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Soil Temperature: A Guide for Planting Agronomic and Horticulture Crops in Nebraska

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Over the last decade there has been a shift toward soil temperatures warming earlier, allowing farmers to plant sooner.

Year to year climate variability is an unavoidable issue for agriculture in Nebraska. Since agricultural practices rely heavily on climatic conditions, it is risky to make certain agricultural management decisions based on the calendar date. One such decision is when to plant agronomic and horticulture crops.

To ensure better germination, one of the key factors to consider is optimum soil temperature. Regardless of the climate zone or year, seeds require optimum soil temperatures to germinate and sustain early development. Farmers who plant before optimum temperatures are reached risk productivity loss due to seed death or poor germination, and limited initial growth that might occur because of the lower soil temperature.

The minimum soil temperature for planting a given crop is reached on different dates from year to year. Averaging soil temperatures over a decade provides insight for better management decisions. The main research questions for this study were:

1. When does the soil temperature become suitable for planting agricultural and horticultural crops in Nebraska?
2. Are the optimum soil temperatures for planting spring and summer crops shifting to earlier or later dates?

Minimum Soil Temperature for Crop Germination

Soil temperature plays an important role in seed germination. Adequate soil temperatures for germination range widely for different crops. For example, the optimum soil temperature for planting field corn is 55°F. Once the soil temperature has remained at or above 55°F for five to seven consecutive days, corn will likely germinate more quickly and have a more uniform stand. If planted before the soil temperature is 55°F, corn germination and emergence may get delayed for several days and growth may be compromised. Meyer and Dutcher (1998) summarized the recommended minimum soil temperature of selected agronomic and horticulture crops (*digitalcommons.unl.edu/extensionhist/733*). Temperature ranges specified in *Table I* are based on cited literature and should be used as a general guideline.

Table I. Recommended minimum temperatures needed for germination of selected agricultural crops.

Agronomic Crops	*Minimum Soil Temperature at Planting (°F)*	*Horticultural Crops*	*Minimum Soil Temperature at Planting (°F)*
Spring wheat	37	Spinach	38
Spring barley	40	Radish	40
Rye	41	Lettuce	41
Oats	43	Onion	41
Alfalfa	45	Pea	42
Spring canola	50	Potato	45
Sugarbeet	50	Cabbage	45
Field corn	55	Carrot	46
Soybean	59	Sweet Corn	55
Sunflower	60	Pepper	57
Millet	60	Snap Beans	57
Sorghum	65	Tomato	57
Dry bean	70	Cucumber	58
		Pumpkin	60

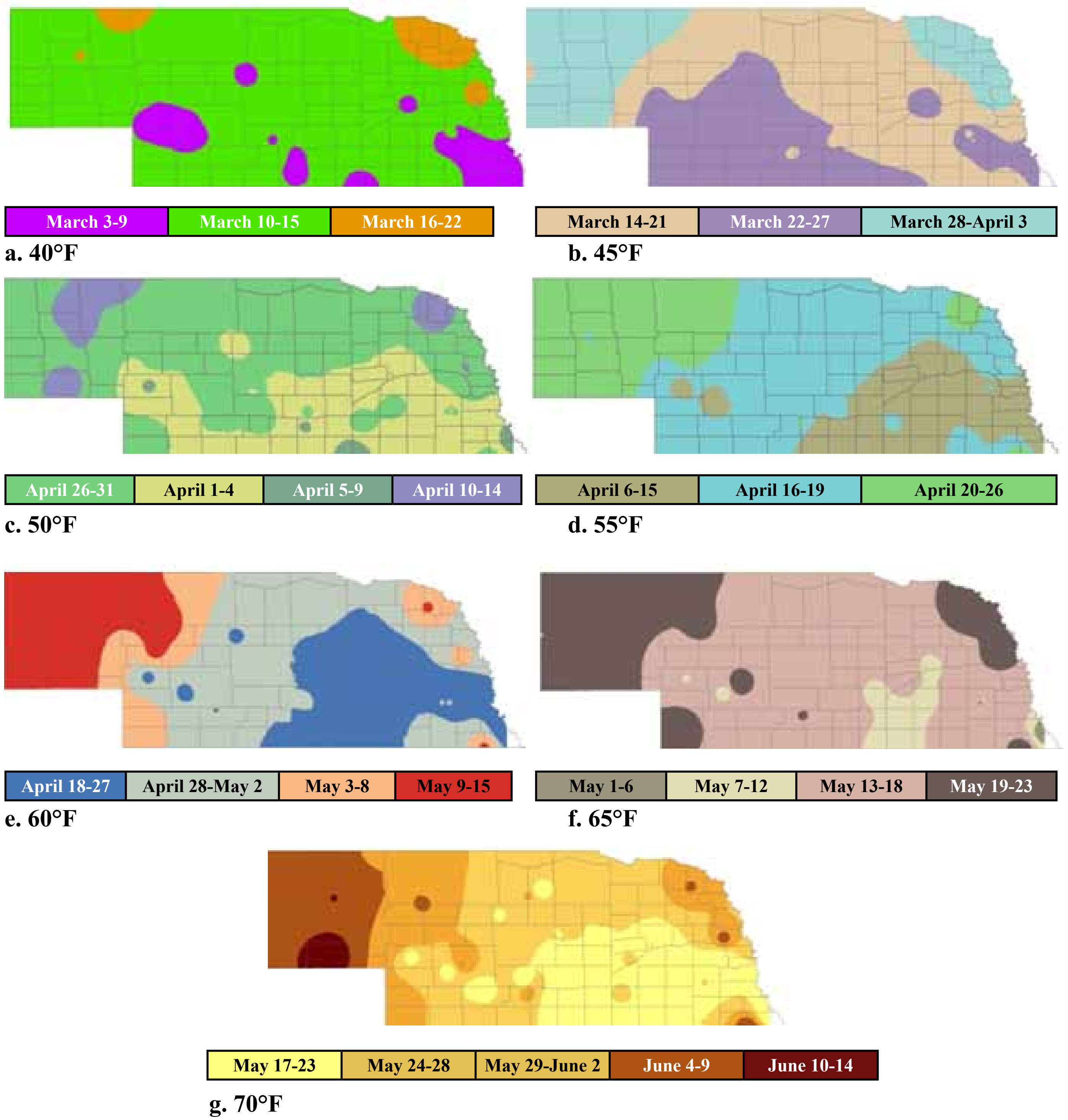

Figure 1. Dates on which average soil temperature reaches temperatures specified with each map.

Soil Temperature Date Maps

Soil temperature data were obtained from the High Plains Regional Climate Center's Automated Weather Data Network (AWDN) stations (*www.hprcc.unl.edu*). At 49 AWDN stations across the state, the date when five-day running average soil temperatures reached selected temperatures between 40°F and 70°F were recorded and averaged for 10 years (2000-2009). Spatially distributed maps showing the days when the optimum soil temperatures were reached were created using ArcGIS inverse distance weighted spatial interpolation (*Figure 1*).

Figure 1 shows the general distribution across the state when the average soil temperature becomes warm enough for germination. For example, based on the average soil temperature for the last 10 years, we can expect that a 55°F soil temperature will be reached between April 6 and April

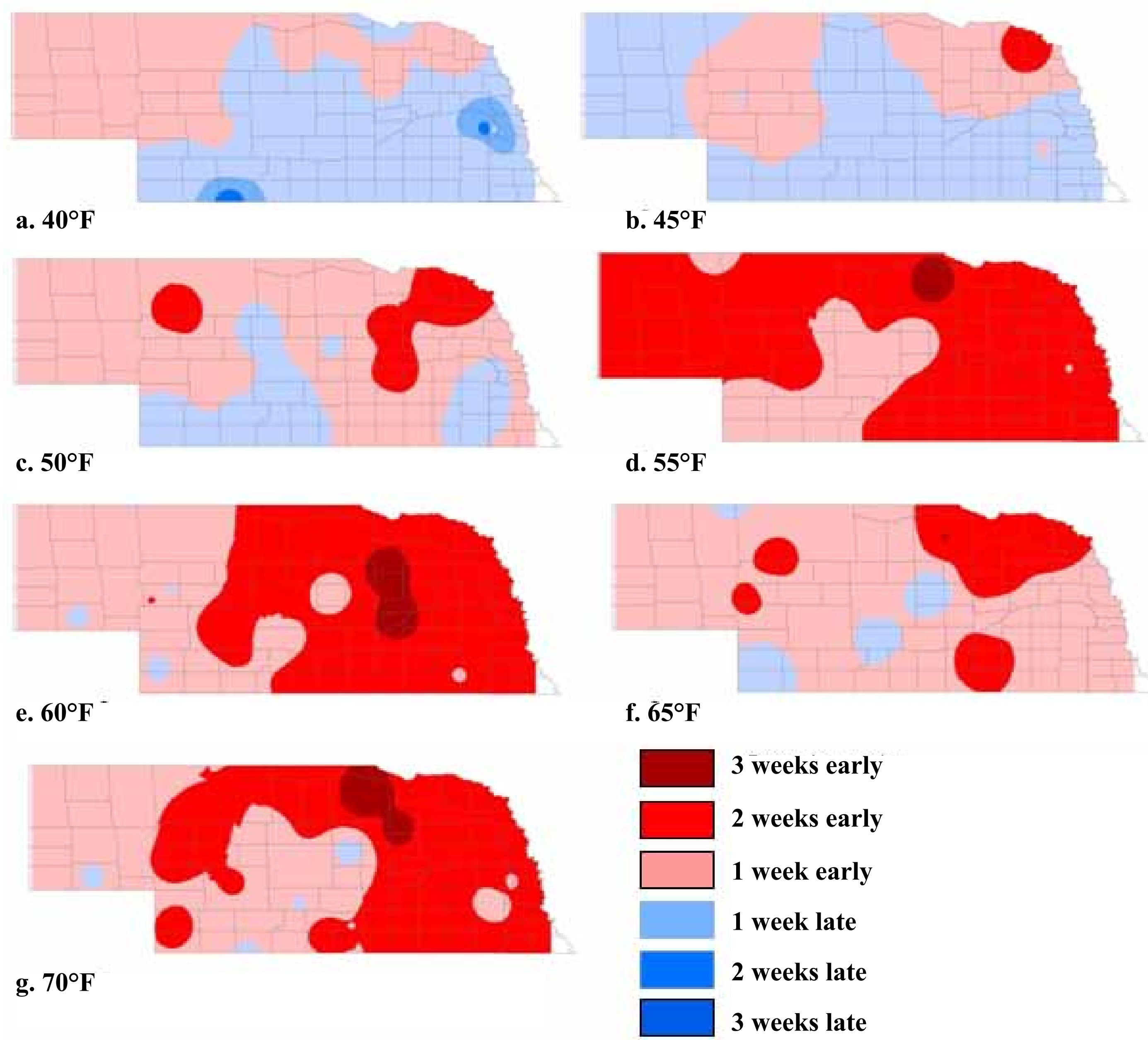

Figure 2. Deviations in planting dates observed in the decade (2000-2009) with respect to the previous decade (1990-1999). Red color indicates that the average planting dates shifted earlier in 2000-2009 compared to 1990-1999.

26 across Nebraska. Since field corn requires a minimum soil temperature of 55°F to properly germinate, the earliest time to plant would be in the second week of April in southeast Nebraska, the third week of April in central Nebraska, and the fourth week of April in most of the Panhandle. Similarly, the average earliest planting time for other crops can be found in *Figure 1* and *Table I*.

It is important to understand that the soil temperature maps shown in *Figure 1* provide an average trend using the last 10 years of data to provide generalized results. When making planting decisions, year to year soil temperature variations also should be recognized. Soil temperature maps can be obtained from the High Plains Regional Climate Center (*www.hprcc.unl.edu*).

Shifts in Planting Dates Between Previous Two Decades

In order to understand if soil temperatures have changed over time, the dates when soil temperature averages reached the temperatures specified in *Table I* during the last two decades were examined.

In *Figure 2*, red shaded areas indicate that average soil temperatures occurred earlier during the 2000-2009 period than in the 1990-1999 period. In other words, red indicates temperature shift towards earlier soil warming and a potential for earlier planting dates, and blue indicates the opposite. The maps for 55, 60, 65 and 70°F indicate areas with significantly earlier planting dates in the most recent decade (red) due to warmer soil temperatures.

The spatial maps show a very prominent trend; the dates when soil temperature averages reach a specific temperature between 50 and 70°F have shifted one to three weeks earlier than in the previous decade. The mean values (*Table II*) from 29 AWDN stations also showed a shift of a week or more in the planting date for 55 and 60°F average soil temperatures. Crops such as corn, soybean, and sorghum fall under the 55 to 60°F average soil temperature planting guideline and may experience earlier planting in the future. This study also shows that the earlier shift isn't consistent for all temperature thresholds. The date when average soil temperature reached the 40°F planting threshold used for spring barley, spring wheat, and other cool season crops occurred at a slightly later date in the 2000-2009 period when compared to 1990-1999, but only by one day at most locations (*Table I*).

Table II. Day on which soil temperature averages reached select values from 40-70°F across 29 AWDN soil temperature stations in Nebraska.

		Day of year when soil temperature averages reached the temperatures shown						
	Year	*40°F*	*45°F*	*50°F*	*55°F*	*60°F*	*65°F*	*70°F*
Average	1990-1999	68	81	96	114	127	138	152
	2000-2009	69	82	93	105	118	134	146
Difference		1	1	-3	-9	-9	-4	-6

Can Shift be Attributed to Climate Change?

The earlier planting dates in the most recent decade occurred because of an increase in soil temperatures. The trend over this short period is consistent with a changing climate but cannot be separated from natural climate variability. For a climate change trend, soil temperature data need to be evaluated over a larger period of time, such as 100 years, but measured soil temperature data is not available for that span of time in Nebraska. Another plausible inference of recent increased soil temperature could be the prolonged drought conditions that were experienced in Nebraska in last decade. Soil moisture is deficient during drought conditions, which typically act as a driver for increasing soil temperature. Although increased soil temperature is difficult to distinguish from climate variability, it can be used as a precursor to alert decision makers of a possible evolving trend.

The general trend supports the fact that the spring planting season has been arriving earlier in the year for warmer season crops like corn, soybean, and sorghum. The spring planting season for spring wheat, spring barley, and oats has been coming later in the year. If climatic conditions are closely monitored and farmers can plant earlier, the benefit would be that a longer-season hybrid could be selected with a corresponding higher yield potential. Similar analysis is recommended for analyzing freeze risk and length of growing season. If the freeze distribution is not shifting at the same rate as soil temperature, it may increase a risk to agricultural production. Conversely, if freeze analyses also show similar pattern as soil temperature, more confidence in earlier planting can be obtained.

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