An Automatic Weather Station Network For North Dakota

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Efficiency of agricultural production will receive greater emphasis in the future. Producers and scientists have often found that higher yields are not necessarily more profitable. In North Dakota "maximum economic yield" has been emphasized, but too often the emphasis has been on "maximum" with little regard for economic or environmental considerations. According to a Michigan State University Extension Service bulletin (1987), efficiency will replace increased yields as the route to improved farm profitability. One strategy for improving agricultural efficiency is to make better use of weather and climatic data.

Many agriculturists argue that more accurate weather forecasts are needed to improve management efficiency. However, the outlook for more accurate forecasts is dim. In the 1950s and early 1960s when computers were first introduced into weather forecasting, hopes were high. However, 30 years have passed and forecasts are only slightly better than they were in the late 1960s. What happened? Despite the tremendous advances of technology and scientific understanding in the past 30 years, the chaotic nature of atmospheric motion still defies projection. It appears that mesoscale (1 to 50 miles) circulation patterns are so complex and change so rapidly that they can never be predicted. This will limit our ability to ever make a perfect forecast.

Since "perfect weather forecasts" are not available, the alternative is to use past weather data and information to help make management decisions. Usually maximum and minimum temperatures and precipitation averages and probabilities have been calculated from historical data and used for various purposes. This information is invaluable for long term planning, but it fails completely in assessing the risk for individual years.

Weather conditions determine the rate of plant, insect, and disease development throughout the season. Thus, a method that uses current weather data could be used to track the development of these organisms and make predictions about the occurrence and severity of disease and insect infestations. This information would greatly improve the efficiency of agricultural production.

DEVELOPMENTAL MODELS AND CURRENT WEATHER DATA

The role of weather in the rate of development for some plants, insects, and diseases has been determined. For these organisms, current weather data and, in some cases, current phenological data have been used very successfully to predict their future development (Figure 1). Often the predictive capability improves by using historical climatic data and information in the model.

Development and use of predictive models require the availability of current (yesterday's) detailed weather data for nearby locations. Daily maximum and minimum air temperature and precipitation are often inadequate for these purposes. Successful models often require additional input like solar radiation, wind speed, relative humidity, and soil temperature. Examples of models already developed that use current weather data and some that could be developed are described below.

Severity of European corn borer infestations can be predicted using a model developed and marketed by the Kansas Cooperative Extension Service (Higgins et al., 1986). The software program provides a systematic analysis of past temperature data that allows a producer to decide when treatments are economical. This model has been successfully used in Kansas and is being evaluated for North Dakota use (Personal communication, Dr. Michael Weiss, NDSU Entomologist).

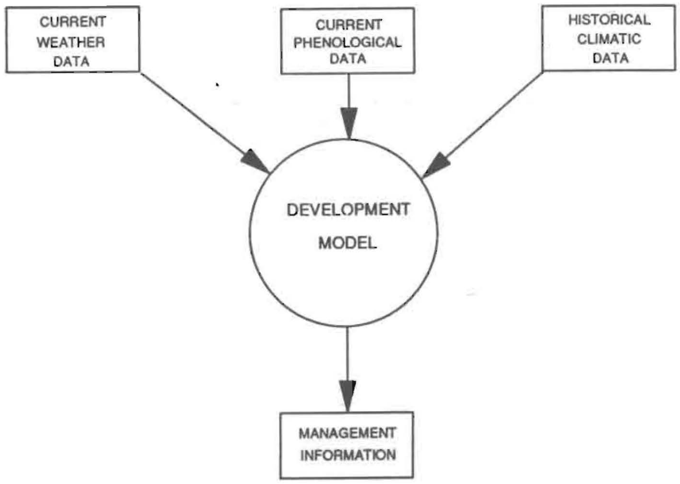

Figure 1. Plant, insect, and disease development models convert current and historical data into management information.

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Whitfield (1984) has shown that sugarbeet root maggot development can be predicted using growing degree days. His model predicts population events which can be used to initiate postemergence control programs. Whitfield stated that postemergence insecticides could replace treatments at planting, but their success depends on proper timing.

Cerscospera leaf spot infection in sugar beets has been a major problem in the Red River Valley. A model to predict Cerscospora infection (Shane and Teng, 1984) is based on average air temperature and the number of hours relative humidity is above 90 percent. This model, in conjunction with field scouting, has been used for several years by American Crystal and Minn-Dak Cooperatives to reduce costs by eliminating unnecessary fungicide applications (Shane and Teng, 1985).

Optimal weed control requires proper timing of herbicide applications (Kopp et al., 1989). Leaf stages of crops and weeds are used to determine proper timing, but leaf loss due to various environmental conditions may make field determination difficult. Calendar days are not a useful indicator because plant growth rates vary with temperature. However, growing degree day models which use current temperature data in conjunction with planting date allow fairly precise determination of the growth stage of wheat (Bauer et al., 1984). When current data were available, extension personnel have used this model to make weed control recommendations for farmers without going to the field. Variations of this method have been used to predict development for many other crops.

Optimal water use for irrigation requires maximum and minimum air temperature and solar radiation to predict crop water use (Stegman and Coe, 1984). A simpler approach using only maximum air temperature has been reported by Lundstrom and Stegman (1988).

Coakley et al. (1988b) analyzed macroscale weather data to develop predictive models for stripe rust and Septoria tritici blotch on winter wheat (Coakley et al., 1985, 1988a). These models, or variations of them, could be calibrated for North Dakota conditions. Since stripe rust shares epidermiology with other rusts, new opportunities exist to develop models for these diseases also.

White mold is rated the number one disease for dry edible beans, but no white mold models exist. According to Dr. James Venette, NDSU plant pathologist, the availability of current weather data would spur research on model development. In addition development, yield, and rust models for dry edible beans already exist and could be calibrated for North Dakota conditions.

Prediction models for grasshopper development based on heat unit accumulation have been developed, but more research is needed before they are ready for general use. Current weather data will aid this effort (personal communication, Dr. Michael Weiss, NDSU entomologist and Dean McBride, extension entomologist).

Models that predict necessary spray applications for several potato diseases have been developed or are under development elsewhere (personal communication, Dr. Neil Gudmestad, NDSU plant pathologist). These models could be calibrated or modified for North Dakota conditions when current weather data become available.

AUTOMATIC WEATHER STATION NETWORK

The High Plains Climate Center (HPCC) located in Lincoln, Neb., coordinates an automatic weather station network (AWSN) consisting of more than 70 stations located in Nebraska and surrounding states. The center provides equipment and personnel to maintain the stations in Nebraska and to handle data from all regional stations on a daily basis. Without this support, networks in surrounding states, including North Dakota, would be impossible. A $25,000 grant was obtained from the HPCC to help establish and initiate operation of a North Dakota network.

Six existing Campbell automatic weather stations (CAWS) located at NDSU branch experiment stations (Williston, Minot, Langdon, Carrington, and Streeter) and the Lippert research site were upgraded, moved to permanent sites, and connected to telephone lines in early 1989 (Figure 2). Additional new stations have since been installed at Hettinger, Grand Forks, and Fargo, and two other existing stations located at Oakes and Prosper have been added to the network. Equipment has also been purchased for a new station in southeastern North Dakota.

Stations are located on permanent sites, at least 600 feet from the nearest trees or structures, chosen to represent the macroclimate as much as possible. Sites in small depressions, valley bottoms, or near shelter belts are unacceptable because of the microclimatic influence of these locations. For example, a site in a small depression would have lower minimum temperatures when compared to other more level sites while a site near a shelter belt would often have lower windspeeds, higher temperatures, and higher humidities. Stations will be operated throughout the year to document seasonal variation. Winter data may be useful for prediction of overwinter survival of insects and diseases. Measurements include air temperature, humidity, wind speed and direction, solar radiation, precipitation, and 10 cm depth bare and turf covered soil temperatures. Data are recorded continuously and summarized hourly.

DATA DISSEMINATION

All stations in the Nebraska network are called shortly after midnight by the HPCC computer to download yesterday's data. Data are then quality checked, archived, and loaded on an electronic bulletin board where they are available to users (Figure 3).

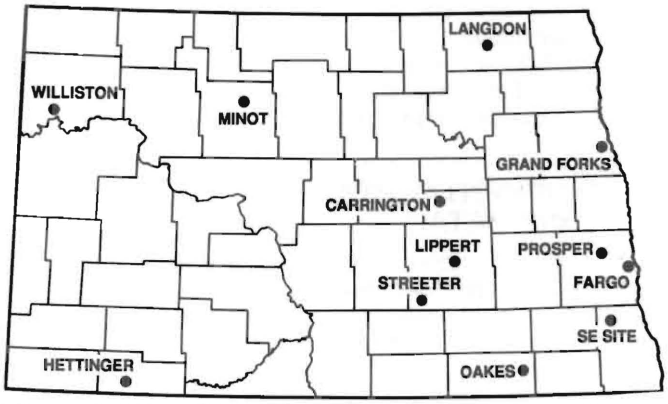

Figure 2. Automatic weather station sites in North Dakota.

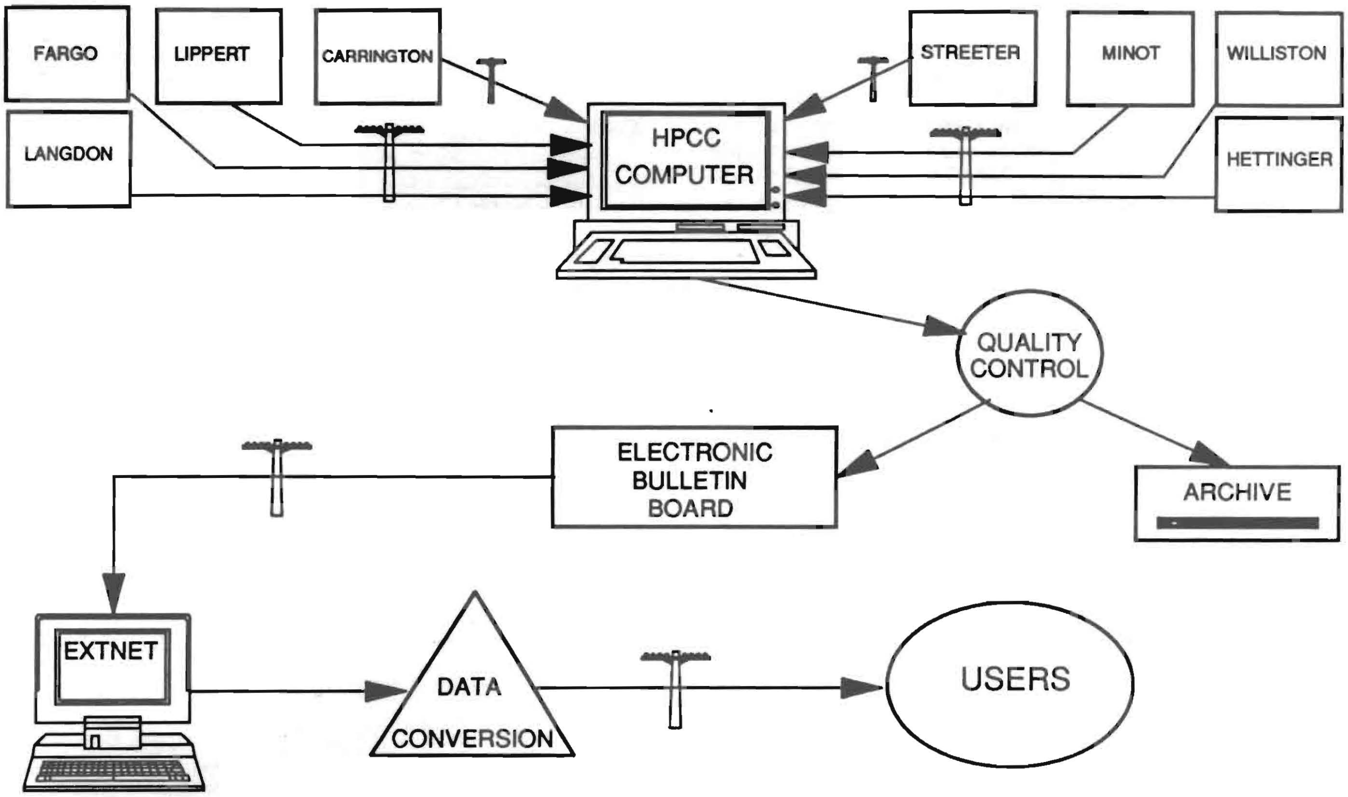

Figure 3. Communications network established to collect and disseminate current weather data to North Dakota users.

A computer system designed to obtain North Dakota data from the HPCC computer and make it available to users has been developed by the communications division of the NDSU Extension Service. It will run on the NDSU Extension network (EXTNET) and will allow users to download both hourly and daily data for any North Dakota station. Data will include those variables mentioned previously plus accumulated growing degree days for wheat, corn, and sunflower, potential evapotranspiration, and dewpoint temperature.

In addition to serving extension personnel, agricultural consultants, agribusinesses, and producers, the availability of current weather data will encourage further research into crop, insect, and disease development models for North Dakota conditions. Many NDSU scientists have not invested time or money in this type of research because weather variables important to plant and pest development have not been available on a timely basis in the past.

SUMMARY AND FUTURE EXPECTATIONS

The availability of timely weather data is a key to more efficient and more profitable agricultural production. Weather information can often substitute for supplies, services, and capital when used as part of a modern farm management program (Michigan State University Extension Service, 1987). Producers can make management decisions using models that predict future crop and pest development based on current weather conditions. These models can warn of impending disease and insect infestations so that corrective action may be taken. On the other hand, a model may indicate that no action is required thus saving a producer time and money as well as reducing pesticide use and its potential adverse environmental effects. Current plant disease control practices often include the use of prophylactic chemicals. Production costs could be substantially reduced if chemicals were used only when needed.

Reducing pesticide use is an important concept because agricultural chemicals are coming under increasing attack from all quarters. Degradation of ground water by fertilizer nutrients and pesticides has become a major agricultural problem. Pesticide control laws (North Dakota Department of Agriculture, 1989) provide stringent regulations on the class, time, place, manner, method, amount, and concentration of pesticide use. Perhaps controls or restrictions on the use of commercial fertilizers are not far away (personal communication, Dr. Ed Vasey, extension soils specialist).

Use of current weather data will be invaluable to North Dakota agriculture in the future. Unfortunately, only 12 Campbell automatic weather stations will be operational during 1990 leaving big gaps in the coverage (Figure 2). At least eight additional stations are required to adequately represent the regional climates in North Dakota. Future operation of this network will require broad support to purchase, operate, and maintain automatic weather stations. Operation and maintenance of an existing station costs approximately $1,000 annually. Purchase and installation of a new station costs approximately $4,500.

following criteria: birth dates between December 1, 1948, and December 1, 1970, and addresses in which the ZIP codes matched those of cities having populations of 2,500 or more.

For some unknown reason, the random sample obtained from the Drivers License Division included a higher than expected number of names in the older age groups as well as a much larger percentage of females than males.

Data was collected by use of a mail survey questionnaire similar to one previously developed by Luft (1986) for collecting data from young rural adults in North Dakota. The questionnaire consisted of two parts. Part I was used to determine the demographic information needed for each respondent. Part II consisted of 69 statements related to leadership characteristics. Respondents were asked to indicate their level of agreement using a Likert-type scale. The following choices were given: 1 = strongly disagree; 2 = moderately disagree; 3 = slightly disagree; 4 = slightly agree; 5 = moderately agree; and 6 = strongly agree.

The questionnaires, along with cover letters and postage paid return envelopes, were mailed to names contained in the sample. The cover letter explained the study and encouraged participation. Approximately three weeks after the first mailing, nonrespondents were contacted again with a second questionnaire. Of the 500 questionnaires mailed, 65 were undeliverable due to addresses being no longer current. In addition, two of the respondents were no longer residents of North Dakota. This reduced the sample to 433. Persons in the sample returned 246 usable questionnaires for a response rate of 56.8 percent. As completed questionnaires were received, they were categorized as either early or late responses. An analysis of the responses in Part II revealed no significant differences between the mean scores of early and late respondents. If nonrespondents are more likely to respond as do late respondents, one can then conclude that the nonrespondent group was similar to the respondent group.

Table 1. Demographic Characteristics of Respondents.

Characteristics	Number	Percent
Age		
24 and under	21	8.5
25 to 29	37	15.0
30 to 34	77	31.3
35 and over	111	45.2
	246	100.0
Gender		
Female	150	61.0
Male	96	39.0
	246	100.0
Marital Status		
Married	160	65.0
Single	56	22.8
Divorced or Widowed	30	12.2
	246	100.0
Children Living at Home		
No	95	38.6
Yes	151	61.4
	246	100.0
Highest Level of Schooling Completed		
12 years or fewer	59	24.0
13 to 15 years	110	44.7
16 or more years	77	31.3
	246	100.0
Where Raised		
On a farm	79	32.1
In the country, but not on a farm	21	8.5
In a town or city	146	59.4
	246	100.0
Current Residence		
On a farm	7	2.8
In the country, but not on a farm	27	11.0
In a town or city	212	86.2
	246	100.0

DEMOGRAPHIC CHARACTERISTICS

Respondents were asked to complete several questions seeking information about their demographic characteristics. Results of that information are shown in Table 1.

A total of 76.5 percent of the respondents were between the ages of 30 and 40. Only 8.5 percent were 24 years old or younger. Females represented a larger percentage of the sample (61 percent) than males (39 percent). About two-thirds (65 percent) of the respondents were married, 22.8 percent were single, and 12.2 percent were divorced or widowed. A total of 61.4 percent indicated they had children living at home. When asked the highest level of schooling completed, 24 percent reported completing 12 years or fewer; 44.7 percent reported completed 13 to 15 years; and 31.3 percent reported completing 16 or more years. Approximately 59 percent of the respondents reported being raised in a town or city, and 32 percent reported being raised on a farm. A total of 86.2 percent of the respondents indicated current residence as a town or city, whereas 11 percent indicated residence in the country but not on a farm.

LEADERSHIP ABILITY

The leadership ability of young adults residing in urban areas of North Dakota was determined by asking respondents to indicate their level of agreement with each of the leadership skill statements. To accomplish the second objective of the study, mean scores and standard deviations were calculated based upon the Likert-type scale mentioned previously. Results of these calculations are presented in Table 2.

Statements are arranged in Table 2 from highest to lowest mean score in each leadership category. Overall, the young urban adults in North Dakota felt their leadership ability was good. In the category **General Leadership,** leadership skills receiving the most desirable mean score ratings (higher on positively stated skills and lower on negatively stated skills) are as follows: I like to see conflicts resolved; I understand others have feelings, motives, goals of their own; Other people can depend on me to accomplish a task for them; I willingly listen to others; and I enjoy sharing information with others. Respondents agreed moderately to strongly with these statements.

The **Speaking Skills** category received the lowest mean scores as a group. Following are the statements that were rated highest in this category: I enjoy expressing my ideas on a given issue; and, I feel confident openly promoting issues I feel strongly about.