does your station give any forecasts besides the normal forecasts which would be directed to any special interest group?

YES NO
(GO TO Q 8)

7a. Who are they? ______________________

8. I'm going to read a list of things that could be included in a weather report. Could you tell me whether you always, sometimes, or never include these things in one of your weather reports?

CURRENT TEMPERATURE	A	S	N
FORECAST TEMPERATURE	A	S	N
CURRENT SKY CONDITIONS	A	S	N
FORECAST SKY CONDITIONS	A	S	N
PRECIPITATION PROBABILITY GIVEN IN PER CENT OF CHANGE	A	S	N
AMOUNT OF PREVIOUS PRECIPITATION IN THE PRECEDING 24 HR. PERIOD	A	S	N
WIND DIRECTION	A	S	N
WIND VELOCITY	A	S	N
HUMIDITY	A	S	N
POLLEN INDEX WHEN IN SEASON	A	S	N
POLLUTION INDEX	A	S	N
BAROMETRIC READING	A	S	N
LOCAL FORECAST	A	S	N
REGIONAL FORECAST	A	S	N
NATIONAL FORECAST	A	S	N

9. Do you have a special person assigned to prepare your weather reports for broadcasting?

YES NO
(GO TO Q 10)

9a. Has he had any meteorological training?

YES NO
(GO TO Q 10)

9b. What kind of training? ______________________________

10. Do you have a policy regarding the rewording of weather forecasts? (IF NO RESPONSE) That is, is your staff free to change the wording or interpret the meaning of the weather forecast, or do they read it in the same form as it is received from your source, or what?

____

____

____

11. Where does you station get its weather information?

	very satisfied	somewhat	dissatisfied
__ the NOAA weather wire	____	____	____
__ a local weather station	____	____	____
__ a news service wire	____	____	____
__ a private meteorologist	____	____	____
__ other (specify)	____	____	____

(NAME THE SOURCE)

12. How satisfied are you with __________ as a source, would you say very satisfied, somewhat satisfied, or dissatisfied?

12a. (IF DISSATISFIED) Why are you dissatisfied with__________?

____

____

13. How often during the broadcast day does____________supply updated information to you?

__________ __________

____

14. How often during the broadcast day does your staff consult your source(s) to update your weather reports?

____

15. What would you estimate to be the average time between when you get weather information and when you put it on the air?

____

16. Have you ever received any feedback from your audience about your weather reports?

YES NO
(GO TO Q 17)

16a. Was any of this feedback favorable? YES NO
(GO TO Q 16c)

16b. In what way?

____

____

16c. Was any of the feedback critical of the weather reports?

YES NO
(GO TO Q 17)

16d. In what ways?

____

____

17. Do members of the public ever call your station for weather information?

YES NO
(GO TO Q 18)

17a. About how many calls do you get per week?

____

17b. What information do they usually ask for?

____

18. Does your station have a special procedure for broadcasting severe weather?

YES NO
(GO TO Q 19)

18a. Could you describe it? __________________________

____

____

19. It is projected that in the next five years, the weather service will be able to give extremely accurate local six hour forecasts by using weather satellite pictures. This is called 'nowcasting'. For the broadcast media to use this information, it probably would require them to update their weather reports more frequently, and to change or extend the format of their weather reports.
Would you be interested in using nowcasting information in your weather reports?

____

____

19a. Would you be willing to pay for this service?

____

20. Is there anything about weather broadcasting that we haven't covered which you would like to comment on?

____

____

____

That's all, thank you for your time.

FOOTNOTES

[1]According to a survey conducted for the Systems Development Office of ESSA in 1966, in Baltimore, Maryland, and Denver, Colorado, the most popular media for weather forecasts were TV (46% of respondents) and Radio (34% of respondents). (Cornog & Bickert, "Consumer" Reactions to the Weather Bureau and its Services. U.S. Dept. of Commerce Publication, September 1969.)

[2]According to a survey of Marshall Space Flight Center engineers, 67% used television as their main source of daily weather information, and 17% used radio as their main source. (Scoggins & Vaugham, Bull. Amer. Meteor. Soc., LII, No. 10, October 1971.)

A sample of top operators in agricultural production was surveyed in Wisconsin on media preferences for receiving weather information. Radio ranked first in preference as well as actual use, followed closely by television. (Ross, John E., "The Role of Technical Language and Communication Systems in Disseminating Meteorological Information to Users", Multi-D, Volume II, June 1971.)

[3]Since all Wisconsin stations' newsrooms can be reached by telephone, it was felt that this method of interviewing was most advantageous in terms of time and resources.

[4]A copy of the questionnaire is supplied in Appendix A.

[5]The NOAA weather wire sends four Wisconsin zone forecasts and four state forecasts daily. The wire services retransmit these forecasts in shortened form within an hour after are received. Current conditions for different cities in the state are sent hourly on the NOAA wire, but not the news wires, which put out abbreviated current conditions three times daily on the radio wire for about a dozen reporting stations in the state.

[6]Cornog and Bickert, op. cit., pp. 141-143.

[7]The fact that stations change forecast wording has been a frequent complaint from Weather Bureau personnel. This complaint has been aired referring to both routine and severe weather forecasts by local Weather Bureau personnel in interviews with this researcher, and by the Weather Bureau's chief, Robert M. White, in an address presented at the 43rd Annual Convention of the National Association of Broadcasters, March 1965 (see: Bull. Amer. Meteor. Soc., XLVII, No. 1, January 1966, p. 23). White had two complaints, accuracy--changing wording, editing, and currency, not using the most up to date forecast.

[8]The Chi-square for the difference between the two areas is 5.76, indicating a significant difference. (At the .05 level of significance, 1 degree of freedom, one-tailed test, critical level = 2.71.)

[9]See Schneider Stacey, this volume.

BIBLIOGRAPHY

Abrams, Elliot, "Problems in the Communication of Routine Weather Information to the Public," M. S. thesis, Department of Meteorology, Pennsylvania State University, 1971.

Anon., AT&T, Weather Announcement Study, November, 1971.

Cressman, George P., N.W.S., "Uses of Public Weather Services," Bulletin of the American Meteorological Society, Vol. 52, No. 7, July, 1971.

McGlenning, Keith, National Supervisor, Public Weather Services, Canada. "A Canadian Experiment in Public Forecasts" given before the fourth conference on Weathercasting, (Radio and Television) of the American Meteorological Society, January 9-10, 1972, New Orleans, Louisiana, and correspondence.

Ross, John E. "The Role of Technical Language and Communication Systems in Disseminating Meteorological Information to Users," Multidisciplinary Studies of the Social, Economic, and Political Impact Resulting from Recent Advances in Satellite Meteorology," An Interim Report, Volume II, Space Science and Engineering Center, University of Wisconsin-Madison, 1971.

Scoggins & Vaugham, Bulletin American Meteorological Society, Vol. 52, No. 10, October, 1971.

Selltiz, et. al., Research Methods in Social Relations, Revised Edition, New York: Henry Holt, 1962.

White, Robert M., "Broadcasting the Weather," Bulletin American Meteorological Society, Vol. 47, No. 1, January, 1966.

WEATHER DISSEMINATION AND PUBLIC USAGE

by

Margaret Schneider Stacey

ABSTRACT:

A PROBABILITY SURVEY OF WISCONSIN HOUSEHOLDS TO DETERMINE THE DISSEMINATION OF WEATHER INFORMATION AND THE USES MADE OF THIS INFORMATION BY THE PUBLIC

The purpose of this study was to examine the existing public usage of weather information. A survey was conducted to substantiate the general public's needs for dissemination of current (0-12 hours) weather information, needs which, in a previous study, were found to be extensive and urgent.

The goal of the study was to discover how the general public obtains weather information, what information they seek and why they seek it, to what use this information is put, and to further ascertain the public's attitudes and beliefs regarding weather reporting and the diffusion of weather information.

Major findings from the study include:

1. The public has a real need for weather information in the 0-6 hour bracket.
2. The visual medium is preferred but due to the lack of frequent (0-6 hour) forecasts, the audio media only, i.e., telephone recordings and radio weathercasts, were more frequently used.
3. Weather information usage is sporadic, but linked to planned activities as well as to the weather conditions themselves. Sensitivity to the weather changes conditioned on these variables.
4. Nowcasting is a real need and will be appreciated during those times when the members of the public are weather sensitive. However, it would have to take the form of a public service, as any weather forecast. The public does not seem to be willing to pay for the convenience.
5. Weather is a topic of discussion for most everyone, but as an object of discussion it is primarily phatic, in the form of small talk, rather than for information seeking, receiving or exchange.

6. Persons tend to seek weather information from the media on a regular basis before they will have weather contact, i.e., first thing in the morning, last thing in the evening. This, however, varies according to weather and personal plans.
7. Weather is a source of new information as well as useful "news" information, past weather as well as forecast information is necessary. This was true to an extent.
8. Persons involved in different activities require specialized weather information, whether this is used for recreation or for occupational needs.

Previous study

Realizing the need to solicit input from the general public in regard to the directions which Nowcasting should take, the Multi-D staff initiated, in June 1972, a Speakers Bureau program as one means by which to gauge the potential uses of the system.

The Bureau's purpose was two-fold. First, it sought to familiarize the public with developments in the field of weather forecasting and to introduce them to the new methods for the presentation of weather information. Second, the Bureau sought to solicit the views of the public concerning their present use of weather information and the ways in which they might use Nowcasting.

In preparation for the program, a brochure was designed by the Multi-D staff which described Nowcasting and a 45-minute presentation which was made by Professor Frank Sechrist, Associate Professor of Meteorology at the University of Wisconsin - Madison. This brochure was distributed to the presidents of all organizations listed in the 1970 Wisconsin Blue Book as well as to program chairmen for conventions to be held in Madison, Milwaukee and Chicago through December, 1972.

In addition, a questionnaire was developed as an instrument for receiving feedback from audiences. The questionnaire was distributed as part of a portfolio given to all audience members prior to the presentations. Following each presentation, audiences were solicited for their opinions.

This second study helps explain why persons who do not outwardly demonstrate a need for weather information, or cannot attribute the weather information as the cause for certain decisions that govern their lives, nevertheless find a need and desire for a service such as NOWCASTING.

Conclusion

We have found that the development of techniques for the dissemination of weather information is not up to the standards of the development of techniques for gathering weather data. Because of this lag, those who use weather information have been unable to profit from advancements in the field of meteorology.

The basic concept of Nowcasting helps to close the gap between the state of the art of weather reporting and that of weather information dissemination. We hope that through further research in both fields the process will become one for optimum service to the public.

INTRODUCTION

The purpose of this two part intensive case study was to examine the existing patterns of public usage of weather information and the sources from which this information is derived in order to improve methods of reaching the user at the best time with the right information to maximize his opportunity to obtain needed information. In addition, the study wishes to substantiate that the general public's need for dissemination of current (0-12 hours) weather information in a new format is extensive and urgent.

The goal in this study was to discover how the general public obtains weather information, what information they seek, and why they seek it. It was important to determine to what use persons put this information, i.e., the decision making process and how weather information influences it. In addition, it was important to ascertain the public's attitudes and beliefs regarding weather reporting and weather information dissemination, and to work with the public in improving weather information dissemination.

Background

Within the framework of the second phase of the Multi-D Project, it was necessary to discover (1) who would be most sensitive to 0-6 hour weather reporting, (2) whether they would use weather information efficiently so that the unique aspect of 0-6 hours would not be lost, and (3) what would be the role of the intervening carriers and communicators of this information.

Initial research indicated that few studies have been conducted in this area. One major effort was a study for the Systems Plans and Design Office of the Environmental Science Services Administration, Department of Commerce.[1] This study was designed to explore, develop, and test potential methods that could be used to obtain more data on user requirements. For this purpose, a public opinion survey was conducted in Baltimore and Denver. The limitations of this study included (a) that data were gathered in cities only, (b) that consideration was given only to the non-income producing activities of these two groups of the urban public, (c) that the results were not fully interpreted in terms of weather bureau applications, and (d) that it dealt with only one type of seasonal weather.

Nevertheless, this survey did much to explore the use of conventional weather information. The survey tested the public's knowledge of format and content of the forecast. Among the questions asked were the consumer's "sensitivity" to, or interest in, various kinds of weather, receiving and using weather forecasts provided by the weather bureau, public use of various communication media to obtain the weather forecasts, perceived reliability of forecasts, recreation practices, vacation usage, interest in weather conditions outside immediate area, attitudes to weather modification, air pollution, and the weather bureau public image.

Our study overlaps this one in many ways though the direction and parameters are different. The accent in our study is to learn attitudes toward the media's presentation; the communication of weather information. Our study not only deals with that in part but also tries to reduce the distance between the user and the data producer by simultaneously looking at the medium and the information it broadcasts, and, through a descriptive paragraph, offering the change "Nowcasting" would bring

---

[1] Cornog and Bickert, "Consumer" Reactions to the Weather Bureau and its Services, U.S.D.C. publication, September, 1969.

(through 0-6 hour satellite forecasts) which would change both the content and the format of a presentation and which would be broadcast in real time.

Since the Commerce Department's 1966 study, many advances in technology have influenced user habits. The use of satellites for collecting weather information, and computers for disseminating and distributing, and the time allotted to weather broadcasts have all increased. Cable television, 24 hour weather forecasts, and greater popular access to weather predictions on color TV all have influenced weather media habits. Greater travel for business and personal use has increased the need for weather information on a national and international scale.

On the other hand, within these six years, many cities and towns have done much to eliminate public contact with the weather. The construction of underground walkways between stores and businesses enclosed shopping malls, windowless office buildings or buildings with artificial environments of air conditioning, central heating and underground parking garages, have reduced the public's need for weather information.

Hypotheses

Several hypotheses emerge when this information is taken into consideration. Weather is a unique variable. It is information that is omnipresent, has universal interest, and affects everyone directly and indirectly. It is not only a piece of information that is input for major decision making with real dollar impact, but also information that is of non-risk nature and therefore among the most neutral of all topics. It is a basic topic for discussion and as such it is surrounded with a whole range of culturally founded rules that determine what communication will prevail in what situation.

The other aspect of weather is that, though there is a large number of sources available from which to obtain information concerning the weather, it can be self-verified, i.e., we can judge for ourselves what the weather will be. With these things in mind the following hypotheses were formulated:

1. That the public has a real need for weather information in the 0-6 hour bracket.
2. That the public prefers the visual medium, but that due to the lack of frequent (0-6 hour) forecasts the media of audio only, i.e., telephone recordings and radio are more frequently used.
3. Weather information usage is a sporadic need, depending on planned activities as well as the weather conditions themselves. Due to these, weather sensitivity changes.
4. Nowcasting is a need and will be appreciated during those times when the members of the public are weather sensitive. However, this will be in the form of a public service -- as any weather forecast -- and persons will not pay for the convenience.
5. Weather is a point of discussion on the part of most everyone but the object of discussion is primarily phatic, i.e., small talk, rather for information seeking, receiving or exchange.
6. Persons tend to seek weather information from the media on a regular basis before they will have weather contact, i.e., first thing in the morning, last thing in the evening. This will vary according to weather and planned activities.
7. Weather is a source of new information as well as useful "news" information; past weather as well as forecast information is necessary.
8. Different persons involved in different activities (i.e., recreation or occupational) require specific weather information.

Generally, these hypotheses suggest that general trends holding for the total public will not be found. It is suggested that certain unique aspects about the need for weather information will emerge.

Part I

Methodology

During the spring of 1972, telephone interviews were conducted with adult members of households throughout Wisconsin. The probability sample was obtained systematically from a list of telephone numbers in the state. Interviewing was done by trained interviewers employed by the Wisconsin Survey Research Laboratory at the University of Wisconsin, Madison. A total of 727 persons were interviewed, representing a response rate of 85%. The percentage of households in Wisconsin subscribing to telephone service is 94%, which suggests that telephone surveys are a valid research tool.

The interview schedule was created through a series of random preliminary interviews and open-ended question formats, after which the final format was pretested. The interviews were conducted over a two week period during the change of seasons, allowing for the full spectrum of weather conditions to occur throughout the state. Though the weather during those weeks was unseasonably cool for that time of year, snow, rain, and warm sunshine occured. The interviews solicited information concerning the activities of persons the previous day and were made between 6:00 and 9:00 in the evening, allowing for a uniform amount of recall on the part of all respondents. Furthermore, limiting the calls to these evening hours allowed an equal opportunity to find both male and female respondents at home, and deriving from them information from the household at large.

The methodology employed eliminated many of the problems associated with the Denver, Colorado survey, by including urban as well as rural subjects, a full range of weather occurrences, and an equal recall lag time for all respondents. In addition, the survey was devised to fit into the 15-20 minute tolerance level usually stated for telephone interviewing.

In summary, the subjects of this study are part of a probability sample of 728 households. The survey was conducted during the evening hours, over a two week period overlapping the end of April and the beginning of May. The sample is divided between men and women, respondents were selected randomly and their responses held anonymous, and an even distribution of contacts was made each day of the week.

The thrust of the study was directed towards the public's use of weather information during the previous day, and questions were worded specifically enough to avoid the respondent's guessing at a response rather than reporting what actually occurred. The sample included both rural and urban communities, a feature unique to this study. The survey did include a discussion of Nowcasting and attempted to ascertain, in a limited sense, how Nowcasting could benefit the public at large.

Demographic information at the conclusion of the survey suggested that the results of the survey can be generalized to most areas of the country. The responses to this survey were analyzed in conjunction with the accompanying survey on media use and the state of weather forecasting (see Byrnes in this volume).

The study was designed with the aid of the multi-disciplinary team at the Space Science and Engineering Center and conducted with the aid of the Wisconsin Survey Research Center.

Results of the Study

The data obtained in this survey are vast and the cross-tabulations and correlations reported here are only the beginning of the analysis that might be made from this data. The results reported here attempt to lend empirical evidence to the hypotheses stated for this study. The results are presented in three main sections--(1) weather information seeking habits, (2) responses to the Nowcasting service, and (3) demographic data on respondents. Each section presents both primary and cross-tabulated results.

Primary results related to weather information seeking habits

Media Habits The first significant finding was that 76% of the respondents said they had "heard a weather report yesterday." This in itself was somewhat surprising since the percentage was expected to be higher. However, there was no particular indication that these 24% do not, as a rule, listen to weather reports; rather, that "yesterday" was an unusual circumstance. Reasons for not listening to the weather reports were not based on some "inherent uselessness" of weather reporting but was directly related to the listener's current needs or to events directly linked to the weather phenomena itself. The most frequently cited reasons included, "was too busy," "had no time," "wasn't home," "had no access to weather information," "wasn't interested," "didn't care," and "it didn't affect what I was doing." Therefore, though we can assume that one fourth of the population does not seek weather information, the makeup of that group changes from day to day. The first weather report was heard typically between 6:00 and 8:00 a.m. on weekdays and respondents listed slightly later times for weekends. Radio was the most frequently cited medium for the first report for 59.5% of the respondents. Television was next most often cited, with some 25% of the viewers having watched TV for their first weather information of the day. More surprisingly, 10% looked to the newspaper for their first contact with weather information.

It can be assumed that this is a relatively accurate division since 82% said that the source they cited was the usual source. Of those who answered negatively, the change was from radio to other media. This indicates that 82% of all respondents use the radio as their usual initial source for weather information. The drawbacks of radio disseminated weather information are great. Radio listening is a one dimensional method of receiving information with optimum possibility for noise interference. This initial weather report is the basis for the major weather sensitive decisions of the day and the fact that for most individuals this information comes via radio is unfortunate.

The population interviewed agrees with the ineffectiveness of radio as a carrier of weather information. 43.2% evaluated television as the best source of weather information because it is more visual, has better accuracy, and more complete and in-depth information. Drawbacks of television are that it is not continuously accessible, that the times of broadcast are few and far between, and that broadcasts are not always at a "prime time" for the decision making needs of the population.

Attitudes toward weather When asked how much attention they had paid to the weather reports, 29% of the respondents said they had "paid very much attention," 23% had "paid much attention," 23% had "paid some attention," and 18% had "paid little attention."

In an attempt to discover what was meant by "attention paid", the respondents were asked if they had sought any specific element of weather information. 53% said they had. 45% simply wanted elemental weather information, or whether or not there would be precipitation, i.e., rain or snow. 28% wanted to know the temperature, and 24% wanted a daily forecast. This suggests that long range information is not the most basic need of the general public. Rather, their interests turn toward immediate information. A weakness in the schedule perhaps is that the question did not allow for enough probing of the respondents. We are unable to suggest for how long a period the information concerning precipitation is in question.

An assumption that can be drawn from reading the coding forms, suggests that the information sought is used in determining whether or not protective measures need to be taken in order to inhibit the effects of weather for that day...that is, should rain gear be taken to work, how should children be dressed, how will the effects of snow and rain affect transportation, recreation, and other plans for the day. This sort of information seems to fall into a 6-8 hour range of weather reporting. Unfortunately, as we know, weather information is several hours old when the public receives it, so its usefulness for such predictions is tenuous.

Specifically the information sought was for the following reasons:

Reasons	Percentage
Wanted to go outside recreation, gardening	34%
Outside employment	22%
How to dress	20%
Curiosity	14%

Since the information was of use and did gain their attention, the respondents who had answered this series of questions were asked about the accuracy. Only 16% of the respondents felt the weather reports had been accurate. The inaccuracy was due to the fact that forecast precipitation had not occurred. 63% felt the inaccuracy was due to the fact that it did not "rain or snow" as predicted.

This is interesting on two counts. First, in a general perspective respondents felt that the weather reports were "sometimes" accurate (71%), 22% felt it was occasionally accurate, and a mere 5.4% felt it was always accurate. This suggests that the public's view is quite different from the Weather Service which claim an 85% accuracy rate. Admittedly, the category described as "sometimes accurate" might have brought in the 71%, but even the 71% "sometimes" and the 5.4% "always" do not add up to 85%. This suggests a major difficulty. The weather bureau is not over-rating itself with the 85% figure; rather, different perceptions of supply and demand exist and until there is understanding here, there will be dissatisfaction. This perception is understandable in light of (a) the loss of time between the weather service report and the reception of that report by the public; (b) the incorrect application of the report by the public through (i) lack of knowledge, (ii) interpretation or (iii) inability to relate the effects of weather to their activities through the data issued to them by the media; (c) differing definitions of the work "accuracy" coupled with a dominate memory of the unfortunate times of inaccuracy due to the inconvenience caused. It is common for persons to remember the unusual or unfortunate in disproportional importance, i.e., the situation in which the fair was cancelled because of predicted rain when in actuality the sun was out all day, will be a stronger memory than when the sun was predicted to shine and it did shine.

The second interesting aspect of these accuracy questions is related to the fact that it was the lack of rain rather than the event of rain that was cited as a frequent area of inaccuracy. This is possibly true since rain precipitation probability may only affect a small area but is reported for a larger territory. A conjecture as to why this is more noticeable and bothersome than the prediction of fair weather when rain arrives, might be due to the reaction of persons to cancel or delay certain planned activities due to inclement weather. The public somehow feels regret and annoyance when the weather remained fair with the feeling that their plans could have remained unchanged. The other aspect is the need for precipitation in agriculture when a decision to irrigate is based on the probability of precipitation. When rain is expected and does not come, the growth of crops is endangered. The areas of weather accuracy and the public's reaction to and need for certain types of weather information is yet to be fully evaluated. However, the possibility of Nowcasting and the realization that an alternative to the present inaccuracy exists will shed greater light on this problem.

Weather sensitivity The discussion on accuracy and Nowcasting brings to light further questions on the habits of the public in regard to weather sensitivity. The next fundamental line of questioning sought to discover "follow-up" weather watching. 71% of the respondents had sought more than one weather report the previous day. This suggests that there was only some 4% that had only had one contact with weather information. The tendency then seems to be an either-or interest in weather, dependent on day, person involved, activities planned, and type of weather--i.e.; severe weather, weekend vs. weekday, mother vs. child, all would have an effect on this number from day to day.

Of the media used for these follow-up reports, radio continued to be the most frequently sought with 42% of the radio listeners having listened to seven or more reports in a day. 38% had watched two or more television weather reports (and since most Wisconsin television stations report the weather only three times daily) this suggests that 38% attempt to watch television reports as frequently as possible. This, of course, excludes cable TV where weather reports are broadcast continually. Considering the high rate of weather report utilization, it was interesting to ask the respondents how frequently they noticed "updating" in these forecasts. Only 20% noticed that there was updating in the reports. A tally of updates by medium indicated that the public generally does not know the frequency with which a medium updates forecasts--although it is claimed that forecasts are updated as soon as new information is received from the weather bureau. Incidently, cable T.V. is cited as the most frequently updated medium, telephone weather service as the next most frequently updated, and radio and television are cited as being "sometimes" updated. This is an accurate estimation of what actually exists. Again, the problem is caused by hardware difficulty radio and television have in getting the revised report out to the public immediately, while their channel is still being used to broadcast other types of informational units. The cable T.V. weather station and the phone message service have only one message format to provide and that is weather. Even the most accurate weather forecasts, delivered in time and filled with current information, would still be delayed due to the other programming requirements of broadcasting. The morning and afternoon newspapers, of course, suffer the most of a lack of updating, but they continue to be useful media for weather information dissemination since they are reference media, visual media, and can provide the most complete analysis of the weather and therefore become educational tools as well as news media.

The table below shows the public's reaction to the various media and why they felt they were the "best" for weather information. This table suggests that weather information is closely associated with the electronic media and no matter what the format or content or accuracy of data, the actual channel chosen is influential to the decision-making process of the weather sensitive user.

Reasons for "Best" Weather Source Choice	Radio	TV	Telephone	News Papers
1. more convenient	48.2	27.9	42.6	36.4
2. accuracy, constantly updated - better for local weather	22.1	17.9	44.7	9.1
3. more frequent	18.0	1.7	10.6	
4. more useful	7.2	0		9.1
5. more complete	1.8	20.8	2.1	36.4
6. more visual		27.9		

As one can see, the reasons cited as the strengths of radio, i.e., convenience, accessibility and greater frequency, are advantages which would also be presented by cable TV.

Cable--two-way--Nowcasting could provide all those criteria that determine the "best" source as cited by the public, i.e., convenience, accuracy, locality of forecasts, continuity, high visual content and completeness would also allow for feedback and user editing rather than sender editing. However, radio will be more useful, in that it is transistorized, can be received in cars and generally is more accessible in more situations and under more conditions.

Weather as information for communication Another aspect of weather that is not accounted for in the economic weather sensitivity studies is the unique characteristics of weather that lead it to be considered newsworthy information. People are curious about weather information, use it as a topic of discussion, and as a means of keeping in touch with reality. This aspect of weather has never been closely examined, perhaps because it is intangible and the measurements of the effect of weather in this area are incomplete. However, certain responses suggest undeniably a use of weather information for these purposes. One purpose was mentioned before in relation to reasons why persons pay attention to the weather reports. Curiosity is one such reason. More evidence of this reason is demonstrated in the fact that 48% of the respondents had watched a national broadcast of weather information. We are interested in the range of weather throughout our country, the highest and lowest temperature, the effects of the weather not only on our activities but of others in the nation as well. The reasons for this were not solicited but could be hypothesized. They could range from an interest in the weather being experienced by distant relatives or friends, or interest in the effects of weather on certain crops for those investing in the commodities market, or those about to travel or planning to move...or simply an interest, a curiosity, in watching the weather journey across the United States. The satellite picture shown on the Today Show, in the morning, catches everyone's eye regardless of the fact that it is 24 hours old and is of little use as far as forecast data are concerned. The historical value of telling what the weather was is as interesting as telling what it is and what it will be. Weather is just interesting; it is strong, weak, mythical, scientific, beautiful, destructive and serene.

Weather is a point of daily interpersonal discussion for 71% of the respondents. We had expected this to be a higher percentage, though we did specify that our question was directed toward discussions other than small talk. However, an analysis of the answers given to this question indicate that weather remains a useful piece of phatic communication that reveals a certain attitude between persons that allows one to fill a period of silence, find out the state of feelings in a situation, or bridge an awkard situation. It is a cross-cultural, cross-class, cross-age universal topic of conversation, and our weather sensitivity must be examined as much in light of the need for weather information to make decisions in relation to how weather affects us and our property, as well as a need to be aware of weather for purposes of social exchange and communication in general. A further study of those persons who did not hear a weather report should be made to ascertain whether they at least became aware of the weather, discussed it (this question was not asked of them) and whether they can recall what the weather had been that day. I would hypothesize that they would answer affirmatively to all three questions.

Is weather information sufficient? Further primary information gained concerning weather information included the fact that weekends were much more important in terms of weather information. 40% of the respondents were more interested in weather reports for weekends than weekdays, whereas 38% sought weather information equally throughout the week. 21% looked more to weather reports for weekday activities. This finding contradicts the media policies which suggest that interest in weather information for weekends is less than weekdays, which results in lighter weather reporting on weekends.

All told, the most surprising finding of this section of the study is the fact that only a few persons felt that there was weather information they did not get now that they saw a need for. Perhaps the situation is just the opposite; that there is too much information communicated when all that is desired, as was shown before, is rain/shine information and the temperature. 19% of those persons who did feel something additional was needed felt that their need was for more accurate information. The rest of the unfulfilled needs were scattered, including a need for more severe weather information [this changed after the severe weather had occurred (see Mills' Severe Weather Study in this volume)]. "Dial in" service was also requested as well as improved explanations, and 7% of the respondents wanted an accurate "long range forecast" which is one need that technologically cannot be met now.

What these scattered replies indicate is that the use of and needs for weather information are highly idiosyncratic, depending on a range of variables, and that the ideal weather dissemination policy would be the situation in which the public could be able to learn and see the effects of the impending weather and be able to interpret what they see for their own use.

Correlations of weather information seeking and attitudes Weather information then seems to be media dependent, diffusing information directly to the public, not subjected to the multi-step flow. The media are the sole distributors of the information and the public looks to them constantly but is not altogether aware of how they affect them and in what way the information could be used.

Correlations concerning weather habits of the respondents included some of the following findings. The greater attention paid to forecasts, the more likely the respondent had a view as to how accurate the weather reports were. Greater attention paid, the more likely they were to notice that the various media updated their forecasts and how frequently they were updated. Therefore, the more likely they were not only to notice what the weather was, but also to notice how the various media dealt with presenting the weather.

In addition, the respondents who paid attention to the weather were in fact using this information to determine weather contact, i.e., those respondents who paid attention to the weather were more apt to describe their time outside as "more or less than usual".

This interest in weather and the attention paid to it also was related to perceptions of Nowcasting. As would be expected, those who paid much attention to the weather were more apt to pay for the Nowcasting Service.

There is a negative correlation between views on accuracy of the weather forecasts and the amount of updating attributed by various respondents to the media. The more accurate the respondent felt the weather report was, the more apt he was to mention that he had spent more or less time outside. This indicated that those persons who find the media accurate are apt to pay attention to it and regulate their exposure to the weather via the weather reports.

Responses to the Nowcasting Service

The second set of questions in the interview dealt with Nowcasting. In this series of questions, 68% of the respondents would make use of the service while 11% of the respondents said it would "depend." Of the 21% who would not use it, most were those who had already indicated that even now they find little use for weather information. No matter how improved or better communicated it might become, it is a product they find little use for.

The ways cited in which Nowcasting would save money included those areas related to: (1) employment and jobs--i.e., farming, driving, transport, construction work, police patrol, etc. (2) transportation costs in gas, carfare, and the savings in reliability of travel plans, (3) avoidance of accidents and property damage in time of storms or other bad weather conditions, (4) plans for recreational activities, i.e., skiing, fishing, camping, (5) additional economic savings through better preparation in times of adverse weather, savings in long range costs of health, etc., and (6) savings in ecological and political areas.

Unestimable savings would be gained through the increased reliability of weather information through better preparation for specific weather conditions. Activities could be planned more precisely and the unknown weather factor which must be calculated into each event could be more precisely estimated. Driving times would be better estimated, various aspects of household work, and work that dealt with contact with the natural climate, would increase in efficiency and be done in less time if the weather is known accurately and timely.

Furthermore, time was interpreted in a slightly different way in that time would be saved not only through utilization of weather information, but also in the reception of it. Nowcasting would allow for faster dissemination of general information to get weather data when needed rather than wait for broadcasts of that information at less useful time slots. This would definitely improve the dissemination process.

Generally, the attractiveness of the Nowcasting service can be interpreted in light of its potential use in emergency situations. Accurate forecast or weather reporting of impending severe weather allows for saving time and money in the light of increased opportunity for taking preventative measures. The need for Nowcasting seen by the sample surveyed here must be considered apart from whether or not, in a given emergency situation, the public would make use of Nowcasting or whether, having obtained the information, they would know what preventative measures to take.

However, there still remains an important psychological reason for Nowcasting which was mentioned by the respondents and that is the reassurance that such a service exists and will be available whenever needed for whatever reason whether the reason is user provoked or weather/nature provoked. The existence of Nowcasting, in a way, is a type of insurance.

However, the reasons cited were not sufficiently strong enough for the respondents to be willing to pay for this service. Only 35% said they would pay a fee for the Nowcasting report; 24% indicated that they would need further information in order to decide and 40% would not pay for the service. This question does not allow for a conclusion to be drawn, however, as the respondents indicated, it is difficult (a) to estimate the cost of such a service and the possible fee that would need to be charged per individual and (b) to imagine a visual service from a verbal description.

Cross-breaks on Nowcasting data   Cross-breaks on Nowcasting data revealed the following. Those who use the telephone weather service are the most apt to use the Nowcasting service without reservations. Next in line are television viewers who see Nowcasting as being able to fit their needs, followed by the radio listeners. One explanation for this can be found in the similarities of media types to the Nowcasting service.

Those respondents who use newspaper and personal contact for their weather data are less likely to want the service.

The more attention paid to weather forecasts the more likely the respondent would want Nowcasting.

There was a direct relationship between a desire for specific weather information and a desire for Nowcasting services. However, three-fourths of those who were not looking for specific information in their weather reports still wanted Nowcasting.

473 respondents want Nowcasting. 425 of these want it even though they have not applied the weather information they now receive to any specific use. They are unaware of any consideration of weather data for any specific decision they have made. This suggests either that these persons are innovators and will be apt to accept most new media developments or, more likely, that people are conscious of weather information, seek weather information, and apply it without conscious awareness.

In relation to the natural inclination toward receiving Nowcasting by those respondents who pay closer attention to weather information and desire specific information, persons who watch national weather programs are more likely to use Nowcasting than those who do not.

Those persons who watch to use weather reports for decision making regarding personal travel are more likely to use Nowcasting than those who use information for decisions regarding their work, what clothing they wear, or any other answer cited in this area. This suggests that the particular attributes of Nowcasting most useful to meet weather information needs for travel are the 6 hour forecasts, the visual presentation, etc.

Those who found weather reports to be inaccurate tend to want Nowcasting more than those who feel that weather reporting is generally accurate, suggesting that Nowcasting's accent on alleviating 0-6 hour inaccurate reporting would be part of a solution to the dissatisfied weather data seeker.

Adults in the 20-40 year old bracket are more likely to want Nowcasting than older age groups where, as age increases from 40 on up, interest in Nowcasting decreases. This might suggest that there exists an intervening variable of exposure to the outside, or reliance on the weather. For those people who have less to do with the weather there is less effect on their lives and hence a lesser need for Nowcasting.

This is further supported by the fact that the more change there is in the activities of the individuals between seasons, the greater their interest in Nowcasting becomes.

Respondents from rural areas showed the greatest interest in Nowcasting; those from urban areas were the next most interested and respondents from small towns and areas with a medium population density showed the least interest in Nowcasting. Additional evidence would be necessary to explain this pattern.

It should be noted that, though the farmers in the rural areas have an economic as well as social interest in the improved reporting of weather information, these areas are largely inaccessible to cable television. Urban areas, which usually contain the innovators in the population, have a ready response to such new developments as Nowcasting, whereas small town communities have less need and interest in such technical developments.

A final list of relevant cross-breaks in this area suggests that the more educated are more interested in Nowcasting; more men than women are interested in Nowcasting and 62% of the heads of the households would use Nowcasting. All of these results suggest that Nowcasting response follows a predicted curve along the same lines as the introduction of any innovation.

Demographic data

The results listed in the last section showed a surprising interest in weather information since the public, as a whole, cannot be considered a "high" user group. Of those interviewed, 48% spent less than an hour a day outside, 25% spent three or less hours outside and only 8% spent a working day outside.

Fifty-one percent spent an hour or less out of doors on the previous weekend, with 44% of the sample responding that that was less than usual for this time of year, and 46% saying it was about the same for this time of year.

A little more than half of the sample find that their activities do change from season to season--something perhaps particular to this intemperate part of the country. This included differences in jobs across seasons and interests in different sports, but primarily this indicated the influence of weather information for recreational choices, increasing the need for weather information on weekends rather than on weekdays. Furthermore, it is of interest to note that activities in the summer with an increase in outdoor activities are more determined by the weather, suggesting that seasonal changes in the makeup of weather reports might be as important as changes in the makeup for days of the week (this concurs with findings from the agriculture study, see Tibbitts & Dancer in this volume).

Only ten percent of the sample hold jobs that are performed outside, but almost all of those employed saw connections between weather conditions and the operation of the business or industry in which they worked. Businesses that were weather dependent included those related to agriculture, forestry, fisheries, mining, construction work, manufacturing of durable goods, manufacturing of nondurable goods, transportation, communication utilities, sanitary services, wholesale trade, retail trade, insurance, real estate, repair service, personal services, professions of all types, public administration, and the postal service. All of these areas are weather dependent, all of these persons find that the success of the industry for which they work is dependent on "suitable" weather; success meaning doing the right thing to make use of, or take preventive measures against, the effects of the weather.

The point here is that weather is a dominant and necessary aspect of everyone's life and any information that will allow the public to be able to take measures to control, make use of, or take counter measures against the weather's effects is vital.

The conclusions shown here suggest that according to the demographic information collected in this survey, the results do suggest that the sample drawn was representative of the population and the conclusions drawn can be estimates of those of the population of the State of Wisconsin.

Part II

Methodology

The difficulty as was mentioned previously with the manner in which we dealt with Nowcasting was that we were soliciting views on a visual idea through an oral presentation. The real question was how the public would react if we presented various films of the Nowcasting idea by representing the format and substance of the new Nowcasting design. Though this was only an initial step that still could not present a real time situation in which persons would receive immediate Nowcasting information at will in the place of their choice, it would give a better indication of the public's evaluation of Nowcasting. Therefore, experimentation designed to incorporate in weather report presentations the information and presentation methods desired by the people interviewed in this survey, was undertaken.

Professor Frank Sechrist, associate professor of meteorology, at the University of Wisconsin, Madison, created several films using Nowcasting type data and presenting it via satellite pictures, time-lapse photography, animation, and on the spot weather coverage to help the individual see what it looks like outside in their locality right now. Together with Professor Sechrist, we showed those films that (a) best represented solutions to the problems and needs cited by the surveyed sample of Wisconsin citizens, and (b) best demonstrated the new visual techniques of this type of weather presentation.

With the Nowcasting type films prepared, we established a Speaker's Bureau through which to distribute these films and trigger reactions from the public as to the potential uses of such weather reporting.

The Bureau's purposes were twofold. First it sought to familiarize the public with developments in the field of weather reporting and to introduce them to the new potential formats in which weather data might be presented. Secondly, the Bureau sought to solicit the views of the public concerning their present use of weather information and ways in which they might use Nowcasting.

In preparation for the program, a brochure was designed to describe Nowcasting and Professor Sechrist completed a narrative for the 45 minute presentation of Nowcasting type films. The brochure was distributed to the presidents of all organizations listed in the 1970 Wisconsin Blue Book as well as to program chairmen for conventions to be held in Madison, Milwaukee and Chicago through December, 1972.

In addition, a questionnaire (see appendix) was developed as an instrument for eliciting feedback from audiences. The questionnaire was distributed as part of a portfolio (see appendix) designed by Kirk Hallahan, who managed the Speaker's Bureau, and was to be given to all members of the audience at the presentation. Following each presentation, audiences were asked to give their opinions and return the questionnaires before leaving.

Special interest groups such as those representing the canning industry and the cranberry growers association and the like watched the films from their specific perceptive along with more general groups such as Kiwanis, Lions Club, and antique collectors associations. All told, some 15 groups were visited in that period with some 300 persons viewing the films. The speaking tour was not actually an experiment but was conducted along the lines of an exploratory study. The films were part of a series designed by Sechrist that has been acclaimed for years and has been instrumental in his teaching. Now the films would gather reactions and suggestions from the general public in relation to this new weather reporting technique in order to provide direction for the next steps in this project, i.e., meeting the needs of the weather information user uncovered in the previous studies.

Results

A semantic differential scale indicated that the viewers found the films to be (a) complete, (b) highly preassurable, (c) very meaningful, (d) quite strong, (e) fast, and (f) leaning slightly toward simple on the complex/simple scale.

Unanimous consensus concluded it was "interesting." There was a strong consensus that the films were just right in length, that they were very useful, and futuristic.

The results were heavily weighted in a positive direction although there was a suggestion that indicated the films flowed too fast for assimilation. Some additional suggestion for improvement included a need for more background information, slower presentation, greater use of radar, different organization of material for different user groups, verbal overlay (Sechrist just presented an oral narrative with the accompanying silent films) and less overlap in the presentations. These expressed difficulties suggested a need for a more gradual change from the conventional reporting to the new methods, an education process which would improve understanding, meaningfulness, and increase the possibility for accurate self-interpretation on the part of those viewing and using weather information presented to them in this new manner.

One aspect of the films that was more appreciated was the lightness of the presentation. Professor Sechrist has an enthusiastic, warm and humorous manner of presentation which allows the films to be not only informative, but entertaining as well. The audiences appreciated the visual presentation, the attraction of seeing the weather, the time lapse photography, the animation, the color, the visual ground activities of the weather, the ATS satellite pictures, the potential accuracy that could found and the beauty of the presentation. As one member of the audience mentioned, "The weather is such a naturally beautiful phenomenon and such a natural for photography, especially through color film." In summary, the presentation should (a) be slowed down, (b) occur in real time, and (c) eliminate the vague references to weather aspects to which the public has not yet been educated, such as the relation between cloud formations on the satellite map and the results in terms of precipitation.

All but four of those who filled out the questionnaire would use Nowcasting if it were available on TV. About 45% would use it twice a day, about 29% would use it three times a day. However, these three times a day would be at their convenience, not the network's.

The usefulness of the new presentation methods was still in question in the minds of the viewers, and they saw it as being of use in relation to work, transportation, agriculture, protection of resources, in making recreation and travel plans, and in education. Two types of questionnaires were distributed. In one there was a list of possible uses for Nowcasting and the public was asked whether or not they would find Nowcasting of use in these area. The response was almost unanimously in favor in all categories. In the other questionnaire the question was open and the sample was asked "How they would use Nowcasting." The answers were indefinite and often left blank. What this suggests is that if the public is told how Nowcasting could be of service, they will use it that way--like any other new product.

About 50% would not pay for a Nowcasting service, while others see it more as a payment for the business or the industry rather than an individual payment out of household expenses. Nowcasting, and weather information in general, remains seen as a part of public service information.

An interesting difference between the information gained from the telephone schedules and the actual questionnaires distributed through the audiences at the Nowcasting presentations shows that the audiences' views as to what sort of information could be presented and what was desired were broadened. In addition to interest in half day forecasts, rain probability, temperature and storm information, the respondents also would seek information for localized forecasts, (very localized parts of the city, etc.) recreation reports, ATS information, road conditions, hail, frost, ice and snow information (type of snow as well as where it will fall, and how much might be expected).

There was also a more pronounced indication that weather reports should change in content and format from season to season, for not only does the weather change and affect daily activities differently, but activities themselves change and the requirements for weather information regarding these activities change from season to season too.

It should be mentioned that these results from the speaking tour cannot be extrapolated to the entire population as the others were. Since the sample questioned was considerably better educated than the population as a whole, this suggests particularly that references made by this sample in regard to a need for better understanding of the situation are particularly important and should be a prime concern in the development of Nowcasting.

Conclusion

We have found that the development of techniques for dissemination of weather information is not up to standards of the development of techniques for gathering weather data. Because of that, those who use weather information have not enjoyed the advancements of the field of meteorology.

The basic purpose of Nowcasting is to help close the gap between the state of weather reporting and that of weather report dissemination. We hope that, through further research in both fields, the process will become one for optimum service to the public.

Appendix A

____Office Number
Project 520
Spring, 1972

The University of Wisconsin-Extension
Wisconsin Survey Research Laboratory

DIFFUSION AND PUBLIC USE OF WEATHER INFORMATION

1. Did you hear or read a weather report yesterday? Yes (GO TO Q 2) No ↓

   1a. Could you tell me why you did not hear or read one yesterday?

   ____
   (SKIP TO PINK SECTION)

2. At what time did you first hear or read a report yesterday? ___A.M. or ___P.M.

3. From what source did you first find out about the weather yesterday? (CHECK ONLY ONE)

   __A. Radio

   __B. Television

   __C. Cable TV forecast

   __D. Telephone weather service (Sears)

   __E. Newspaper

   (GO TO Q 4)

   __F. Other (Specify)

   ↓

   3a. Besides this source, did you get any weather report yesterday from a news media such as radio, TV, cable TV forecast, telephone weather service, or newspaper?
   Yes ↓ No (SKIP TO Q 11)

   3b. What time did you first get this media report? __A.M. or __P.M.

   3c. What was the source?

4. Is this where you usually get your first media daily weather reports of the day?
   Yes (GO TO Q 5) No ↓

   4a. What is your usual media source?

5. How much attention did you pay to yesterday's first media weather report? Was it very much, much some, a little, or no attention?

____

Interviewer:__________ Date:________ Sample No.:________

Project 520

6. Were you looking for some kind of specific information? Yes No (GO TO 7)

6a. What information were you looking for?

6b. What was your reason?

7. As the day progressed, did you find that this first media weather report you heard yesterday was accurate?

Yes (GO TO Q 8) No

7a. In what was it inaccurate?

8. Generally, do you find the weather reports are always, sometimes, occasionally, or never accurate?

9. You may have mentioned these, but I want to be sure I get everything: thinking back over yesterday, did you get any weather reports from: (READ ALL CATEGORIES)

YES	NO			(IF YES) 9a #
___	___	A.	Radio	___
___	___	B.	Television	___
___	___	C.	Cable TV weather service	___
___	___	D.	Telephone weather service	___
___	___	E.	Newspaper	___
___	___	F.	Relative or friend	___
___	___	G.	Other (Specify)	___
___	___	H.		___

9a. (FOR EACH YES ANSWER, ASK) How many times yesterday would you estimate you got a report from _________? (RECORD IN COLUMN 9a ABOVE)

9b. Did you notice much updating in the weather reports yesterday?

Yes No Only heard one

10. Generally, how frequently do you find weather reports are updated by each of these media I'll read? Would it be often, sometimes, seldom or never?

A.	Radio	Often	Sometimes	Seldom	Never	Don't know
B.	Television	Often	Sometimes	Seldom	Never	Don't know
C.	Cable TV Station	Often	Sometimes	Seldom	Never	Don't know
D.	Telephone Weather Service	Often	Sometimes	Seldom	Never	Don't know

ASK ALL RESPONDENTS

11. Overall, what do you find is the best source for weather information?

______________ Don't know (TO Q 12)

↓

11a. Why?

12. In what way--if any--did weather reports influence any of the decisions that you made yesterday?
None, or

13. Would you say you listened or watched the weather reports yesterday more than usual, about the same, or less than usual?

More ↓ Same (GO TO Q 14) Less ↓

13a. Why?

14. Besides the local weather report, did you hear or read a national weather report yesterday?

Yes No

15. About how many hours did you spend out-of-doors yesterday not including in a car or other transportation?
________hours

16. Is that more than usual, about the same, or less than usual for this day of the week at this time of year?

More Same Less

YESTERDAY WAS WHAT DAY OF THE WEEK? ______________(DAY)

17. (IF SATURDAY OR SUNDAY WAS RECORDED ABOVE AS "YESTERDAY", THEN ASK FOR FRIDAY)
About how many hours did you spend out-of-doors last Sunday (Friday)?
________hours

18. Is that more than usual, about the same, or less than usual for a Sunday (Friday) at this time of year?

More Same Less

19. Do you look more to the weather reports for weekends or weekdays?

Weekends Weekdays Equal

20. Is there any type of weather information you would like to get that you do not get now?

Yes ↓ No (GO TO PINK SECTION)

20a. What is it?

(GO TO PINK SECTION)

21. Did you discuss the weather with anyone yesterday? Yes ↓ No (GO TO Q 22)

 21a. Other than in small talk, why did you discus the weather?

 Small talk, or

22. Suppose a system were set up so that you could go to your TV set and push a button any time of the day and have a picture of the weather as it is right now and will be in the next six hours. It is possible to set up this kind of system using pictures of the weather taken from a satellite. The pictures would show the clouds and how they are moving over your area as well as show the temperature, wind, and rain or snow.

 Special pictures could be added to show bad driving conditions, severe storms, tornadoes, etc. This service would present the weather as it really is right now and how it will change during the next few hours. This type of service is called "now casting". If this new service were available on a TV set, would you use it?

 Yes ↓ Depends ↓ No (GO TO Q 27)

 22a. How many times each day?_________(#)

23. Could you see any way in which you might save money through this new service?

 Yes ↓ Depends ↓ No (GO TO Q 24)

 23a. How? (OR, on what does it depend?)

24. Could you see any way in which you might save time through this service?

 Yes ↓ Depends ↓ No (GO TO Q 25)

 24a. How? (OR, on what does it depend?)

25. In what other ways--if any--would this service be helpful to you?
 None, or

26. If you had to pay for this service, would you be willing to pay ten dollars, five, one, or how much per month?

 $10 $5 $1 , or $___(PER MONTH) Depends Nothing Don't know

27. Now, we would like to get some background information from you. We assure you the information will be kept strictly confidential and you won't be identified by name. Do you have access to a ...
    A. radio?

    B. cable TV?

    C. television?

    D. car radio?

28. Do you, yourself, read a newspaper daily?

29. What is your present age? ________(AGE)

30. Are you presently married, separated, divorced, widowed, or never married?

    Married ↓ Separated ↓ Divorced ↓ Widowed ↓ Never married (GO TO Q 31)

30a. How many children 16 years of age or under do you have living with you? ________(#)

31. What is the highest grade of school or year of college you have completed?

    ________(GRADE OF SCHOOL), OR ______(YEAR OF COLLEGE)

32. Do your weekday activities change from season to season?

    Yes ↓ No (GO TO Q 33)

    32a. In what way?

33. Are you presently employed, looking for work, retired, a housewife, or what?

    Employed ↓ Looking Retired (GO TO Q 34) Housewife Other (Specify) _____ (GO TO Q 34)

    33a. What is your occupation?

    33b. What type of business or industry is this? (PROBE)

34. Do you live in a single family house, a duplex, apartment, rooming house, trailer, or what?

    Single Duplex Apartment Rooming Trailer Other (Specify)

35. Are you the head of the household? Yes (TO Q 36) No ↓

35a. What relationship are you to the head?

36. What is the name of the town or city you live in, or nearest you?

Thank you very much.

(TERMINATE INTERVIEW)

SEX OF R. Male Female

COMMENTS:

N 74-22271

IMPROVED WEATHER INFORMATION AND AVIATION

by Kirk Hallahan
and Vytautas Zdanys

INTRODUCTION

Central to the future of aviation is the provision of adequate and up-to-date meteorological information. Ever since man recognized aviation as a major means of transportation, the integral part played by meteorology has been recognized.

The purpose of this preliminary report is to review the major aspects of the impact of weather information on aviation. As a preliminary report, it is preparatory to a larger study specifically addressing itself to the potential uses of Nowcasting by the private pilot and the commercial airline.

This report is divided into six parts. Part 1 considers the present and projected structure of American aviation. Part 2 discusses the weather problems considered particularly important for aviation. Part 3 deals with the projected needs for improved weather information by aviators. Parts 4 and 5 consider the two major benefits to be derived from improved weather information--safety and economics. Part 6 summarizes the major findings of this preliminary report and presents a format for the development of future studies utilizing satellite meteorology.

Chapter One

THE PRESENT AND PROJECTED STRUCTURE OF AVIATION

In order to understand the implications of improved systems of weather information, it is important to comprehend the scope of the aviation field today, as well as projected growth in the field.

Aviation enjoys one of the steadiest growth patterns of any system of transportation in the United States. In 1969 the FAA reported a total of 127,164 aircraft which were eligible for registration in the United States. This represents a growth rate of 229% from 1954. Table I -1 is a summary of FAA statistics on the dimensions of aviation development.

Table I-1

The Growth of Aviation Aircraft, 1954-1969

Year	Total
1954	55,505
1956	60,432
1958	67,153
1960	70,747
1962	82,853
1964	87,267
1966	97,741
1968	116,781
1969	127,164

Source: FAA Statistical Handbook, 1969, p. 180.

Aviation is usually understood to consist of two categories: general aviation and commercial aviation.

General Aviation

General aviation is that portion of the total fleet of aircraft not presently being used for commercial purposes. This includes pleasure planes as well as aircraft used for business and other non-commercial purposes.

Since 1954, general aviation has accounted for 98% of all registered craft, and the size of the general aviation fleet itself has more than doubled, from 58,790 to 124,237 craft. (1954-1969). The FAA reports that general aviation compiled a total of more than 3.7 million aircraft miles during 1968, about 1.5 million more than commercial airlines. Further, general aviation accounts for more than one-third of the domestic passenger miles.

Table I-2 summarizes the uses of general aviation for four types of flying in 1968 in the United States. The table shows that the largest single use of general aviation was for business uses (38%) followed by instructional (22%), personal (21%), commercial (18%) with the remainder devoted to other types of flying.

Table I-2

Hours and Miles Flown in General Aviation, by Type of Flying, 1968

Type of flying	Hours flown (thousands)	Percentage of total	Miles flown (millions)	Percentage of total
Business	6,976	29	1,406	38
Commercial	4,810	20	666	18 18
Instructional	6,494	27	814	22 22
Personal	5,532	23	777	21 21
Other	241	1	37	1 1
Total	24,053	100	3,701	100

Source: Federal Aviation Administration, FAA Statistical Handbook of Aviation, 1969, pp. 207-8. Figures are rounded and may not add to totals.

The rapid growth of general aviation can partly be seen by considering the production of craft by leading manufacturers. Table I-3 summarizes the total production of seven major manufacturers for selected years from 1947 to 1970. With manufacturing reaching a peak in 1966, with production approaching the total of 1947 (showing the impact of the post-war economy on aircraft manufacturing), there has been a slight decrease in total production, partly due to the economic conditions of 1970.

Table I-3

Production of General Aviation Aircraft by Selected Manufacturers, Selected Years, 1947-70

		Manufacturer							
Year	Total	Beech	Cessna	Lear	Lockheed	Mooney [a]	NAR*[b]	Piper	Other
1947	15,764	1,288	2,390	--	--	--	--	3,634	8,452
1952	3,058	414	1,373	--	--	49	39	1,161	22
1956	6,738	724	3,235	--	--	79	154	2,329	217
1960	7,588	962	3,720	--	--	172	155	2,313	266
1964	9,371	1,103	4,188	3	6	650	109	3,196	116
1965	11,967	1,192	5,629	80	18	775	110	3,776	387
1966	15,747	1,535	7,888	51	24	917	354	4,437	541
1967	13,577	1,260	6,233	34	19	642	386	4,490	513
1968	13,698	1,347	6,578	41	16	579	471	4,228	438
1969	12,456	1,061	5,887	61	14	376	344	3,951	762
1970	7,391	793	3,730	35	2	c	450	1,675	706

Sources: Aerospace Industries Association of America, Aerospace Facts and Figures, 1970 (1970), p. 33; Aviation Week and Space Technology, Vol. 94 (March 8, 1971), pp. 154-55.

* North American Rockwell

a Includes production of Imco

b Includes production of Acro Commanders through 1969, and of Aerostars in 1970

c Consolidated with a manufacturer included in "other"

In 1970, as Table I-4 shows, production was valued at $359,310,000. Eighty-four percent of production could be attributed to three major companies: Beech, Cessna and Piper.

The importance of weather information and air traffic control systems in general can be inferred from considering the movements of general aviation at the twenty-five largest airports in the United States. Table I-5 summarizes the activities of general aviation at the busiest airports serving general aviation.

Table I-4

Shipments of General Aviation Aircraft by Selected Manufacturers, 1970

Manufacturer	Number of units	Percentage of total	Value of sales*a	Percentage of total
Aerostar	238	3	9,588	3
Beech	793	11	80,689	22
Cessna	3,730	50	97,423	27
Gates Learjet	35	b	26,890	7
Grumman	111	2	47,825	13
Lockheed	2	b	3,500	1
North American Rockwell	212	3	29,187	8
Piper	1,675	23	48,530	14
Others	595	8	15,578	4
Total	7,391	100	359,210	100

Source: Aviation Week and Space Technology, Vol. 94 (March 8, '70), pp. 154-5. Percentages do not total 100 because of rounding.

* Thousands of dollars

a Data for Grumman, two Lockheed craft, and seven North American Rockwell craft are estimates, based on list prices of basic aircraft minus interiors, avoinics, and other customer options.

b Less than 0.5 percent.

Table I-5

Movement of General Aviation at 15 of the Busiest 25 Airports in the U.S.

1	Van Nuys, California	317,816
2	Opa Locka, Florida	301,610
3	Long Beach, California	280,513
4	Fort Lauderdale, Florida	245,099
5	Santa Ana, California	214,043
6	Seattle, Washington	198,201
7	Phoenix, Arizona	196,015
8	San Jose, California	192,483
9	Denver, Colorado	178,121
10	Columbus, Ohio	176,720
11	Oakland, California	176,084
12	Santa Monica, California	161,945
13	Torrance, California	158,240
14	Minneapolis, Minnesota	148,158
15	Dallas, Texas	145,798

Source: FAS Statistical Handbook of Aviation, 1969, pp. 27-30.

With this number of movements in general aviation alone, the need for adequate systems of information transfer concerning both air traffic and weather information is evident.

The economic impact of general aviation is yet another indicator of the importance of general aviation in American society. Table I-6 is adapted from a report of the SPEAS analysis of the present and projected dimensions of general aviation. It shows that total economic benefit derived from commercial aviation was about 2.234 billion dollars in 1967. This economic impact of general aviation is projected to exceed $4.1 billion in 1975 and $7.1 billion in 1980.

Table I-6

Economic Impact of General Aviation: 1967 - 1975 - 1980
Millions of Constant Dollars

	1967	1975	1980
Value of Production			
Domestic Sales of Aircraft	$ 475.3	$1,108.5	$1,660.6
Exports of Aircraft	76.5	173.7	253.6
Avionics	45.7	106.7	159.8
Exports of Engines & Avionics	70.0	159.0	232.0
Transaction Costs of Used Aircraft Sales	22.0	54.0	86.0
User Costs	683.1	1,491.0	2,488.0
Pilot Wages & Administration Overhead	521.0	941.0	1,139.0
Value of Net Investment			
Producers	66.0	153.9	230.6
Distribution	25.1	50.0	68.8
FBO	31.8	69.4	115.8
Government Expenditures			
FAA Operations	167.6		
FAAP - Federal Funds	16.8	465.6	695.5
- State Funds	33.6		
Grand Total Economic Impact	$2,234.5	$4,772.8	$7,129.7

Source: SPEAS Analysis

Projections for future growth of general aviation suggest a steady increase in development. Table I-7 shows the FAA's projected numbers of craft anticipated from 1970 through 1980.

Table I-7

Active Aircraft by Type: Forecasts for Selected Years, January 1, 1970-80

Year	Air carrier[a]	General Aviation				
			Piston			
		Total	Single-engine	Multi-engine	Turbine	Other
1970	2,746	131,000	109,700	15,600	2,050	3,650
1971	2,790	139,000	116,000	16,600	2,450	3,950
1972	2,860	147,000	122,050	17,800	2,900	4,250
1973	2,960	155,000	128,150	19,000	3,350	4,500
1974	3,050	162,000	133,400	20,000	3,850	4,750
1979	3,480	205,000	166,200	25,500	7,000	6,300
1980	3,600	214,000	173,000	26,650	7,800	6,550

Source: Federal Aviation Administration, Office of Policy Development, "Aviation Forecasts, Fiscal Years 1969-1980" (FAA, 1969; processed), pp. 25, 28.
a. Includes only aircraft actually in service.

Another projection compiled by SPEAS is based on a number of economic indicators of the economic state of the country. Among these indicators are: gross national product, U.S. population, disposable personal income, population with a college education, households with an annual income over $10,000, automobile registrations, expenditures on plants and equimment, and commercial airline passengers in scheduled service. All these have been correlated with the number of planes in the active fleet and have been found to have correlations exceeding .90 (Pearsonian r). The best predictor found was gross national product, which results in a coefficient of .989. Using gross national product and correcting for errors, a final model equation used in these predictions was $Y = 1.068 (97.14 + .142X)$. Table I-8 shows the projected growth of general aviation in the field. Figure I-1 plots the SPEAS forecast. Both are based on projections of the gross national product.

Table I-8

Gross National Product and General Aviation Fleet Population
-Actual and Forecast-

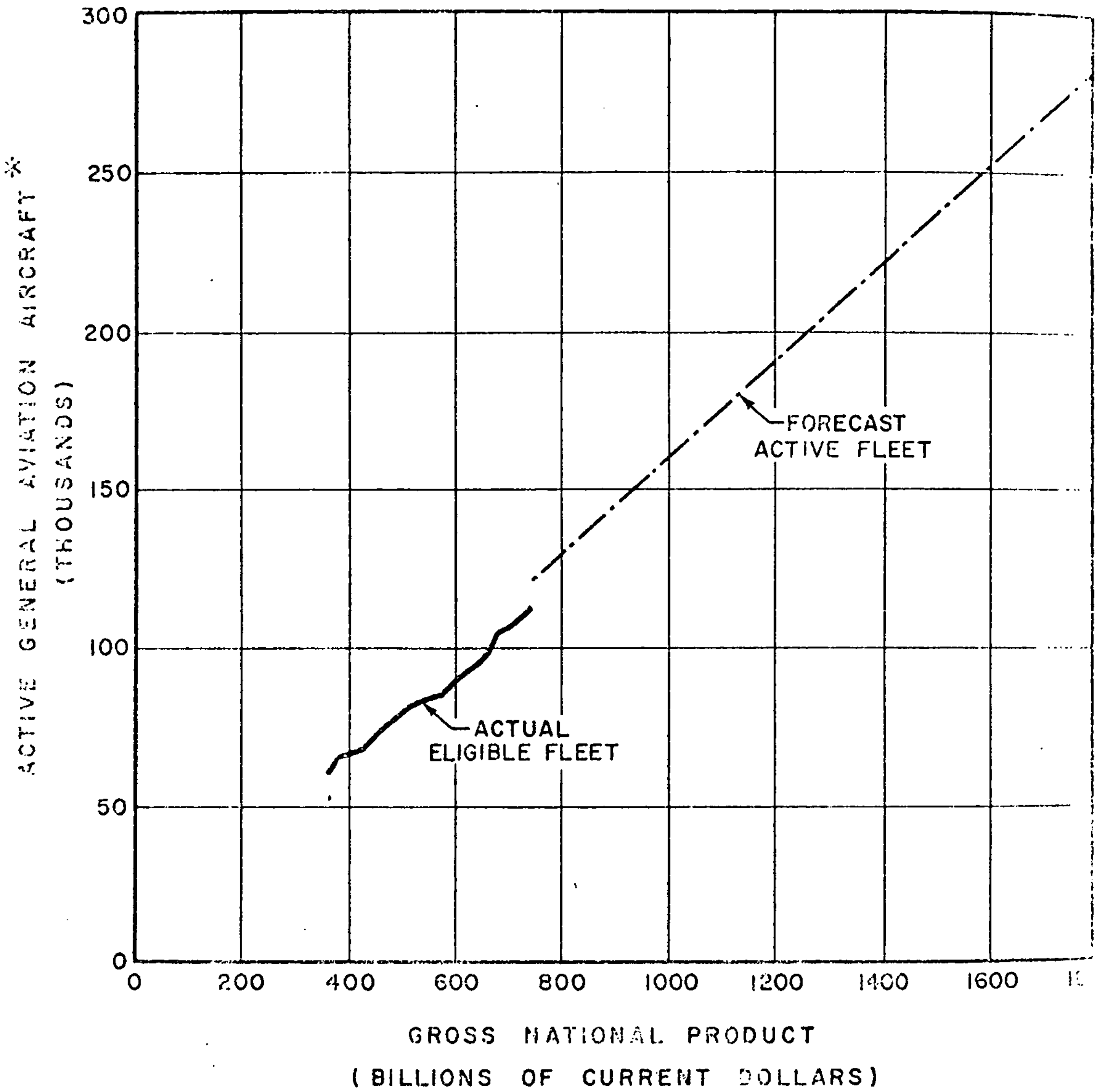
Year	GNP Billions of Current Dollars	Population of the General Aviation Fleet: FAA Data[a] Eligible a.c.	Population of the General Aviation Fleet: SPEAS Estimate and Forecast[b] Active a.c.
Actual			
1953	365.4		
1954	363.1	61,290	
1955	398.0	58,790	
1956	419.2	62,886	
1957	442.8	66,520	
1958	f47.3	67,839	
1959	482.1	68,727	
1960	503.8	76,550	
1961	520.1	80,632	
1962	560.3	84,121	
1963	590.5	85,088	
1964	631.7	88,742	
1965	681.2	95,442	
1966	739.6	104,706	
1967	793.5	114,186	122,200
1968	865.7	122,200	130,000
Forecast[a]			
1969	885.3		136,000
1970	939.7		143,000
1971	997.6		152,000
1972	1059.8		161,000
1973	1127.5		170,000
1974	1200.0		181,000
1975	1276.7		192,000
1976	1357.6		204,000
1977	1444.5		216,000
1978	1539.2		229,000
1979	1640.8		244,000
1980	1749.7		260,000

[a]GNP forecast includes 2% inflation in the general economy.
[b]FAA reported statistics.
[c]Based on SPEAS adjustment of base year data for 1967 and a one-year time lag correlation between GNP and the active fleet.

Source: FAA
McGraw-Hill "The American Economy," June 1968
SPEAS Development and Analysis.
Dept. of Commerce: "Survey of Current Business."

Figure I-1

FORECAST OF GENERAL AVIATION AIRCRAFT
IN THE UNITED STATES
(GROSS NATIONAL PRODUCT PROJECTION)



NOTE: PROJECTION IS BASED ON VALUES OF THE GNP FOR THE YEAR "X" AND VALUES OF THE ACTIVE FLEET FOR YEAR "(X+1)."

* SHOWING HISTORICAL FAA REPORTED DATA. FORECAST BASED ON 1967 ADJUSTED POPULATION OF 122,200 AIRCRAFT

SOURCE: SPEAS ANALYSIS

Commercial Aviation

Commercial aviation, the use of aircraft by common carriers to provide commercial transportation service, adds an equally important consideration to assessment of weather information needs for aircraft. While comprising only about 2% of the total number of aircraft, the increased size, speed and use of commercial planes make them an integral part of the topic.

According to the most recent FAA records, over 1.7 million persons per week use commercial planes as a means of transportation on more than 18,000 weekly flights in the United States. The daily number of miles flown by airlines is estimated at five million.

Approximately 3000 aircraft are presently used for commercial transportation. This number is almost double the 1954 total of 1,615. Table I-9 is a summary of the growth of commercial aircraft during the last two decades.

Table I-9

The Growth of Commercial Aircraft, 1959-69

1959	1,850
1960	2,135
1961	2,104
1962	2,047
1963	2,079
1964	2,081
1965	2,125
1966	2,272
1967	2,452
1968	2,586
1969	2,690

Source: FAA Statistical Handbook, 1969

The Aerospace Industries Association of America, Inc. reports that, as of January 1972, 2,493 airlines were in operation. This constitutes an important part of the total assets held by airlines in the United States. As of June 30, 1971, assets of domestic airlines (including buildings and ground equipment, flight equipment and working capital) totalled $7.664 billion dollars. Of these assets, about 82.8% or $6.347 billion were invested in flight equipment (net after depreciation, Civil Aeronautics Board in p. 118).

Table I-10 shows the growth of assets and flight equipment of domestic aviation.

Table I-10

Total Assets and Net Investment in Flight Equipment

(Billions of Dollars)

	Total Assets	Net Investment Flight Equipment
1958	1.182	.852
1959	1.492	1.048
1960	1.760	1.374
1961	2.099	1.734
1962	2.273	1.874
1963	2.211	1.818
1964	2.415	2.030
1965	2.816	2.391
1966	3.747	2.981
1967	5.003	3.833
1968	6.294	5.096
1969	7.107	5.864
1970	7.417	6.030
1971	7.664	6.347

Source: AIAA Inc., 1972.

While the number of craft suggests a phenomenal growth in commercial aviation, there are ever stronger indicators. Table I-11 shows the recent growth of American and foreign commercial aviation since 1960 in terms of passengers carried and passenger-miles flown.

Table I-11

The Growth of Passenger Usage of Commercial Aviation

Year Ending December 31	Domestic: Passengers Carried (Thousands)	Domestic: Revenue Passenger Miles Flown (Millions)	International: Passengers Carried (Thousands)	International: Revenue Passenger Miles Flown (Millions)
1960	52,377	30,556.6	5,499	8,306.2
1961	52,712	31,062.3	5,699	8,768.5
1962	55,950	33,623.0	6,598	10,138.0
1963	63,925	38,456.6	7,513	11,905.4
1964	72,988	44,141.3	8,773	14,352.4
1965	84,460	51,887.4	10,195	16,789.0
1966	97,746	60,590.8	11,646	19,298.4
1967	118,669	75,487.3	13,424	23,259.3
1968	134,423	87,507.6	15,728	26,450.6
1969	142,340	95,945.8	16,848	29,468.3
1970	153,662	104,146.8	16,260	27,563.2
1971	156,098	106,293.9	17,569	29,357.9

Source: Aerospace Facts and Figures, 1972-73, Aerospace Industries Association of America, Washington, D.C., p. 117.

The table suggests that the number of passengers in both the domestic and international categories has tripled in the last decade and that the number of passenger miles flown is three to almost four times as large as the 1960 distance.

While the growth can be seen in passengers and passenger miles flown, yet another important indicator is the increase in the number of operations. The operations of airlines have increased at the same phenomenal rate. Table I-12 shows the number of air carrier operations for 1968-69 at the 25 largest airports in the United States.

Table I-12

Number of Air Carrier Operations at 25

Largest Airports in U.S. (Commercial)

City	Airport	
Chicago	O'Hare	632,030
Los Angeles	International	443,236
New York	JFK	376,404
Atlanta	Municipal	361,257
San Francisco	International	306,929
Miami	International	275,443
Dallas	Love	275,317
New York	La Guardia	263,112
Washington D.C.	National	221,831
Boston		216,849
Detroit		213,130
Newark		202,020
Philadelphia		195,272
St. Louis		191,689
Pittsburgh	Greater	182,712
Denver		167,703
Cleveland		149,108
Minneapolis	World Chamberlain	142,268
Kansas City	Municipal	136,561
San Juan		133,818
Baltimore	International	133,358
Honolulu		127,787
New Orleans	Moisant Field	119,958
Memphis		113,476
Seattle		108,111

Chapter Two

AVIATION WEATHER PROBLEMS

Weather conditions present particular problems for most industries under consideration in this volume. Aviation is no exception. The purpose of this section is to review briefly some of the major meteorological problems which have been cited for their impact on aviation.

Beckwith (1972) notes that aviation weather problems have changed with the changing technology of aviation. In the case of commercial aviation, for instance, the problems which plagued operations in 1935, i.e., low clouds, precipitation, static and mechanical turbulence, have been completely eliminated. New problems, however, have replaced them.

General and commercial aviation share some common weather problems, and have some peculiar problems. As such, it is best to consider the particular problems facing each.

General Aviation

General aviation, mainly comprised of small aricraft, is subject to traditional aviation problems which no longer interfere with the operations of the big jets. Because of their size, the limits concerning the amount of turbulence they can handle and the altitudes at which they can fly are quickly reached. Moreover, since most of these planes have only VFR instruments, their use is often limited to the visual possibilities of the naked eye.

Important weather problems facing general aviation in flight and in take-off include: surface cross-winds, turbulence, wind-shear, hail, snow, thunderstorms, and icing. Surface cross winds can make a pilot miss the runway when landing and will make many landings uncomfortable, if not dangerous. Turbulence can make the pilot lose control and is capable of causing structural damage to the plane, sometimes bending or even cracking it. Wind-shear, a sudden change in the speed or direction of wind, can cause the same effect. Hail damages the airplane by denting the airfoil (sometimes actually punching holes in it) and reduces the pilot's visibility and the efficiency of his machine. Like hail, wet snow may keep a small plane on the ground but when encountered in the air, it reduces visibility, makes landings dangerous by reducing the plane's braking power, and increasing the possibility of hydroplaning, both of which increase the required runway space.

Except for visibility, the most severe problems for small craft already in the air are thunderstorms and icing. Thunderstorms are characterized by poor visibility, severe turbulence, hail, lightning and icing. Lightning is the least dangerous of these phenomena, but it can affect the compass and temporarily blind or distract the pilot. If it strikes the plane, it can ignite the fuel system and damage the frame and electronic equipment. One of the cardinal common sense rules of VFR flying is to stay on the ground under such conditions. Thunderstorms are reasonably predictable and can be seen from the ground.

There are two kinds of icing: carburetor and structural. Carburetor icing limits air intake and could cause the engine to choke. Although this extreme result is rare, carburetor icing always reduces efficiency by increasing the engine's fuel requirements. When combined with structural icing or other problems it can cause serious trouble. Structural icing is of three types: frost, which forms mainly on glass and reduces visibility; clear ice, which is transparent and smooth and takes the shape of the surface; and rime ice, which is opaque and bumpy and changes the shape of the surface. Frost is the least serious of the three.

Ice often accumulates in good weather as well as bad. Since clear ice is especially hard to see, pilots are often unaware of the problem until their plane's performance is seriously hampered. Icing conditions are very poorly forecast at present and the ice itself is frequently difficult to detect until it has reached problem proportions. Icing is probably the VRF pilot's most hazardous weather condition when aloft.

Large Commercial Airliners

Because of their greater size and speed, much higher flight altitudes, and detailed systems of instruments which can guide the pilot through almost any condition, the problems of the large commercial jets are completely different from those of smaller planes. These jets can fly above most bad weather, can get through almost any turbulence by merely slowing down and are capable of landing in visibility of 1600 feet. Weather hazards of smaller airplanes--thunderstorms and icing--are generally handled easily by climbing, detouring, slowing down and the use of de-icing boots, hot air and ethelyne glycol on the wings.

Various weather conditions curtail the normal operation of commercial airlines. Most critical and frequent of these are fog, snow and freezing rain, strong cross-winds, and wet runways that are cluttered with ice, slush[1] and other impediments to normal landing.

Fog is the most serious of these problems, costing the airline industry over $75 million[2] annually with the cost rising as the scope of airline operations increases. About half of the flights not completed are due to fog.[3] At present there is no reliable way to forecast this weather phenomenon. Even if there were, however, the fog would have to be modified or dissipated in some way before the problem could be overcome. Seeding programs have been instituted at several western airports with encouraging results, but the benefits would be greater if prediction were more accurate

The problems involved in forecasting snow are predicting the time of onset, the duration and accumulation, the direction and speed of the accompanying winds, and the snow/rain line.[4] Especially along the coasts (but also at inland airports such as Chicago's O'Hare) this last condition often means the difference between relatively harmless rain and inches of snow which could close the airports. The only danger presented by rain is wet runways, which create the possibility of hydroplaning and generally mean that landing airplanes will need more runway space. Special problems in forecasting snow and freezing rain lie in the accurate prediction of where and how fast the storms are moving and where and when they will stop. Flights cannot be planned without this information.

Often, several problem conditions occur at the same time and create an emergency situation. For example, jets are allowed to land with a cross-wind of thirty knots. However, when braking is affected by runway clutter--standing water, slush, ice, snow, etc.--the allowable cross-wind may be reduced to as little as five knots.[5] Such a situation would greatly reduce an airport's capabity and could close it entirely. Obviously, the meteorologist's job here would be not only to gauge the speed and direction of the cross-wind, but also to determine its effect on a plane in combination with the condition of the runway.

Another condition which is potentially hazardous in the terminal area is low-level wind-shear. "At least one case has been measured of a 30-knot speed change in 30 meters, but the shear need not be this great to compromise safety."[6] At John F. Kennedy Airport in New York, two hours of low-level wind shear during one day in December 1971 resulted in eight aborted runway approaches.[7] Low-level wind-shear, with capsizing waves on a warm front, can create upsets for a pilot on a climb-out. The worst conceivable result would be a nose-dive, but the usual result is passenger discomfort and occasional injury. For the descending pilot, low-level wind-shear often means "undershoots, overshoots, hard landings, or worse."[8] The general conditions for low-level wind-shear are known and pilots can be told when to expect it. However, there is "no observational technique at present for furnishing the actual magnitude of the shear to incoming aircraft.[9] Since the category II bad-weather-landing requirements specify a "decision altitude of 100 feet, this information is essential."[10]

Thunderstorms are rarely a problem in flight even though the turbulence which accompanies them can cause a great deal of discomfort to passengers. Inaccurate forecasts, however, can mean detours from the planned route or altitude once a plane is in flight. Such departures require the clearance of Air Route Traffic Control Centers of the Federal Aviation Administration. Sometimes this clearance is refused because of insufficient airspace.[11] The results are delays, diversions, and sometimes flights through "corridors narrower than is prescribed for maximum turbulence avoidance."[12] In the terminal area thunderstorms cause sudden and often very strong wind shifts which present problems similar to those of low-level wind-shear. Sometimes a "cluster" of thunderstorms over an airport will close all of the runways because of wind, hail, lightning, and "heavy accumulations of water on runways."[13]

Turbulence, which always accompanies thunderstorms, is a problem in itself. Turbulence has cost airlines the loss of customers even though no such documented evidence is available. It has been known to result in passenger injuries and subsequent lawsuits, not to mention general passenger discomfort. Statistics on the number of people who do not fly to avoid airsickness would show the validity of these allegations.

Clear air turbulence (CAT) and wave induced turbulence (WIT) are two of the most critical weather problems for airline companies. Since the airlines have started using jet planes, three fatal accidents have been attributed to WIT. Severe WIT is encountered once in about every 35 million miles of flying.[14] Since commercial airliners fly about five million miles each day in the United States,[15] this means that severe WIT is encountered about four times per month, mostly in winter and spring.[16] General areas in which WIT may be expected (such as mountains) are known, but it is presently extremely difficult to predict. It is frequently found at the tropopause, which airline meteorologists have no reliable way of locating. The tropopause is marked by a change in ozone concentration, and an ozone detector on a satellite could supply data to help solve the WIT problem.

High surface temperatures present problems in airline take-offs and in-flight operations. Payload may be restricted to accommodate the extra fuel in addition to the original weight restrictions. Precise hour-by-hour temperature predictions are needed during all seasons. Headwinds and tailwinds also present serious economic problems. The economic impact of these meteorological problems will be considered in part VII.

Chapter Three

PROJECTED NEEDS IN AVIATION WEATHER INFORMATION

The needs of aviation for improved weather infromation can be summarized as two-fold. First, there is the need to overcome the presently encountered problems posed by weather conditions. Secondly, there is the need to anticipate the yet unencountered problems which will evolve as new developments in aviation come about. The purpose of this section is to review the major needs of aviation weather information as found in the aviation literature.

The needs of aviation can be categorized as: improved methods of data collection, data transmission and data use.

Weather Data Collection

The needs for improved systems of weather data collection can be characterized as the need for 1) more precise information, and 2) more frequent weather information.

Improved Information

Various authorities and conferences in the field of aviation have pointed to the need for improving the quality of weather information provided to airlines.

The specific types of improved information have been suggested by various meteorologists. Beckwith (1972a) suggests the following as the major types of meteorological information required still lacking in sufficient levels of information:

a) Fog - there is at present no reliable method of forecasting it.

b) Snow and freezing rain - time of onset, duration, accumulation, the speed and direction of the accompanying winds, and the snow/rain line, especially along the coasts.

c) Thunderstorms - sudden wind shifts in the terminal area are very difficult to predict. Also, the zones of turbulence en route are arrived at by inference (not actually depicted), and are sometimes unreliably forecast.

d) Crosswinds - strength, direction, and effect of runway clutter.

e) Headwinds - predictions of strength are often inaccurate, especially in winter and early spring, when "almost explosive changes in wind and temperature patterns occur. These and peaks in jet stream velocities are presently unpredictable." 17

f) WIT is almost unpredictable.

g) Low-level wind-shear magnitude is presently unpredictable.

h) Surface temperatures - hour-by-hour expectancies are needed.

Likewise, there is the need to reduce the sources of error in weather forecasting. This requires the ability to better cope with the factors which can precipitate significant changes in the weather. Beckwith (1972b) points to the following meteorological phenomena which must be considered.

a) Trough deepening and rapid displacement. Results in wind direction and speed errors.

b) Timing of cut-off of low pressure centers as the bottom of troughs. Results in reversal of forecast wind direction, but at lower ranges of wind speed.

c) Rapid horizontal displacement of jet stream cores. Results in wind speed errors in the high range of values.

d) Strong polar and subtropical jet streams with observed super-gradient winds. Model (NMC equipment) frequently underforecasts peak values, particularly over tropical Pacific routes.

e) Ridge development and collapse in subtropical ocean areas. Affects wind direction at low to moderate speeds and to a lesser degree contributes to temperature field errors.

f) High tropopause in subtropical latitudes and associated advection of cold tropospheric air. Results in large temperature errors at 250 mile level and higher.

g) *Rapid changes in height of tropopause. Results in large temperature errors over short time periods.*

At the Conference of the World Meteorological Organization (WMO) held in Geneva in 1969, R. R. Shaw, of the International Air Transport Association, outlined the major information needs facing aviation in the future. Referring to a recent WMO/ICAO meeting as supplying a base for many of his points, he foresaw the following needs in relation to the improvement of the actual information.

Surface Wind Information

a) Information on current surface wind direction and speed, including significant variations from the mean speed and direction, to be provided to an aircraft as soon as practicable after it has established communication with the unit providing approach control service. This information should be updated at the commencement of final approach if changes in the mean wind for the runway in use occur which correspond to the following changes in the mean head, tail or cross-wind components: (i) Head wind, 10 knots; (ii) tail wind, 2 knots; (iii) cross wind, 5 knots.

b) Observation over a period of time sufficient for the provision to the pilot of a representative mean wind for the take-off and landing area in use.

It seems likely that similar information will also meet the needs of future generations of aircraft, though at this stage we do not know [enough] about their operational characteristics to be sure. It should also be noted that the thorny question of the period of time over which an observation should be made so as to be representative of the mean wind will remain to be solved. Probably more work will need to be devoted to this question, but we believe that the ten-minute period which has been advocated in some quarters is excessive, and that a period of the order to two to five minutes is probably more appropriate.

Runway Visual Range Information

The requirements were well sumamrized at the recent WMO/ICAO Meeting as follows:

a) At the commencement of the final approach--the current RVR value representative of the touchdown zone and, as applicable, current RVR values for any further observation points along the runway.

b) During the subsequent stages of the approach, without delay--changes in the RVR value representative of the touchdown zone, and as applicable, RVR values for further observation points along the runway, in accordance with the reporting scale in use.

c) Prior to or while taxiing for take-off--the current RVR value(s) as applicable for the departure runway.

By the 1970's there will certainly be an increasing number of Category III operations and fully automatic landings in normal scheduled passenger service. Although such operations will continue to require RVR information so as to enable pilots to assess in advance the expected terminal conditions, probable ATC delays and the need for any necessary diversions because of the impracticability of having to wait for longer periods over busy terminal areas. It does not appear, however, that the accuracy required in such cases wlll be any more demanding than for Category II operations. On the contrary, the greatest demands for accurate and detailed RVR observations would appear to be required for Category II operations. It should also be noted that even though Category III operations will be taking place, the majority will still be of the Category I or Category II type, at least in the first half of the 1970's.

Visibility Information

No change is foreseen in the recently expressed requirement--namely:

a) At the commencement of the final approach--the current visibility for the aerodrome, representative of the direction of the approach and landing.

b) During subsequent stages of the approach, without delay--changes in the visibility for the aerodrome, representative of the approach and landing area, in accordance with PANS-MET, Chapter 2, Table 1 (c).

c) Prior to or while taxiing for the take-off--the current visibility for the aerodrome, representative of the departure runway and the direction of the initial climb-out.

Slant Visual Range Information

Although turbine-powered aircraft have operated for many years now without this information, there is a school of thought that is firmly convinced that warning of the decrease in the pilot's visual segment during approach in shallow fog might well have prevented at least one known accident. In the case of fully automatic approach and landing operations, this argument will, of course, no longer apply, but as has been previously mentioned, there will still be many civil aircraft, probably the majority, which will not be so equipped. For this reason, we believe that developments to provide this information should still continue.

Short-Period Forecasts of RVR

The pilot requires assurance that he will have sufficient visual guidance during all stages of the flare and roll-out. A short-period forecast of RVR should therefore be transmitted to the aircraft with the clearance for final approach.

Although it is some ten years since the requirement for forecasts of RVR has been voiced, in most countries, as far as can be ascertained, efforts so far to develop techniques to provide this information have been limited. It is foreseen that trend forecasts of RVR will be particularly necessary for the SST and its successors throughout descent for the destination aerodrome, and during climb for the departure aerodrome in the event of a return being necessary. As mentioned earlier, there is also an operational requirement for the supply of terminal forecasts of RVR prior to departure of SST aircraft.

Amount and Height of Base of Low Cloud

Up-to-date observations of the amount and height of the base of low clouds are necessary to enable the pilot to assess the probability of having visual reference with the ground on reaching decision height. The recent WMO/ICAO Meeting agreed that the information should furthermore be representative of the conditions over the final approach, missed approach, circling approach and landing areas, and that where the information relates to an approach to a precision approach runway, it should be representative of conditions at the ILS middle marker.

This is envisaged as a continuing requirement for many years to come. We would stress, however, that the days of estimation by eye or by pilot-balloon measurements should have long since gone, and that this information should be provided by instrumental means at all international aerodromes.

Vertical Wind Shear

The importance of this item will probably prove to be of a lesser degree than had been thought some years ago. However, at those aerodromes where the local situation is such that marked vertical wind shear is a characteristic feature, provision should be made to measure and report this element on a properly organized basis.

Meteorological Conditions of Operational Significance in the Climb-out and Approach Areas

Detailed information on the location of cumulonimbus and associated phenomena (particularly hail and turbulence) is a requirement for current operations and will remain so in the future. Its importance is likely to be greater with future generations of aircraft, and in the 1970s we consider that weather radar should be an essential element at every aerodrome together with the necessary facilities and procedures to pass the information to aircraft in the area.

Information on State of the Manoeuvring Areas

Although it might be debatable as to whether the provision of up-to-date reports of the state of runways and taxiways due to the presence of snow, slush, ice or water is a meteorological responsibility, there is certainly a meteorological connotation since operational decisions on this matter are often taken in conjunction with reports of other meteorological elements (e.g., surface wind for landing). Additionally, for all-weather operations, there is certain to be a requirement for information about the distribution of thick fog over the taxiways."

The use of the digital computer in the data collection will increasingly have important implications for the processing of weather information. Von Kann notes that the use of the computer as a collection agency and depository for cited weather conditions on a continually updated basis will improve weather information collection. In particular, he points to the development of automatic ground reporting of essential weather conditions as one means of improving weather collections. The use of automatic position devices in space, an extension of such a scheme, is another feasible alternative.

Increased Frequency of Collection

The need for improvement in due frequency of collection of weather information has been recognized as much as the need for improved information. Von Kann, for instance, suggests that a four-times-a-day cycling of weather information, instead of twice a day, needs to and will become common. (p. 103) Shaw agrees with this position, elaborating on the importance of increased frequency in weather information.

Data Transmission

The needs for improved systems of data transmission can be categorized as those of: 1) improved systems and forms of transmission, and 2) increased speed in the transmission of information.

Improved Transmission Systems

The need for improved systems of data transmission do not center as much on the development of new media as on the new uses of the existing media. The present system of weather information transfer in the United States is probably the most sophisticated system in the world. Facsimile and teletype systems already provide the means by which data, once observed and collected, can be distributed to users. However, definite areas for improvement have been recognized in the form in which the information is transferred through these media.

Pointing to the needs to develop new forms of information transmission, Shaw has outlined the following areas for future development in the field of information systems:

> The adoption of a standard format for the transmission of computer forecasts to airline computers is an urgent requirement. This is a task which WMO and ICAO should undertake at the earliest opportunity. At the present time, there are differences in the format of existing forecasts prepared by computer on a national basis which make them incompatible without special programming. This should not be allowed to persist or spread further as it would greatly hinder the utilization of computer forecasts on a global basis. It is suggested that the entire computerization programme be co-ordinated through the WMO World Weather Watch and

implemented under the WMO/ICAO Area Forecast System. We will have more to say later about the detailed requirements to be placed on the Area Forecast System with regard to computer flight-planning.

Upper-air significant weather could be available in numeric form by developing a system of numbers for different weather elements--i.e., 1 for clear air turbulence, 2 for cloud turbulence, etc.--which would be stored directly in the computer along with the co-ordinate data to mask their occurrence. Thus, the flight-planning computer would have all of the information necessary to produce the best flight plan on its initial run. Currently, significant weather is subjectively introduced into the system after the initial track is produced by the computer, resulting in some cases in a cut-and-try operation.

Concurrently, a visual display of the significant weather could be made available to the dispatcher and flight-crew by means of a print-out in chart form from the flight-planning computer or a cathode-ray tube display direct from the forecast computer.

We would like to advance the requirement that all Area Forecast Centres should have digital transmission and reception capability in addition to their currently planned facsimile transmission and reception capability. The logic of such a requirement can be related back to our brief history of computer flight-planning. One does not even have to be a meteorologist to predict that local requirements for digital forecasts will be as common in the foreseeable future as North Atlantic requirements are today. Mohawk Airlines, an operator of a fleet of BAC-111's and FH-227's with a longest non-stop stage length of 450 n.m. (770 kilometres), has completely computerized the flight-planning for this turbine-powered fleet. This stage length is less than from Copenhagen to Brussels, from Barcelona to Seville, or from Istanbul to Beirut. In the future, requirements for digital forecast data in these three areas, and countless other areas of the world, will be as valid as they are today in the northeastern U.S.A. The Area Forecast System must be prepared to meet these requirements, and it will not be enough that the requirements are met solely at the major AFS Centres. The capability to receive digital forecasts should parallel the capability to receive what can now be called the old-fashioned facsimile broadcasts.

As already mentioned, a requirement is foreseen for documentation in the form of conventional upper-air charts and charts showing significant weather to be processed by numerical methods and transmitted to departure stations over high-speed communications channels. With regard to the presentation of aerodrome forecasts and other operational MET information about aerodrome conditions, it is considered that streamlining could be accomplished if greater progress could be achieved in developing a direct reading form of message. The new METAR and TAF forms have gone somewhere towards self-evidency, but there is considerable room for improvement. If such improvement sould be achieved, there would be no objection to such data being prepared for documentation in the form of a straight copy of the message as received on the teleprinter.

IATA acknowledges the need to reduce documentation to a minimum, but considers that the pilot will continue to require some information in conventional form prior to departure. For the SST this might well be restricted to aerodrome forecasts and significant weather over and near to the flight path, and to include jet streams and tropopause data in the climb-out area, "warm" regions at cruising altitudes and perhaps, in addition, warnings of solar flares.

There is no question that there is an urgent requirement for the basic or raw-data processing to be conducted four times daily rather than twice daily as is currently being done. In our opinion, sufficient basic meteorological data already exist to support four computer runs per day, and the added forecast accuracy will justify the additional computer time. Also, the availability of new forecasts four times daily will mean fewer forecasts will have to be provided to the airline users. Currently, users are receiving four forecasts covering twenty-four hours. With a computer system processing data four times daily, we will only need three forecasts covering eighteen hours.

A second urgent requirement is for the development of procedures in the numerical forecast programme which will take into account, on a timely basis, the vast numbers of AIREPS being made over areas with sparse basic observational networks. In the current numerical forecasting programme, as AIREP can be as much as thirteen hours old when it is used in making a forecast which in turn may not be utilized in a flight plan until another six hours later. The forecast computer is not running on AIREP data twelve to twenty-four hours behind the flight using the forecast. Just making computer runs daily would reduce this lengthy delay to six to eighteen hours, but additional procedures are required.

The increased frequency in the collection and processing is an important element in the total improvement of the weather information system. The quality and quantity of weather data collected sets an upper limit on possible improvements in other phases of the weather information system.

Increased Speed in Transmission

More significant, seemingly, than the improvement in the form in which other information is transmitted is the speed at which information is transferred. There has been growing concern--particularly as the average speed of large aircraft increases--that information concerning meteorological conditions be made available at a faster pace than is presently possible.

Von Kann (1970) has considered this problem in his overview of the major requirements of aviation in the 1970's. He concluded:

> Up until now we have not fully benefited from the ground-based weather radar network. Presently, these storm data get into the system an hour after observation. Thus, information derived is too old by the time it gets to the customer, an airliner moving at 600 m.p.h. (p. 103)

Lieurance cites an FAA-U.S. Weather Service-Department of Defense Ad Hoc Group Final Report of 1963 which outlined what were considered the major meteorological user requirements of aviation. These are summarized in Table III-1.

The data suggest that the minimum time periods necessary for different types of weather information range from as little as 2 minutes as in the case of visibility cloud base and surface winds, to as high as 24 hours. In all types of weather conditions, there is a recognized need to reduce the present time lag of reporting meteorological conditions.

Shaw has also pointed to the problem of reducing the time periods in which weather information is transmitted for aviation use. While he notes that the introduction of winds and temperatures in digital form decreased the time span between observation and use of the data by avia-

Table III-1

Aviation Meteorological User Requirements*

Information requested	Area Covered	Time Period
Visibility, cloud base, surface wind speed and direction	Airport surfaces	2-5 min.
Terminal area ceiling, prevailing visibility, wind and altimeter setting	Terminal area	1-0 hr local 0-12 hr nationwide
Cloud bases over runways and approach/departure paths	Controlled terminals	1-0 hr, all terminals
Slant range visibility along approach paths and runway visual range (RVR)	Controlled terminals	0-1 hr, all terminals
Cloud lines and areas containing hazards (hail, turbulence)	As required	0-12 hr
Wind and temperature in significant regions over approach paths and runways from surface to at least 800 ft.	Approach paths and runways	0-12 hr
Area cloud distribution through airspace	As required	0-12 hr, all airspace
Temperature in departure airspace	Departure area	2-5 min
Winds and temperatures aloft, flow patterns over nation at operating levels in intervals of at least 5, 10, 15, 20, 30, 40, 60, 80 thousand ft.	All airspace	0-24 hr
Storm centers and associated frontal positions with hazardous weather description	As required	0-12 hr 0-24 hr
Fronts on surface and aloft, distribution nationwide of highs and lows	As required	72,48,24 hr
Precipitation accumulation	Airport runways	0-5 hr

* All but final item from FAA-USWB-DOD Ad Hoc Group Final Report (1963).

From N.A. Lieurance, "Report of the Committee on Aeronautical Meteorological Problems," Bulletin of the American Meteorological Society, Vol. 53, No. 4, April 1972, p. 351.

tors, he also indicates that aviation is still largely operating on eighteen to twenty-four hour forecasts. The immediate goal he calls for would be to reduce this period to twelve to eighteen hours. More importantly, he foresees the long-term requirement of further reducing this time span to six to twelve hours. Such a time span would allow a cycling of weather information as follows:

Period after data time	Operation to be accomplished
0 - 2-1/2 hrs.	Observations made, data collected and entered into forecast computer.
2-1/2 - 3-1/2 hrs.	Forecasts made by computer, transmitted and received by flight-planning computer.
3-1/2 - 4 hrs.	Flight plan produced and transmitted to departure station.
6 - 12 hrs.	Aircraft departs on forecasts based on 0 hour data.
6 - 8-1/2 hrs.	Cycle repeated with new observational data.

Shaw outlines a number of other meteorological requirements as follows:

> We feel that the air-to-ground and ground-to-ground transmission of AIREPS should not exceed ten minutes from aircraft to forecast computer. Further, we feel that with a continuous flow of AIREPS into the forecast computer as a source of raw data, a computer programme should be devised which would revise the forecast once it has been determined that the data from sufficient AIREPS meet the criteria for an amended upper-wind or temperature forecast. Work is in progress along these lines in the U.S. National Meteorological Centre, but a satisfactory solution is not yet in sight.
>
> Another urgent requirement under this heading is the development of a new communications procedure to get the digital forecasts into the flight-planning computer nearly instantaneously.
>
> An even better system would be a data link between the aircraft and the forecast computer, possibly via an ATC communications system, to ensure that reports of wind, temperature, significant weather and other meteorological elements are inserted directly and automatically into the forecast computer.

The current paper-tape system takes nearly one hour to transmit the digital forecast data for about one-quarter of the globe and to ensure proper reception. A system is within reach today which can transmit and receive the same amount of data in half-an-hour.

For future airline operations, we foresee the need for global forecast data coverage which, even with the system within reach today, would take two hours and, with the current system, four hours.

We feel that a reasonable and attainable requirement would be the transmission and receipt of digital forecasts for the complete globe in a period of about an hour. This would mean that data for a small part of the globe (such as the North Atlantic) would be received in less than ten minutes. This requirement envisions transmission speeds of the order of 6,000 words per minute, not an unreasonable future requirement in this day and age.

This brings us to another future requirement: that of a faster system for the transmission of flight documentation. Already we are experiencing problems with aircraft departing on a computer flight plan prepared from digital data without having available the flight forecast documentation corresponding to the computer forecast.

With the requirements we have previously stated for a speed-up in the transmission and receipt of digital forecasts, the gap will widen further until the current and planned facsimile communications system will barely provide the flight-forecast documentation after the flight arrives at the destination, let alone prior to its departure.

Assuming we have a continuing requirement for flight-forecast documentation, we foresee a future requirement for high-speed digital transmission and reception of flight forecast documentation. This currently is operational in certain military weather services over extensive geographical areas, in some services nearly hemispheric. Thus, it may be wise to consider placing on the Area Forecast System two new requirements. First, as previously mentioned, a capability to transmit and receive digital data, and second, a concurrent capability to transmit and receive weather charts at the same speed as the digital forecasts. Possibly this will involve an ability to generate charts from digital data. (Ibid.)

From this discussion of the projected needs for improved transmission of weather information to aviation, it is evident that there is room for sizable improvement. While the quality and quantity of collection dictates in many ways the possible improvements in the transmission of data, the latter is also a necessary condition for the improvement of the modern weather information system.

Chapter Four

POTENTIAL BENEFITS FROM IMPROVED WEATHER INFORMATION: SAFETY

The first of the major benefits to be derived from improved weather information is safety. As in the case of any form of transportation, the maintenance of standards of safety is a key consideration in the aviation field, whether it be general or commercial aviation.

An analysis of recent records points to the need for safety guidelines in the industry. A total of 203 persons were killed in airline crashes in 1971. This represented an increase of 57 over the previous year. In general aviation, 1,322 persons were killed, increasing by 68 the previous year's total.

In its preliminary report detailing the accident record of aviation, the National Transportation Safety Board enumerated these 203 aviation fatalities, noting that they occurred in a total of eight accidents. Of these, three were mid-air collisions which killed 49 persons in airliners and five in other types of craft; two were the result of non-precision instrument approaches to airports, resulting in 139 deaths; one was a non-flight accident in which a truck driver was killed when a van collided with an aircraft during the boarding process; one occurred during a training flight and one in a cargo flight--the latter two resulting in the deaths of two crew members only. In general aviation, out of a total of 4686 accidents, 622 of them resulted in 1,254 deaths.

These statistics are most meaningful when considered in light of the number of hours flown. In the case of commercial aviation, the accident rate on the basis of 100,000 hours flown was .757. This is down from .850 in 1970. Paralleling this was a decline in the fatality rate, down from .124 per 100,000 hours flown to .097. In the case of general aviation, the fatal accident rate was down from .194 per million miles flown to .176. Total accidents were down from 1.45 to 1.27 per million miles flown. (Aviation Week, January 27, 1972, p. 54.)

Considering both commercial and general aviation, the overall accident rate per 100,000 hours flown was 17.8, unchanged from 1970. The fatal accident rate per 100,000 hours flown was 2.47, representing an increase from 2.39 in 1970.

Thus, simply on the basis of the safety records, the need for reducing the number of fatalities from aviation accidents is evident. Improved weather information is not the only way this record can be improved but it is an integral part of the effort.

The importance of weather information to safety has been acknowledged by various authorities in aviation and meteorology. Maunder (1967) states that while accidents represent a fractional percentage of the total number of aviation operations, "as better methods are found to give an even more accurate picture of the weather, pilots will be able to lessen the chances of weather associated air crashes." (p. 111)

Halaby (1968) has recognized safety as a key element in the operation of airlines:

> Why do we reach for all-weather operations? The first reason is to assure safety of operations. If we can operate with instrumented precision during bad weather, we can systematize operations during good weather so as to reduce incidents and accidents under fairer conditions.

Safety is a problem which affects the normal operation of aviation in potentially drastic--if not catastrophic--ways. When meteorological conditions are such that the safe operation of aviation is impaired--

regardless of the degree of safety hazard involved--finding ways of eliminating unsafe conditions is vital concern. Because weather is an integral part of the total operation of aviation, reducing unsafe conditions through improved weather knowledge stands as a major benefit to be derived from _any_ system of improved information.

Chapter Five

POTENTIAL BENEFITS FROM IMPROVED WEATHER INFORMATION: ECONOMICS

While the concern for safety in aviation is of immediate concern, economy is another important benefit to be accrued from improved weather information. Economics plays an integral part in not only the operation of commercial aviation, but in the day-to-day operation of general aviation as well. This section is an attempt to summarize the complex aspects of economic benefits and the way in which weather information is a key variable in aviation economics.

Estimates of the economic losses to aviation due to weather are difficult to ascertain. However, several have been made. Halaby places the price tag for bad weather at about $70 million per year. In addition he notes that there are no reliable estimates of the total annual cost to travelers and shippers resulting from bad weather and the need to alter plans and the like. Halaby's estimate is comprised of the costs of diversions, increased flying time and passenger handling, and losses from potential sales prevented by fears of poor weather, losses from "next flights" for which a particular aircraft is to be used, and losses in wages to maintenance crews and subsequent overtime wages paid to compensate for the delays in maintenance resulting from weather related delays.

Halaby notes that there are two primary economic considerations in zero-zero operations: direct monetary return from the ability to operate in bad weather and fear of lost revenue.

Another study completed by the United Research Institute in the 1960's put the figure at $55 million a year. This study categorized the losses into three groups: 1) cash losses when airlines are forced to delay or divert flights, 2) short and long-term costs resulting from landing accidents, and 3) losses from the reduced demand for air travel as unreliability of aviation increases in bad weather conditions. This estimate included neither indirect expenses nor overhead costs which would increase the weather related losses.

While the weather results in significant losses for the airline industry, a key question is the degrée to which improved weather information can reduce this loss. Unfortunately, no system of weather information is capable of eliminating weather related losses. However, it would seem possible that improved weather information systems could reduce that amount. Indeed, the degree to which improved weather information systems could reduce these losses is the central problem facing this report.

Unfortunately, no previous research has been found which would suggest the degree to which such weather related losses might be reduced through the introduction of improved weather information systems. However, the comments of some of the leading figures in aeronautical meteorology suggest a definite possiblity. For instance, Beckwith states:

> The great progress made in the past 35 years in aircraft development, in ground and airborne naviagtion systems, _in weather communications_, in airport field facilities, and in more exacting flight crew training have lessened the impact of weather on the airline industry. The same degree of progress has not been made in forecasting some of the weather elements, although basic meteorological knowledge and observational techniques have advanced significantly. (emphasis added) (p. 863, B.A.M.S., Sept. 1971.)

Three major types of economic losses requiring consideration include: flight cancellations and lost sales, delays and diversions, and inaccuracies in prediction of weather conditions.

Flight Cancellations and Lost Sales

The cancellation of flights by airlines due to unfavorable weather conditions is a factor in the economics of aviation which is steadily decreasing in importance, but which still must be considered. Cancellation previously served as the best means of avoiding unfavorable weather conditions, particularly with smaller craft. As the average airliner costs about $500 per hour to operate, the savings in actual operation costs are small compared to the potential income lost due to cancellation. Additional costs accrue from the airlines' need to pay terminal costs, maintenance, personnel and ticketing, including customer relations. Economic losses are also generated in some instances by necessitating airlines to eventually "fly empty" in order to place needed equipment in destination terminals for the origin of other flights.

Flight cancellations and lost sales from weather induced factors have particular influence on the economic state of airlines in light of the need to obtain minimum passenger levels for economic operation. These minima, known as the "load factor" have important implications for the prosperity of airlines.

The load factor necessary for the economic operation of airliners varies with the airliner and airline, though minimum, average estimates have been made. Maunder estimates that a commercial airliner breaks even within a 28% to 35% occupancy range. However, Beckwith places the figure higher, at about 45%. The average present load factor for commercial aviation is placed at 60-65% by Maunder and 52-53% by Beckwith. One of the leading trade journals, Airline Management and Marketing, reported that the average load factor in the first quarter of

1970 for the domestic trunk flights of eleven airlines (United, American, Eastern, TWA, Delta, Northwest, Western, Continental, Braniff, Northeast and National) was 47.0%. During the same period, Hawaiian flights by United, Pan Am, Northwest, Western, Continental, Braniff and TWA showed an average load factor from the United States of 49.1%. Nine local service airlines (Allegheny, Frontier, Air West, Piedmont, Mohawk, Texas International, North Central, Ozark and Southern) maintained an average load factor of 41.3% for this period.

The result of reduced sales from weather conditions, could very well place the average load factor of commercial airlines below the level considered necessary for economical operation. Maunder has noted that "a small percentage of trips cancelled could turn profit into loss." Likewise, particularly in the case of the local service lines, the reduction of merely a couple of percentage points in the load factor could result in losses for the line. The economic plight of these smaller lines is evidenced by the fact that they are presently being federally subsidized.

Table V-1 shows Maunders' analysis of airline expenditures and cost of cancellations for 1959 and 1962. The data suggest that the cost per flight cancellation was approximately $139 per passenger in 1962, representing an increase of $19 over the 1959 figure.

Delays and Diversions

Greater economic impact than flight cancellations is caused by the delay and diversion of flights. Of all air traffic control delays of aircraft in the United States, an overwhelming 88% are weather induced,

Table V-1

Estimated cost of flight cancellations in the Unived States due to weather: 1959 and 1962 (after United Research Incorporated, 1961)

Costs	1959	1962
Passenger revenue loss due to flight cancellations	$14,989,000	$22,730,000
Expense of operating non-revenue ferry mileage	605,000	628,000
Passenger service - interrupted trip expense	2,443,000	3,116,000
Duplicate reservations, ticketing and accounting expense	652,000	978,000
Gross costs	18,689,000	27,452,000
Less: Savings in aircraft operating expense	12,165,000	18,941,000
Net costs	6,524,000	8,511,000
Number of flight cancellations	54,309	61,101
Cost per flight cancellation	120	139

From Manuder, Ibid., p. 111. (1970).

the remaining delays being caused by mechanical problems and non-weather related traffic and passenger problems. Together these caused the industry 24 million minutes of delay.

A look at the number of delays at key airports in the United States suggests the scope of the delay problem. New York's John F. Kennedy International Airport has an estimated 5,358 arrivals per day or 223 an hour. (These are complemented with approximately the same number of departures per week.) During 1969, it is estimaged, between 19,500 and 39,000 flights were delayed in New York City alone. At O'Hare Field in Chicago, up to 1,000 flights have been diverted or cancelled in one day due to snow.

The average number of delayed flights in the United States was estimated at approximately 2.4% of all flights in 1971. Of these delays, over half were attributable to fog. While this is a small percentage of the total number of commercial operations in the United states in that year, the figure represents a large amount of delay in terms of flights and income. Table V-2 projects the number of flights which would be delayed at leading airports in the United States if delays represented only as little as one or two per cent of total operations.

Table V-2

Movements at selected United States airports*

Airport	Arrivals†			Delayed flights per year**	
	/week	/day	/hour	1%	2%
Atlanta, Ga.	8,633	1,233	51	4,488	8,976
Boston, Mass.	10,841	1,548	65	5,637	11,274
Bufflao, N.Y.	3,968	567	24	2,064	4,123
Chicago, Ill.	19,215	2,745	114	9,989	19,978
Denver, Colo.	4,866	691	29	2,532	5,064
New York, N.Y.	37,505	5,358	223	19,500	39,000
Omaha, Neb.	2,858	408	25	1,487	2,974
Reno, Nev.	8,687	1,241	52	4,519	9,038
Salt Lake City	2,320	331	14	1,206	2,412
Seattle, Wash.	7,853	1,122	47	4,082	8,164
Washington, D.C.	19,663	2,809	117	10,223	20,446

*All airlines are included. Data derived from International Edition, Official Airline Guide, January 1967, and North American Edition, Official Airline Guide, October 1967.

†Double all figures for total movements.
**Number of delayed flights per year assuming 1% or 2% delays due to weather.

From Maunder, (1970), Ibid., p. 108.

In terms of dollars lost, the delay and diversion of flights represent significant operational air and ground costs to the airline. Considering the costs for operating an aircraft in the air which is being diverted or held for delayed landing, suggests the price tags involved; particularly considering the number of flights which are involved. Losses per hour for selected planes are as follows: $454 for a DC-8, $459 for a B-720, $357 for a B-727, $337 for a Caravelle, and $310 for a B-737. On-the-ground costs are $317 for a DC-8, $334 for a B-720, $264 for a B-727, $271 for a Caravelle, and $233 for a B-737.[17] Ground costs involved in the diversion of a plane for inclement weather include alternate transportation (usually busing), meal and hotel expenses, overtime pay for crews, and sometimes--such as in the Los Angeles and Ontario airports in Southern California--the rental of terminal space for the deplaning and loading of passengers affected by poor weather conditions. The average costs suggest the economic magnitude of the problem: $1,500 in Los Angeles, $1,200 in Seattle, $700 in Salt Lake City, $900 in Boise, $582 in Des Moines, $500 in Medford, Oregon, and $375 in Omaha.[18]

Overall, the average air delay costs airlines $409.23 per hour; the average diversion $1,079.33 per day. (There are more flights connecting larger and more expensive cities than smaller ones.[19])

<u>Inaccuracies in Forecasts</u>

A final area in which weather information influences the economics of the aviation industry is in the inaccuracy of weather information used in flights which are not cancelled, delayed or diverted due to weather conditions. These "normal" operations do not present blatant economic losses for airlines, but represent more covert, yet important economic problems for the airlines. This probably represents the most important and most complex area in which improved weather information systems can affect the economics of aviation.

Knowledge of weather conditions in the atmosphere is a key element in the design of flight plans for commercial as well as general aviation.

A consideration of the economic and technological factors involved in efficient employment of aircraft is beyond the scope of this present paper. Several excellent discussions are available on the problem. Yet, some understanding of the importance of atmospheric factors in flight planning in necessary to fully understand the importance of weather information.

Stratford (1967) has suggested four principal characteristics which determine the commercial performance of a transport aircraft. They are:

1. The maximum available payload and the disposable volume for passenger and/or cargo use above and below the principal floor.

2. The range for which the maximum payload may be carried with specified fuel reserves and allowances.

3. The maximum economical cruising speed under specified conditions of aircraft weight, engine thrust and ambient air temperature.

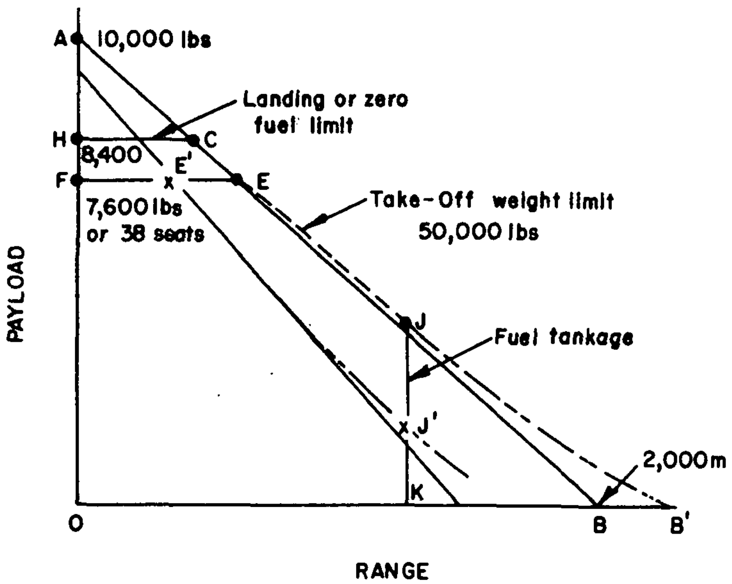
4. The airfield requirements in length of runway for take-off and landing for a specified altitude above sea level and given meteorological conditions.

Weather phenomena have important implications for all of these economic factors because of the influence which meteorological conditions have on the operation of aircraft. The relationship between payload-range, for instance, and the use of fuel has been summarized in Figure V-1.

Several meteorological factors, in particular the temperature of the air and the amount of clear air turbulence, have important implications for aviation economics. The temperature of the air is directly related to the rate at which fuel is consumed. On the one hand, it is necessary for an aircraft to load sufficient fuel to complete its designated route and have additional fuel for possible emergency purposes. On the other hand, it is desirable to eliminate aircraft unnecessarily carrying too much fuel which would result in wasted fuel, and thus increased operating costs for the airlines. Studies on fuel consumption have found that a temperature excess of 11.1° C between 25,000 and 52,000

Figure V-1

The payload-range relation in aviation flight



PAYLOAD-RANGE CHARACTERISTICS OF TRANSPORT AIRCRAFT

feet would result in the use of an additional 4,350 pounds of fuel. While this represents only 2.3% of the total fuel consumed in a flight, it could result in the necessary displacement of twenty passengers and baggage in a case where a critical estimation of payload is needed.

The importance of the conservation of fuel is illustrated by the case of United Airlines. With an annual fuel bill of about $200 million, United used about 1.7 billion gallons of fuel in 1970. A fuel conservation campaign coupled to an employee incentive plan accrued a net savings of about $8 million after distributing employee dividends. The potential for savings in this area is difficult to estimate, but since United flies about one-fourth of the revenue miles flown in domestic passenger flights, the figure for the industry could approach as much as $32 million.

An important problem related to temperature is that of icing. While icing has been known to present severe safety problems (proper operation of operation and control surfaces, brakes, landing gear, radio communication; and proper operation of the altimeter, speedometer and climb and turn indicators, when accumulated in the pilot tube), it also presents problems for the economic operation in more normal operations.

The second type of key weather information, air turbulence, also has important implications for improving the economy of commercial aviation. Knowledge of the existence and intensity of air turbulence allows for more precise planning of fuel needs. It also allows a more careful evaluation of flight plans and possibilities of alternative routes which would result in less fuel consumption and thus reduced operating costs.

Chapter Six

CONCLUSIONS AND RECOMMENDATIONS

From this preliminary report on the implications of weather and weather information for aviation, a number of broad conclusions can be drawn:

1) The development of aeronautical meteorology and meteorology in general has been concomitant with the development of aviation during this century. New technological capabilities have developed in both fields which complement those in the other. There is little to suggest that this reciprocity will not continue.

2) Aviation, both commercial and general, is increasingly a major mode of transportation, with important implications for the ordering of modern society. Projections on the future development of aviation suggest that this pattern will continue and aviation will increasingly become an integral part of modern life.

3) The present systems of providing weather information for American aviation are probably the most sophisticated of all weather information systems now in existence, and probably one of the most sophisticated systems of information processing found anywhere.

4) Weather continues to present major problems for aviation as atmospheric conditions sometimes hamper the safe and economical operation of aviation today. The specific weather conditions which create problems range from the more accurate prediction of air temperatures to the prediction of severe storms.

5) Various needs for specific types of improved weather information have been cited as essential for the future development of aviation. These are: improvements in the quality and quantity of data collected and improvements in the quality and quantity of data transmitted.

6) Real benefits are to be derived from improved weather information for aviation. These include the safer operation of aircraft as well as more economical operation of aircraft. Both these benefits have major implications for the future development of aviation as a means of transportation.

Thus, the necessity for improved weather information shall continue as a major point of concern for the aviation industry.

By surveying the parameters of the problem of improved weather information and its implications for aviation, this report has attempted to provide a point of departure for further research of this complex problem. There is little question that a need exists and benefits await, yet the question remaining is in what way improved weather information can specifically aid the industry.

The Satellite in Improved Aviation Weather Information

In evaluating possible media for the improvement of the present systems of providing weather information, the capabilities presented by satellite technology present unique possibilities for attaining that goal.

Aviation shares with other human endeavors dependence on the supply of complete, accurate and up-to-date weather information the opportunity to substantially gain from this new technological capability. The geosynchronous weather information satellite system which has been proposed, will substantially contribute to the collection and transmission of weather data.

There is little question that the satellite possesses capabilities essential to the provision of meteorological information which is not offered by other present systems. At the same time, the satellite would appear capable of offering these important services: 1) the coverage of a wide area, yet the capability of concentrating on relatively small areas as conditions within areas change, 2) the increased frequency of data collection, as data collection could increasingly become a continuous operation, where the time span in the cycling of weather information might be reduced to as little as six hours, 3) the capability of multiple beaming of weather information to earth, including aircraft in flight, which would eliminate the need for the relaying of information from centralized locations as is done today.

Already the meteorological satellite has proven its utility in the aviation field on an experimental basis. The Tiros and Nimbus satellites developed the basic scientific capabilities of meteorological satellites and are now used to provide limited graphic as well as other information. In 1966, the Federal Aviation Administration made the first experimental test of weather photographs transmitted from satellites directly to planes in flight. The Automatic Picture Transmission (APT) capability of Nimbus II was considered of sufficient quality to experiment with the installation of receivers and a facsimile recorder of a Gulfstream I aircraft and was used to beam information to craft in flight over the Atlantic. Pictures were successfully transmitted to the plane, which flew at an altitude of 20,000 feet, with a signal strength of -115 dbm.

The satellite clearly possesses the hardware through which improved weather information can be distributed to aviation. Yet, its potential benefits extend beyond that. The increased capabilities offered by the satellite have important implications for the way in which weather information is used by the "weather information consumer," i.e., the aviator, whether he be an airline dispatcher or pilot, or the owner of a small private craft. Satellite technology is in a position to literally revolutionize the very way in which weather is used by aviators. Use is the key variable that must be considered in any discussion of weather information. Information collected and transmitted, through any technology, whether conventional or satellite, is only as good as the way in which it is finally consumed. Surprisingly, little research is found to date concerning the ways in which aviation information is actually used, the habits of flyers, what information is sought, and when, where, how, etc. Yet, the advent of a technology which can revolutionize the very nature of information itself implies that it also would have important implications for the problem of use. Much suggests that, in addition to satellite technology providing improved collection and transmission of weather information, it would also contribute to what can be considered the third phase of the information processing model, data use.

Recommendations for Further Research

Serving as a point of departure for further research, this overview of the problem would suggest that further research on the implications of satellite technology on the safe and economic operation of aviation needs to be done in a number of key areas. It is impossible, within the scope of this brief survey, to provide the type of exacting analysis which is required of each of the major aspects of the problem, but it has attempted to suggest some of them.

In particular, four areas need to be considered in more depth. Each presents in its own right a substantial research undertaking. These areas include:

1) The further analysis of the problems of weather which affect the operation of aviation and how data related to them can best be collected and transmitted by satellite for optimum use by the aviation field.

2) The further analysis of the safety benefits to be derived

from improved weather infommation systems, and, in particular, what proportion of the total safety losses in aviation might be eliminated through improved weather information. Little suggests that safety losses can totally be eliminated, but the improvement of weather information certainly can contribute to the reduction of these losses.

3) The further analysis of the economic benefits to be derived from improved weather information systems. In particular, what proportion of the total economic losses in aviation may be eliminated through improved weather information. As in the case of safety, it is doubtful that economic losses related to weather can ever be totally eliminated, yet, these losses may be reduced through the improvement of weather information systems.

4) Finally, considerable analysis must be made of the way in which weather information is presently used by commercial as well as general aviation. The development of hardware in meteorology, both in weather information collection and transmission, is only as good as the human use to which it is put. The development of any improved weather system is dependent on this use if it is to be a meaningful societal investment. Among the problems to be considered are: a) in what ways the present information is being used, b) what types of information are presently being used or unused, c) the adequacy of present weather information, d) the credibility of present weather information, and e) the ways in which users believe that weather information services can be improved.

In the final analysis, just as aviation evolved with the development of meteorology, the future growth of aviation is dependent on the future growth of meteorology and ways of providing meteorological information. The future growth of aviation dictates the need of improving weather information, in whatever way possible. The task remaining is exploring the best way.

Appendix

PRESENT SYSTEMS OF PROVIDING AVIATION WEATHER INFORMATION

Because aviation is so integrally dependent on the provision of weather information, an important element in understanding the implications of weather information is understanding the present ways in which weather information is collected, distributed and used.

The provision of aviation weather information is a specialized function of the United States Weather Service, of the National Oceanographic and Atmospheric Administration (NOAA). Within the U.S. Weather Service the Aviation Weather Service provides data for both domestic and international use.

Domestic Service

The objective of the domestic service, according to the Weather Service, is the following:

> To further weather information for safe and efficient flight operations both at terminals and along flight routes within the conterminous forty-eight states, Alaska and Hawaii. Service for flights originating in the continental United States (including Alaska), but terminating in Canada, and for most flights to Mexico and short range Caribbean flights, is provided in accordance with domestic procedures.

In terms of the model suggested in Part I, the activities of the United States Weather Service can be categorized as data collection and data transmittal. The problem of data use is separate.

Data Collection

According to an official Weather Service description, aviation forecasts are prepared in 34 Weather Service Forecast Offices which distribute once every six hours a total of 430 12-hour forecasts (coded FT-1) and 137 24-hour forecasts (FTUS-24) for specific airports.

Other reports prepared include: 1) Area Forecasts (FA) for designated geographic areas, 2) In-flight (FL) advisories (either classified as AIRMET, for light aircraft only, or as SIGMET for general types of craft), and 3) Winds and temperatures aloft (FD's), prepared by the National Meteorological Center in Suitland, Maryland, and updated by regional authorized Weather Service Forecast Offices.

Figure VII-1 shows the twelve major aviation forecasting centers. Figure VII-2 shows the aviation forecast centers and 12-hour terminal forecast network of the Weather Service. Figure VII-3 shows the 24-hour terminal forecast locations.

Data Distribution

The present means of distributing aviation weather information include: 1) telephone services, 2) face-to-face contacts, 3) teletype hookups and 4) broadcast systems. A total of 53 stations are using a Pilots' Automatic Telephone Answering Service (PATWAS) operated by the Federal Aviation Agency. Pilots can telephone designated numbers listed in the FAA Airman's Information Manual and other aviation publications. In addition, Flight Service Stations (FSS) are established in various cities, providing a service in which the National Weather Service, in cooperation with the Federal Aviation Agency, gives a pilot weather briefing service. These "one-stop" centers provide all the necessary weather and flying information a pilot might require in a flight. A total of 43 one-stop locations are now found in the United States while 54 one-call stations can be found in the United States.

A number of teletype hookups distribute domestic weather information for aviation. The most important of these is the Service A Tele-

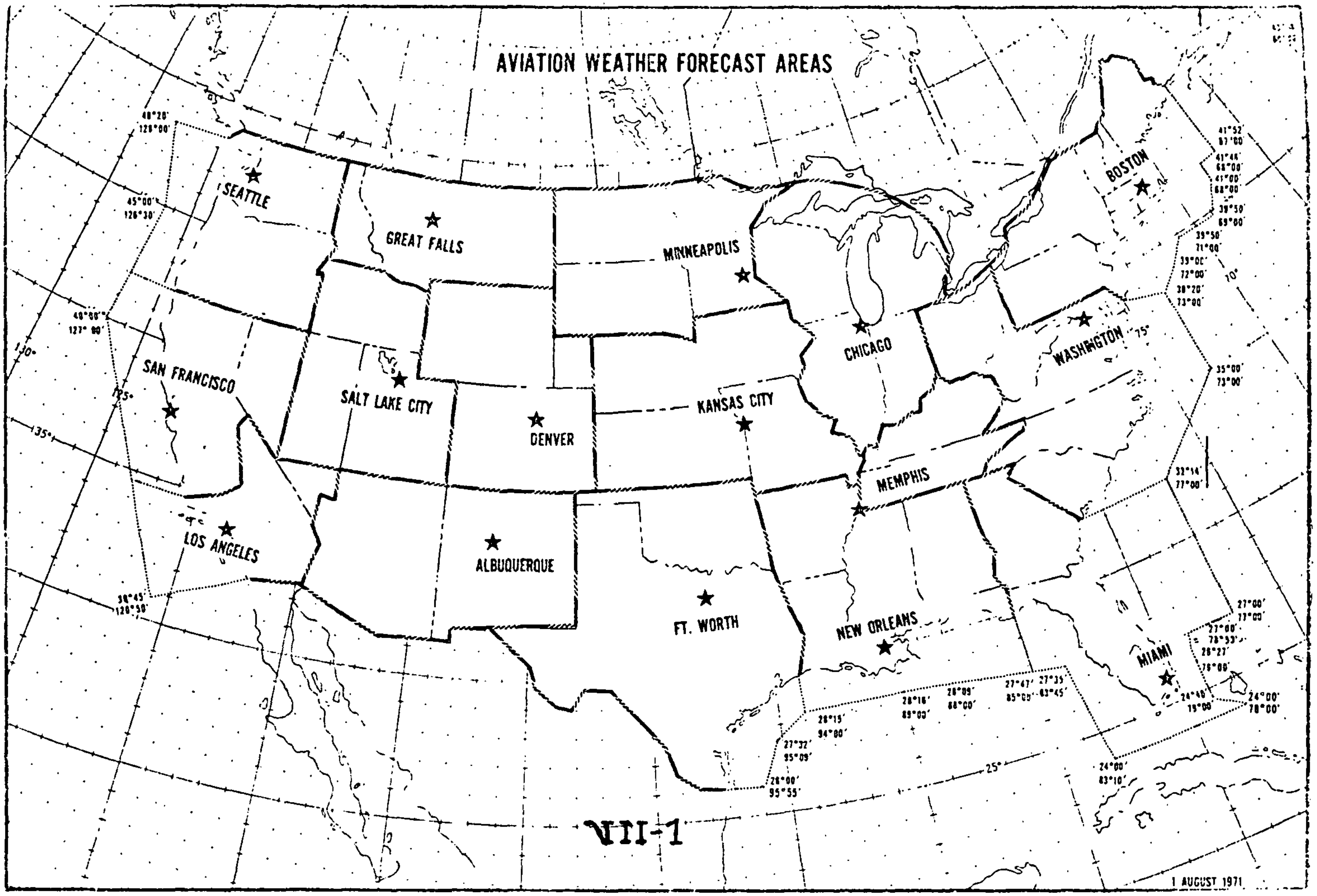
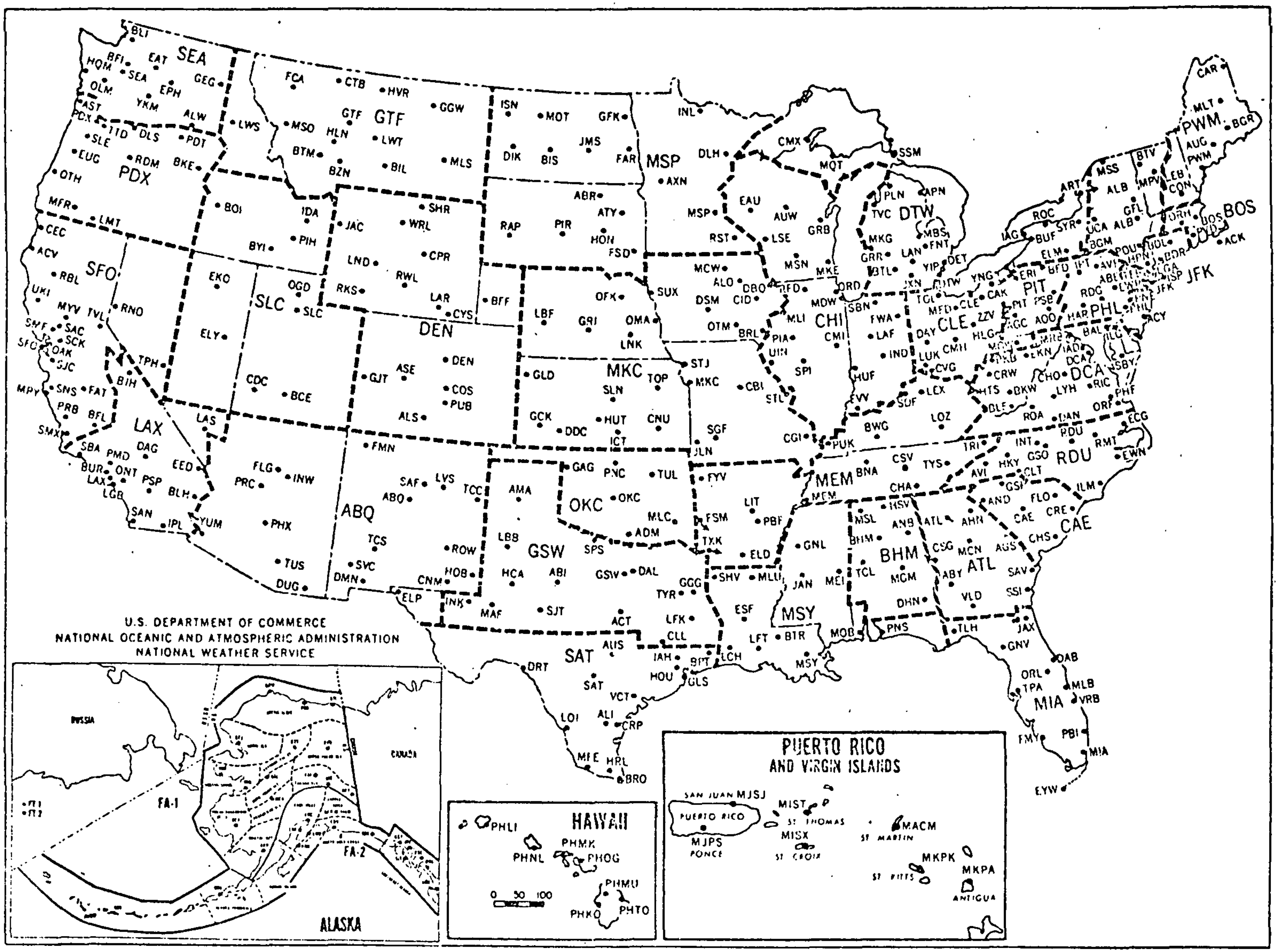
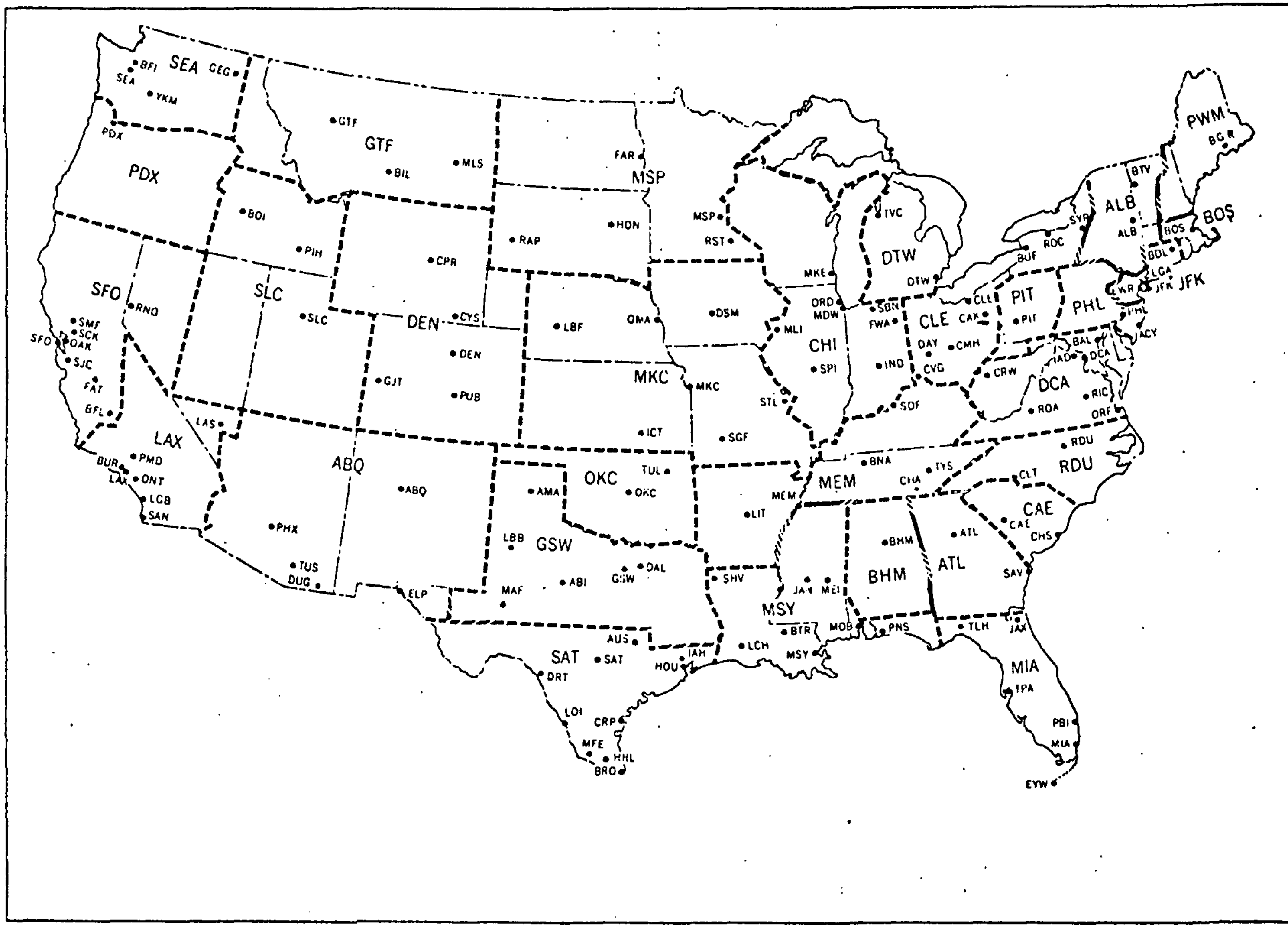

AVIATION WEATHER FORECAST AREAS
SEATTLE
GREAT FALLS
MINNEAPOLIS
BOSTON
SAN FRANCISCO
SALT LAKE CITY
DENVER
KANSAS CITY
CHICAGO
WASHINGTON
LOS ANGELES
ALBUQUERQUE
FT. WORTH
MEMPHIS
NEW ORLEANS
MIAMI
VII-1
1 AUGUST 1971

Figure VII-1



AVIATION FORECAST CENTERS AND AREAS, PLUS 12-HOUR TERMINAL FORECAST NETWORK

Figure VII-2

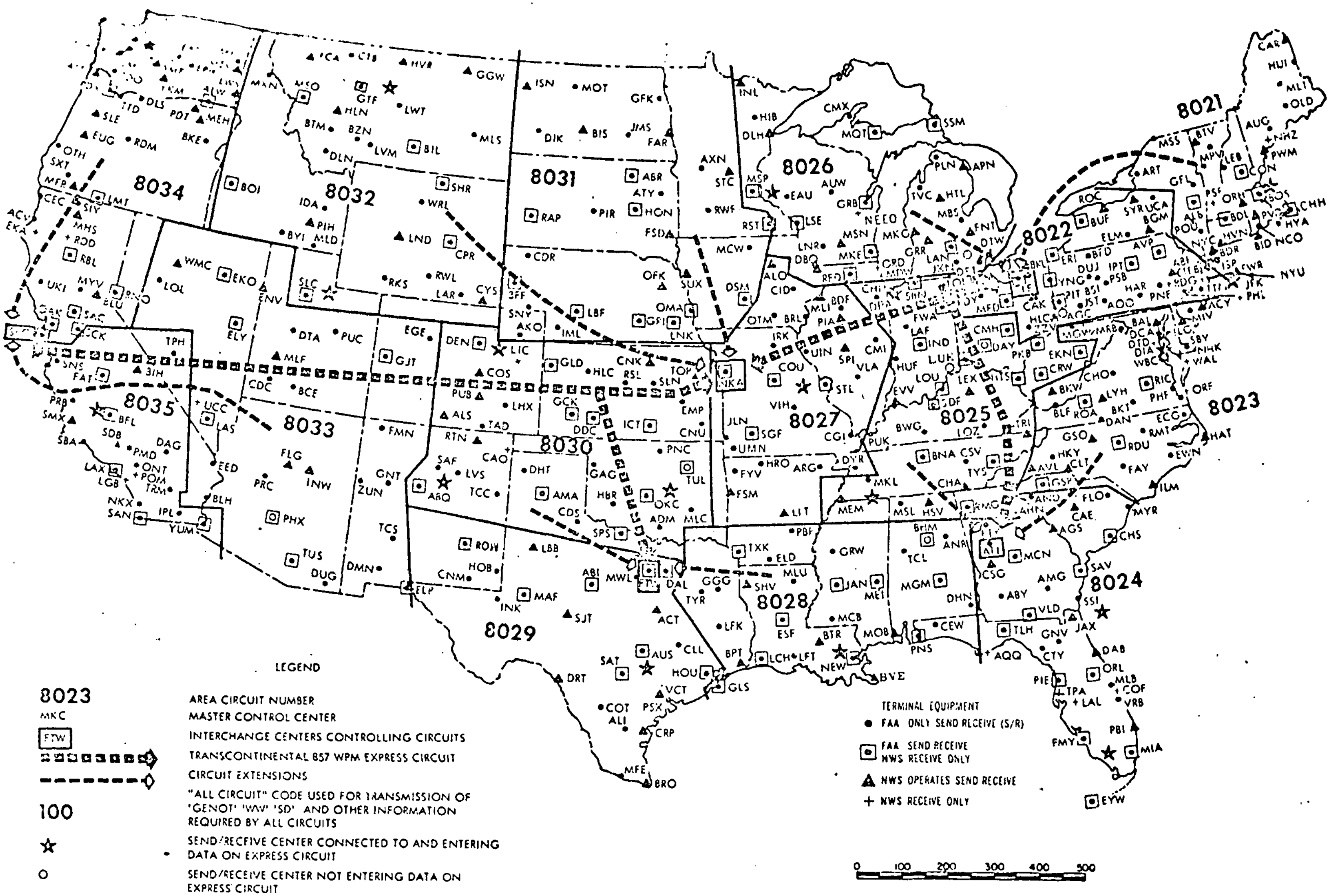


24-HOUR TERMINAL FORECAST LOCATIONS FT2

Figure VII-3

typewriter Network. The purpose of the Service A Network is to "collect and distribute hourly surface observations, and to disseminate products of the Aviation Weather Service and Notices to Airmen (NOTAMS)." The service is a long-line system, operated by the FAA and sometimes called the "Aviation Network." The system is comprised of fifteen multi-point collection and distribution area circuits covering the entire United States as well as fourteen distribution-only circuits and an additional 52 local circuits which serve special major units, such as FAWS units, the air carriers and the military. Area, supplemental and local circuits which operate at 100 words per minute are connected by an 857 words-per-minute circuit. The local circuits have the capability of being individually programmed to meet specific user requirements. While most information carried is domestically originated, the Suitland, Maryland, Center enters Canadian information and the Miami Center enters reports from the Mexcian and Caribbean areas. Military information is processed through and entered by the center in Oklahoma City. Figure VII-4 shows the organization of the Service A Network.

Supplementing the information transmitted by the Service A Network is graphic information supplied by the National Facsimile Netowrk. The purpose of the facsimile system is to provice the government weather office and a variety of other users with a comprehensive set of charts depicting analyses, prognoses, and selected observational data. The National Facsimile Network serves 250 weather service offices, 320 military and government units and about 350 non-government users. With most information originating from the National Meteorological Center in Suitland, the system extends throughout the United States with Canadian



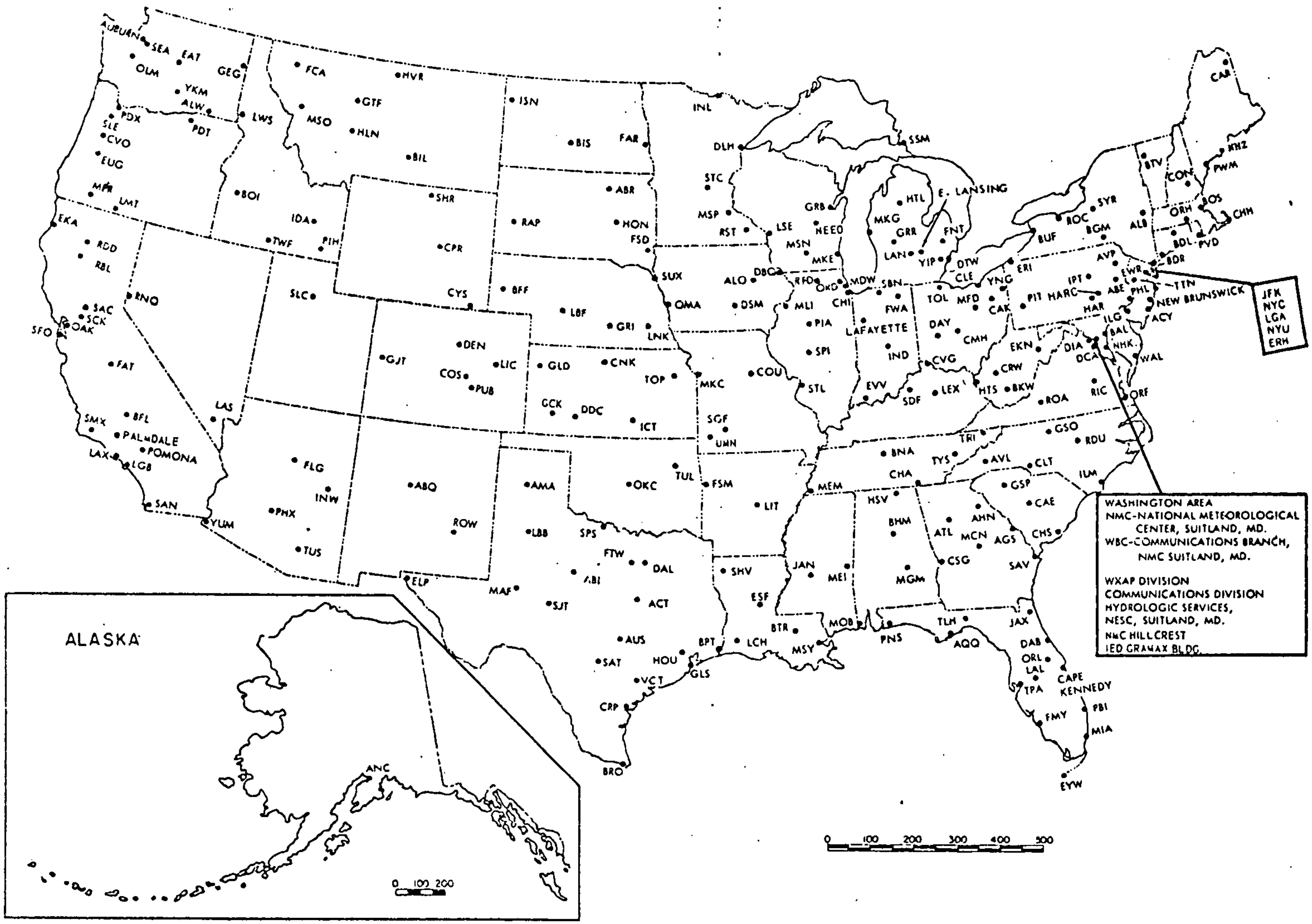
SERVICE A TELETYPEWRITER SYSTEM

Figure VII-4

hook-ups in Vancouver and Montreal. Figure VII-5 shows the stations connected by the National Facsimile Network.

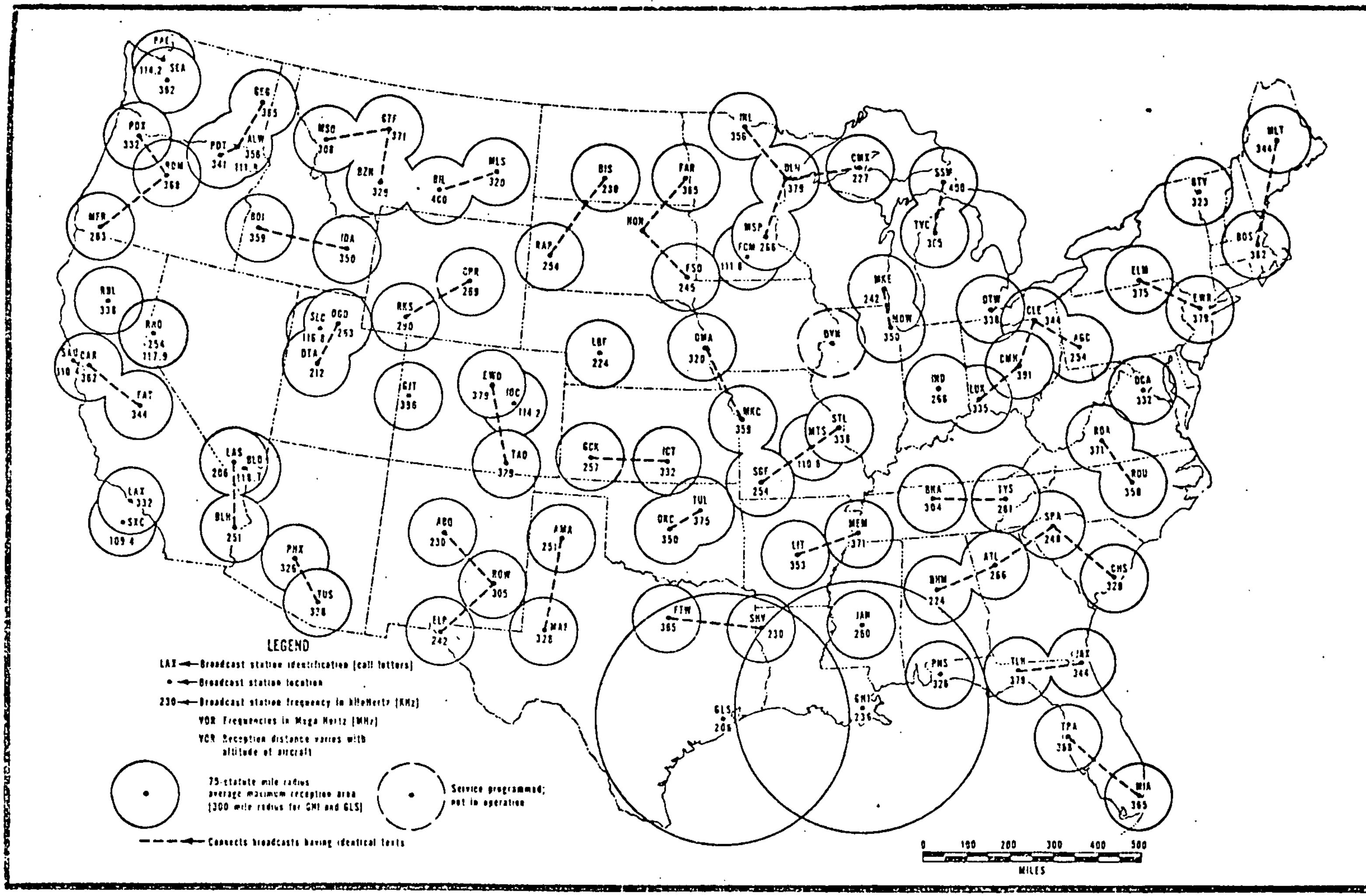
The broadcast systems include the Continuous Transcribed Weather Broadcasts (TWERB) system in which preflight weather briefings for local or limited cross-country flights are available in 100 locations. Figure VII-6 shows the TWERB system.

Supplementing the systems specifically designed for aviation use are the other major domestic services which are sometimes used at least by the general aviation pilot. These include the Service C Teletypewriter Network which is also operated by the FAA and which carries surface synoptic and upper air data and basic public forecasts. The NOAA Weather Wire Service distributes consumer-oriented weather warning forecasts and data to the mass media for relay to the public and various specialized users. State and area-wide circuits are presently being installed and are designed to eventually reach every city or town having one or more daily news medium. Eventually, the system will serve approximately 5,000 radio stations, 600 TV stations and 1700 newspapers. The media subscriber pays only for the lease of the printer and for the use of a local line. WSO centers have the only direct-entry rights on these circuits, with forecast offices furnishing broad-scale information and regional or area offices adding local information. The Multiple Access Recorded Telephone Announcement System is designed to provide "on-demand" service. Of the three types of systems used, the largest can handle 100-200 calls simultaneously with 45-second announcements operated by telephone companies in 18 cities. The second system is for limited access and can handle two to ten calls simultaneously and is used



WEATHER SERVICE OFFICES ON NATIONAL FACSIMILE NETWORK

Figure VII-5



CONTINUOUS TRANSCRIBED AVIATION WEATHER BROADCAST SERVICE NETWORK

Figure VII-6

for local and specialized weather information, such as motorist forecasts, marine forecasts and extended outlooks. The third system is similar to the first in that it is operated by telephone companies, but usually includes commercial messages and has forecasts of shorter duration (usually seven seconds in length) for the general public. The system is operated through a special automatic coding system by which forecast offices can actively select from a collection of more than 1000 prerecorded messages.

International Service

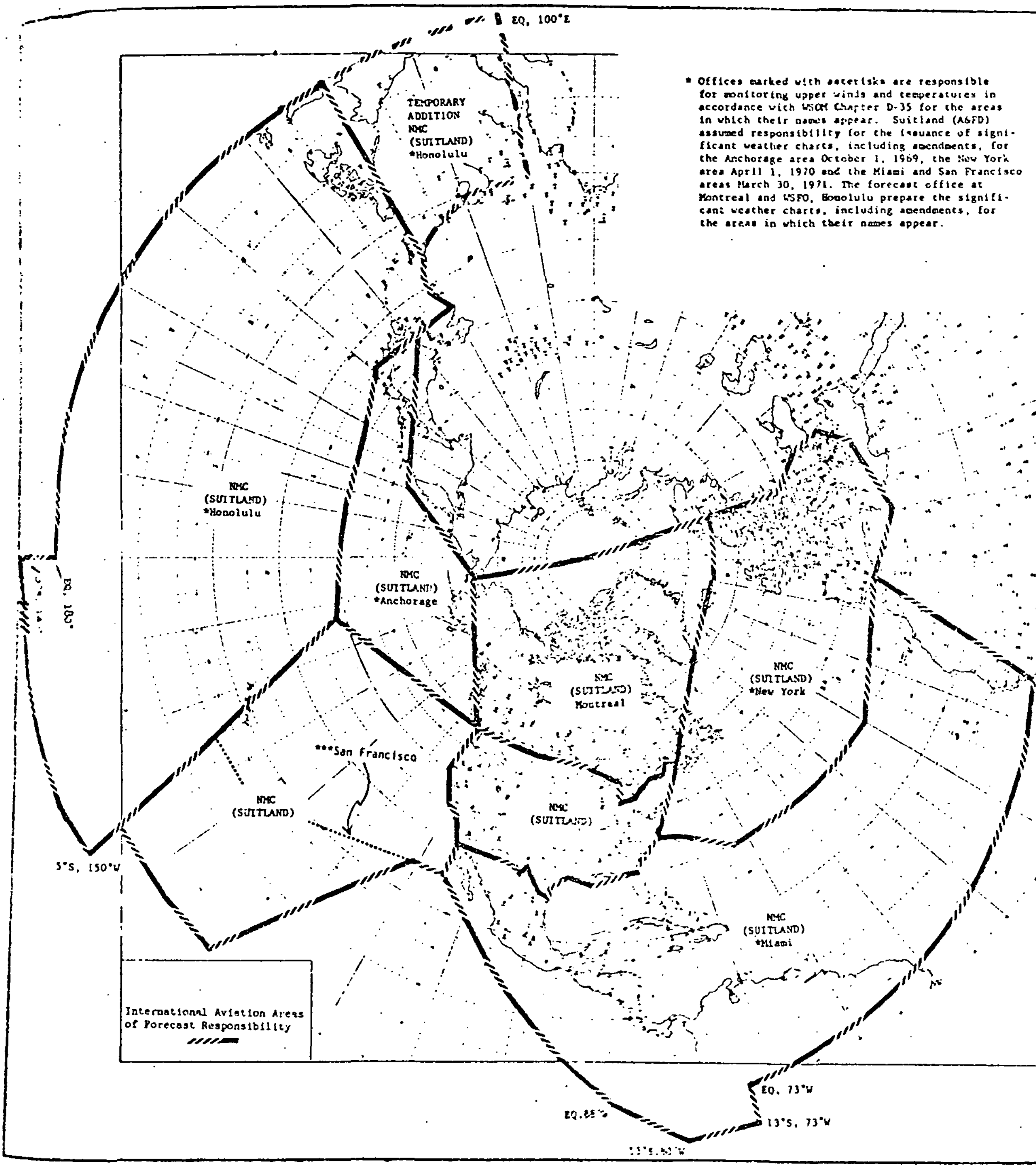
In addition to its domestic service, the National Weather Service provides flight weather information for flights which extend beyond the United States, Mexico and Canada through its International Program. The objective of the international service is as follows:

> To provide service for international aviation flights for (or long overwater domestic flights) departing or crossing the United States and its possessions, in accordance with the procedures of the International Civil Aviation Organization (ICAO) of which the United States is a contracting member.

Data Collection

A total of five forecast centers in addition to the National Meteorological Center in Suitland, Maryland, provide service to aircraft falling within the auspices of the International Service. These five centers include: Anchorage, San Francisco, Honolulu, Miami and New York. Figure VII-7 shows the areas of responsibility of these five United States Centers.

The data collection activities of the International Service are largely similar to the Domestic Service as far as the types of informa-



INTERNATIONAL AREAS OF FORECAST RESPONSIBILITY

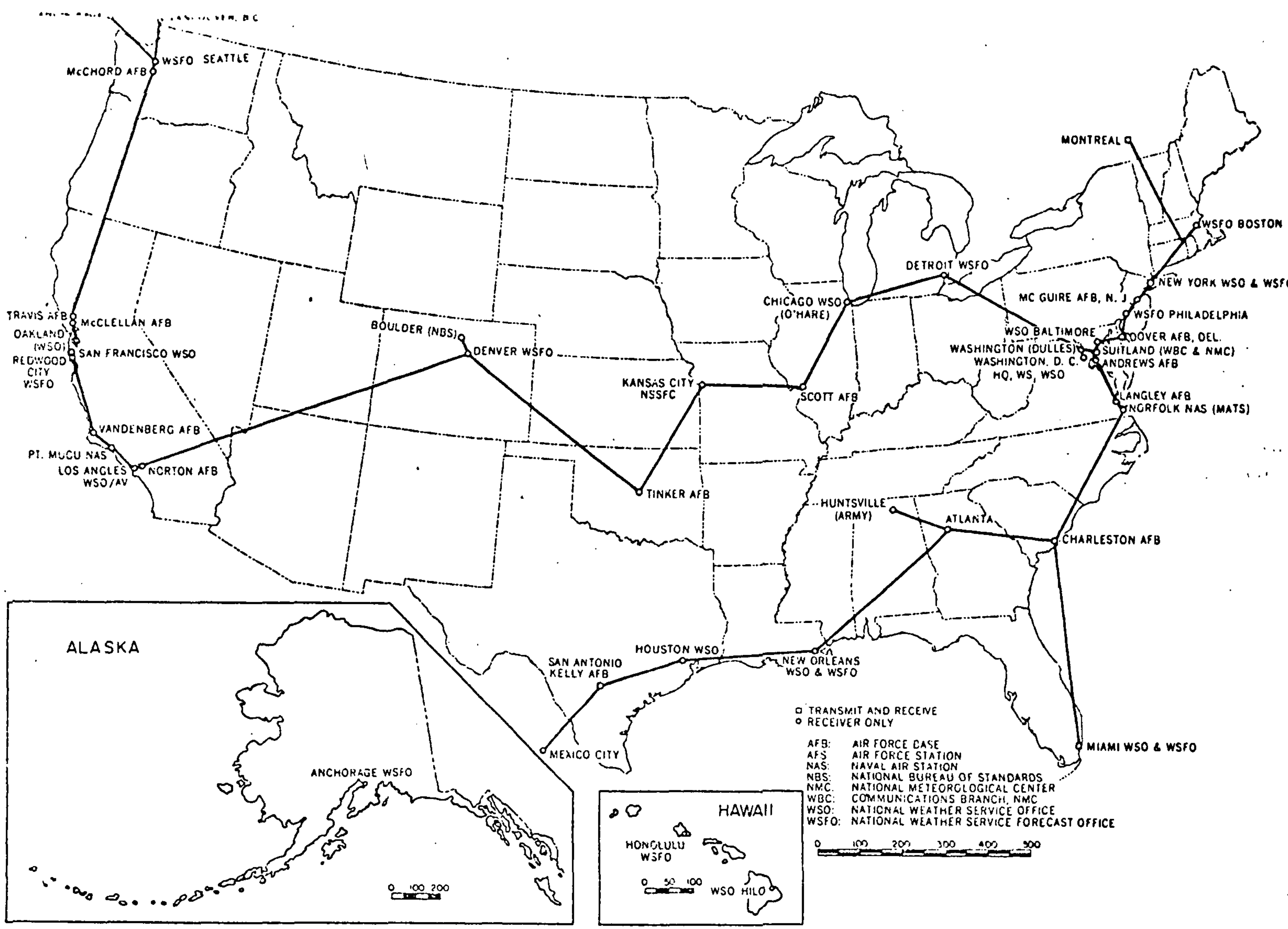
Figure VII-7

tion collected. Services include weather briefing and flight documentation which are supplied to each flight crew and other services required by international aviation. These include weather charts, wind forecasts and temperature predictions and selected terminal forecasts as prepared by Weather Service Forecast Offices of the Domestic Service.

Data Distribution

Several major systems are involved in the exchange of international aviation information. Probably the most important is the Aviation Meteorological Facsimile Network (AMFAX). The purpose of AMFAX is to distribute analyses and prognoses to offices supporting international high altitude aviation operations; particularly those over 20,000 feet. Materials are introduced into AMFAX at Miami, San Francisco, Honolulu and Suitland, Maryland. Figure VII-8 shows the organization of the aviation Meteorological Facsimile Network. Supplementing the AMFAX system are several other international services which contribute to it. The International Exchange System (IES) is involved in the transmission of international weather data to domestic users. The channels include a radio teletypewriter, long-line cable, cable and satellite channels relaying from 30 to 3000 words per minute. Transmissions are coordinated through the communications computer at Suitland. The Service - Teletypewriter Network accommodates the exchange in information between the United States and international locations through a teletypewriter system carrying primarily synoptic surface and upper-air data. The system is coordinated by the communications computer of the National Weather Service at Suitland. The International Radio Facsimile Broadcast system is designed

C-3



AVIATION METEOROLOGICAL FACSIMILE NETWORK

Figure VII-8

to distribute selected graphic materials to foreign meteorological services. Twice daily broadcasts are beamed toward the Caribbean, Central America and northern South America. Another broadcast is beamed toward the southwest Pacific, including Australia, during periods in which weather satellite data on the southwestern Pacific are available. Two circuits, Circuit GF-10204 and GF-10205, feed the New York and San Francisco commercial radio transmitters responsible for the broadcasts. In addition, two special systems, the WSFO-Honolulu Radio Facsimile Broadcast system and the Suitland-Honolulu Facsimile Data Circuit provide for the exchange of meteorological data in the south Pacific.

Other Services

While the National Weather Service is engaged in a variety of other weather forecast activities, one other service has important implications for aviation and should be mentioned. The Aviation Safety and Quality Control Program of the Aviation Weather Service is a support program designed to aid in the investigations of aviation safety and to improve the quality of aviation weather services. The program extends to fifty states and all NWS and FAA facilities engaged in aviation forecasting or pilot briefing. According to an official description of the National Weather Service, the Aviation Safety and Quality Control Program has the following goals:

1. Analysis and evaluation of services available to pilots and to identify service weaknesses.

2. Support to and participation in aviation safety investigations and associated proceedings.

3. Evaluation of training programs for personnel responsible for providing pilot weather briefings.

4. Evaluation of training programs on weather for pilots and operations personnel. (p. 54)

The program is coordinated from the National Weather Service Headquarters and receives assistance from regional headquarters throughout the country.

Footnotes

1. W. Boynton Beckwith, "The Effect of Weather on the Operations and Economics of Air Transportation Today," Bulletin of the American Meteorological Society, Vol. 52, No. 9, September, 1971, p. 868.

2. Ibid., p. 864.

3. W.J. Maunder, The Value of the Weather, p. 112.

4. Beckwith, "Airline Meteorology Today," reprinted from Technology Review, February 1972, p. 6.

5. Beckwith Op. cit., p. 866.

6. Beckwith, "Airline," p. 9.

7. Beckwith, interview June 6.

8. Beckwith, "Airline," p. 9.

9. Ibid., p. 9.

10. Ibid., p. 9.

11. Ibid., p. 16.

12. Ibid., p. 17.

13. Ibid., p. 7.

14. Ibid., p. 8.

15. Beckwith, interview, June 6.

16. Ibid., p. 8.

17. "Fog Seeding Program, Economic Analysis," published by United Airlines, p. 5.

18. Ibid., p. 4.

19. Ibid., p. 5.

BIBLIOGRAPHY

Reports of Scholarly Bodies and Governmental Agencies

Barr, Neal M. "Climatology for the Airplane Designer: Some Results and Requirements." Conference and Workshop on Applied Climatology of the American Meteorological Society, Asheville, North Carolina, October 29-31, 1968.

Beckwith, W. Boynton. "Meteorological Analyses and Forecasts Required for Computer Flight Planning," Fourth Conference on Weather Forecasting and Analysis, American Meteorological Society, Portland, Oregon, May 1-4, 1972.

Bedel, B. L. "Meteorology and Civil Aviation," Seminar on the Role of Meteorological Services in Economic Development in Africa, University of Ibadan, September, 1968. Proceedings published by the World Meteorological Society, 1969, pp. 124-126.

Christopherson, James E. "Aviation Terminal Weather Forecast Study," San Jose: Department of Meteorology, San Jose State College, August, 1966.

Conference on Air Traffic Control Systems Engineering and Design. Proceedings. London, 1967.

Cornell University Guggenheim Aviation Safety Center. "Survey of Research Projects in the Field of Aviation Safety: 1966 Annual Report Supplement." Ithaca: Guggenheim Aviation Safety Center, 1966.

Council of Europe. "Certain Financial and Economic Aspects of Air Transport Operation. Strasbourg, 1964.

Crutcher, Harold L. Climatology of the Upper Air as Related to the Design and Operation of Supersonic Aircraft, Washington: Government Printing Office, 1963.

Glahn, Harry R. and Roger A. Allen. Preliminary Results of a Program for the Automation of Terminal Forecasts. U.S. Air Weather Service Technical Report #292. Washington: Government Printing Office, 1971

Hovey, R. L., R. J. Grace and R. S. Ludwig. Pilot Weather Briefing Using Time Share Computers. Silver Spring, Maryland: U.S. National Weather Service, 1970.

International Civil Aviation Organization. All Weather Operations Panel, Third Meeting, Montreal, April 4-21, 1967.

Laufer, Thomas, "Problems in Operationally Significant Weather Forecasting," SMF-AMS Joint Conference on Aeronautical Meteorology, Paris, May 24-26, 1971.

Lile, Robert C. Aviation Terminal Weather Forecast Study: Final Report. San Jose: Department of Meteorology, San Jose State College, July, 1968.

Maier, Lewis, et. al. "Information Requirements for Supersonic Transport Operation. U.S. National Aeronautics and Space Administration Contractor Report 1570, July, 1970.

Samson, C. A. et. al. "Weather Effects on Approach and Landing Systems," United States Federal Aviation Administration Report FAA-RD-7047, July, 1970.

Swedish Society of Aeronautics and Astronautics. International Symposium on Air Traffic Control, Stockholm, 1969.

Teweles, Sidney and Raymond M. McInturff. "Physical and Synoptic Meteorology in Relation to the Special Requirements of Supersonic Aircraft Operation," Report prepared for the Executive Committee, World Meteorological Society, May 30, 1966.

Thompson, James K. "Radar 'flight weather' Detection System Problems and Opportunities," Thirteenth Conference on Radar Meteorology, McGill University, August 20-23, 1968.

United Aircraft Corporate Systems Center, "Phase I of the Design of a Weather Bureau Aviation Forecast Organization," SCR 274.

United Aircraft Corporate Systems Center, "Phase II of the Design of a Weather Bureau Aviation Forecast Organization, SCR 314, January, 1967.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Operations of the National Weather Service. Washington: Government Printing Office, October, 1971.

U.S. Department of Transportation, Federal Aviation Administration, Economic Division. General Aviation: A Study and Forecast of the Fleet and Its Use in 1975. Washington: Government Printing Office, 1966.

U.S. Department of Transportation, Federal Aviation Administration. Guidelines for Federal Aviation Meteorological Service, Fiscal Year 1969-1973. Washington: Government Printing Office, August, 1968. (OFCM 68-5).

U.S. Federal Aviation Administration and U.S. Weather Bureau. Aviation Weather for Pilots and Flight Operations Personnel. Washington: Government Printing Office, 1965.

U.S. National Transportation Safety Board. "Aircraft Accident Report: Texas International Airlines, Arlingen, Texas, January 11, 1970." NTSB-AAR-70-28, December 2, 1970.

U.S. National Transportation Safety Board. "Statistical Analysis of Weather Effects in Aircraft Accidents: Briefs of Accidents Involving Weather as a Cause Related Factors, General Aviation, 1968." Washington: Government Printing Office, 1969.

World Meteorological Organization. La Meteorological aeronautica en America Latina. Memoria del Seminario de Formacion Regional de la OMM, Costa Rica, 29 de noviembre-17 diciembre, de 1965. Published as WMO Technical Note No. 88, 1969.

World Meteorological Organization. Lectures Given at Regional Seminar on Operation and Maintenance of Meteorological Telecommunications in Africa, Geneva, October 7-18, 1968.

World Meteorological Organization. Potential Contribution of the World Weather Watch to a Global Area Forecast System for Aviation Purposes. World Weather Watch Planning Report #19, 1967.

World Meteorological Organization. Potential Economic Gains from Weather Forecasting Service Improvement. World Weather Watch Planning Report #27, 1969.

World Meteorological Organization. Scientific and Technical Conference Proceedings, WMO Bulletin, 17:121-126, July, 1968.

World Meteorological Organization. The Role of Meteorological Satellite in the World Weather Watch, World Weather Watch Planning Report #18, 1967.

World Meteorological Organization. Scientific and Technical Conference on Aeronautical Meteorology, WMO Bulletin No. 95.

Books

Bowie, Edward. Weather and the Airplane,

Buck, Robert N. Weather Flying. New York: MacMillan, 1970.

Cagle, Malcolm W. and C. G. Halpine. A Pilot's Meteorology. Third edition. New York: Van Nostrand Reinhold Co., 1970.

Eaton, Elbert Lee. Weather Guide for Air Pilots. New York: Ronald Press Co., 1939.

Fleagle, Robert G. (ed.). Weather Modification, Science and Public Policy. Seattle: University of Washington Press, 1969.

George, Joseph Johnson, Weather Forecasting for Aeronautics. New York: Academic Press, 1960.

Great Britain Meteorological Office, Handbook of Aviation Meteorology. Second edition. London: H. M. Stationery Office, 1971.

Halacy, Daniel Stephan, The Weather Changes. New York: Harper and Row, 1968.

International Civil Aviation Organization. Air Transport Operating Costs. Montreal: International Civil Aviation Organization, 1966.

Kreindler, Lee S., Aviation Accident Law. Albany: M. Bender, Publishers, 1963.

Lowell, Vernon A. Airline Safety is a Myth. New York: Bartholomew House, 1967.

Maunder, W. J. The Value of Weather. London: Methuen, 1967.

Serling, Robert J. The Probable Cause: The Truth About Air Travel Today. Garden City: Doubleday and Company, 1960.

Schriever, Bernard A. and William W. Seifer. Air Transportation 1975 and Beyond. (Report of the Transportation Workshop, 1967). Cambridge: MIT Press, 1968.

Straszheim, Mahlon R. The International Airline Industry. Washington: Brookings Institute Transportation Research Programs, 1969.

Stratford, Alan H. Air Transport Economics in the Supersonic Era. London: Melbourne, 1967.

Taylor, James Allen (ed.) Weather Economics. Oxford: Pergamon Press.

Von Kann, Clifton F. "Airline Requirements for the 1970's." Chapter in James Caskey (ed.), A Century of Weather Progress, Boston: American Meteorological Society, 1970.

Witnah, Donald R. Safer Skyways: Federal Control of Aviation, 1926-1966. Ames: Iowa State University Press, 1966.

Journal Articles and Monographs.

Anonymous, "Accident Rate Down, Fatalities Up," Aviation Week, 96:54, January 24, 1972.

Anonymous, "Flying Weather Signposts," Flying, 77:49-51, November, 1965.

Anonymous, "Information Lack Revealed in 747 Probe," Aviation Week, 95: 21-4, August 0, 1971.

Anonymous, "Selective Bibliography in Meteorology," Weatherwise, 24:208-26, October, 1971.

Anonymous, "Temperature Can Slip SST Range," Aviation Week, 84:41, May 2, 1966.

Anonymous, "Washington Advisory: Aviation Weather Service," Flying, 82:104-5, June 1968.

Bates, F.C. "Fine Art of Forecasting," Flying, 79:50-1, August, 1966.

Bates, F. C. "Things Upstairs," Flying, 79:52-4, July, 1966.

Bear, Fred G., J ., "Breaking Through the Air Traffic Jam," Private Monograph.

Beckwith, W. Boynton, "The Effects of Weather on the Operations and Economics of Air Transportation Today," Bulletin of the American Meteorology Society, 52:863-8, September, 1971.

Beckwith, W. Boynton, "Airlines Meteorology Today," Technology Review, February 1972.

Block, T. H. "Pro's Nest: Getting the Weather," Flying, 87:94-5, December, 1970.

Blodget, R., "Pilots Weather Outlook," Flying, 81:88-93, August, 1967, 81:53-5, September, 1967.

Bryan, M. R. "The Secret of the Sequence Report," Flying, 89:70-1, November, 1971.

Clodman, J., "Terminal Forecasting and the Supersonic Transport," Atmosphere, 6:1-7, 1968.

Coleman, H. J. "Concorde Route Study Nears Completion," Aviation Week, 90:34, March 17, 1969.

Crossley, A. F., "Atmospheric Environment of Supersonic Transport Aircraft," Royal Meteorological Society Quarterly Journal, 95:784-8, October, 1969.

Duverge, P., "Meteorological Factors in Supersonic Transport Operation," Journal of the Institution of Navigation, 20:64-74, January, 1967.

Guttman, N. B. and H. L. Crutcher, "Wind and Temperature Effects on Supersonic Aircraft Operation", Weatherwise, 21:220-6, December, 1968.

Halaby, Najeeb B., "All Weather Operations: Progress and Challenges," Astronautics and Aeronautics, 6:63-9, May, 1968.

Hicks, J. J. and others, "Clear Air Turbulence: Simultaneous Observations by Radar and Aircraft," Science, 157:808-9, August 18, 1967.

Jones, R. F. "Meteorology and Supersonic Flight," Nature, 212:1181-5, December 10, 1966.

Lefkowitz, Matthew, "Upgrading Terminal Weather Observations," Journal of Air Traffic Control, 10:20-2, March, 1968.

Miller, B., "Solid State Air Data Computer Developed," Aviation Week, 85:96-7, November 14, 1966.

Palmieri, Sabino, "Selection of the Optimal Route as a Decision Under Conditions of Risk," Revista de Meterologica Aeronautica, 31:3-18, January-March, 1971.

Parke, R. B., "Weather Check," Flying, 79:32, June 1966.

Roach, W. T., "Weather and Concorde," Weather, 25:254-65, June, 1970.

Scherhag, Richard, Gunter Warnecke and Werner Wehry, "Meteorological Parameters Affecting Supersonic Transport Operation," Journal of Institute of Navigation, 20:53-63, January, 1967.

Singer, Frederick G. and Raymond McInturff, "Meteorology and Supersonic Transport," Science, 167:16-25, January 2, 1970.

Trammell, A., "Whence Weather Wisdom," Flying, 87:30, September, 1970.

Traylor, W. L., "Pilot Error," Flying, 90:18-9, March, 1972; 90:27-8, May, 1972.

Von Braun, W., "That Puzzling Problem for Space Launches: Weather," 191:102-4, September, 1967.

Wright, R. B., "An Assessment Scheme for Aerodrome Forecasts," Meteorological Magazine, 100:285-93.

Wurtle, Morton G., "Meteorological Conditions Surrounding the Paradise Crash of March 1, 1964, Journal of Applied Meteorology, 9:787-95, October, 1970.

N 74-22272

LOSSES DUE TO WEATHER PHENOMENA IN THE BITUMINOUS CONCRETE CONSTRUCTION INDUSTRY IN WISCONSIN

by Herman A. J. Kuhn

INTRODUCTION

The purpose of this study is to determine the losses (costs) due to weather phenomena as they affect the bituminous concrete industry in Wisconsin. This particular study is the second part of a three phase multi-disciplinary study of weather benefits which would accrue from improved long range weather forecasting. In this, the second phase, the bituminous concrete industry's response to precipitation, in the form of rain, is identified through the use of a model, albeit crude, which identifies a "typical" industry decision-response mechanism. Using this mechanism, historical weather data and 1969 construction activity, dollar losses resulting from rain occurrences were developed.

Development of Decision-Response-Cost Model--Bituminous Concrete Paving

Bituminous concrete paving as used in this model includes those activities in which a bituminous concrete (hot plant mix) surface course is constructed over a newly constructed base or as an overlay to an existing older pavement. Bituminous concrete paving, typically, is part of a larger project, the scope of which may vary considerably from one project to another. It might include, as often times occurs in both rural and urban work, just the resurfacing of streets or roads. On the other hand, it might also include fairly substantial amounts of drainage, base, curb and gutter or shoulder work and other incidental activities.

Development of "Typical" Construction Activity and Sequence of Operations

A number of bituminous concrete projects, ranging in size from small to quite large, were looked at in detail by evaluating the individual project construction progress reports. This allowed identification of a "sensitivity period" for bituminous concrete operations -- the period during the course of a bituminous concrete construction project when the actual paving operation is taking place. The period has been defined relative to the time span on the project. Typically, this varied with the beginning point anywhere from 18% to 33% into the project time and the completion point from 65% to 74% of the total project period. The mean "sensitivity period" began at 24% of project time and ended at 69% of project time with time periods of 25% to 75% used for modeling purposes. The period immediately preceding and following the "sensitivity period" is also weather sensitive but to a very different extent, depending on the nature of the work being conducted. Generally, however, during these periods bituminous concrete projects are far less sensitive to weather phenomena. Because of the extreme difficulty in identifying, except in general form, the specific sensitivities during these periods and the degree of sensitivity, this portion of the projects was not modeled.

Area of Study

Two areas, identified by the weather service as the south-central and south-west portions of Wisconsin, were selected as the study area.[1] This was done so that projects could be selected within an area which had relatively homogeneous weather occurrences and for which detailed precipitation data were available. Rainfall data from only one recording station (Madison, Wisconsin) were used for the period 1965 through and including 1970. It was felt that the use of data from such a long time period would provide "time-averaged" weather data and would also preclude the need for utilizing data from more than one station.

Decision Model

The basic losses which accrue to a bituminous concrete paving operation are labor losses, resulting from wages paid to crews for work not done, either because they are waiting out a period of precipitation or

---

[1] South-central: Columbia, Dane, Dodge, Green, Jefferson and Rock Counties. South-west: Crawford, Grant, Iowa, Lafayette, Richland, Sauk and Vernon Counties.

because of union contract payment requirements; and material losses, resulting from the fact that materials at a paving site cannot be used because of the weather.

The decision model used to develop these losses is depicted in Figure 1. The mechanism is developed on the assumption that: (1) a work crew does not report for work because of a long prior period of rain and the fact that they had been told not to report under such circumstances, (2) the crew did report to work but had to remain idle because of rain, and union contract clauses require a certain amount of "show-up" time to be paid, (3) the crew had begun work which had to be discontinued because of rain at the job site and where union clauses require a certain number of hours of pay afterwards, and (4) material losses based on average amount of paving materials used in one half hour.[2] This latter cost is based on an average rate for straight paving.[3]

Each of the labor loss-material loss phenomenon was defined as a numbered situation type, 0 through 13, (Figure 1), with a total situation loss per occurrence as noted. For modeling purposes, work days were assumed to be ten hours long, from 8 a.m. to 6 p.m. for the period May 16 to June 15, twelve hours, from 7 a.m. to 7 p.m. for the period June 16 through September 15, and ten hours, from 8 a.m. to 6 p.m. for the period from September 16 through October 15.

Each of the jobs occurring during the 1969 construction season--a season which could be considered typical--was analyzed by 15-day periods and project losses were calculated for each period based on average historical rainfall data[4] for that period. Although projects were actually underway from the latter part of April through early October (Table 1), the weather sensitivity period for each, based on the 25% to 70% sensitivity period, occurred only during the later 15 days of May through, and

---

[2] A one-half hour loss period was used as a logical figure for estimating purposes. As fewer on-site portable bituminous concrete plants are used, haul distances will become longer, more trucks will be en route at a given time, and material losses could be considerably greater.

[3] Straight paving refers to paving time done basically by paving machine without the need for considerable hand work at intersections and other areas.

[4] Rainfall data for the years 1965-1970 inclusive were calculated to develop average weather phenomenon.

including, the first 15 days of September. Consequently, costs were developed for the period May 16 through September 15, inclusive. The six years' data were analyzed only for that period.

Projects Underway

In order to utilize the situation type cost data and the daily independent probability of a particular situation type occurring for each of the 15 day analysis periods, the varying number of projects underway at any given time had to be converted to mean projects per day. This was done as noted in Table 2, "Mean Number of Projects Underway." Table 2 is derived from calculations based on Table 1, "Sensitivity Period Summary," and Table 3, "Number of Projects in the Weather Sensitivity Stage."

Development of Model Rainfall Data

Detailed hourly precipitation data, recorded by the U.S. Weather Service in a format as shown in Figure 2, were evaluated for the period 1965 through, and including, 1970 for each 15 day period beginning May 16 and ending September 15. The data were used to develop rain periods to be used in the decision model noted in Figure 1. To exclude the possibility of utilizing rain of a non-shower type (periods during which intermittent showers occurred) rainfall data were used only if reported for a period of three or more consecutive hours. In some cases, trace activity (noted as "T" in the summary) is also considered--particularly when four or more consecutive hour periods of "T" occurred. Rainfall criteria used are as noted in Table 4.

The data were aggregated for each 15 day period for the 6 years of historical data and then independent probabilities of occurrence were developed for each situation type.

Development of Losses for Projects Considered

The probability of occurrence was developed from historical data by enumerating the number of times each particular occurrence happened.

Dollar losses were developed according to the calculations in Table 5, "Calculation of Savings," for each of the 15 day time periods. The daily costs during each period were developed by using the cost model below:

$$TC_D = \sum_{s=0}^{13} [P(s) * \overline{J} * C_s]$$

where:

TC_D = total cost per day during a given 15-16 day period.

s = situation type

P(s) = independent probability that situation type "s" will occur during period.

$\overline{J}$ = mean number of projects underway per day.

C_s = cost (loss) per situation type.

For each 15-16 day period, total losses were aggregated on a daily basis and the daily losses multiplied by 15 or 16, dependent on the length of the time period. These were then aggregated in the Project Cost Summary (Table 6) by area (South-central and South-west) and individually by project.

Proportionate costs were developed on the basis of: bituminous concrete construction costs only (Item #40701 in the Wisconsin Department of Transportation Construction Specifications); and as a proportion of the total contract cost, including all incidental work such as miscellaneous grading, shouldering, or curb and gutter work as appropriate; and other contract costs.

Total losses account for approximately 2.5% of the dollar value of the bituminous concrete work (Item 40701) or approximately 1.3% of the total gross contract cost.

Losses in other Areas in the State of Wisconsin

Losses due to temperature induced paving constraints were not applied to the south-central and south-western portions of Wisconsin, because the historical data indicated that between the dates under consideration (May 16 - Sept. 15) temperatures were rarely a constraint. This would not be the case, however, in the northern portions of the state, where some labor losses due to temperature delays would be incurred. This would increase the total dollar loss to the industry in these areas. Also, there are a number of areas, notably in the northern parts of the state, where rain probabilities are slightly greater than in the south-western and south-central portions. Consequently, these areas could also experience slightly greater total loss due to rainfall. Losses calculated for the part of the state under study, which indicate an approximate loss to the paving operation itself of 2.5%, should not increase much more than one-half percent due to the slightly greater rainfall amounts and temperature constraints in other areas of the state.

Variations in Cost Estimates Due to Model Approximations and Assumptions

The cost estimates made in the model are based on "typical" paving crew sizes and haul distances. Variations in either could materially change the estimated losses. For example, maximum haul to the job is partly a function of the size of the job. For relatively small projects, e.g., those in which the tonnages are less than 50,000 tons, materials would very likely be hauled from a permanent plant sometimes up to distances of 50 miles away. During the 1969 construction season, 93% of the rural bituminous concrete projects were 50,000 tons or less. In fact, median tonnage was 23,300 and the upper quartile tonnage 32,000 tons. This would indicate that most projects would obtain their materials from permanent plants. In addition, the so-called "vagabond" plant--that is, a plant erected at a job site for that particular job or several jobs, will very likely become a thing of the past. This is because environmental considerations and land-use zoning are placing more stringent constraints on the operation of such facilities.

It should also be pointed out that labor losses are directly related to union contract requirements. Any change--such as a guaranteed work week--would materially change the labor-wage related losses.

Summary

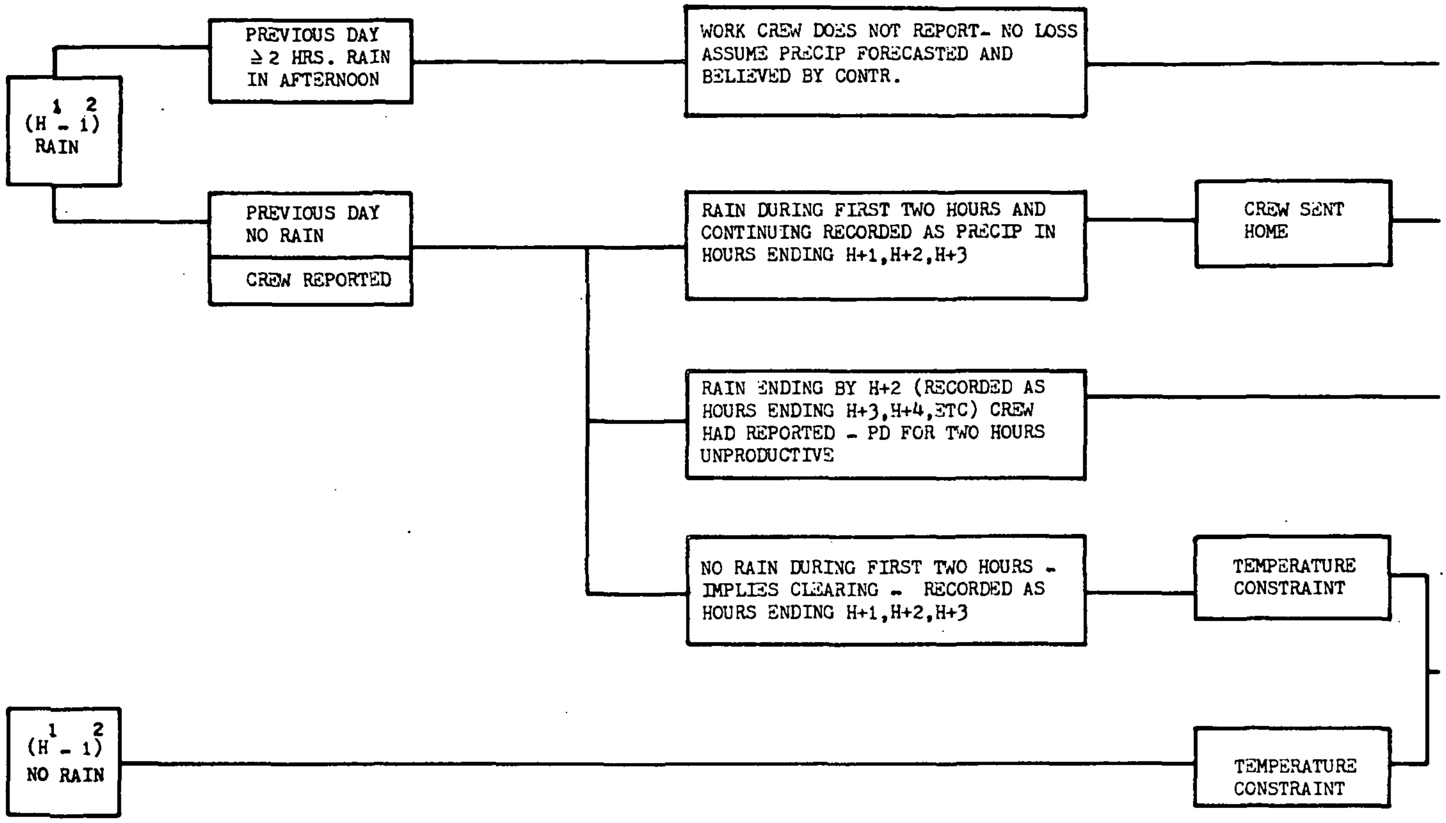
Accurate weather information in a form which could be readily utilized by the bituminous construction industry would permit savings on the order of 2.5% or more of the dollar cost of the bituminous concrete operation itself, or approximately 1.3% of the gross contract costs for bituminous concrete jobs. The major savings would be realized for those losses associated primarily with precipitation in the form of rainfall. In some areas of the state, notably in the northern portions, where morning temperatures during the early and late portions of the construction season are apt to hover around the freezing mark, temperature could also be a constraint resulting in losses. The actual losses themselves are the result of wages which have to be paid under union contract for which no work would have been performed and material losses resulting from the need to discard materials at the outset of a weather occurrence.

Variations in the loss estimate would accrue from differences in hauling distances and, as a result, the amount of material which would have been on the road and would have been discarded at the outset of a weather occurrence, differences in contractor construction procedures and different union contract requirements. Other activities in bituminous concrete construction projects such as crushing granular materials, laying granular base courses, curb and gutter work, and other incidental items, are less susceptible to weather phenomenon. As a result, losses in those areas would be considerably less.

These losses could only be averted through the development of more accurate short-term weather forecasts, the means of adequately disseminating this information to the users, and getting the user to rely on the more accurate weather forecasts. At the present time, weather forecasts are not used to any great extent and most contractors play the weather by the "seat-of-the-pants."

Fig

Decisi



1. H: HOUR OF BEGINNING; MAY 16- JUNE 15: 8 AM (10 HOUR DAYS ASSUMED: 8AM- 6:00 PM)
   JUN 16- SEPT 15: 7 AM (12 HOUR DAYS ASSUMED: 7AM- 7:00 PM)
   SEP 16- OCT 15: 8 AM (10 HOUR DAYS ASSUMED: 8AM- 6:00 PM)

2. (H-1) HOUR ENDING FOR PRECIP RECORDING

3. TEMPERATURE CONSTRAINT NOT CONSIDERED SINCE WEATHER SENSITIVE PERIOD FOR PROJECTS EVALUATED WAS FROM MAY 21 - SEPT 13 INCL.
   JOB PERIOD WHEN WEATHER SENSITIVE: 25-70 PERCENT OF THE TIME PERIOD

4. RAIN RECORDED IN THREE CONSECUTIVE HOURS IMPLIES NOT SHOWERS

5. AVERAGE CREW ASSUMED TO CONSIST OF 21-22 MEN; 10-11 @ PAVING OPERATION, 6 TRUCK DRIVERS, 5 PLANT

6. ≥ 4 HOURS BUT BEFORE LUNCH NO PAY LOSS

ure 1

on Model

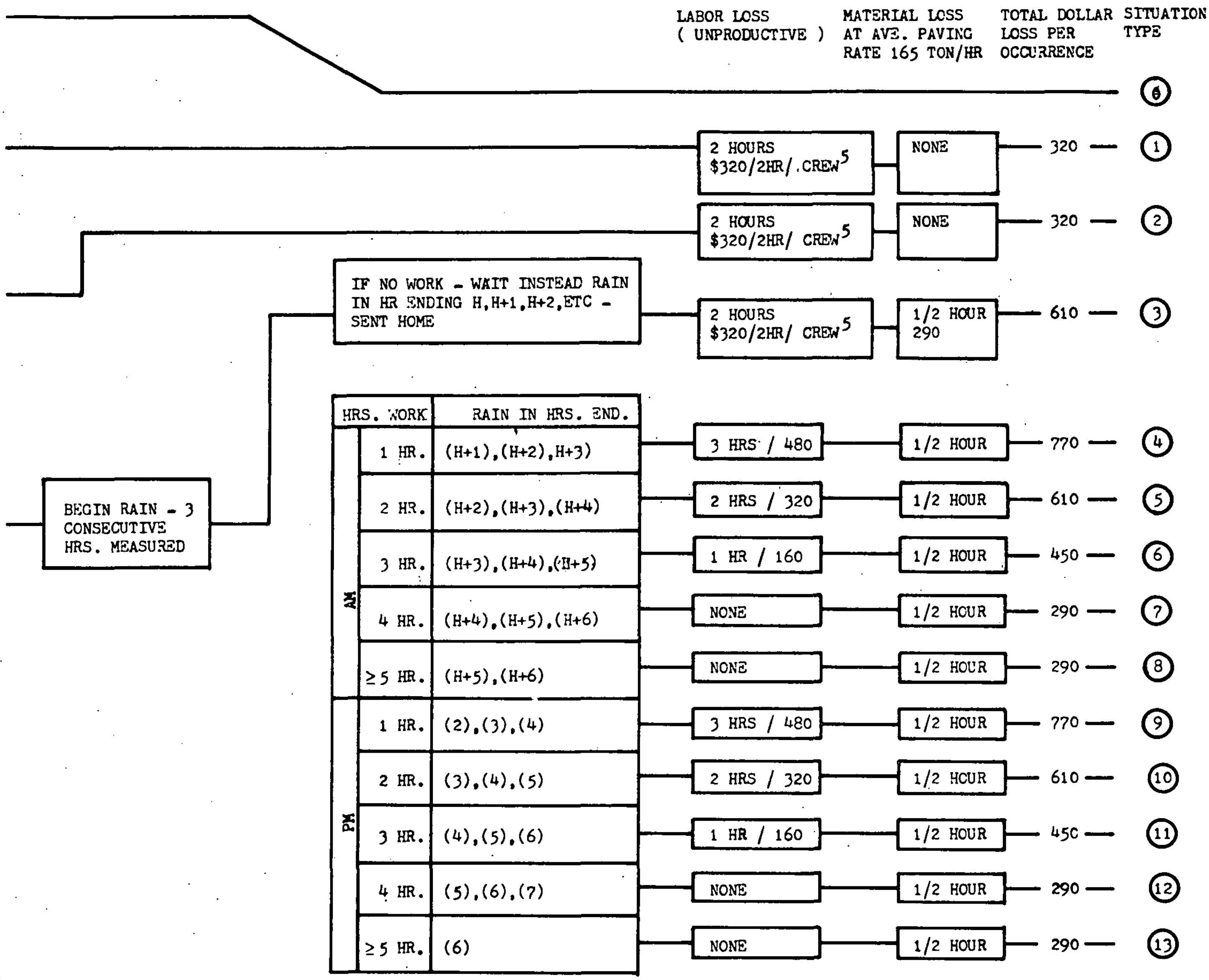


Table 1

Sensitivity Period Summary

Projects Underway--South-central & South-west--1969

	Job #	Time Period Begin	Time Period End	Days[a]	Sensitive Period Inclusive Days from Contract Start
South-central (SC)	1	5/23	7/18	55	14 - 39
	4	5/19	7/17	58	15 - 41
	5	4/28	8/1	93	23 - 65
	6	8/4	10.1	57	14 - 40
	8	not analyzed[1]			not used
	11	7/17	8/19	32	8 - 22
South-west (SW)	2	5/12	8/14	92	23 - 64
	3	5/19	9/11	122	31 - 85
	7	7/17	9/17	60	15 - 42
	25	4/29	7/25	86	22 - 60

Sum (SC + SW)

Weather Sensitivity During 25% - 70% of Project Time

a. Assuming 30 day months

1 Incomplete in 1969

Table 2

Mean Number of Projects Underway

South-west & South-central

1969

Time Period[1]	Mean Number of Projects Underway Per Day
May 16 - May 31	1.33
Jun 1 - Jun 15	4.13
Jun 16 - Jun 30	5.53
Jul 1 - Jul 15	2.20
Jul 16 - Jul 31	1.40
Aug 1 - Aug 15	2.60
Aug 16 - Aug 31	1.87
Sep 1 - Sep 15	0.80
Sep 16 - Sep 30	--

[1]30 day months used for all calculations

Table 3

Number of Projects in Weather Sensitive Stage

Inclusive Dates	Number of Days[1]	Number of Projects in Weather Sensitive Stage
May 21 - June 3	13	2
June 4	1	3
June 5 - June 6	2	4
June 7 - June 19	13	5
June 20 - June 28	9	6
June 29	1	5
June 30 - July 1	2	4
July 2	1	3
July 3 - July 15	13	2
July 16 - July 25	9	1
July 25 - Aug 1	7	2
Aug 2 - Aug 8	7	3
Aug 9 - Aug 12	4	2
Aug 13 - Aug 14	2	3
Aug 15 - Aug 28	14	2
Aug 29 - Sep 13	15	1

[1]Based on a 30 day month

Figure 2

The Hourly Rainfall Data[a] Used to Develop Model Situation Types

HOURLY PRECIPITATION (Water equivalent in inches)

Date	A. M. Hour ending at												P. M. Hour ending at												Date
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	
1							T	.10	.17	T															1
2										T	.05	T	.10	.03	.02	T	T	T	T						2
3								T																	3
4						T		.13	.28	.11	T				.03	.90	.03								4
5																									5
6														T	.05	T	T	T	T	T	T				6
7														.10	.17	.07	.05	.03	.03	.05	T	.04	T	T	7
8			T																						8
9																									9
10																									10
11			T	.05	.03			T	.01	.04		T	T				T	T						T	11
12	.45	T		.25	T							T				T	.10	.01							12
13																									13
14											T	T													14
15																									15
16																									16
17	T	T	T										T	.14	.02										17
18	.03	T			.05	.04	T	T																	18
19	T	T											T						T	T		T	T		19
20																									20
21										T	T					T	T		T				T	T	21
22											T	T		T					T	T					22
23	T	T																					T	T	23
24	T			T	T	T	T	T	T		T	T			T										24
25									T	T						T	.65	.17	.13	T		.07	.98	.17	25
26	.05									.28	.21	T									T	.20	.01	.01	26
27	.25	.10	T	T																					27
28																									28
29				.22	.31	.24	.10	.01	T	T		T	T				T	.03	.01	T	T	T	T		29
30																									30

[a]Source: Local Climatological Data, U.S. Department of Commerce Station, Madison, Wisconsin.

Table 4

Rainfall Criteria
(Periods considered "rainy" for modelling purposes.)

Word Description	Examples*
Three or more consecutive hours of precipitation (P)	P, P, P P, P, --P--, P
Four or more consecutive hours of trace (T)	T, T, T, T T, T, T, ---T---,T
Any combination of consecutive hours of measureable (P) or trace in which at least two hours of measureable (P) are intermixed with at least one hour of trace (T)	P, T, P P, T, T, P P, ---T or P ---,P
Any combination of consecutive hours of measureable (P) and trace (T) with at least three hours trace (T) and at least one hour of measureable (P)	T, T, P, T T, T, P, ---T or P---,T T, P, T, T T, P, ---T or P---,P

Note: Two consecutive hours of rain (P,P) were not considered since they could be shower activity, spanning the hour point with a recorded amount then shown during each of 2 hours.

*P denotes a measureable amount of precipitation during one hour.

T denotes a trace amount of precipitation during one hour.

Table 5

Calculation of Savings - Bituminous Concrete Paving

Situation		May 16 - May 31				June 1 - June 15				June 16 - June 30			
No.	Cost per Occr.	# of Times (X)	P(x) (out of 96)	Mean Proj/ Day	Loss/ Day (2)(4)(5)	# of Times (X)	P(x) (out of 96)	Mean Proj/ Day	Loss/ Day (2)(8)(9)	# of Times (X)	P(x) (out of 96)	Mean Proj/ Day	Loss/ Day (2)(12)(13)
1	2	3	4	5	6	7	8	9	10	11	12	13	14
0	--	5	.0521	1.33	--	3	.0333	4.13	--	4	.0444	5.53	--
1	320	3	.0313	↓	13.3	2	.0222	↓	29.3	6	.0667	↓	118.0
2	320	3	.0313		13.3	1	.0111		14.7	0	0		--
3	610	0	0		--	0	0		--	0	0		--
4	770	2	.0208		21.3	3	.0333		105.9	2	.0222		94.5
5	610	0	0		--	2	.0222		55.9	2	.0222		74.9
6	450	3	.0313		18.7	2	.0222		41.3	1	.0111		27.6
7	290	2	.0208		8.0	1	.0111		13.3	1	.0111		17.8
8	290	0	0		--	0	0		--	0	0		--
9	770	2	.0208		21.3	3	.0333		105.9	2	.0222		94.5
10	610	2	.0208		16.9	0	0		--	0	0		--
11	450	0	0		--	2	.0222		41.3	1	.0111		27.6
12	290	0	0		--	0	0		--	0	0		--
13	290	0	0		--	0	0		--	0	0		--
					112.8				407.6				454.9

112.8 x 16 = 1805

407.6 x 15 = 6114

454.9 x 15 = 6824

Table 5 con't.

Situation No.	Cost per Occr.	July 1 - July 15: # of Times (X)	P(x) (out of 96)	Mean Proj/ Day	Loss/ Day (2)(16)(17)	July 16 - July 31: # of Times (X)	P(x) (out of 96)	Mean Proj/ Day	Loss/ Day (2)(20)(21)	August 1 - August 15: # of Times (X)	P(x) (out of 96)	Mean Proj/ Day	Loss/ day 2)(24)(25)
1	2	15	16	17	18	19	20	21	22	23	24	25	26
0	--	2	.0222	2.20 ↓	--	1	.0104	1.40 ↓	--	2	.0222	2.60 ↓	--
1	320	4	.0444		31.3	2	.0208		9.3	3	.0333		27.7
2	320	1	.0111		7.8	2	.0208		9.3	0	0		--
3	610	0	0		--	0	0		--	0	0		--
4	770	2	.0222		37.6	3	.0313		33.7	0	0		--
5	610	0	0		--	1	.0104		8.9	3	.0333		52.8
6	450	4	.0444		44.0	0	0		--	1	.0111		13.0
7	290	0	0		--	0	0		--	2	.0222		16.7
8	290	1	.0111		7.1	1	.0104		4.2	1	.0111		8.4
9	770	2	.0222		37.6	4	.0417		45.0	0	0		--
10	610	0	0		--	2	.0208		17.8	1	.0111		17.6
11	450	2	.0222		22.0	0	0		--	1	.0111		13.0
12	290	0	0		--	0	0		--	0	0		--
13	290	0	0		--	0	0		--	0	0		--
					187.4				128.2				149.2

187.4 x 15 = 2811

128.2 x 16 = 2051

149.2 x 15 = 2238

Table 5 con't.

Situation		August 16 - August 31				September 1 - September 15			
No.	Cost per Occr.	# of Times (X)	P(x) (out of 96)	Mean Proj/ Day	Loss/ Day (2)(28)(29)	# of Times (X)	P(x) (out of 96)	Mean Proj/ Day	Loss/ Day (2)(32)(33)
1	2	27	28	29	30	31	32	33	34
00	--	2	.0208	1.87	--	9	.1000	0.80	--
1	320	6	.0625	↓	37.4	4	.0444	↓	11.4
2	320	0	0	↓	--	2	.0222	↓	5.7
3	610	0	0	↓	--	0	0	↓	--
4	770	1	.0104	↓	15.0	1	.0111	↓	6.8
5	610	0	0	↓	--	1	.0111	↓	5.4
6	450	1	.0104	↓	8.8	0	0	↓	--
7	290	1	.0104	↓	5.6	2	.0222	↓	5.2
8	290	1	.0104	↓	5.6	0	0	↓	--
9	770	4	.0417	↓	60.0	2	.0222	↓	13.7
10	610	0	0	↓	--	0	0	↓	--
11	450	1	.0104	↓	8.8	2	.0222	↓	8.0
12	290	1	.0104	↓	5.6	2	.0222	↓	5.2
13	290	0	0	↓	--	0	0	↓	--
					146.8				61.4

146.8 x 16 = 2349

61.4 x 15 = 921

Loss Recap

Period	Loss
May 15 - May 31	1805
June 1 - June 15	6114
June 16 - Jn 30	6824
July 1 - July 15	2811
July 16 - Jl 31	2051
Aug 1 - Aug 15	2238
Aug 16 - Aug 31	2349
Sep 1 - Sep 15	921
	25113

Table 6

Project Cost Summary

Area	Project Number	Bit. Conc. Cost (Item 40701)	Total Contract Cost	Bit. Conc. as Percent of Total Cost
	1	100,130	205,700	48.7
	4	54,780	94,200	58.1
SC	5	249,800	454,200	55.0
	6	174,340	298,300	58.4
	11	108,580	179,400	60.4
		687,630	1,231,800	
	2	74,400	170,700	43.5
SW	3	114,450	270,900	42.2
	7	93,220	176,200	52.9
	25	35,950	76,500	47.0
		318,020	694,300	
		1,005,650	1,926,100	52.2%

% Saving (Loss) (Item 40701): 25,113/1,005,650 = 2.50%

% Saving (Loss) (Gross): 25,113/1,926,100 = 1.30%

SEVERE WEATHER STUDY N 74-22273

by Craig J. Mills

ABSTRACT

The purpose of this study has been to discover and evaluate current methods of severe weather information dissemination and the impact of this information on the general public. From the description of the situation here, it is hoped that the design and function of future NASA programs will be responsive to the communications needs as discussed, thereby facilitating the development of more effective means of providing emergency weather warnings to the general public.

The study is based on the responses of the general public and the local broadcasters to a severe weather incident which occurred on August 14, 1972 in the Dane County-Madison Metropolitan area. Because Madison is the state capitol, we were able to contact the appropriate state and local government and agency officials and collect documentation necessary to a complete evaluation. Additionally, because the county is on the north end of the lesser of two generally recognized "tornado alleys", the chances for the occurrence of a severe weather incident in the survey area during the test period were quite good. Furthermore, we felt that the experiences here would be more 'typical' than those in Topeka, Kansas or Galveston, Texas, for instance, where a completely unique set of variables would be expected to be in force. On the basis of the work here presented, and in light of the Agness Panel statements, though severe weather events vary in characteristic and frequency, a basic communication problem remains on the local, state, and national levels. It is this communications problem that contributes more to the ineffectiveness and inefficiency of the emergency warning system than any other single aspect.

A public usage survey, designed by Margaret Schneider Stacey served as the basis for this research project. A complementary media survey was developed by James Byrnes, and used to measure broadcast media response and performance during the severe storm situation.

By executing both the public usage and media surveys within a 60 hour period, we were able to elicit as near "real time" responses as possible, given the 'one shot' nature of the study. This information was then correlated with information collected through personal interviews with NWS staff, Emergency Government personnel at both the state and local levels, and other representatives of safety and emergency service groups. Operations documents, instructional materials, and newspaper clippings pertaining to various aspects of the study have also been selected and included.

The results of the study have been somewhat startling, though not totally unexpected. From our sample, for instance, we found that 45% of the Dane County population was not aware of the severe thunderstorm warning. In this case this may or may not have been critical, but had the storm been extremely severe or had a tornado and flooding been associated with the storm, a large segment of the population would have been in great danger.

We found a heavy dependence on the broadcast media for the dissemination of emergency information. Though good cooperation exists between the media and emergency warning agencies, the lack of a dedicated warning system and the resultant levels of decision making leave serious doubts as to the emergency effectiveness of the present system.

Our study also revealed that different groups with seemingly different responsibilities chose separate solutions to similar problems. With each group concentrating on its own immediate responsibility, primary consideration of collective, cooperative exchange of different bits of information is impossible. Needless duplication of effort as well as 'tiers' of inefficiency result. There is no one group to which 'blame' can be assigned, nor is one group more responsible for system inefficiency than any other.

What this study has shown us, is that the real problem with the dissemination of severe weather information is not the lack of it, but the inability to transfer it in useful form to an overwhelming majority of the general public.

STUDY CONSTRAINTS

The practical geographical limits of this study include the State of Wisconsin with more specific emphasis on the Madison-Dane County area. As is often the case, time and budget considerations precluded a national or even regional study. With this in mind, we chose to proceed in such a manner as to provide a carefully detailed and documented study of the Madison-Dane County area, thus using the "limitations" to our own best advantage.

Since the study began we have contacted and interviewed representatives of the Dane County broadcast media (fourteen radio and television stations), and four groups charged with the responsibility for the safety of the residents of Dane County. Our study has also included what we feel to be the most important and unique evaluation of user needs. Through cooperation with the UW-Extension Survey Research Laboratory, our center has drawn and studied a probability sample of the area's population which yielded highly significant results from which we have drawn inferences concerning the general public's needs and perceptions regarding severe weather.

We are most confident that the research design provides a well defined and accurate description of the threat and event of severe weather on Dane County citizens and, most importantly, the effectiveness of the existing mechanisms in the transfer of information and warnings of impending storm situtations.

BACKGROUND

This researcher has been most careful in the construction of this segment to clearly define the source and scope of our data as well as our methodology. In this way we hope to maintain a proper balance between the three interdependent segments of this study. When the analysis of the pertinent hard data is coupled with appropriate supportive data, giving perspective to the statistics, the figures become most useful in helping to describe the total picture.

With this basic hypothesis in mind, this "statistical review" has been developed as an analysis of the severity of particular storms and their effect on personal safety and property. It is a charge of this study to show that threats to life and property losses are of sufficient magnitude to warrant further development of meteorological satellite technology as applied to severe weather information.

It is of particular interest to us here to discover, as best as we can, how and to what extent the user of weather information is affected by severe weather.

Part One

PROPERTY LOSS DUE TO SEVERE WEATHER

We have chosen as our major source of data, the NOAA Storm Data and Unusual Weather Phenomena publication. The data is compiled and reported each month by the NOAA Climatologist of each of the states.

> The Climatologist of each state plays an important role in the National Weather Service's severe storm service program: he collects, evaluates, summarizes, and tabulates reports of severe storms for publication in "Storm Data" and has the final word on the validity of these reports.[4]

Hans E. Rosendal, NOAA Climatologist for the State of Wisconsin has been most helpful in providing background information for this study. During an interview, we discussed the various sources of the aforementioned data.

Many reports come to the Climatologist from cooperative field observers who send storm sighting information and available damage estimates with their monthly rain and temperature measurements. These observers are scattered throughout Wisconsin and are proven, reliable sources of regular information.

Rosendal also collects press releases and any other print materials dealing with severe weather incidents, keeps records of these, both to map the storm and to help compile and verify damage estimates. When a particular storm incident appears to have had especially severe effects, the Climatologist personally investigates the damage to the area and makes his own estimates from his observations.

Insurance claims and estimate are taken into consideration as guidelines in determining property losses. However, because some damage is not covered under certain policies, other damage only partially covered, and much property is completely uninsured, this latter source is the least used.

The data we have gathered from Storm Data include the recorded estimates of severe weather damage in the State of Wisconsin through 1969, 1970, and 1971. Any consideration of a longer period of time (5-10 years) would require an evaluation of the past estimating techniques, any modifications of these techniques and transition periods, the size of the network of field volunteers, the effects of inflation, news reporting through that period, and a raft of other complicating variables.

The three year time period includes enough data to show the magnitude of year to year variations in severe weather incidents, while minimizing the effects of other variables. These estimates most closely represent the recent losses due to severe weather, and, given an identical reporting and estimating technique, allow a reasonable basis for expectation of future loss. Because complete and updated figures will not be available for all of 1972, we felt it to be inappropriate include any figures for that year.

Additionally, while the second and third segments of this study are specifically centered on Dane County, the sporadic nature of severe storms makes the single county damage analysis difficult and misleading at best.

For every tornado or thunderstorm that sweeps through a large population center, there are a number of others that move across open, virtually uninhabited countryside. Unreported occurrences and unverified sightings describe the opposing limits of the difficulties presented to the severe weather statistician. Thus, from year to year, variations in the number of severe weather incidents and the effects of such incidents cannot be predicted in any but general terms.

Consider the figures for the number of injuries due to severe weather in 1969 (see Figure 3). One hundred and fifty-nine people were hurt that year. Furthermore, 147 were injured in Milwaukee County alone. However, a closer look puts the figure in perspective. On August 11, 1969 a tornado touched down at State Fair Park in West Allis, Wisconsin at about 2:30 in the afternoon. The Fair, held in this Milwaukee suburb, was underway and 146 people were injured as three tents collapsed. Similar occurrences, involving complicated circumstances and misleading figures appear throughout the studied period.

Severe Weather Incidents

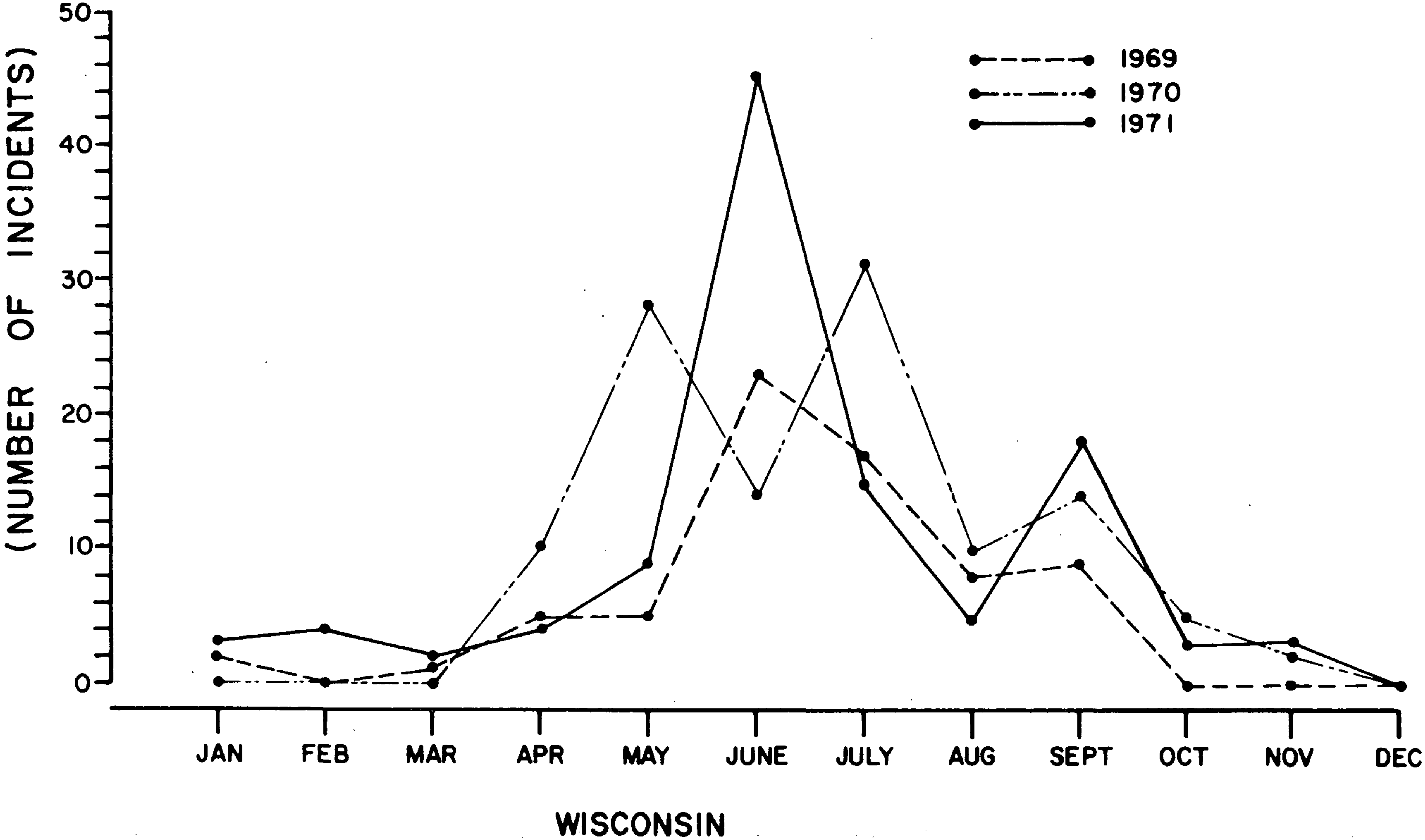
Figure 1 shows the number of severe weather incidents by the month for 1969, 1970, and 1971.[5] It is interesting to note the variations in the curves for the three years and the extreme variations within each year from month to month. It is obvious that no predictions about the following year could be made from these curves in any specific sense, yet, the general trend indicated can be found useful.

In 1969, for instance, eighty-nine per cent of the severe weather occurred between (not including) April and October. In 1970, eighty-six per cent of the incidents occurred during the same period and in 1971, eighty-three per cent. The data from that three year period leads one to expect about the same distribution for 1972.

In addition, while expected precipitation may be estimated on the basis of previous years and early year totals, the number of severe weather incidents and their type is a variable which becomes evident only as the storm develops. Thus, another consideration of importance to this study and of ultimate concern to the general public, are the

Figure 1

The Number of Severe Weather Incidents



role of adverse weather in traffic accidents was acknowledged. It would seem likely that a good many more traffic injuries and deaths not attributed to the weather may, in fact, have been affected or even caused by poor visibility, wet slippery roads, high gusty winds, and changing conditions.

The role that severe weather may have played in other accident situations, particularly in weather sensitive professions, and the number of weather related accidents not reported lead us to believe that the reported death and injury figures are low.

Economic Loss

In addition to storm characteristics, date and time of the specific severe weather occurrence, and the death and injury due to those events, the Storm Data form includes a damage estimate procedure that puts losses in particular categories varying from one to nine. These damage estimate categories correspond to dollar loss ranges. For our purposes, the ranges are unsatisfactory, and we have converted these ranges to a more useable form in the following manner:

category	range	assigned value
category one	less than $50	$25
category two	$50 to $500	$275
category three	$500 to $5000	$2,750
category four	$5000 to 50,000	$27,500
category five	$50-500 thou.	$275,000
category six	$500,000 to 5 mil.	$2,750,000
category seven	$5-50 million	$27,500,000
category eight	$50-500 million	$275,000,000
category nine	$500 mil. to 5 bil	$2,750,000,000

types and effects of severe weather which occur most often.

In Wisconsin, the potential for severe and/or unusual weather phenomena (though less in some seasons than others) is present in any season. Figure 2 is an illustration of the number of reported severe weather incidents and their extreme characteristics. Careful attention to Storm Data has led us to a choice of seventeen manifestations of severe weather. These particular characteristics represent the entire range of severe weather as it occurs and has been reported in the State of Wisconsin.

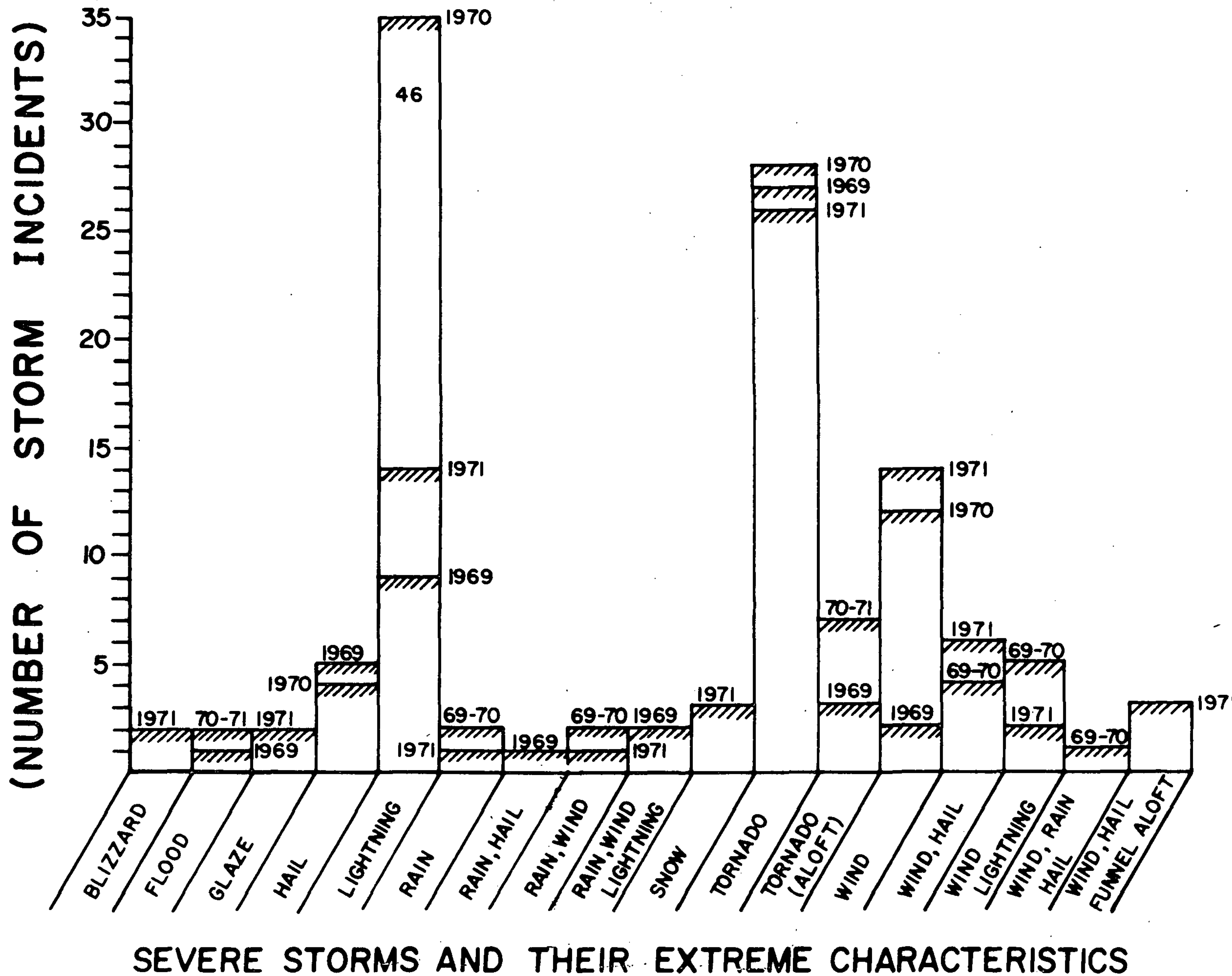
While some of the categories may appear to be quite similar in nature, they are arranged in descending degrees of severity. For example, the rain and wind listing indicates that the most severe characteristic was heavy rainfall and that high winds accompanied that rainfall. Conversely, the wind, rain, hail category indicates that the most severe characteristic was a high wind and that heavy rains and a third variation, hail, accompanied these winds.

Injury Due to Severe Weather

The extent and nature of injury due to severe weather is specified only when that information is available. Because of the difficulty in reliably collecting this type of information, a correlation between the storm characteristic and the severity of the resulting injuries cannot be made. These are, however, general categories of severe weather responsible for most of the injuries. Lightning, for instance, over the last three years struck and injured eight people. Tornadoes, and the associated flying debris accounted for 42 injuries (and an additional 146 slight injuries in the fair tent collapse). Thunderstorms with accompanying high winds hurt 27 persons while blizzards were

Figure 2

The Number of Severe Weather Incidents and Their Extreme Characteristics



responsible for another 7 injuries.

Figure 3 is an illustration of the number of injuries per storm characteristic for the three year study period. As one can see, the only two characteristics that appear each year throughout the 3 year period are lightning and tornadoes. The incidents over that same period vary in characteristics as well as numbers affected and that variation is probably due as much to the victim's being in "the wrong place at the wrong time", as any other single factor.

Death due to severe weather effects seems to be a case very similar in nature in injury due to severe weather (see Figure 4). There are some striking variations between the major causes of death and those of injury, however.

It is evident that while tornadoes were consistently responsible for a proportionally large number of injuries during the last three years, only a single death resulted from this most violent type of storm. The majority of deaths directly attributable to severe weather effects were drownings. Seven of these were boaters caught out on various Wisconsin lakes; the eighth, a child drawn into a culvert by rushing waters. Lightning was responsible for six home fire deaths and two others as a result of direct strikes. A blizzard caused four traffic deaths while a fifth person died of exposure in the same storm. In three separate incidents of wind damage, another three Wisconsin residents died.

All but one of the above was the result of "common" severe weather occurrences. Thunderstorms with the attendant high winds, heavy rain, hail and lightning were by far the most dangerous of the phenomena.

The blizzard, which accounted for traffic related deaths, was the only instance in the three years under consideration in which the

Figure 3

The Number of Injuries per Storm Characteristic

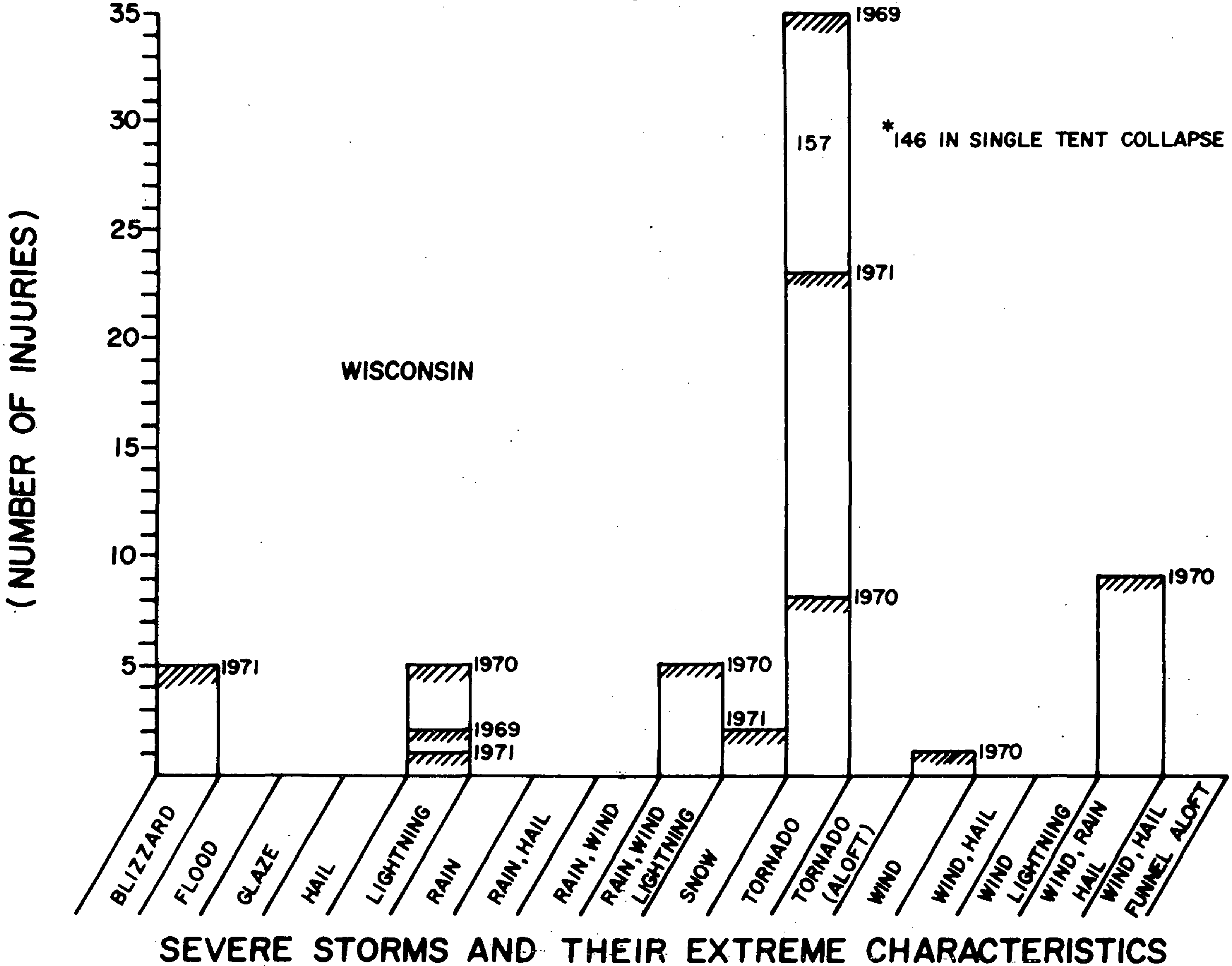
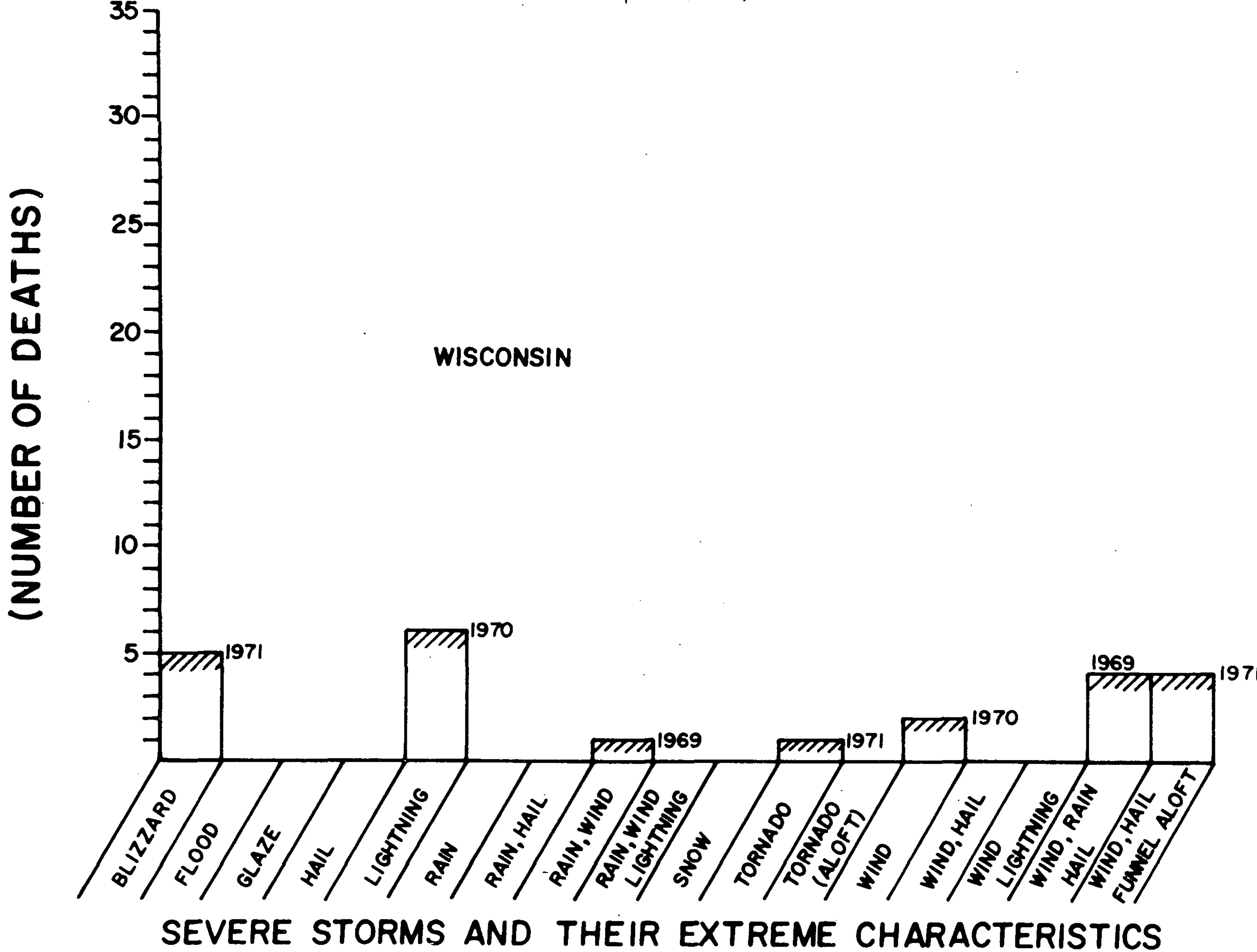


Figure 4

The Number of Deaths per Storm Characteristic



We have selected the median of each range and equated it with the appropriate category. This seems to be the most straightforward method of reducing the unwieldy range figures to computable figures. It is understood, however, that these figures are indeed estimates and represent our efforts at most closely approximating actual losses. According to Rosendal, the method used in gathering and reporting Storm Data ensures a nearly equal probability of the adjusted figures being greater or less than actual loss. To the best of our knowledge these new adjusted figures reflect that same probability. In some instances, specifically in the highest damage estimate categories encountered in the study (six and seven), we find that we are dealing with a range including millions of dollars. We have paid particular attention to these cases and have found that in many of the most severe incidents, actual total damage estimate figures are included. In any instance where we are given a total dollar figure for a damage estimate in addition to a specific figure range, we have used the total figure for computation. These adjusted figures will be indicated in the tables.

Over the past three years (see Table 1) in the state, Wisconsin residents have sustained substantial financial losses due to severe weather. Property losses to the general public statewide came to nearly $96 million. Crop losses added another $13 million to that figure for the same three year period.

Severe weather, though a problem to farmers only during Wisconsin's relatively short growing season, can be quite devastating, particularly when a storm strikes just before harvest. High winds just before wheat harvest will flatten and destroy the ripe grain crop. Heavy driven rains are especially bad as these rains may literally wash away an entire crop, especially when it's too early in the season to have been able to realize a return and too late to re-plant .

TABLE 1

WISCONSIN

		PROPERTY DAMAGE	CROP LOSSES	NO. OF STORM INCIDENTS
1969*	JANUARY	$ 3,025,000	$ 0	2
	FEBRUARY	NONE REPORTED	---	0
	MARCH	0	0	1
	APRIL	** 1,082,000		5
	MAY	63,250	27,500	5
	JUNE	**26,940,000	8,525,000	23
	JULY	555,500	552,500	17
	AUGUST	635,250	305,250	8
	SEPTEMBER	192,500	0	9
	OCTOBER	NONE REPORTED	---	---
	NOVEMBER	NONE REPORTED	---	---
	DECEMBER	NONE REPORTED	---	---
	TOTAL	$32,494,000	$9,410,250	70
1970*	JANUARY	NONE REPORTED	$ ---	---
	FEBRUARY	NONE REPORTED	---	---
	MARCH	NONE REPORTED	---	---
	APRIL	$ 4,218,500	0	10
	MAY	** 4,988,750	27,500	28
	JUNE	3,473,250	580,250	14
	JULY	3,833,250	302,500	31
	AUGUST	423,500	275,000	10
	SEPTEMBER	3,203,750	0	14
	OCTOBER	3,107,500	0	5
	NOVEMBER	3,025,000	0	2
	DECEMBER	NONE REPORTED	---	---
	TOTAL	$26,273,500	$1,185,250	114
1971*	JANUARY	$ 5,775,000	0	3
	FEBRUARY	6,050,000	0	4
	MARCH	302,500	0	2
	APRIL	357,500	0	4
	MAY	937,750	0	9
	JUNE	2,546,500	0	45
	JULY	** 1,641,000	**1,307,750	15
	AUGUST	8,552,500	825,000	5
	SEPTEMBER	* 5,385,500	275,000	18
	OCTOBER	5,502,750	0	3
	NOVEMBER	305,000	0	3
	DECEMBER	NONE REPORTED	---	---
	TOTAL	$37,356,000	$2,407,750	111

* These are approximate figures developed from damage estimate ranges used in NOAA Storm Data and Unusual Weather Phenomena.

** These are adjusted figures and include actual damage totals.

June 1969 is a case in point. Wisconsin farmers suffered $8.5 million worth of damage between the 26th and 29th of the month. Hail, heavy rains, the flooding of low fields and severe soil erosion were responsible for the destruction. Of the 23 storm incidents in the month of June, three were responsible for the damage. For the same month in 1970, 6 of 14 storms accounted for a $580,250 loss. In June of 1971, there were 45 incidents of severe weather but no reported crop damage.

Thus, another important factor to be considered as applied to analysis of both property and crop damage and losses is that the number of incidents of severe weather is not directly proportional to the amount of damage done. Accordingly, in June of 1969, twenty-three incidents accounted for $26,940,000 in property damage. The following month with seventeen severe weather events, property damage totalling $550,500 was reported.

A number of conclusions can be legitimately drawn from the data here presented.

First, while the number of severe weather incidents, their character, the totality of their effects, and the dates of occurrence cannot be easily predicted, a general trend can be seen. It is reasonable to conclude from the three years being considered that none of the three stands out as being particularly more or less severe than either of the others. The three year period being considered is likewise no more or less severe than other years within the past decade. Furthermore, there is every indication that 1972 will follow this general trend and at this point there is no reason to expect that this general trend will not continue for the next several years. From this, it is not unreasonable to predict that losses due to severe weather should continue to roughly equal those recorded for our study period.

The most effective methods for the reduction of losses due to severe weather may include more complete and up-to-the-minute general weather reporting, a more informed public, a more efficient warning system combined with a monitoring system, or a combination of these and/or other variables not yet explored.

Sections two and three will deal with the general public's response to a specific severe weather incident, which will be correlated not only with the responses of groups and agencies with safety responsibilities to the public, but also with media responses and the amount of information made available to the public.

PART TWO

SHORT RANGE SEVERE WEATHER SURVEY: THE MEDIA

Purpose

The purpose of the media survey is to determine the broadcast media's performance in this specific severe weather situation. The focus is on what sources the broadcast media depend on in such a situation, the nature of these sources, and the time differential involved in the transfer of the source information to the general public. We also hope to discover the media's treatment of this material and their opinion of the adequacy of the information they receive.

Field Study Method

We studied the population of 9 radio and 4 television stations whose broadcast range includes Dane County. Our plans called for a telephone survey of this population as soon after the occurrence of a severe storm as possible. In this way we hoped to be able to reach the involved media personnel and perhaps secure records of broadcasts of severe weather bulletins.

Survey Administration

The severe thunderstorm warning, issued August 14th, expired at 3:00 p.m. As the warning period expired we notified the WSRL to begin the public usage survey, and our staff began telephoning each of the selected radio and TV stations. Calls could not be made on the hour, half hour or quarter hour, because many times, the person responsible for weather bulletin was busy preparing other broadcast materials. However, only a few schedules were uncompleted by 5:30 p.m., and these were completed by the same time the next day.

Special Considerations

Some of the interviews were quite rushed as the respondents we spoke to often were trying to meet news broadcast deadlines. Thus, comments tended to be brief, and some questions were left unanswered. We also found that some of the personnel that were on duty during the storm were not available when we called. A third problem we encountered, especially in establishing broadcast times, was that very few of the broadcasters kept a log or record of the weather bulletin information received and/or broadcast.

These special problems, though affecting the results of the survey, also serve to point out the way the broadcast media deal with severe weather information, the importance they attach to these bulletins, and the range of responses to the immediate situation.

Results

We contacted all thirteen radio and television stations within 24 hours following the expiration of the thunderstorm warning. Nine radio stations received the watch and warning from identified sources and three of the four television stations also received storm information. Channel 21, WHA-TV in Madison, a public television station, and PBS affiliate, did not use or broadcast any severe weather bulletins according to the spokesman we contacted. We did not include this station in the following analysis, as we chose to define our population as those broadcasting stations in, or broadcasting to Dane County, who received severe weather information.

The Thunderstorm Watch

Of the broadcasters we contacted (WHA-TV excluded), 58% received notification of the severe thunderstorm watch on the NOAA Weather Wire.

This figure includes all three network affilitated commercial television stations, and four radio stations. Another 25% received notification through direct telephone contact with the NWS station at Truax Field. Two of these three stations were contacted through the same office as they are jointly owned and operated. The two remaining radio stations (16%) received their severe weather bulletins through the wire services, one from AP and the other from UPI.

Of these broadcasters, 75% did not in any way change or edit the releases.

The severe thunderstorm watch was issued at 1:21 p.m. C.D.T. by the National Weather Service station at Truax Field. Forty-two percent of the sample received this information and broadcast it by 1:30 C.D.T. One station received notification and broadcast at 1:45 p.m. C.D.T.; another received both the watch and warning at 1:51 p.m. C.D.T. The remaining 25% confused the Dane County watch with other county watches and the times they cited were obviously inaccurate.

When asked whether any additional information was received, 42% said they had no additional sources. Another 42% did get additional information from UPI, 8% from AP, and another station got its additional information from monitoring the police frequencies.

The Thunderstorm Warning

The response to the warning was very similar to that of the watch. As one would expect, the sources were the same for this more immediate bulletin (although in three instances direct response to this question were not obtained). Again, the media, on the whole, did not edit, the releases. Fifty-eight percent transmitted the bulletins as received while thirty-three percent of the stations shortened and localized the report.

The severe thunderstorm warning was issued from Truax Field at 1:33 p.m. C.D.T. Thirty-three percent of the population had broadcast the vital information by 1:42 p.m. C.D.T. One broadcast it at 1:50 p.m. C.D.T. and another at 1:55 p.m. C.D.T. Three stations were unable to tell us when they issued warning information, and the remainder did not directly respond to the question.

Updates

We were also interested in the stations' ability to follow the progress of the storm and whether they updated bulletins or received updated information. One station, a subscriber to the UPI wire, had this as its sole source. Generally, the response of the UPI wire to weather wire outputs is slow, considering the real time needs. Thus this was not considered sufficient for effective warning purposes. Another station reported that it had facilities for monitoring storm progress but did not specify the nature of those facilities. Of the remaining stations, three called the weather service to receive additional information. Another 25% monitored either state, county or local police frequencies. One station has access to the police teletype and three stations used the weather wire for this purpose.

Emergency Instructions

The National Weather Service, the Dane County Chapter of the American National Red Cross, and the Dane County Office of Emergency Government have all issued instructional materials in the form of films, tapes, slides and printed matter describing courses of action to be taken during severe weather events. However, during the warning period, only 42% of the media studied broadcast any instructions.

All Clear

As the warning period ended, 66% of the Dane County broadcast media did not receive an "all clear". Of the remainder, one station got the all clear from the Associated Press, another after calling the National Weather Service, while two others did not directly respond to the question.

Some Effectiveness

When we asked the respondents for comments on the effectiveness of the sources that they relied upon, 33% felt the NWS Weather Wire to be quite adequate. Another third of the group had no comments; two stations thought the Weather Wire a bit slow and an additional station cited problems created by confusing information. In general, however, the temper of the statements seemed to indicate rather strong advocacy and not criticism of present weather warning procedure and this subject does not appear to be an issue among broadcasters.

Discussion

This segment presents a description of the patterns and characteristics which best represent the media's role in providing the general public with severe weather information. It should be kept in mind that these results represent a single incident, and the respondents' perceptions of their reaction to this incident. It should also be remembered that these responses are unique to this particular situation and that we are dealing with extreme variance from incident to incident-- both in the nature of the storms and the ability of the media to handle their warning responsibilities.

There appears to be no concerted or organized effort to provide severe weather information to the public. Fifty-eight percent of the broadcasters subscribe to the NWS Weather Wire which they use on a day-to-day basis, and the severe weather bulletins are, for the most part, taken verbatim from that service. Perhaps as a matter of expediency or because of the lack of the ability to qualitatively add to the information, the media generally choose to play the role of a passive intermediary. Though the time lag in most instances was 15-20 minutes, the unexpected storm development into Dane County, caused any location in or north of an e-w line through the city of Madison to be in the midst of the storm within 10-15 minutes of the issuance of the warning. It could be argued that many areas in Dane County received absolutely no warning, and two stations receiving and broadcasting at approximately 1:50 p.m. C.D.T. were unable to provide their audiences with ample warning time.

We also found that the broadcast media did not have facilities for monitoring the progress of the storm although they showed interest in getting such information by calling the weather station (25%), monitoring police radios (25%) and watching the Weather Wire closely for latest developments (25%).

The fact that 42% of the broadcasters transmitted instructions to the public while 50% did not, indicates a serious deficit in vital information that must be provided to the entire population.

If one were to generalize on the basis of this survey, two major characteristics seem to have emerged. First, the media broadcast whatever is received through readily available channels and operates primarily as a passive member in the communications link. Finally, the media accept their responsibilities to the general public to the extent that pertinent information is not withheld.

PART II A

SHORT RANGE SEVERE WEATHER SURVEY: THE PUBLIC

Purpose

The purpose of this study is to determine the nature of the general public's usage of severe weather information. We are particularly interested in the source, its frequency and accuracy; and the effects, both direct and indirect, that present forms of severe weather information have on the general public. Once we feel this evaluation is complete, we hope to find and/or create new weather information dissemination techniques that will maximize user benefits and most efficiently reduce severe weather threats to life and property.

Goal

To discover (1) how the public obtains severe weather information, (2) when it is obtained, (3) what information the public gets and what information they think they get, (4) what information the public seeks, (5) why they seek it, and (6) how they apply this information. In one word, we are looking at the impact severe weather information has on the general public.

In addition, we hope to describe the efficiency of present weather warning techniques and assess the realized and potential capabilities of the media in handling severe weather information.

Field Study Method

Since we were most interested in determining the impact that present severe weather information systems have on the general public, it was decided to run our survey on the two days immediately following the occurrence of an issued severe storm watch and warning in Dane County.

In this way we hoped to measure the actual effect of the storm warnings and warning sources as they exist and try to determine these effects in as "immediate" a time frame as possible. We felt that within a 50-72 hour period following severe storm conditions, people would be less likely to confuse their most recent experience with other storm situations or forget details important to our study.

Study and Sample Development

The survey was conducted in cooperation with the Wisconsin Survey Research Laboratory (WSRL) of the University of Wisconsin Extension. A telephone survey schedule was developed and administered to a probability sample of adults in Dane County 18 years of age or older. A sample of 1200 telephone numbers was drawn, 600 of which were expected to be active residential numbers. Of this number, the WSRL staff completed 404 codeable schedules within the projected time.

Because of the "one shot" nature of our survey, a pretest under actual severe weather conditions was impossible. However, since the schedule had been developed in accordance with WSRL criteria and been approved by the WRSL director as well as the Center staff involved, the form and schedule concept presented no particularly difficult problems and we were able to go ahead and set up a useful pre-test under simulated conditions.

Three WSRL interviewers were contacted and briefed on the schedule and its objectives. Each interviewer then conducted four telephone interviews, two with other WSRL interviewers and two with friends or acquaintances. All agreed to "pretend" that severe weather had weather had occurred and the interviewees were to either imagine how they would have reacted or remember how they had reacted in previous situations. Those people contacted who were not involved with WSRL were expected to give us clues as to the clarity of the questions and the fluidity of the entire schedule. The "informed" interviewees were asked to be highly critical and play the role of a difficult respondent. "Informed" interviewees' suggestions were then taken into consideration in finalizing the interview schedule.

Special Considerations

It becomes immediately evident that the survey technique required for the measure of public response to a single specifically unpredictable incident presents a number of problems which must be dealt with at the outset. First, we had to develop a highly coordinated survey strategy to facilitate administration of the survey on a few hours notice. For this reason public opinion surveys of different types were considered on their individual merits. Door to door personal interviews were ruled out because they would require more interview staff than was available and it was felt that the time element required a faster survey technique. Mailing of the questionnaire was considered an unsatisfactory method because of the characteristically low return rate and the time required in editing and deciphering the returns.

The telephone survey technique was finally chosen as the most appropriate for our purposes. It would allow a staff of ten to fifteen trained telephone interviewers to complete the required number of schedules in less than 72 hours. Because most of the interviewers work in their homes, we had to arrange to notify them and deliver the materials so the survey might begin a few hours after the storm's occurrence. Using this method, we could expect the most accurate and informed response with little information lost due to forgetfulness or confusion.

We were also satisfied that little bias would be introduced as a result of our sampling of telephone numbers, as more than 95% of the residents in Dane County subscribe to telephone service.[6]

Because the survey was designed to be undertaken during the two days immediately following the occurrence of a storm, the incidence of a severe storm on a Friday or Saturday would have been unsatisfactory for our survey. There are several reasons: the Weather Service Staff is not at full strength on week-ends; Wisconsin Survey Research Lab facilities are not available on week-ends; and many WSRL interviewers might not have been available either.

Since the professional interview staff works on a project to project basis, and operates from private homes, WSRL could not commit any of their staff to our project until after the storm struck and the survey machinery was set in motion. This meant then, that our final "n" would not be specifically estimable until the surveying had actually begun (although a minimum was set).

Finally, and most importantly, we had to wait for an event severe enough to warrant a severe weather watch and warning. Though our survey was operational during prime severe weather months, we were never really sure whether the test area would be effected by a severe storm or whether the event would occur within the appropriate time interval. With an eye on all available weather information, all we could do at this point was wait.

Administration of the Survey

On Monday, the 14th of August, a severe thunderstorm struck Dane County, our study area. (see Appendix A) We were aware of its formation and noted the storm's movement into the Madison area. Our records indicate that high winds and heavy rains moved into the immediate vicinity at 1:55 p.m. The most severe part of the storm then passed through, so that by 2:30 p.m. only moderately heavy winds and rain prevailed. At 3:15 p.m. our office notified WSRL of a tentative go ahead for 9:00 a.m. the following day. Verification of the issuance of the watch and warning was received from the NWS office at Truax Field and the final go ahead for our survey was given to WSRL at 3:45 p.m.

Upon receipt of official word on the storm status, our office contacted the WSRL who in turn notified approximately ten of the WSRL interview staff. Study staff members delivered interview materials to the notified interviewers. The WSRL staff began interviewing immediately upon receipt of these materials. All interviewers received the necessary written instructions and interview schedules by 11:00 a.m. The interviewers telephoned until 9:00 p.m.; then began again at 9:00 a.m. the following morning and continued until 9:00 p.m. that same night.

The distribution of survey packets and the actual interviewing took place as planned, without complications. Midway through the first day of interviewing, approximately 75 completed interview schedules were selected and scanned for any indications of problem areas; none were found. All schedules and interview packets were collected and returned to WSRL for coding by 11:00 a.m., August 17, approximately 60 hours after the severe thunderstorm struck Dane County.

Hypotheses

Our survey was designed to focus on a number of severe weather information questions that had yet to be asked. We expected to find, for example, a certain amount of confusion about the distinction between a severe weather watch and a severe weather warning. It was hoped the administration of the survey helped to eliminate such confusion during the survey and was set up so that by the end of the interview the respondent would at least know that the watch preceeds the warning, and would ideally understand the meaning of each term.

We also expected that the size of the family and property holdings would have a direct relationship to the impact that severe weather information has. The more someone stood to lose--the more we expected that person to want to know about severe weather.

A description of media habits, an evaluation of the public's access to weather warning sources, the frequencies, channels, and media preferred were among the objectives of this survey.

We expected to find that more people would listen to radio for severe weather information. Our research to date has led us to believe that radio tends to repeat and announce warnings more frequently than television. Also, many people unplug their televisions during storms to protect them from damage and may, for this reason, refer to the radio for information.

We felt that the frequencies preferred would most probably be dependent on signal strength. Commercial TV stations should have had the greatest number of viewers as there is only one public broadcasting station in the Dane County area. It seemed that the further out from the city a person lived, the more likely he would be to select Channel 3, the only VHF station in Dane County, with the highest signal strength of all TV stations.

Static interference and strength of radio signals were expected to be major determining factors in frequency choice. It was more difficult to discover a single radio station preference, however, as there are nine radio stations service Dane County residents.

Only the broadcast media were of immediate concern in the study because the print media could not have responded within the critically short time frame. The print media did become important to us, however, after the storm. Here we were concerned with the amount of interest the public showed in the effects of the storm. We hypothesized that the public would show interest in the storm commensurate with its severity.

The zero to six hour Nowcast concept was also mentioned in the schedule and the respondent was asked his opinion of Nowcasting and whether he would be willing to pay for such a system. It has been our experience that a willingness to pay for a new technique or idea is the most solid indicator of genuine interest. The more money someone pledges to pay for severe weather information, the more vital he considers the information.

Our hypotheses were carefully calculated "guesses" based on related and significant but unsubstantiated data. We executed the public usage survey and the complementary media survey to substantiate or nullify our hypotheses and give us answers regarding previously unexplored areas.

Results

The results of the survey suggest a number of trends and characteristics of public response to serve weather and severe weather information. In this section, the results will be considered in four major interest areas describing the most significant of these findings.

Public Awareness

This storm situation is of particular interest because the sirens in Dane County were not actuated. Thus, all public response and knowledge of the storm was totally dependent upon the media (although it must be recognized that personal observation and word of mouth were factors in alerting the population).

Of our sample of 404 Dane County residents, 343 or 85% were either at home, at work, or in their cars and could be considered to have had access to the broadcast media in one form or another. When the sample was asked whether they were aware of the severe thunderstorm watch, 59.2% said yes, while 40.8% of the sample was unaware of the situation. We found that of those who heard the watch (which was issued at 1:21 p.m. C.D.T.) 64% heard it by 1:44 p.m. C.D.T. The remainder received the watch bulletin as the storm was moving through the County.

For the more critical severe thunderstorm warning, we found that 55% of the sample was aware of this information while 45% was not. Of the people who did hear the warning (which was issued at 1:33 p.m. C.D.T.) 41% heard by 1:44 p.m. C.D.T. Of the remainder of those who heard the warning, 31% heard the warning between 1:45 and 2:15 p.m. C.D.T.

In general, then, we can say that nearly 85% of all respondents had access to the media, that 38.4% of them heard the watch by 1:44 p.m. C.D.T. while 22.5% heard the warning by 1:44 p.m. C.D.T.

Since it has been determined that the storm struck the city of Madison at approximately 1:55 p.m. C.D.T., we can say that of the residents who received the storm warning, those on or north of the East-West line through the center of the City of Madison received no more than eleven minutes warning.

Media Habits

As we expected, a clear majority of the sample received their first information of the storm from radio (53%). Thirty-four percent were watching television when the warning was released, while the other 11% received the same information from various other sources.

Of the four television stations, only one person was watching WHA-Channel 21, the public television station. The three commercial stations were quite evenly represented. Approximately 10% of those who heard the warning were watching WISC-TV; 8.6% for WKOW-TV; and 9.9% for WMTV.

Six radio stations accounted for the bulk of the remaining segment of the sample receiving the warning. WISM-AM and FM was the most listened to of the six with 9.4% of the sample audience. WIBA-FM was next with 8.1% of the audience, while WMAD-AM, FM and WTSO each accounted for 7.2% of the audience. WISN with 1.8% and WKOW with 3.6% were the two drawing the smallest audience. Another 4.9% were divided among the remaining stations.

We found that 79.3% of the audience continued to use the same source for information on the storm, whereas 20.3% did not. In general, additional sources of information were not used; only 16.7% chose them. Of these respondents, 7.2% turned on their radios, 4.1% their television sets, and the remaining 5.4% relied on other means.

Of the respondents who chose other sources than those they were originally listening to, 11% chose radio, 1% television, while 3% chose to rely on their own personal observations.

Other information thought to be important was the interest the public showed in the progress of the storm and how frequently most people chose to seek storm information.

Of the respondents who heard the warning, 82% generally followed the progress of the storm from the moment they first heard about it, while only 18% did not. Of those following the storm's progress, 84%, listened for information continuously, while 12% listened every 1/2 hour.

Another important function of the media in a storm situation is the provision of timely useful instructions. We were interested in how many people received instructions and also in the identity of the major sources of these instructions.

We found that of those who were aware of the severe weather warning, 37% received instructions about what to do as the storm approached. The remaining 63% received no instructions. We also found that radio provided 52% of the instructional information, television 37%, and that 5% was provided through other sources.

The study also showed that the public is interested in finding out about the storm after it has passed through their immediate area. When asked if, since the storm, the respondents had read or heard any news about it, 74% said they had. Of these, 20% got their information from the radio, 28% from television, 58% read a newspaper, while 5% relied on friends or personal observation.

Economic Considerations

The Dane County sample was asked a number of questions to try to outline the extent of their property holdings to determine the amount the population stood to lose as a result of severe weather. We found that 81% of the sample had homeowners' or personal property insurance. Of those with such insurance, 13% had between \$1000 and \$10,000 coverage; 20% had between \$12,000 and \$25,000; another 17% fell in the \$26,000-\$60,000 range and 4% had damage insurance ranging from \$61,000-\$100,000. Nineteen percent were not sure, or did not know, how much coverage they had.

The study also found that 27% of the sample thought the storm hit their area directly, 43% felt the side effects, while the remaining 20% felt little or no severe effects.

The number that actually reported damage to their property was only 7%. Of these losses 65% involved fallen trees, fallen limbs, or lost fruit. Damage to homes or apartments was reported by 10% and another 10% reported crop damage. Nineteen of the twenty-nine people reporting damage estimated losses totalling $466, of which their insurance covered less than 20%.

Nowcasting

The interviewer also presented the respondent with a simplified description of the concept of Nowcasting. It is understood that soliciting opinions on the basis of an idealized concept often results in less than accurate information. The series of questions was designed to minimize this effect, however, and emphasis was placed on the respondents' desire for accurate, zero to six hour forecasts, and constant weather information updating. On the basis of this description, and the respondents' desire for accurate and timely storm information, the survey found that 63% would make use of the "nowcast" service, 10.6% qualified a "yes" answer, and 18% said they would not. The remaining 7.7% did not know. We found that 61% of those commenting on the use of the service would, in fact, seek nowcast information continuously. Another 22% would refer to the nowcasts every half-hour, while the remainder would use the service each hour or at more convenient intervals.

Most of the respondents (77%) felt the information would be most useful to them in three major areas. They would know when to take protective action and seek shelter. Secondly, they would be able to watch the progress of the storm and see for themselves exactly where it was going; and finally, the respondent would know when and to what extent their own respective areas would be affected. When asked how much people would be willing to pay per month for such a service, 37% said they would pay nothing, 26% would pay between one and ten dollars per month, another 14% qualified their answer, while 24% did not know how much they would pay.

Discussion

A. The Dane County Severe Weather Warning System is a cooperative effort headed by the Dane County Office of Emergency Government and the NWS office at Truax Field. The broadcast media are instrumental in the dissemination of information for these groups.

B. Only 55% of the population received warning of the impending storm situation.

C. Of those receiving the warning, too few received the information with sufficient advance notice.

D. Only 27% of the sample received any instructions before or during the severe thunderstorm.

E. The sample indicated a desire for more frequent warnings as well as instructions.

F. The study showed that people turned to radio more frequently than any other source because it provides the most immediate updates.

G. People would use Nowcasting if it were made available because it satisfies an identified need.

H. Severe weather generates sufficient public concern and interest to warrant major warning system improvements.

The severe weather warning system for Dane County is a cooperative effort in which the National Weather Service Office (NWS) and the Dane County Office of Emergency Government (OEG) hold primary positions of safety responsibility. The broadcast media are the primary information channels through which these groups notify the general public, although OEG does have a siren system which will reach 50% of the Dane County population.

In the particular instance we have chosen for our study, the sirens were not sounded. Thus anyone who did not have access to the media depended solely on chance personal observation for information transmitted by word of mouth. Our results indicate that approximately 80-85% of the population had access to the broadcast media, leaving perhaps 15-20% of the population uninformed of storm development. In fact, as was related earlier, only 55% of the sample had received a warning of any kind. Thus, it becomes apparent that though the information necessary might have been issued sooner, the communication channels were incapable of transferring vital information to more than a simple majority of the sample. Furthermore, any delays that may have occurred in the issuance of the warning were multiplied as the information moved through the channels so that many of those receiving the warning had no more than 11 minutes to respond.

We asked our sample what sort of action they took to protect themselves and found that, aside from closing windows, gathering the children, and retreating to the basement, no other specific action was taken. While this is perhaps entirely appropriate for a moderately severe thunderstorm, it would not have been for a tornado, a flood, or a flash flood. Furthermore, our study found that 63% of the sample received no instructions as to what action to take and were thus required to react on the basis of their own final analysis of storm severity and their own best recollection of the appropriate steps to take. This instructional aspect of severe weather warning requires immediate attention and must be optimized.

Finally, we discovered a great deal of interest on the part of this sample in being able to follow the progress of the storm from the first instant information is made available. We found that more people turned to radio for storm information than any other source (53%, vs. 37% for television). While the difference may be partially explained by a reluctance to use television during a severe storm, these figures, combined with other subordinate questions, seem to indicate that radio is chosen as an authoritative source providing the most frequent updating. When we asked the group whether they would make use of a 0-6 hour forecast and continuous weather monitoring service, 73% said they would.

PART III

SAFETY RESPONSIBILITY

Purpose

The purpose of this segment is to identify the groups or agencies with primary safety responsibility for Dane County residents. We are especially interested in defining the respective roles of each group and in reporting their performance during the severe weather incident we have chosen for our study.

Goal

We hope to provide the user with an accurate description of the mechanism used for severe weather warning in Dane County, and how the mechanism functioned before and during the severe thunderstorm on August 14, 1972.

Primary Safety Responsibilities

Our study found that four distinct groups in the Madison Dane County area could be considered to have primary responsibilities in events of severe weather.

The National Weather Service Office at Truax Field functions as the initial severe weather information source. It is through this office that advisories from other offices as well as from the Severe Storm Forecast Center in Kansas City are directed to the public. This office also has resources to generate its own advisories and reports. While this office is responsible for observing and forecasting weather phenomena, dissemination of weather information is also a NWS task.

The Dane County Office of Emergency Government has direct radio contact with the NWS office at Truax Field. Its major function is to disseminate warnings of threatening conditions to the general public as quickly as possible. Although printed materials and instructional broadcast media materials are provided by this group, the real time emergency warning function is provided through a multiple tone (and use) siren system. The most immediate function of the office of Emergency Government's Operations Center is the coordination of police services and the handling of emergency communications traffic.

The Safety Director of the University of Wisconsin Physical Plant is responsible for the safety of students, staff and faculty within the University. The weather sensitive safety responsibilities are limited to the maintenance and operation of the Lifesaving Station on Lake Mendota and the single siren in the University's Eagle Heights housing area.

The Director of Disaster Services of the Dane County Chapter of the American National Red Cross is most interested in post disaster information. His sole responsibility is to provide disaster relief and search and rescue support to those in affected areas.

Conversations with these directors yielded the following comments:

Norbert H. Schmidt, Director, Dane County Office of Emergency Government:

-- "the severe weather watch period is quite sufficient"

-- "we are concerned with severe thunderstorms as well as tornadoes"

-- "the severe weather warning period is critical"

-- "the NOAA weather wire was too slow"

-- Direct radio contact exists with Mr. Edwin Addison of the National Weather Service at Truax Field.

-- 550 tornado spotters have been trained by OEG; most of them are policemen.

-- OEG is responsible for Civil Defense instructions and storm information.

-- OEG is in contact with all local police forces and all media (not verified) and has issued severe weather warnings and sounded sirens six times in 1971.

-- "50% of Dane County is covered by sirens"

-- "sirens are often confusing--people don't understand what they mean"

-- The rural areas and their spotting abilities are essential to the security of the City of Madison.

-- Tornadoes and severe effects are verified by visual sighting and checked with Truax.

-- Sheriff's dispatcher is often responsible for siren sounding.

Earl V. Rupp, Safety Director, University of Wisconsin Physical Plant:

-- Every Spring storm safety information is distributed for posting in all University of Wisconsin offices.

-- The Physical Plant's weather sensitive safety responsibilities are the life saving station on Lake Mendota and the siren at Eagle Heights.

-- Truax, which used to give pertinent weather information, now only calls in situations of extreme severe weather.

-- There is a need for information on wind velocities. The lake must be cleared of sail boats which takes 10 to 15 minutes. For this purpose winds in excess of 30 mph are considered severe weather.

-- The siren at Eagle Heights is confusing. People don't understand what the signals mean. Some towns use sirens to call volunteer firemen or signal town meetings.

Joseph Schwartz, Head Lifesaver, University of Wisconsin Lifesaving Station, Lake Mendota:

-- Access to NOAA weather wire service, which is good. Members of lifesaving team are "amateur meteorologists" who watch developments carefully. In extreme conditions Truax is called for verification.

-- Also expressed a need for good wind velocity information. Major responsibilities are to clear the lake of the University of Wisconsin's 50 sailboats and 20 canoes; and to prevent drownings.

-- In June 1972 the Lifesaving Station made 222 runs to assist boaters on Lake Mendota.

-- No other Dane County lakes have similar lifesaving service or flag and light warning systems.

Charles Gregory, Director of Disaster Services, Dane County Chapter of the American National Red Cross:

-- The Red Cross needs information about the storm's effect and what areas were involved so that disaster teams can be dispatched.

-- Sometimes, storm information is not received until an hour after it has struck.

-- Reports a reliance on radio monitoring to overhear spotters report to Truax and Sheriff's Office and so to learn of storm's progress or effect.

-- The Red Cross distributes storm information and instructions issued by the National Red Cross.

-- "...the siren system of alert is not well understood" (by the general public).

The Warning Mechanism

The severe weather warning system as it existed and functioned on August 14, 1972 consisted of cooperating groups who discharged their varied safety responsibilities through different means with differing degrees of success. In our study, we not only found a variety of uses of information sources and channels, but a variety of levels of decision making as well, often including judgements on the basis of personal observation.

The Dane County Office of Emergency Government

The Dane County Office of Emergency Government has established two-way radio transceiver communications with the Madison National Weather Service Office. While this office is a part of the National Warning System (NAWAS) the Dane County group decided to establish a direct radio link with the WSO at Truax Field because, (according to Walter Kind, Acting Director of the Dane County Office of Emergency Government) they can exchange vital information much more quickly in this fashion.

It is the decision of OEG and often the sheriff's dispatcher (who has access to the siren controls) to sound the sirens for the affected areas. In the particular incident under consideration, the Sheriff's dispatcher's personal observations were the first indication to OEG of impending severe weather. Subsequent police reports were relayed to WSO at Truax Field via radio and the dispatcher was advised to stand by to sound the siren. The decision not to sound the sirens was made by OEG. On the basis of incoming information, it was felt that the situation did not warrant siren warnings. OEG's prime responsibility then became the coordination of police services and, because the sirens were not sounded, their general public warning function was not performed at this occasion.

The National Weather Service

The National Weather Service Office at Truax Field maintains a log, written records and a standard procedure checklist to document their performance during a storm. This office was well aware of the impending storm, but it was expected throughout the morning that the storm would pass to the North and East of Dane County. Thus, while other counties to the North and West were given a standard one hour's notice as the storm progressed, the sudden shift in direction of storm development gave WSO little time to issue a warning for Dane County. In this particular instance, one station in the NAWAS circuit, which was to relay the storm warning through the Dane County Office of Emergency Government, failed to respond. The Dane County Office finally received the warning via telephone at 2:10 p.m. as the storm moved through the City of Madison. It is clear that, had there been no alternative communications link, whether through OEG or from WSO to other sources, the public would have received no warning.

The University of Wisconsin

The University's responsibilities were handled most efficiently in this instance. Mr. Earl Rupp's office was not directly involved in this case because the sirens were not sounded (the Eagle Heights siren can be sounded independently but is generally sounded by the OEG). The UW Lifesaving Station, under the direction of Mr. Joseph Schwartz, is responsible for the 70 UW boats and also has responsibility for all craft on the lake. The station staff has access to the NOAA Weather Wire and radio, and, in addition, could have called WSO on the telephone if it had seemed necessary. In this instance, however, the lake was cleared a full 25 minutes before the storm struck on the basis of what was later termed an "amateur meteorologist's" opinion. No information was received prior to or during the storm.

All during the day, the station staff was aware of the fact that severe storm warnings had been issued for northern counties. Although Dane County was not included in these warnings, the staff watched the skies and checked the station's instruments regularly. On the basis of these observations, Schwartz activated the flashing red lights at both the station and at the Tenny Park locks and had the University of Wisconsin Hoofers Outing Club Boathouse activate its flashing red light and raise the red flag. This system of flags and lights is relied upon to indicate sailing conditions to all boaters on Lake Mendota. According to Schwartz, it takes about fifteen minutes to clear the lake. If we allow that the storm moved onto lake Mendota at about 1:50 p.m. and that the lake was cleared 25 minutes before that, as Schwartz has related, then the lake was clear at 1:25 p.m. and Schwartz's warning issued at approximately 1:10 p.m.

While it is clear that the area of responsibility is quite limited for this group and that the responsibility is to a very specific segment of the general public, it is also clear that the warning methods worked quite effectively.

By using standard nautical signals which the boaters are trained to understand and respect, Schwartz has assured an immediate and totally comprehendable system. Furthermore, had any of the boaters ignored the warning or been unable to respond for one reason or another, the Station's cruise boat would have escorted them ashore. This was the only segment of the warning "system" that was 100% effective.

The Dane County Chapter of the American Red Cross

The Red Cross Disaster Services Director described the responsibilities of his group as dispatching disaster rescue and relief teams to affected areas in as short a time span as possible. Presently, reaction time is nearly two hours, though Director Charles Gregory hopes to reduce this to one half hour.

In the situation under consideration, the Red Cross also reacted initially on the basis of personal observation. A Red Cross employee alerted the rest of the staff to the worsening conditions, at which point the Chapter's office turned to radio for information regarding storm developments. An alert was then telephoned to a designated radio station which broadcast a readiness alert for disaster team leaders. Had the situation worsened, the team leaders would have telephoned respective team members who would have assembled and been dispatched from the Red Cross Office. Although this office has a radio capable of monitoring police bands, it is not regularly manned, and the Red Cross depends almost exclusively on the broadcast media (radio) for storm information. At the time of this interview, no plans for the development of direct contact with primary information sources existed, or were being considered.

System Components

Because the Office of Emergency Government did not sound the siren system, we were not able to evaluate total warning system effectiveness or the value of the siren system as a warning device in this instance. We feel we have gathered sufficient information from those who have had extensive experience with siren systems, however, to provide an evaluation of the usefulness of such a system based on past experiences.

Mr. Norbert Schmidt, Director of the Dane County Office of Emergency Government, depends on the siren for conveying emergency warnings to the general public on a real time basis. Presently, sirens are deployed in such a fashion that one-half of the Dane County population is within hearing range. Schmidt's Office has set priorities for additional areas to be equipped with sirens, but local government's unwillingness to fund such devices has prevented these additions.

Furthermore, Schmidt has found that the "sirens are often confusing (to the public); people do not understand what they mean." Earl V. Rupp, Safety Director of the University of Wisconsin Physical Plant agrees, "Sirens are confusing, people don't understand what the signals mean. Some towns use sirens to call volunteer firemen or signal town meetings." Charles Gregory, Director of Disaster Services of the Dane County Chapter of the American National Red Cross feels much the same "...my experience with warning systems has been sufficient to demonstrate that the siren system of alert is not well understood." (see Appendix B.)

Although OEG frequently prepares and/or updates instructional information to remedy this critical problem, the combination of an incomplete system and a confusing alert siren makes a solution seem quite distant.

Another problem which has tended to impair the credibility of the siren has been that the mechanical malfunction (a short sets the siren off) or unscheduled tests. The susceptability to such occurrences seems quite high and makes one wonder about the possibility of failure in critical situations. Public reactions vary from fear and confusion to indignation when the sirens are set off. The Dane County Office of Emergency Government receives numerous phone calls when the sirens are thought to have been sounded for no apparent reason, as well as when the sirens have not been set off when it is thought that they should have been.

Another characteristic of this system is a very high dependence by all segments on the telephone--a link that is characteristically quite vulnerable to severe weather effects.

Although two-way radio with independent power source is being used in an increasing number of instances, the cost makes total dependence on two-way impractical. In a very severe situation a heavy reliance on telephones could lead to severe disruption of internal communications.

Perhaps the most critical and, apparently, the weakest link, is the central role the broadcast media play. As indicated previously, on August 14th, with total dependence on the media, only 55% of the Dane County population was aware of the severe weather warning. With only 54% of the media receiving the weather wire in the first place, this is not surprising, nor is it difficult to understand the timing of some of the warnings, when the NWSO at Truax had to telephone the warning to three stations.

The NWS Weather Wire could be particularly effective if more users would subscribe. It provides the user with useful information on a regular time basis, and can be used by the local weather office when necessary to provide emergency information. In this instance, the warning was issued at 1:33 and was "on the wire" at 1:38. Although the weather office likes to give a one hour lead time, the wire can be accessed in a short enough time to present warning information as sudden, unexpected developments take place (as in this instance).

Of the material discussed in this segment, the following seem to stand out most clearly:

A. There is a high level of cooperation between the National Weather Service Office at Truax Field, and the Dane County Office of Emergency Government.

B. While the severe weather warning system is a cooperative effort, it is not a fully dedicated one.

C. Although those charged with weather sensitive safety responsibilities have different missions, the required information could be obtained from the same source.

D. The broadcast media are incapable of bearing single responsibility for the safety of the general public.

E. The siren system of alert is confusing and offers inadequate coverage for Dane County.

F. The telephone (which seems to form an integral part of the present system) is unacceptable as an emergency communications device because of its ineffectiveness as an efficient mass alert link, as well as its easily being subjected to disruption.

Office of Emergency Government Log

1:40 p.m. C.D.T.--spotters in Sun Prairie report moderate winds

1:48 p.m. C.D.T.--Mazomanie reports storm

1:52 p.m. C.D.T.--City Police call in report

1:53 p.m. C.D.T.--Report from Middleton, 50-60 mph winds--Sheriff's dispatcher given instructions to activate sirens if necessary

1:55 p.m. C.D.T.--State Director of Emergency Government at Hill Farms called

1:57 p.m. C.D.T.--Emergency Government announcement, Civil Defense personnel alerted, encoded alert activated

2:02 p.m. C.D.T.--Contacted by Truax on radio report 59 mph winds

2:04 p.m. C.D.T.--Called weather service to find out where warning on teletype was-turned out to be missing link in NAWAS chain--not weather services fault, actually on wire at 1:38

2:10 p.m. C.D.T.--Warning came through dispatcher by phone from 151/94 patrol headquarters.

2:10 p.m. C.D.T.--Second weather service announcement

2:11 p.m. C.D.T.--Activated command post team, extra men at dispatcher's --sent out P.D.--Sheriff's Department heavy duty wrecker to place crash

2:55 p.m. C.D.T.--Still activated--notified that Green County handled plane crash--called wrecker back

3:15 p.m. C.D.T.--Deactivated command post

NWS Records

10:45 a.m. C.D.T.--Neenah radar summary

11:45 a.m. C.D.T.--Neenah radar summary

12:45 p.m. C.D.T.--Neenah radar summary

12:45 p.m. C.D.T.--Neenah radar summary, SV TRW WN for Columbia County

1:00 p.m. C.D.T.--Special Weather Statement (Madison)

1:21 p.m. C.D.T.--SV TRW WCH #400 National Weather Service

1:33 p.m. C.D.T.--SV TRW NW NWS (Madison)

1:33 p.m. C.D.T.--record of SV TRW WN for Sauk Columbia, N.E. Richland, Iowa, and Dane County, Wisconsin

1:45 p.m. C.D.T.--Neenah radar summary

2:25 p.m. C.D.T.--Special Weather Statement (Madison) advised of upcoming warning

2:30 p.m. C.D.T.--SV TRW WN (Madison) for Green and Rock County, Wisconsin

2:45 p.m. C.D.T.--Neenah radar summary

2:55 p.m. C.D.T.--Special Weather Statement (Madison)

NWS Log

12:35 p.m. C.D.T.--Call from Neenah, spotted hook echo just north of Randolph at 45,000 feet--called state patrol and Columbia Sheriff's Department--sent cars

12:53 p.m. C.D.T.--Called warning to WIBU

12:55 p.m. C.D.T.--Called warning to WPDR

1:05 p.m. C.D.T.--District 1 State Patrol reports heavy rains and high winds, checking funnel cloud report at Randolph

1:42 p.m. C.D.T.-- Possible funnel cloud 8 miles east of Reedsburg on County H

1:48 p.m. C.D.T.--Called watch and warning to WMAD

1:53 p.m. C.D.T.--Called watch and warning to WMFM

1:57 p.m. C.D.T.--County Sheriff reports 50-60 mph winds in Middleton.

Discussion

The problem we have studied here seems, on the surface at least, to be one of a relatively simple nature. That is, the observation and professional assessment of an event must be transmitted to the general public to cause them to take specific action. Because we are dealing with severe weather, the failure of either the observers or the communicators may cause unnecessary injury, loss of life, and economic disaster. While it is difficult to cope with those members of the general public who either ignore or refuse to follow directions, it is the ultimate responsibility of the communicators to present the messages in such a fashion that an overwhelming majority of the general public could take appropriate action.

What we discovered, (and what has been clear in similar studies of both the Hurricane Agnes disaster and the Rapid City, North Dakota incidents) is that the disaster warning systems barely served their function, and then only because individuals made them work. The difficulties we encountered are generally in the communication of the message rather than in the timeliness or accuracy of the message transmitted by the observers to the communicators.

A most interesting finding derived from this study was the relative independence which is assumed by all those in positions of safety responsibility. Because each group felt it had different responsibilities, it sought separate solutions to similar problems using a collective problem solving approach.

We also discovered that two presently existing information links were not being used to full potential, and, though they do not present complete solutions, their full use would provide a much more efficient system than exists now.

The National Weather Service, for instance, has a very heavy workload during severe weather incidents. Vital personnel must be recalled to observe, compile, record a large volume of weather information in addition to producing vital short range forecasts. At the same time, the staff must send bulletins over the weather wire (for the 54% of the media that subscribe), update the WSO telephone tapes, communicate on the National Warning System (NAWAS) circuit, telephone the warnings to three broadcast media, and communicate via two-way radio with the Dane County Office of Emergency Government. With this array of communication tasks, the WSO staff is forced to handle an extremely heavy work load during every critical time period.

This problem is further complicated by the number of decisions that must be made between the initial determination of threatening conditions and the reception of the warning(s) by the public. The Weather Service Office has the necessary expertise and resources, as well as the authority, to issue severe weather warnings. It would seem that these warnings would be issued and communicated without question. We found, however, that the form of the warning, the multiplicity of channels activated, and the frequency at which the updates occur, varies from incident to incident. Because so many human factors are involved in the warning system (which after all is composed of human beings manipulating specialized hardware) this variation can be quite extreme.

In the storm incident we have chosen to study, the Office of Emergency Government received the severe thunderstorm warning, but decided not to sound the sirens. The variation among the media receiving the warning indicates that the broadcasters, though deciding to broadcast warnings, made very different decisions on when to broadcast, how often they would broadcast, and whether an all clear would be issued or not. By definition, the method of delivery of a warning, its exact content, and the priority it is given dictate the ultimate effectiveness of the signal. From earlier discussion the reader will remember that it is through the broadcast media (and telephone) that the Dane County Chapter of the American National Red Cross gets its disaster information. It is on the basis of this source that Red Cross rescue and relief decisions have been made.

PART IV

SOLUTIONS

Ultimately, a completely dedicated and perhaps centralized warning system with lights, sirens, and complete media saturation including special radio and TV frequencies, police loudspeakers, or automatic devices installed in the home, may become a reality. In such a system, all possible communication channels would be activated to ensure saturation on a national scale 24 hours per day,seven days a week.

It does not seem at this time, however, that the problem will be solved with hardware. It is suggested that there already exists more hardware than we are able to handle efficiently. What must be dealt with primarily are the communication channels, the connections between people with safety responsibility and the general public.

Perhaps the most immediate improvement that could be instituted would be solely based on the simple agreement between responsible parties to depend on specific systems. If the safety responsible groups were to agree to communicate via the National Warning System (NAWAS) circuit, contact with the authoritative source would be immediate and accurate. The Red Cross would get appropriate advance warning of impending disaster, the U.W. lifesaving station would receive the necessary information, and the Office of Emergency Government, with additional radio inputs from police spotters, would keep the other groups as well as the WSO at Truax Field immediately up to date. Linking broadcasters into this circuit would further speed the flow of information. By shortening and standardizing warning statements, only a minimum of time would be lost in transmission.

Another source which might be valuable is the NOAA weather wire. About 54% of the broadcast media in Dane County subscribe to the service; most police services get it, and the system is also dedicated. Encouragement of the use of this type of terminal with local WSO inputs every 10 minutes could provide a backup to the agreed upon principal source.

Because much of the information is transferred through police band radio, it would not be unreasonable for the media, as well as other agencies involved, to monitor police bands (including NAWAS frequencies). This would provide vital communications in the event of effects so severe that all physical communication links are rendered inoperable.

Such a cooperative effort between the agencies discussed here and communicators (many of whom already have access to two of the three channels suggested above) would facilitate better relations and would result in a real team effort to which all would contribute. Standardization of messages, and a clear description of necessary warning information, including specific instructions, could proceed in a cooperative environment much more quickly than as the "system" stands.

An effort with like or similar goals, would provide a base for evaluation and criticism of vital functions, a critical redefinition of roles and provide the proper wedding of existing hardware with the message which must be transmitted to make the public take protective action.

Appendix A

THE STORM

A moderately severe thunderstorm, approaching Wisconsin from the northwest and sweeping through the state in a generally southeasterly direction, occurred on Monday, 14 August 1972, and served as the impetus for the public usage survey. No weather advisories were issued by the Kansas City Severe Storm Forecast Center for the affected areas until the squall had moved through most of the state. Neenah radar picked up the first indications of the storm at about 9:40 a.m. local time, however, and followed its development from that point on.

The storm in its earliest stages was characterized by a generally southeasterly movement at about 20 mph. Moderately high winds and driven rain with some cloud tops at 28,000 feet were reported. As the thunderstorm progressed, the tops were measured at 46,000 feet in spots while the speed of the storm had increased to 25 mph. Radar pictures were, at this point, being transmitted at 10 minute intervals from Neenah, Wisconsin. By 12:25 p.m. local time, cloud tops were measured at 50,000 and 51,000 feet. The storm was still approaching from the same direction, but at 30 mph.

All during this time, severe thunderstorm warnings were being issued for areas directly in the path of the formation and each area was given approximately a one hour notice. Dane County was not yet included in either a watch or warning as the squall was expected to cross to the north and east.

By 1:02 p.m. local time, the general development of the storm appeared to change. The squall's easterly development seemed to slow while its southerly development accelerated. Cloud tops in a cell near Dane County reached 58,000 feet, while the speed of the storm increased to 35 mph. Radar pictures were being transmitted at the rate of one every five minutes.

At 1:21 p.m. a severe thunderstorm watch was issued and recorded by Madison's Truax Field, and a severe thunderstorm warning at 1:33 p.m. By 1:45 p.m. a severe horseshoe shaped cell with tops at 56,000 feet and a speed of 40 mph was well into Dane County. At about 1:50 p.m. the storm moved into the city of Madison.

Driven rains and high winds (no reported hail) blew down trees and power lines. They made driving difficult and damaged some small structures, but caused little serious damage. An airplane was overturned as the pilot attempted an emergency landing and a number of cars were damaged by fallen trees and limbs. Many power and telephone lines were down and the Madison Fire Department responded to 22 calls within 52 minutes. Madison Police were contacted 52 times during the same period in response to reported fallen trees and limbs.

Winds were reported at 50-60 mph in Middleton on the westside of Madison, while Joseph Schwartz at the U.W. Lifesaving Station on Lake Mendota recorded 55 mph winds before the station's power was cut off by a falling tree limb.

Temperatures dropped 21 degrees within a two hour time span but returned to the 80 degree mark shortly after the storm passed. This squall, which moved through Madison in about 35 minutes, accounted for .24 inches of precipitation in the city while some nearby outlying areas recorded more than one inch.

Wisconsin State Journal

WEATHER: Cloudy, Chance of Thundershowers Today. High in Upper 80s. Low in Low 60s.

★ ★ ★ MADISON, TUESDAY, AUGUST 15, 1972 ★ ★ ★

Storm Rips City, Area, Slashing Trees, Power

But Squall Fails to End Hot Spell

By STEVEN LOVEJOY
Of The State Journal Staff

A late summer squall with high winds and hard rains scampered across central and southern Wisconsin Monday afternoon, knocking down trees and power lines but causing no serious damage.

The squall brought momentary respite from the 90-degree temperatures and 80 per cent humidity which Madison recorded at 12:30 p.m., but today's forecast calls for a return of the hot, sticky weather.

NATIONAL Weather Service specialists here said Madison's temperature dropped 21 degrees in two hours as the squall line moved from north central Wisconsin into the area on winds gusting from 50 to 60 miles per hour.

They predicted that temperatures will rise to the upper 80s today, with a chance of thundershowers and rising humidity again this afternoon.

Partly cloudy skies were forecast for tonight, with clearer weather due on Wednesday.

MADISON escaped the brunt of the storm, recording only .24 of an inch of rain, while much of the area reported rainfall of about an inch. Funnel clouds were reportedly sighted in Jackson County.

The squall caused problems for light planes, causing two crashes with no serious injuries.

A Waunakee woman, Judy Bindl, 32, attempted to make an emergency landing in a hay field near the Dane-Green County line in the Town of York, but the rough winds tipped the plane onto its back. She was treated for minor injuries and released from a Monroe hospital.

Another light plane was blown off the runway as it attempted to land at a Necedah airport. The pilot, from Lake Forest, Ill., was not injured.

IN THE CITY, most of the problems were caused by high winds. The lakes were ruffled, but most boaters cleared off before the squall hit, although a pair of canoers were caught and capsized in the middle of Lake Waubesa.

They were both wearing life jackets and managed to hang onto their canoe until a pontoon boat hauled them ashore before Monona police or county sheriff's men got to them.

Ominous storm front moves in at 2:30 p.m. Monday, ready to whip and drench city moments later.
—State Journal Photo by A. Craig Benson

The Madison Fire Dept. answered 22 alarms in 52 minutes, from 2:06 to 2:58 p.m., most of them involving arcing streetside wires and one shorted television set at 1826 Camelot Lane that involved no fire.

Madison police responded to 52 calls during the same time, most of them involving trees and limbs blocking streets.

AN ELEVATOR shaft roof at a campus rooming house, 632 N. Frances St., blew off about 2:40 p.m. and smashed two unoccupied, curbside parked cars owned by Ralph Horkanson, 2205 Commonwealth Ave., and Michael G. Moore, 931-C Eagle Heights. Another parked car was smashed by a city street light blown down in the 1500 block of Campus Dr. about 2:20 p.m.

Dane County officers reported flooded roads and trees down on all sides of the county. Traffic men in the southeast Stoughton area said their squad cars "felt airborne" in the strong wind. Squadmen in the north Dane area said their cars were out of control from wind and water.

Sheriff's Sgt. John Kuenning said cars, going southwest to help in a Green County plane crash near Belleville, reported "the sheriff's boat would work better" than their cars in 3 to 4 inches of water that covered Highways 18-151 and 69.

MADISON POLICE reported three traffic accidents during the downpour with one injury—Walter Benway, 52, of 217 S. Marquette St.— in "satisfactory" condition at Methodist Hospital with a fractured leg received when his motorcycle and a car collided at Ingersoll and Williamson Sts.

Most drivers just pulled to the side of the road and waited for the end of the storm.

Sgt. Charles Campbell, head of the city lakes patrol, said his crew and the University of Wisconsin-Madison patrol boat searched throughout the storm for a reported overturned sailboat on Lake Mendota.

"IT OBVIOUSLY was a crank call," Campbell said. The searchers found one sailboat that had broken loose from a buoy on the Shorewood Hills side of the lake, and a broken loose rowboat just west of Spring Harbor, neither of which had occupants during the storm.

A Madison Gas and Electric official said Madison had a large number of small local outages caused by lines and powr poles down, but no extended areas out of service.

He said the power demand here was still on the increase when the storm hit, but dropped off rapidly when residents began turning off air conditioners, fans, and other appliances.

WILLIAM FERRIS, senior vice-president of Wisconsin Power and Light Co. (WPL), said the hot weather coupled with normal higher usage on Monday when industries start up again produced a record breaking demand of 930,000 kilowatts on WPL's system.

"All generating units on our system and in the companies making up the Wisconsin pool, are operating at full capacity," Ferris said. "While our reserves are being stretched to the limit, we feel we will get by unless we lose a major generating unit."

WPL serves 250,000 electrical customers in a 15,000 square mile area of south and central Wisconsin.

Madison, Area Ripped by Sudden Summer Squall

Madison, along with other communities in central and southern Wisconsin, was buffeted Monday afternoon by a summer squall of high winds and heavy rainfall. Trees and power lines were downed, but no serious damage was reported.

The squall brought temporary relief from 90-degree temperatures and 80 per cent humidity, recorded by the National Weather Service Office at Truax Field at 12:30 p.m., but a return of the hot, humid weather is expected.

The Weather Service said that Madison temperatures dropped 21 degrees in two hours as the squall line moved across central Wisconsin, with winds reaching a velocity of 50 to 60 miles an hour.

While much of the Madison area received about an inch of rainfall, Madison recorded only .24 inch of rain.

* * *

A Waunakee woman, Mrs. Judy Bindl, 32, attempted to make an emergency plane landing in a hayfield in the Darwin Jorede farm in York Township, one half mile south of the Dane County line in Green County, but rough winds tipped the plane on its back.

The accident occurred about 2:30 Mrs. Bindl was treated for shock and glass in one eye, then released from a Monroe hospital.

The high winds caused most of the problems in Madison. Most boaters cleared off Lakes Mendota and Monona before the squall hit, but a pair of canoers was capsized on Lake Waubesa. Both were wearing life jackets and managed to hang onto their canoe until a pontoon boat hauled them to shore.

* * *

Madison firemen answered 22 alarms in 52 minutes from 2:06 to 2:58 p.m. Most of the calls involved arcing wires. A television set at 1826 Camelot Lane shorted out, but there was no fire. Madison police responded to 52 calls. Most of them involved fallen trees and limbs that blocked streets.

An elevator shaft on the roof at a campus rooming house at 632 N. Frances St., blew off and smashed unoccupied cars owned by Ralph Horkanson, 2205 Commonwealth Ave. and Michael G. Moore, 931-C Eagle Heights. Another parked car was smashed by a blown-down city street light in the 1500 block of Campus Drive.

The Madison Gas and Electric Company reported a small number of outages caused by the storm, but said no extensive areas were out of service.

Madison police reported three traffic accidents during the heavy rain. Walter Benway. 52, of 217 S. Marquette St., received a fractured leg when his motorcycle and a car collided at Ingersoll and Williamson Streets. He is in satisfactory condition at Methodist Hospital.

In the Madison area Janesville reported stong winds, but little rain, and some trees and lines down. Dodgeville reported that the storm went east of the city. There were high winds in the Highland area, but no rain. In Jefferson county a few trees were blown down and a few wires were downed in the city of Jefferson. Rain fall was not heavy.

A few trees were downed in the Albany-Brodhead area in Green county. Wind was reported to be strong and rainfall was heavy.

A few trees and wires were blown down in Columbia county. Strong winds were accompanied by a half inch of rainfall. and hail was reported at Randolph.

Appendix B

The Use of Sirens

THE CAPITAL TIMES, Tuesday, August 15, 1972—21

Siren Salesman Goofs, Turns on C-D Alarm

By JUNE DIECKMANN
Of The State Journal Staff

An unauthorized test of a civil defense-type siren, by a sales promoter shortly after 6 p.m. Wednesday in southwest Madison's Greentree Section, caused at least 125 calls from frantic residents to police, firemen, sheriff's men, and The Wisconsin State Journal.

Richard E. Dieter. 1802 Redwood Rd., former deputy director of Dane County Civil Defense now selling siren equipment for Milwaukee and Chicago firms, said he "thought he was far enough in the country" to demonstrate the siren to a prospective customer. He turned on the siren along Gammon Rd. just south of West Towne Mall.

"THE SOUND must have bounced off the hills and carried in the high humidity farther than I thought it would," Dieter said.

Acting Civil Defense Director Walter A. Kind was irate and said he will call a meeting today to obtain county laws prohibiting siren demonstrations.

"We never test civil defense sirens without advance notice in all news media prior to a set time of 12:05 p.m. on the first Wednesday of each month." Kind said.

Kind said he just met Tuesday with County Board Chairman Merton Walter, city traffic engineers, and electricians to alleviate short circuits in the siren wiring and other causes of sirens sounding when not scheduled.

KIND SAID he also has asked for a change in some volunteer fire department sirens. such as Monona, which closely sound like the Civil Defense emergency sirens.

"Like the old story, you can't cry 'wolf' too many times in this business and expect response when the sirens blast an actual emergency warning.", Kind said.

Kind said that if Dieter had advertised his test in advance, it probably would have been acceptable. "He should have known better, having been on the Civil Defense staff previously." Kind said.

Dieter said he thought it would be only a "brief test, a merely physical demonstration of the quipment, and nothing to alert the people living nearby."

"WE DIDN'T blow the three warning signals. but I guess the public thinks any siren blast is an emergency," Dieter said.

He referred to the steady 3-minute blast, which is a Civil Defense warning for such things as tornadoes; the undulating high-low siren blast that means an enemy attack, and the similar alternating high and low blast that is used by some fire departments to summon their volunteer firemen.

Asked if he planned unpublicized demonstrations in the future for siren-buying customers, Dieter said:

"Absolutely not. There will be no more without proper notice in advance to officials and the public."

MADISON Wisconsin State Journal SUBURBAN
THURSDAY, OCTOBER 12, 1972 SECTION 5, PAGE 1

Wisconsin State Journal
Page of Opinion
PAGE 6, SECTION 1 MONDAY, JANUARY 29, 1973

BEDROOM RADIO ALERTS

CD Scores Again

Those wonderful folks who gave you backyard bomb shelters have come up with another screwball idea — individualized bedroom disaster alert receivers.

Mazomanie has the dubious distinction of being chosen as one of 10 sites where federal Civil Defense plans to build radio transmitters for a nationwide emergency warning system.

According to Robert B. Martin, project director, the emergency information would be sent to special receivers which citizens would be urged to buy and install in their bedrooms.

If this harebrained scheme works like everything else the Civil Defense people have come up with, such as the faulty siren system in Madison, a good night's sleep will become a thing of the past.

President Nixon is in the process of trimming the fat from many federal agency budgets and eliminating others altogether. We hope he does not forget about Civil Defense.

Appendix C

Sample Interview Schedule

Severe Weather Media Survey

STATION______________ DATE____________

(SPEAK WITH ANYONE ON DUTY IN THE NEWSROOM AT THE TIME OF THE STORM)

As you know, there was a severe weather watch and warning yesterday for Dane County. I would like to ask you a few questions on how these notices reached the public. First I'd like to ask you about the severe weather WATCH. Now remember, these first questions are about the watch only.

1. From where did you first receive notification of the severe weather watch?

2. Did you edit or change this notice at all before broadcasting it?

   YES NO

   How?

3. Did you receive notification of the watch from any other sources?

   YES NO

   What sources were they?

4. At what time did you air the watch for the first time?

   And how often after that?

Now I would like to ask you about the severe weather warning.

1. From where did you first receive notification of the severe weather warning?

2. Did you edit or change the warning at all before broadcasting it?

   YES NO

   How?

3. Did you receive notification of the warning from any other source?

   YES NO

   What sources were they?

4. When did you air the weather warning for the first time?

   And how often after that?

5. Do you have any facilities for keeping up with the storm's progress?

   YES NO

   Could you describe what kind?

6. Did you play or read any instructions on what to do during such a storm?

7. Where did you get an all clear notice?

8. How often did you repeat it?

9. What kind of audience response did you receive, any calls?....

   How many?

   What was the usual reason for the calls?

10. Did you have any technical difficulties during the storm? (specify)

11. Did your station suffer any damage from the storm? How much?

12. Any other comments?

Name ____________________ Title ____________________

INTERVIEWERS COMMENTS ON REVERSE SIDE

Appendix D

(Sample Schedule)

Wisconsin Survey Research Laboratory

SHORT RANGE SEVERE WEATHER STUDY

______________ at ______________ a __________ watch was put into effect,
DAY OF WEEK   TIME   indicating the conditions were such that
a __________ might occur, and at
______________ a __________ warning was issued, indicating
a __________ had actually been sighted.

1. Did you know a __________ watch was in effect ______________?
DAY OF WEEK

/Yes/ /No/ (GO TO Q 2)

1a. At what time did you first hear about the watch? ______ A.M., ______ P.M.

1b. What steps, if any, did you take to protect yourself, family and property?
/None/, or ______________________________

____

____

2. Did you know a __________ warning also was in effect ______________?
DAY OF WEEK

/Yes/ /No/ (GO TO Q 10)

3. At what time did you first hear the warning? ________ A.M., ________ P.M.

4. From what source did you first hear this warning?

/Cable TV/ /Radio/ /TV/ Other: (Specify)______________ (GO TO Q 5)

4a. If you recall, which station were you tuned to? ____________

5. Did you continue to use the same source for information on the storm?

/Yes/

5a. What additional sources did you use, if any?
/None/, or ______________

____

/No/

5b. What other sources did you use?
/None/, or ______________

____

Interviewer: ______________ Date: __________ Sample No.: _____

6. Did you follow the progress of the storm from the time you first heard the warning?

/Yes/ ↓ /No/ (GO TO Q 8)

6a. How frequently did you follow the storm's progress...was it continuously, at half-hour intervals, hourly, or what?

/Continuously/ /1/2 hour intervals/ /Hourly/ Other: ______

7. Do you feel the information you got on the storm was accurate?

/Yes/ (GO TO Q 8) /No/ ↓ /Don't know/ (GO TO Q 8)

7a. How was it inaccurate? ______________________________

8. Did you get any instructions on ______________(DAY OF WEEK) about what you should do in such a storm?

/Yes/ ↓ /No/ (GO TO Q 9)

8a. From what source did you get these instructions? ____________

8b. What information from these instructions was most useful to you?

____

9. What steps, if any, did you take to protect yourself, family, and property?

/None/, or ____

____

____

10. Do you have any homeowners or personal property insurance?

/Yes/ ↓ /No/ (GO TO Q 11)

10a. How much coverage would you estimate you have? $____________

11. Did the storm hit your area or neighborhood directly, did you feel the side effects, or did it miss entirely, or what?

/Direct hit/ /Side effects/ /Miss/ Other: ____________________

12. Did the storm cause any damage to your property?

/Yes/ ↓ /No/ (GO TO Q 13)

12a. Would you describe your damage? ____________________

____

12b. Would you estimate the cost of your damage? $______________

12c. (IF INSURED, ASK) Will your insurance cover the damage, totally, partially, or not at all?

/Totally/ /Partially/ /Not/

13. Since the storm, have you read or heard any news stories about it?

/Yes/ /No/ (GO TO Q 14)

13a. From what source? (CHECK ALL THAT APPLY) /Radio/ /TV/ /Newspaper/ Other: ____________________

When a __________ watch is in effect, it is possible to show pictures taken from a satellite on your television set. For example, __________ (DAY OF WEEK), during the storm, the pictures would have shown the storm center and how it was moving toward your area. These pictures would also show the effects of the storm and the current temperature, wind, hail, and rain. Special pictures would be shown in between to show the expected behavior of the storm during the next six hours. This is called "NOWCASTING".

14. If this service were made available in the near future, would you use it?

/Yes/ /Depends/ /No/ (GO TO Q 15) /Don't know/ (GO TO Q 14c)

14a. How frequently...would it be continuously, every 1/2 hour, hourly, or what?

/Continuously/ /1/2 hour/ /Hourly/

Other: __________

14b. In what way would it be most useful to you? ____________________

____

____

14c. If you had to pay for this service, would you be willing to pay ten dollars, five, one, or how much per month?

/$10/ /$5/ /$1/, or $______ (PER MONTH) /Depends/ /Nothing/ /Don't Know/

15. Now we would like to get some background information from you. Do you have access to a ...

A. radio? /Yes/ /No/

B. cable TV? /Yes/ /No/

C. television? /Yes/ /No/

D. car radio? /Yes/ /No/

E. weather wire teletype? /Yes/ /No/

16. Do you, yourself, read a newspaper daily? /Yes/ /No/

17. What is your present age? _______________ (AGE)

18. Are you presently married, separated, divorced, widowed, or never married?

/Married/ /Separated/ /Divorced/ /Widowed/ /Never married/

19. What is the highest grade of school or year of college you have completed?

__________ (GRADE OF SCHOOL), or ___________ (YEAR OF COLLEGE)

20. Are you presently employed, looking for work, retired, a housewife, or what?

/Employed/ /Looking/ (GO TO Q 21) /Retired/ (GO TO Q 21) /Housewife/ (TO Q 21) Other (Specify) _____ (GO TO Q 21) _________

20a. What is your occupation? ______________________________

____

21. Do you live in a single family house, a duplex, apartment, rooming house, mobile home, or what?

/Single/ /Duplex/ /Apartment/ /Rooming/ /Mobile/ Other: (Specify)

____

22. Do you own or rent? /Own/ /Rent/ Other: _______________

23. Do you or anyone in your household own a farm in Dane County?

/Yes/ /No/

24. How many buildings, if any, do you own in Dane County...we mean houses, separate garages, business places, or out-buildings?

_____________ #

25. Do you or any member of your household own a car, boat, or camper?

(CHECK, IF OWN) 25a. (FOR EACH ITEM OWNED, ASK) Was it in Dane County on ____________? (DAY OF WEEK)

_______ A. Car(s) /Yes/ /No/

_______ B. Boat /Yes/ /No/

_______ C. Camper /Yes/ /No/

26. Where were you on _______________ (DAY OF WEEK) at _______________ (TIME OF WARNING)?

____

27. Are you the head of the household? /Yes/ (GO TO Q28) /No/

27a. What relationship are you to the head? _______________

28. In what village, city, or township do you live? ____________________

Thank you, we appreciate your help.

TERMINATE INTERVIEW

SEX of R: /MALE/ /FEMALE/

COMMENTS:

FOOTNOTES

1. "The concept of linker has been developed to describe the process and problems of transferring information from one technology to another. Linkers are essential because 1) they can assess use needs 2) they act as 'gatekeepers' between sources and users allowing only relevant messages to pass, and 3) they halve the heterophyly gap between sources and users." (Haas et al, Draft Report of Panel in Dissemination, CAS Review of Atmospheric Sciences, 1970)

2. The National Severe Storms Forecast Center in Kansas City, Mo. defines severe weather as thunderstorms in which any or all of the following occur, 1) hailstones, three-quarters of an inch thick, or greater 2) surface gusts of 50 knots, or greater, and/or 3) tornadoes

3. The occurance of severe weather conditions verified by Hans E. Rosendal, State Climatologist, or the National Weather Service Office located at Truax airfield.

4. Operations of the National Weather Service, United States Department of Commerce, October 1971, p. 188

5. All data used in the development of this and the following charts was taken directly from the NOAA Storm Data and Unusual Weather Phenomena publication for the years 1969, 1970, and 1971

6. 1970 Census Data, Wisconsin Profile Series Housing, Document #BSP-IS-71-6 prepared by the State of Wisconsin Department of Administration

7. The National Warning System (NAWAS) was initially developed in the 1950's for attack warning purposes, but now exists on a national scale as an emergency communications and warning system for natural disaster situations. The system consists of a dedicated telephone link using speaker phones. Two-way radio as well as teletype and telegraph serve as backup communications links. (from an interview with Norman H. Blume, Director Warning and Communications, NAWAS Operations Center II, Hill Farms Office Building)

BIBLIOGRAPHY

1. American National Red Cross, Dane County Chapter, Chapter Center Bulletin, April 1972

2. Dane County Civil Defense Office, Community Shelter Plan (Wisconsin State Journal Supplement), January 1970

3. Department of Defense, Office of Civil Defense, A Citizen's Handbook, March 1968

4. Executive Office of the President, Office of Emergency Preparedness, Report to the Congress, Disaster Preparedness, January 1972

5. Office of Civil Defense Region Four, Emergency Readiness Report, December 1971

6. State of Wisconsin, Division of Emergency Government, Annex C, Warning, June 1972

7. State of Wisconsin, Division of Emergency Government, Warning Plan and SOP, September 1971

8. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Operations of the National Weather Service, October 1971

9. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Storm Data and Unusual Weather Phenomena, 1969, 1970, and 1971