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A LOOK AT THE WISCONSIN CRANBERRY WEATHER FORECAST INCLUDING VERIFICATION STATISTICS

Timothy W. Oster
National Weather Service Forecast Office
Milwaukee, Wisconsin

1. Introduction

Twice a day during the growing season, WSFO Milwaukee issues a product unique in the Central Region. Those unfamiliar with the area may raise their eyebrows when they see a product called the Wisconsin Cranberry Weather Forecast come over the wire. And while Wisconsin has a reputation for being a cold state, they may wonder why the forecast at times calls for temperatures well below freezing in the middle of summer. This paper will discuss how micrometeorology relates to the cranberry industry and will review verification of the cranberry forecasts over the past several years.

2. Occurrence of Low Temperatures in Cranberry Bogs

Cranberry cultivation is restricted to very small areas in the U.S. Massachusetts is normally the number one producer of cranberries in the country but Wisconsin is consistently number two, and in some years has been number one. In 1986, Wisconsin grew 34 percent of the national cranberry crop (Wisconsin Agricultural Statistics Service, 1987).

Cranberry growth is confined to low marshy areas in northern climates. These areas, known as bogs, have a unique meteorological problem. Bogs are often the site of the coldest temperatures during the growing season. Being lower than their surroundings, cold air drains into the bogs early at night and forms a strong temperature inversion, which in turn cuts off surface mixing by the wind. Dikes that are part of the irrigation system also block some of the wind.

The thick vines and damp ground add to the problem. The vines not only prevent the sun from heating the ground during the day, but also act as strong radiators at night. Much of the warmth and sunshine that does reach the ground is used in evaporating surface moisture. This effect is enhanced when dew points are low which is exactly when nighttime radiation will also be the greatest. The overall result is that on clear, cool, dry summer nights, Wisconsin cranberry bogs can reach temperatures well below freezing. Because Wisconsin bogs generally have less water drainage and thicker vines than those in the east and Pacific Northwest, they have been shown in the past to experience colder temperatures than bogs elsewhere in the U.S. (Cox, 1910 and Georg, 1960).

Since cranberries will grow only in these frost prone areas, growers have had a special need for detailed accurate temperature forecasts which will enable them to take the proper protective measures when needed. Cranberry weather forecasts have been issued by the NWS (and the old Weather Bureau) in Wisconsin since 1947, and were issued before that by the Chicago forecast office (Georg, 1960).

3. The Cranberry Weather Forecast

Forecasts for the cranberry bogs are issued daily by WSFO Milwaukee at 11:30 a.m. and 8:30 p.m. from about mid-April until late October. Figure 1 shows the primary cranberry growing regions. Each morning, five cranberry growers call the forecast office and report precipitation, sheltered high and low temperatures and bog minimum temperature. The bog readings are taken with an unsheltered thermometer placed just above the vegetation. The locations of the five reporting stations are also shown in Figure 1.

The cranberry weather forecast includes predicted bog temperatures for the tonight period, along with an outlook for the next night or two. The first period is the critical one as growers must make final plans and preparations based on that forecast. Sprinkler systems are normally used to combat freezing temperatures, but given extreme weather conditions bog flooding is sometimes required.

The forecast for the tonight period is restricted to a 4°F interval for temperatures below 40° (such as 20°-24°, 32°-36°, etc.). Readings above 40° are not important to the growers, so forecasts are then given as simply "40° or above." The forecaster is given the option of breaking the forecast down to prescribed geographical regions (northwest, northeast and south as shown on Figure 1). This greatly helps the forecaster in confining the temperatures to a 4°F interval.

Nevertheless, being restricted to a 4°F range, regardless of circumstances, can be very difficult at times. In some instances, the three stations in the southern bogs will differ by more than this amount.

A further aid to the forecaster is use of the phrase "caution advised." This is confined to mainly two circumstances. One is when clouds will cover most of the area, but random large breaks in the cloud cover may result in scattered areas of much colder temperatures. The other is when clearing is expected to occur late in the period but the timing is uncertain. If the clearing takes place an hour before sunrise, bog minima can be 10° to 15°F colder than if the clearing takes place an hour or two after sunup. In this way, the growers are alerted that the possibility exists for much colder readings than are being forecast. Because of its catch-all nature, forecasters are urged not to overwork the phrase, and over the years this has worked out very well.

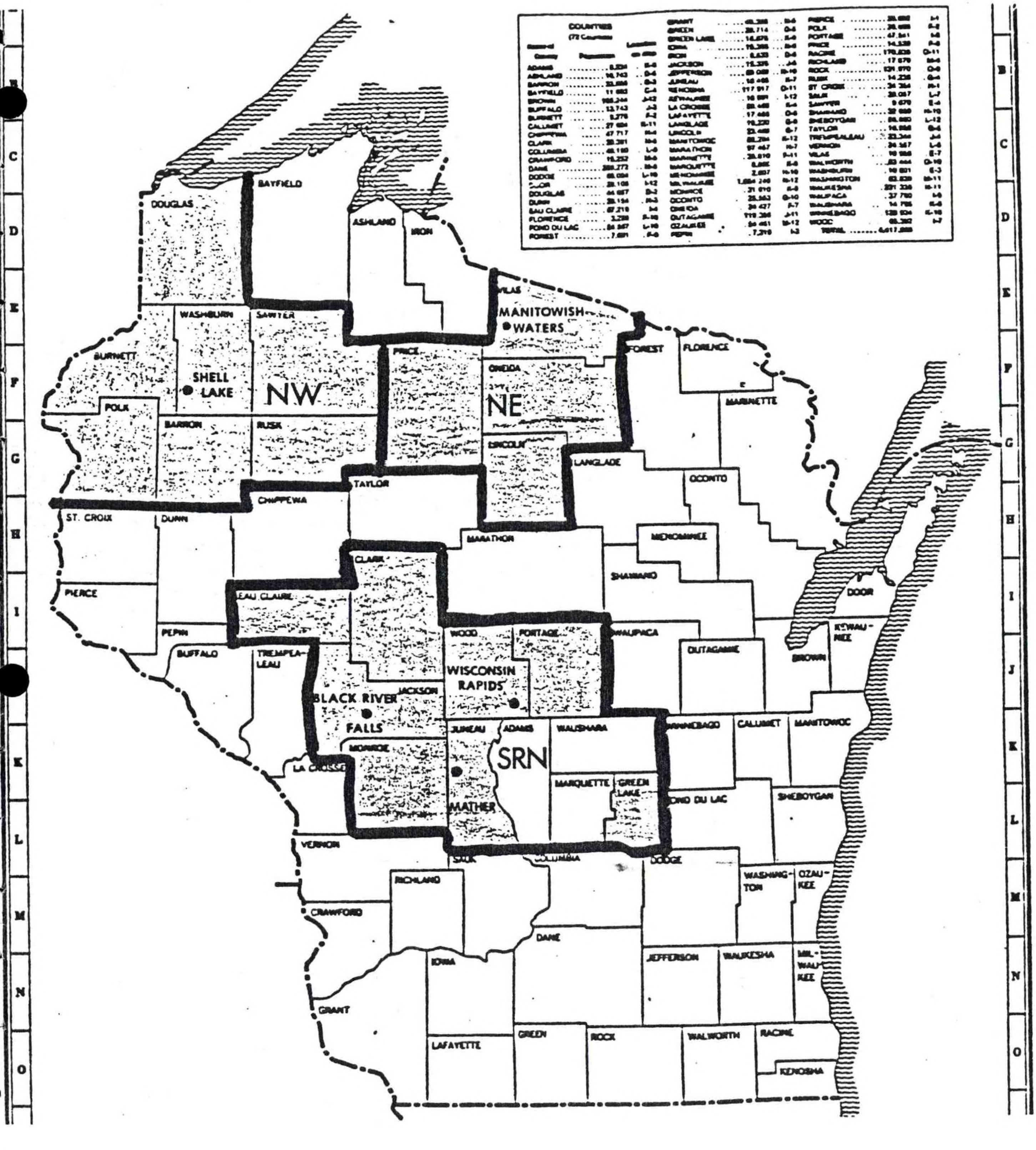

Figure 1. Wisconsin counties in which cranberries are grown (shaded). Also shown are the five temperature reporting stations and the geographical divisions used in the cranberry forecast.

The forecast bog temperatures are based on several previous studies. Field studies utilizing radiometers were used to further refine the earlier work. The primary forecast scheme used is based on forecasts of dew points and radiation conditions. The type of radiation (good, fair, or poor) depends, in turn, on the expected wind speeds and cloud cover. A secondary scheme has limited usefulness and utilizes the 850 mb temperatures and the precipitable water.

4. Verification of the Cranberry Temperature Forecasts

Some form of verification of the first period cranberry forecast has been done most years since 1979. The results are presented in Tables 1 through 5. Each bog is considered separately, thus when the data is complete for each day it accounts for 10 forecasts; one for each of the five bogs in the morning and again in the evening. Verification statistics are not available for 1984 and 1985.

First the general reliability of the forecast has been examined by tabulating the percentage of forecasts with errors less than 5°F. These are given in Table 1. The error was computed using both ends of the temperature range that was forecast. Thus, if a bog was 30° and the forecast was 35°-39°, the error is 5°F. In spite of forecaster turnover through the years, the numbers are extremely consistent, ranging from 81 to 87 percent, with an average of 84. In most years, the evening update showed some improvement over the morning forecast, with this past year being the sole exception.

1979	81%		81% AM,	82% PM
1980	84%	(1483/1760)	82% AM,	86% PM
1981	82%			
1982	84%	(1401/1672)		
1983	87%	(1609/1845)	86% AM,	88% PM
1986	83%	(1470/1768)	81% AM,	86% PM
1987	87%	(1657/1907)	85% AM,	88% PM
1988	84%	(1562/1849)	85% AM,	84% PM
Avg	84%			

Table 1. Percent of first period cranberry forecasts with errors of less than 5°F. Where available, the actual number of occurrences and number of forecasts are given in parentheses. Data not available for 1984 and 1985.

Since many of the forecasts were for 40° or above in summer, the errors were also tallied for times when the bogs reached freezing or lower so as to evaluate the forecasts when the temperatures are more critical. The results are given in Table 2. The numbers are very close to those in Table 1. Considering the restrictions on the forecaster, the results are quite good. Most of the large errors have been found to occur when the cloud cover is forecast incorrectly, as this is the most critical element of the forecast scheme. It is also the most challenging.

1979	81%		79% AM,	83% PM
1980	81%	(297/366)	80% AM,	83% PM
1981	80%			
1982	87%	(316/362)		
1983	83%	(364/440)	80% AM,	86% PM
1986	85%	(304/357)	82% AM,	88% PM
1987	88%	(395/450)	85% AM,	91% PM
1988	85%	(478/562)	85% AM,	85% PM
Avg	84%			

Table 2. Same as Table 1 except only for cases when the observed bog minimum was 32°F or less.

In the latter five years of the data set, the information in Tables 1 and 2 were broken down for each reporting station. These numbers are presented in Table 3, Parts A and B. For the most part, these figures show more year to year variability, possibly because the data set for each individual bog is much smaller than that for the overall calculations. It is interesting to note that in many cases a bad year for one location was offset by a good year at another.

Part A

	SHELL LAKE		MAN. WATERS		BLACK RVR FALLS		MATHER		WISC. RAPIDS	
1982	82%		84		84		85		85	
1983	81		90		88		88		89	
1986	81		82		80		85		85	
1987	80	(305/383)	85	(323/381)	87	(333/383)	90	(344/381)	93	(352/379)
1988	78	(293/375)	80	(300/375)	87	(325/375)	89	(333/375)	89	(311/349)
Avg	80		84		85		87		88	

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Part B

	SHELL LAKE		MAN. WATERS		BLACK RVR FALLS		MATHER		WISC. RAPIDS	
1982	80%		90		90		88		88	
1983	78		92		83		82		78	
1986	87		90		80		83		83	
1987	84	(49/58)	83	(78/94)	89	(93/104)	86	(81/94)	94	(94/100)
1988	81	(83/103)	80	(86/108)	91	(108/119)	86	(102/119)	88	(99/113)
Avg	82		87		87		85		86	

Table 3. Percent of errors less than 5°F for first period cranberry forecast, broken down by individual reporting station. Part A is for all forecasts and Part B for times when the bog minimum was 32° or less. Where available, the actual number of occurrences and forecasts are given in parentheses.

The forecasts for Shell Lake have been generally worse than those for the other four points. Part of the reason for this is that Shell Lake will often have warmer bog readings than the other four bogs in spite of the fact that it is one of the more northern sights. The observer at Shell Lake has noted this and, in checking temperatures at other bogs, found most of them to be colder than at the official observation point and closer to the forecast bog minima. However, changing the observation point could cause problems. The grower there has stated that he would not want to see the forecast adjusted just to match that poor observing sight. This sight obviously raises the overall error rate somewhat in the verification statistics. It also demonstrates that considerable temperature variation can be seen across small distances even in areas of comparable terrain.

As a method of assessing the number of false alarms raised by the forecast, a tally was made of the number of times no bog reached freezing when the forecast was entirely at or below 32^{o} (Table 4). In the majority of years this occurred less than 10 percent of the time and in three years occurred in only two percent of the forecasts.

1979	2 %	
1980	7 %	
1981	2 %	
1982	13%	(11/86)
1983	2 %	(2/82)
1986	11%	
1987	5 %	(5/98)
1988	5 %	(6/122)

Table 4. Percent number of times no bog reached a minimum of 32^{o} or less when the first period forecast was entirely 32^{o} or below. The number of occurrences and number of forecasts are given in parentheses when available.

To evaluate the opposite effect (i.e., frost situations that were missed), days with one or more bogs reaching 30^{o}F or lower (a significant frost or freeze) were summed for those times when the forecast was for 34^{o}F or higher (significantly above freezing). The results are in Table 5. The number of occurrences ranged from seven in 1983 to none in 1987. Many of the cases were found to occur very early or very late in the season when bog readings are more erratic and frosts not as critical. Also, a good number of these were caught in the evening update.

1979	3	(2 May, 1 Oct.)
1980	5	(2 May, 1 Sept., 2 Oct.)
1981	Missing	
1982	3	(1 May, 1 June, 1 Sept.)
1983	7	(2 May, 3 June, 1 Sept., 1 Oct.)
1986	3	
1987	zero	
1988	6	(1 May, 2 June, 1 Aug., 1 Sept., 1 Oct.)

Table 5. Number of times one or more bogs reached 30°F or less when the forecast was for 34°F or higher. The number of occurrences in each month are also given when available.

5. Discussion

Observations from cranberry farms show that even in a state like Wisconsin with relatively flat terrain, geographical features have a very strong impact on nighttime temperatures. Observations from other points in the state that are in low boggy areas (such as Lake Thompson and Harrison in Oneida County) also show the same temperature characteristics. In the winter, the inversion is so strong at times that even the daytime readings at those locations will run 10°F lower than at other nearby sights, in spite of significant (10 mph or so) gradient winds. This, in turn, can have a strong impact on precipitation forecasts, as parts of a county will have rain while other sections will receive freezing rain or several inches of snow.

Variations of the opposite sort often show up in Wisconsin fire weather observations that are received in the summer. Then some points located in dry sandy areas can show maximum temperatures many degrees higher than the official stations, and dew points as well as relative humidities may run much lower.

The zone forecaster is often faced with the dilemma of either ignoring these local effects and thus concede to large temperature busts for localized areas, or in using such a wide range of temperatures that the forecast becomes useless to everyone. Except in cases of damaging frost or freeze, the most prudent course has been determined to be the first. But these local effects must be kept in mind when making precipitation forecasts when the precipitation type is in doubt. The wide variations make it virtually impossible to strictly follow guidelines for the agricultural forecast which suggest using only 5°F intervals in forecasting highs and lows.

A 1961 article published on the back of the old Daily Weather Map series explained local temperature variations and gave a method for farmers and other interests to use to adjust NWS minimum temperature forecasts to their local areas (U.S. Weather Bureau, 1961). Perhaps this article should be resurrected and used once again to educate the public to the fact that the NWS forecast will never be able to cover all the many temperature variations due to local terrain.

In the meantime, the demand for specialized forecasts will remain great as they are needed to deal with important problems ranging from protection of a large crop such as cranberries to fire weather considerations.

Verification of the Wisconsin cranberry forecasts shows that forecasters can very effectively provide useful forecasts for small scale weather variations. This is noted by the fact that forecast accuracy has been extremely consistent over the years.

6. References

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