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# Likelihood of Damaging Low Temperatures During the Growing Season

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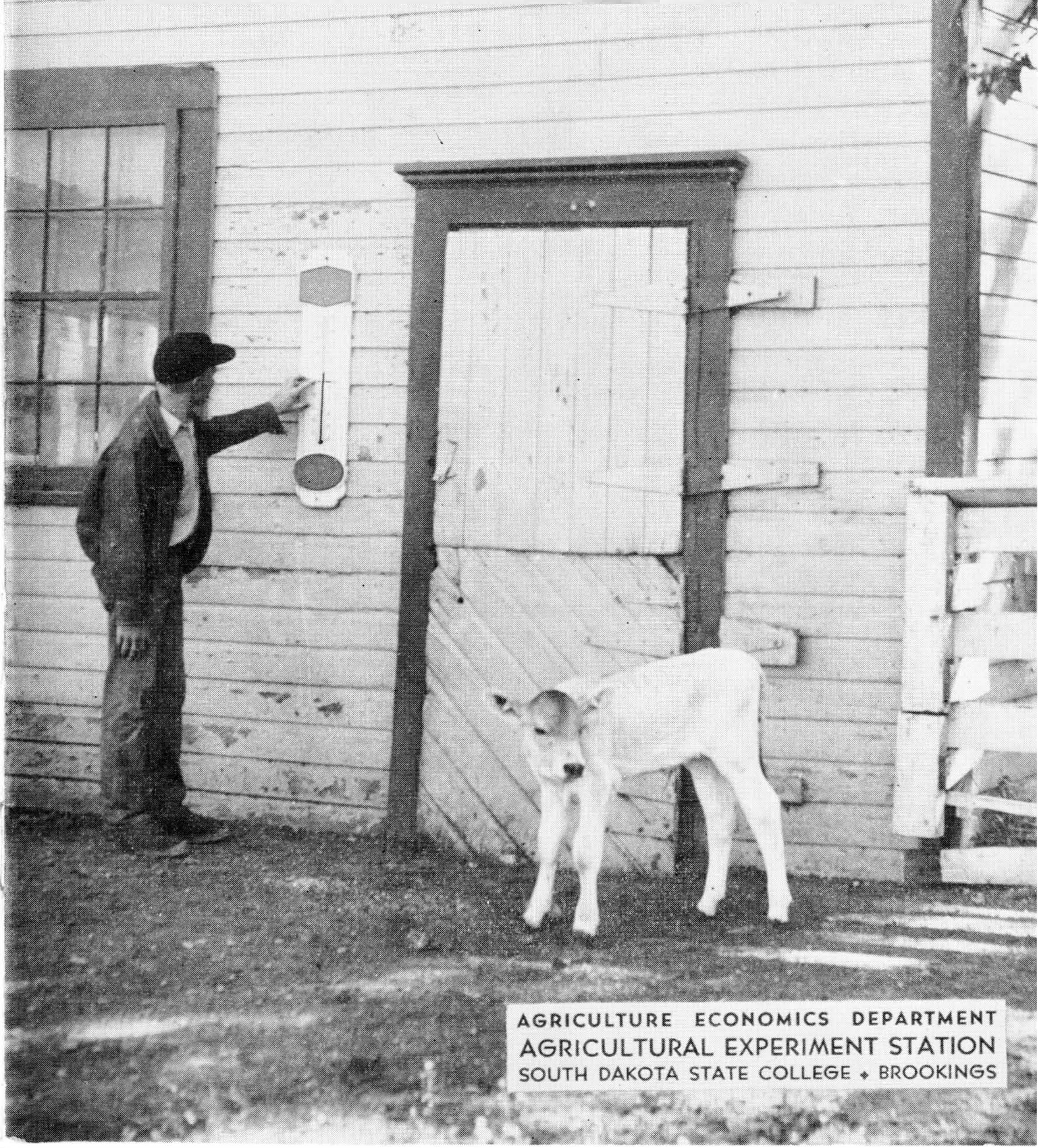

AGRICULTURE ECONOMICS DEPARTMENT
AGRICULTURAL EXPERIMENT STATION
SOUTH DAKOTA STATE COLLEGE ❖ BROOKINGS

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# Likelihood of Damaging Low Temperatures During The Growing Season

RAY F. PENGRA and M. D. MAGNUSON[1]

Weather factors are one of the most important risks involved in farming operations. Crops that may be grown successfully within an area are determined largely by temperatures. The length of the growing season or the number of days between dates of damaging low temperatures is also important as it limits the number and variety of crops that may be grown in any locality.

Freezing temperatures that damage crops are often experienced in South Dakota. Damage in the spring to horticultural and garden crops is frequently extensive. Fruit setting during the period of tree bloom may be impaired or entirely prevented by the occurrence of freezing temperatures.

The present study is concerned with frost data, the length of the growing season, and the likelihood of various temperatures, within critical temperature categories, occurring during the spring and fall months within various areas of South Dakota.

In order for the farmer to plan his spring and fall farming operations in advance he must have information as to the most probable dates for the beginning and end of the growing season. Data are presented here which can be used in estimating the length of the season in various parts of South Dakota as well as evaluating the risk of freeze damage to various crops during the spring and fall months.

## Definition of a Damaging Freeze

Temperatures that cause plant injury vary from one plant to another due, in part, to the moisture content or amount of water present in the plant. While the presence of visible frost is often associated with plant injury the two may not always be synonymous, at least in regard to plant damage from reduced temperatures. Frost is frozen dew and is caused by the condensation of water vapor directly into the crystalline form on objects or plants whose

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This report was made possible as a result of a joint cooperative project to place South Dakota weather data on International Business Machine punch cards. The South Dakota State College Agricultural Experiment Station, the United States Weather Bureau, and the United States Bureau of Reclamation represented by Ralph E. Johnston and Everett Jennewein cooperated on the project. The weather data are from the United States Weather Bureau of the United States Department of Commerce.

Acknowledgment is also made to J. E. Grafius and Victor Dirks of the Agronomy Department as well as to S. A. McCrory and Ronald Peterson of the Horticultural Department for advice and assistance in compiling and presenting the data.

temperatures are below the freezing mark. Dew is formed if the temperatures of the objects or plants remain above the freezing mark.

It is true that other factors than temperature present at any given time may operate to alter the effect of a definite temperature on a particular plant. Temperatures within the enclosed shelter where weather records are obtained may vary from those outside and air currents over any area may at any time carry warmer or colder air to a particular point and so the effect of identical reported temperatures at different times may result in considerable difference in plant injury.

While the following temperatures are only approximate they are given as a general indication of temperatures that are likely to result in damage to various farm plants.

During the seedling stage flax will be likely to be damaged by temperatures of 20 to 22° F. For wheat, oats, and barley 25 to 28° F. will cause some damage. During the blossoming or flowering stage 32° F. will damage all the above. In the fall near harvest time 28 to 30° F. will result in some damage to small grain. Corn will be damaged by temperatures of 34° F.

The temperatures at which fruit and vegetable crops are damaged depend upon their stage of growth, the duration of the temperature, humidity, and other factors. During the blooming period apples, apricots, plums, and pears may be damaged at temperatures from 25 to 32° F. Fruit of apples and pears may tolerate a temperature of 27° F. or lower in the fall.

Tomatoes, peppers, beans, and vine crops can be killed by temperatures of 32 to 34° F. Some vegetables, such as carrots, cabbage, cauliflower, onions, and beets can tolerate a temperature of 28° F. or lower without much damage. A number of vegetables can be conditioned to withstand much lower temperatures than they would otherwise.

## Historical Record of Weather Stations Studied

In order to properly interpret weather factors it is necessary to have background information regarding conditions under which the data were secured. Therefore, a brief historical statement covering each station is included here.

**Aberdeen.** Weather records at Aberdeen in Brown County extend back to 1896. The equipment now is located at the Aberdeen airport which is several miles from the city while all records prior to 1940 were from residential exposures with only two relocations. The topography at Aberdeen is very level and flat and the station is well within the old lake bottom of Lake Dakota. The present coordinates are 45° 27′N latitude 98° 26′W longitude, and the elevation is 1,296 feet.

**Academy.** Weather records at Academy in northern Charles Mix County began in 1898. At first, the instrument shelter was a homemade box mounted 5 feet above the

ground on the north side of a shed. Since 1901, a standard instrument shelter has been used. This long weather record at Academy has been continuous without any interruptions.

The station has been at only three locations and has been manned by only four observers. These station sites have been within a distance of 2½ miles of each other so that the record can be considered rather homogeneous in many respects. Academy lies within the physiographic division known as the Missouri Hills. The Missouri River itself is approximately 5 miles west-southwest of town while 4 miles north are the Bijou Hills. The present coordinates of the station are 43° 27′N latitude, 99° 5′W longitude, and the station elevation is 1,675 feet.

**Brookings.** Weather records began in Brookings in Brookings County in January, 1896. During this entire period, personnel from the South Dakota State College Agricultural Experiment Station have been the official observers. There have been two minor moves in the location of the equipment, all within a radius of 1 mile so that a complete and homogeneous record exists at the point.

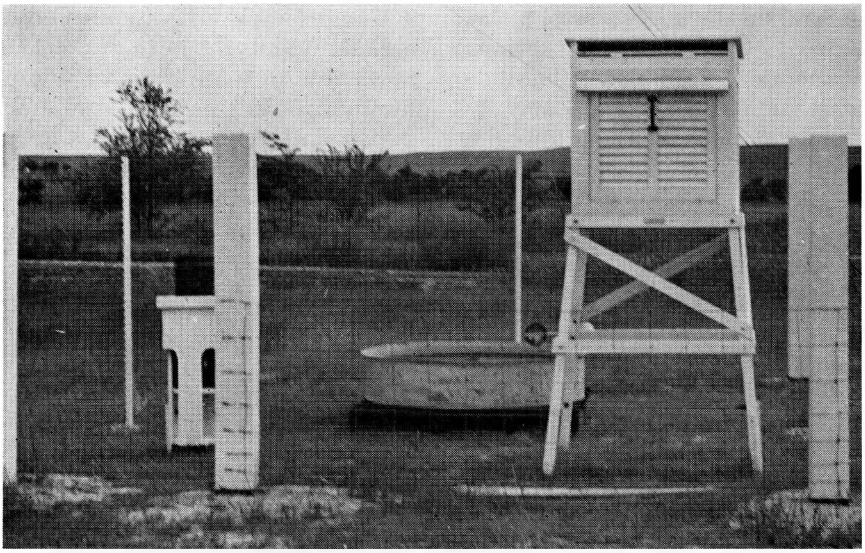
This station is located in the Big Sioux River Basin in an area called the "Dissected Till Plains." The terrain in the vicinity of the station is slightly rolling. The coordinates of the station are 44° 20′N latitude, 96° 46′W longitude, and the elevation is 1,650 feet.

**Camp Crook.** The Camp Crook area represents the farthest point in northwestern South Dakota that has weather records prior to 1900. The initial station was known as Ashcroft which is some 10 miles north of the town of Camp Crook. Temperature and precipitation observations began at Ashcroft in June, 1892. The station was located on rolling prairie country and on high ground on the west side of the Little Missouri River. Until 1901, a homemade temperature shelter was used. The station was moved into Camp Crook in 1910 where it has remained to the present.

The Forest Service has contributed the greater portion of the climatological record; but with changing personnel, it has necessitated a number of relocations within the town. The local terrain at Camp Crook is quite similar to the location at Ashcroft, being on open prairie and about ½ mile west of the Little Missouri River. Both areas are in the cretaceous tablelands. The Custer National Forest is about 4 miles to the west. The present location is 45° 32′N latitude, 103° 59′W longitude, and the elevation is 3,120 feet.

**Cottonwood.** A continuous record of temperature and precipitation has been maintained at one location at the Range Field Station, Cottonwood in northwestern Jackson County since June, 1909. Farm managers of the Field Station have taken the observations since the station was installed.

The station is located 2½ miles east of Cottonwood on a flat and



**Weather observation equipment at Range Field Station, Cottonwood**

level plain near the Bad River. Close by to the east are a series of small and rolling hills while to the south about 20 miles distant are the South Dakota Badlands. The entire area is a part of the topographical region known as the Missouri Plateau. The coordinates of the station are 43° 58′N latitude, 101° 52′W longitude, and the elevation is 2,414 feet.

**Eureka.** Temperature and precipitation records began at Eureka in western McPherson County in August, 1908, with the installation of the equipment at the North Central Substation on the east edge of the town. The record is continuous from that date at the same location with the farm managers as observers.

The Eureka station is located on a slightly high and rather flat table while the over-all area is a part of the Missouri Hills. The Bowdle Hills are 20 miles to the south and the Missouri River is some 35 miles to the west. In the immediate area, the terrain is gently rolling. The coordinates of the station are latitude 45° 46′N, longitude 99° 37′W. The elevation is 1,884 feet.

**Highmore.** Weather records at Highmore in central Hyde County extend back to 1896. Since 1908 the weather station has been located at the Central Substation about 1 mile west of town and since 1909, the record has been continuously kept by one observer. Highmore is located on a high and level plateau with lower elevations to both the east and the west. The terrain in the immediate vicinity of the weather station is very flat and level. The coordinates of the station are 44° 31′N latitude, 99° 28′W longitude, and the elevation is 1,890 feet.

**Milbank.** Weather records at Milbank in northeast Grant County date back to 1890. There has been quite a number of relocations and changes of observers, particularly during the early years, but the station at all times has remained in the immediate vicinity of Milbank. Being located in the Minnesota Valley, this station is lowest in elevation (1,150 feet) from which long-time weather records are now available. The station, itself, is located on level terrain in the valley. To the west about 8 to 10 miles is the rather steep escarpment—the prominent Prairie Hills—which rises some 700 feet within a short distance. The station coordinates are 45° 13′N latitude, 96° 38′W longitude.

**Mitchell.** Weather records began at Mitchell in Davison County during January, 1896. The weather equipment was located within the city limits in residential sections until 1949 when it was relocated to a rural exposure a short distance to the southeast. The station has been manned by six observers and located at six different exposures. Nevertheless, all locations are within a radius of 1½ miles. Being a part of the James Basin, the terrain features are rather level and flat, but with the change in 1949, the present terrain is more rolling since it is only about 1 mile from the James River. The coordinates of the station are 43° 42′N latitude, 98° 00′W longitude and the elevation is 1,295 feet.

**Oelrichs.** Weather observations began in Oelrichs in southern Fall River County in March, 1890. This station is about 20 miles from the Black Hills and is a part of the area known as the Missouri Plateau. Since 1918, the equipment has been located in the immediate vicinity of Oelrichs where the local terrain is level to slightly rolling. Prior to 1918, the station location is not exactly known but it evidently was located on ground that was decidedly rolling and hilly. The station has been manned by five observers at only six observation sites. The present coordinates of the station are 43° 11′N latitude, 103° 14′W longitude, and the elevation is 3,342 feet.

**Redfield.** Continuous weather records have been maintained at Redfield in Spink County since 1897. During this period there have been seven different sites with 10 changes in observers. All sites have been within the immediate vicinity.

This area is in the heart of the James Basin and Redfield is at the south end of a great flat and extremely level area described by geologists as the bottom of an old lake (Lake Dakota) which was formed in front of the last retreating ice sheet. The present location is 44° 52′N latitude, 98° 32′W longitude and the elevation is 1,295 feet.

**Sioux Falls.** At Sioux Falls, weather records used in this study go back to 1896. The greater portion of the record was taken within the residential area of the city at only two relocations, both within a radius of 1 mile. Since 1946, comprehensive observations have been taken by the U. S. Weather Bureau at the Municipal Airport which is about 1 mile

from the former location.

Minnehaha County is a part of the hilly highland called the "Dissected Till Plains" and the area is marked by rolling hills and some roughness. The present location is in the flood plain of the Big Sioux River and the station coordinates are 43° 34′N latitude, 96° 44′W longitude, and the elevation is 1,420 feet.

## Analysis of the Data

In Fig. 1 the long-time normal daily mean temperatures for the Huron station are shown. During the winter and summer months there is little variation in average temperatures from day to day. The variation in long-time average temperatures for Huron for the month of July is only from 70 to 72° F. For the 50 days following the spring equinox there is a variation in the long-time average temperature of 23° F. and the change in temperature during this critical spring seeding period is relatively uniform. Similarly for the period of about 50 days following the fall equinox there is a regular and relatively uniform decrease in temperatures. Both periods may well be represented by a straight line relationship as is shown in Fig. 1. This would seem to support the claim that for these two critical seeding and harvesting periods, temperatures follow a regular or normal distribution as has been shown by Reed and Tolley[2] in their statistical manipulation of these data.

Reed and Tolley were the first to notice that there was a progressive uniform change from day to day in the spring and fall frost data. In statistical terminology they discovered that frost data constitute a random sample and that the dates of the last killing frost in the spring and the first in the fall follow an independent normal distribution.

H. C. S. Thom and R. H. Shaw[3] of Iowa State College more recently have analyzed frost data from a statistical standpoint. As a result of their investigations the findings of Reed and Tolley were further established to support the contention that frost data follow a normal distribution. No attempt is made here to assess or further develop their findings, rather, the results of their study are applied to South Dakota freeze data through the use of probability graph paper.

Probability graph paper is so constructed that data from a normal distribution plotted on this paper will fall on a straight line. The slope of the frost lines on the graph was determined therefore by plotting the average mean date for each temperature occurrence on the 50 percent line of the graph and plotting twice the standard deviation of the freeze data on lines corresponding to 2.275 and 97.725 percent proba-

[2]W. G. Reed and H. R. Tolley, "Weather As a Business Risk in Farming," *Geographical Review*, II (1916), 48.

[3]H. C. S. Thom and R. H. Shaw, "Evaluation of Spring and Fall Freeze Hazard," unpublished manuscript, Iowa State College, Ames.

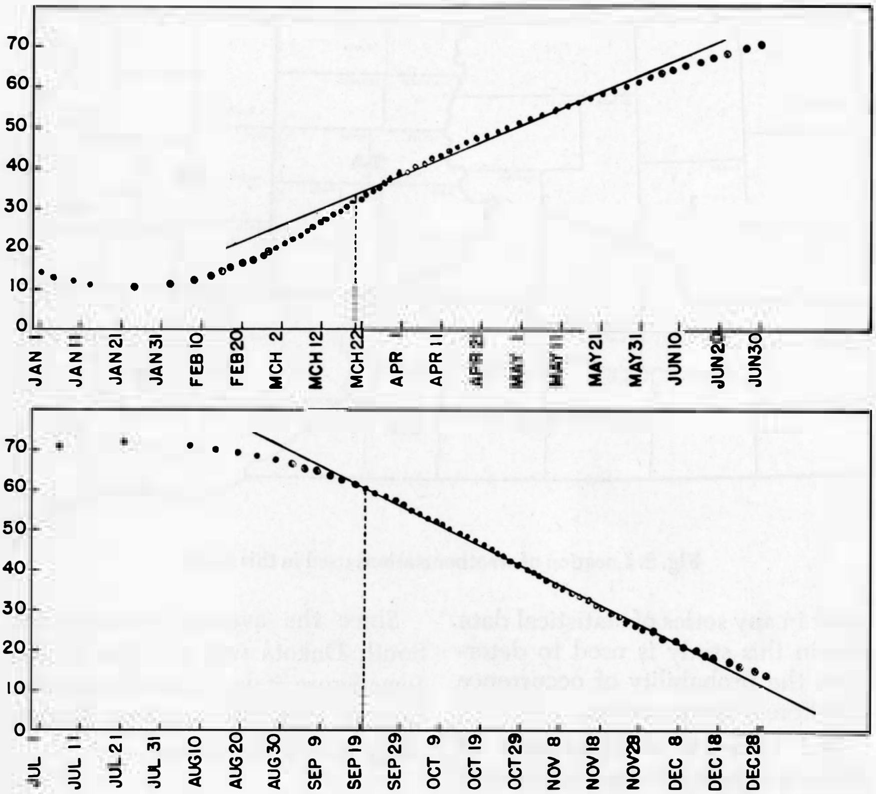



**Fig. 1. Average mean temperatures at Huron, South Dakota, during critical spring and fall periods**

bility lines respectively. In the case of both spring and fall freezes for South Dakota this results in a variation of eight days from the 50 percent date to either the 25 percent or 75 percent date—the same as has been found for Iowa[4] and Missouri[5] freeze data.

The state map in Fig. 2 shows the location of stations for which data were used in this study. Locations were chosen near experimental agronomy field stations with special emphasis also given to stations within the prospective irrigation areas in central South Dakota.

The mean or average date that a temperature within each selected category has occurred during the period for which temperature data are available is used as the date temperatures may be expected to occur in 50 percent or in half of the years. The variance is a measure of the amount of change about a central

[4]Thom and Shaw, *op. cit.*

[5]Wayne L. Decker, *Probability of Killing Freezes in Missouri,* Bulletin 555, Missouri Agricultural Experiment Station, Columbia, June 1951.

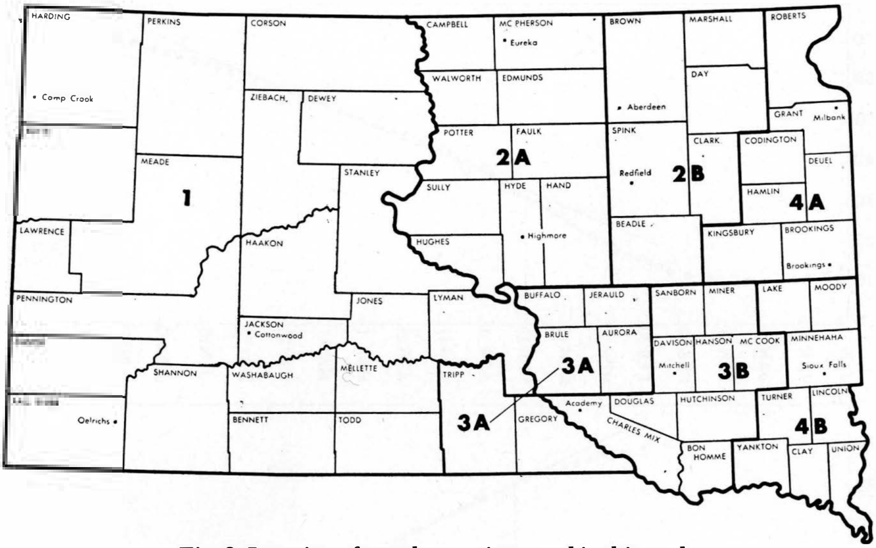



**Fig. 2. Location of weather stations used in this study**

point in any series of statistical data and in this study is used to determine the probability of occurrence of different temperatures.

The variance of occurrence of freeze temperatures for five selected South Dakota stations is given in Table 1. The average variance of these five stations as compared with the average of 20 Iowa stations is as follows:

| | Spring | Fall |
|---|---|---|
| South Dakota | 140.7 | 154.2 |
| Iowa | 139.3* | 154.8* |

*Thom and Shaw, *op cit.*

Since the average variance for South Dakota was so close to the Iowa figure, it was decided unnecessary to carry the analysis further using additional stations.

**Table 1. Variance of Freeze Temperature Occurrence for Selected South Dakota Stations**

| Station | March 21-May 10 Variance | Sept. 21-Nov. 9 Variance |
|---|---|---|
| Aberdeen | 167.0 | 187.8 |
| Academy | 144.7 | 121.3 |
| Brookings | 168.5 | 185.2 |
| Eureka | 91.1 | 117.7 |
| Highmore | 132.4 | 159.0 |
| Totals | 703.7 | 771.0 |
| Mean Variance | 140.7 | 154.2 |

## Likelihood of Freeze Damage After a Given Date in the Spring

Records from 12 weather stations distributed over the state make it possible to estimate likelihood of frost damage to farm crops resulting from low temperatures over the state, except for the Black Hills area where the pattern of temperature occurrence appears to vary considerably from the more open country.

Figures 3-14 (see pages 16 to 21) are designed to indicate probabilities of frost occurrence at various dates in spring for the 12 areas.

By using these figures, a farmer can decide the critical dates or the probable risk in his farming operations as they relate to freezing temperatures. For example, the problem of a farmer living in the Aberdeen area may be to determine the risk of a 32° F. freeze on or after May 2. By referring to Fig. 3 (page 16) the date corresponding to May 2 can be located along the left hand side of the figure. Then by moving along this date horizontally to the right until it intersects the freeze line, the risk or percent chance of the 32° F. freeze can then be read off the scale on the lower portion of the figure. In this case, the risk is 80 percent.

Similarly, based on the risk that a farmer is willing to assume, one can easily determine the critical date for this risk using the same figures. For example, again assuming that the 32° F. temperature in the spring is the critical temperature and the risk the farmer is willing to assume is 10 percent, the critical date for the Aberdeen area can be determined from Fig. 3 (page 16). The risk of 10 percent is located on the lower side of the chart. Then, move upward on this line until it crosses the freeze line. From this intersection point, proceed left on a horizontal line and read the date from the left hand side of the chart. In this example, a risk of 10 percent falls on May 28. In the same manner, the figures for the other areas and for the fall season can be fully utilized.

Several tables have been prepared to simplify the interpretation of these figures. These tables show likelihood of freezing temperatures at selected probability intervals. Table 2 shows the average dates for the last freeze in the spring at each of the 12 locations.

In Table 3 spring dates are listed for each location after which temperatures of 34° F. or lower can be expected in 40 percent, 30 percent, 20 percent, 10 percent, and in 5 percent of the years. Tables 4, 5, and 6 show similar dates for temperatures of 32° F. or lower; 28° F. or lower, and 24° F. or lower.

For the dates given in the columns headed 40 percent, in 4 years in 10 one should expect a temperature within this temperature category for each respective table. Similarly one should expect temperatures for the dates given within other categories as follows: in column headed 30 percent, in 3 years in 10; in column headed 20 percent, in 2 years in 10; in column headed 10 percent, in 1 year in 10; and in the column headed 5 percent, in 1 year in 20.

**Table 2. Average Dates of Last Freeze in Spring for Selected South Dakota Stations**

| Station | Temperature Category 34° F. and lower | 32° F. and lower | 28° F. and lower | 24° F. and lower |
|---|---|---|---|---|
| Aberdeen | May 17 | May 12 | May 4 | Apr 23 |
| Academy | May 13 | May 8 | Apr 28 | Apr 20 |
| Brookings | May 17 | May 13 | May 5 | Apr 25 |
| Camp Crook | May 22 | May 16 | May 11 | Apr 29 |
| Cottonwood | May 24 | May 18 | May 7 | Apr 27 |
| Eureka | May 27 | May 19 | May 10 | May 3 |
| Highmore | May 17 | May 14 | May 5 | Apr 26 |
| Milbank | May 16 | May 11 | May 4 | Apr 20 |
| Mitchell | May 14 | May 7 | Apr 29 | Apr 15 |
| Oelrichs | May 18 | May 15 | May 4 | Apr 24 |
| Redfield | May 20 | May 14 | May 4 | Apr 25 |
| Sioux Falls | May 11 | May 6 | Apr 26 | Apr 15 |

**Table 3. Spring Dates After Which There Is the Given Likelihood of a Temperature of 34° F. or Lower**

| Station | 40% | 30% | 20% | 10% | 5% |
|---|---|---|---|---|---|
| Aberdeen | May 20 | May 23 | May 27 | June 1 | June 5 |
| Academy | May 16 | May 19 | May 23 | May 28 | June 1 |
| Brookings | May 20 | May 23 | May 27 | June 1 | June 5 |
| Camp Crook | May 25 | May 28 | June 1 | June 6 | June 11 |
| Cottonwood | May 27 | May 30 | June 3 | June 8 | June 13 |
| Eureka | May 30 | June 2 | June 6 | June 11 | June 16 |
| Highmore | May 20 | May 24 | May 27 | June 1 | June 6 |
| Milbank | May 19 | May 22 | May 26 | May 31 | June 5 |
| Mitchell | May 17 | May 20 | May 24 | May 28 | June 3 |
| Oelrichs | May 21 | May 24 | May 28 | June 2 | June 6 |
| Redfield | May 23 | May 27 | May 31 | June 5 | June 9 |
| Sioux Falls | May 14 | May 17 | May 21 | May 26 | May 31 |

**Table 4. Spring Dates After Which There Is the Given Likelihood Of a Temperature of 32° F. or Lower**

| Station | 40% | 30% | 20% | 10% | 5% |
|---|---|---|---|---|---|
| Aberdeen | May 15 | May 18 | May 22 | May 28 | June 1 |
| Academy | May 11 | May 14 | May 18 | May 23 | May 27 |
| Brookings | May 16 | May 19 | May 23 | May 29 | June 1 |
| Camp Crook | May 19 | May 22 | May 26 | May 31 | June 4 |
| Cottonwood | May 21 | May 24 | May 28 | June 2 | June 7 |
| Eureka | May 22 | May 25 | May 29 | June 3 | June 8 |
| Highmore | May 17 | May 20 | May 24 | May 29 | June 3 |
| Milbank | May 14 | May 17 | May 21 | May 26 | May 31 |
| Mitchell | May 10 | May 13 | May 17 | May 22 | May 27 |
| Oelrichs | May 18 | May 21 | May 25 | May 30 | June 3 |
| Redfield | May 17 | May 20 | May 24 | May 29 | June 2 |
| Sioux Falls | May 9 | May 12 | May 16 | May 21 | May 26 |

**Table 5. Spring Dates After Which There Is the Given Likelihood of a Temperature of 28° F. or Lower**

| Station | 40% | 30% | 20% | 10% | 5% |
|---|---|---|---|---|---|
| Aberdeen | May 7 | May 10 | May 14 | May 19 | May 24 |
| Academy | May 1 | May 4 | May 8 | May 13 | May 17 |
| Brookings | May 8 | May 11 | May 15 | May 20 | May 25 |
| Camp Crook | May 14 | May 17 | May 21 | May 26 | May 30 |
| Cottonwood | May 10 | May 13 | May 17 | May 22 | May 27 |
| Eureka | May 13 | May 16 | May 20 | May 26 | May 30 |
| Highmore | May 8 | May 11 | May 15 | May 20 | May 25 |
| Milbank | May 7 | May 10 | May 14 | May 19 | May 24 |
| Mitchell | May 2 | May 5 | May 9 | May 15 | May 19 |
| Oelrichs | May 7 | May 10 | May 14 | May 19 | May 23 |
| Redfield | May 7 | May 10 | May 14 | May 19 | May 23 |
| Sioux Falls | Apr 29 | May 2 | May 6 | May 11 | May 16 |

**Table 6. Spring Dates After Which There Is the Given Likelihood of a Temperature of 24° F. or Lower**

| Station | 40% | 30% | 20% | 10% | 5% |
|---|---|---|---|---|---|
| Aberdeen | Apr 26 | Apr 30 | May 3 | May 8 | May 13 |
| Academy | Apr 23 | Apr 26 | Apr 30 | May 5 | May 9 |
| Brookings | Apr 28 | May 1 | May 5 | May 10 | May 15 |
| Camp Crook | May 2 | May 5 | May 9 | May 14 | May 19 |
| Cottonwood | Apr 30 | May 3 | May 7 | May 12 | May 17 |
| Eureka | May 6 | May 9 | May 13 | May 19 | May 23 |
| Highmore | Apr 29 | May 2 | May 6 | May 11 | May 16 |
| Milbank | Apr 23 | Apr 26 | Apr 30 | May 5 | May 9 |
| Mitchell | Apr 18 | Apr 21 | Apr 25 | Apr 30 | May 3 |
| Oelrichs | Apr 27 | Apr 30 | May 4 | May 9 | May 13 |
| Redfield | Apr 28 | May 1 | May 5 | May 10 | May 14 |
| Sioux Falls | Apr 18 | Apr 21 | Apr 25 | Apr 30 | May 4 |

## Likelihood of a Freeze Before a Given Date in the Fall

The first occurrence in the fall of a temperature that will damage a specific crop will determine the growing season for that crop. In order to select varieties best adapted to any locality the farmer needs to know when damaging temperatures are likely to occur as well as the time required for the different crops to mature. Table 7 shows the average dates for the first freeze in the fall for 12 South Dakota areas included in this study.

The likelihood of temperatures, within the various temperature categories, occurring in the fall are shown in Figs. 15-26 (see pages 22 to 27). Tables 8 to 11 are presented as an aid in reading the information presented in the figures.

**Table 7. Average Dates of First Freeze in Fall for Selected South Dakota Stations**

| Station | Temperature Category | | | |
|---|---|---|---|---|
| | 34° F. and lower | 32° F. and lower | 28° F. and lower | 24° F. and lower |
| Aberdeen | Sept 20 | Sept 24 | Oct 1 | Oct 11 |
| Academy | Sept 23 | Sept 28 | Oct 7 | Oct 18 |
| Brookings | Sept 19 | Sept 24 | Oct 2 | Oct 11 |
| Camp Crook | Sept 13 | Sept 18 | Sept 27 | Oct 5 |
| Cottonwood | Sept 18 | Sept 21 | Oct 2 | Oct 12 |
| Eureka | Sept 12 | Sept 16 | Sept 28 | Oct 6 |
| Highmore | Sept 20 | Sept 25 | Oct 2 | Oct 12 |
| Milbank | Sept 23 | Sept 27 | Oct 7 | Oct 15 |
| Mitchell | Sept 24 | Sept 30 | Oct 8 | Oct 19 |
| Oelrichs | Sept 18 | Sept 20 | Oct 1 | Oct 10 |
| Redfield | Sept 19 | Sept 24 | Oct 3 | Oct 11 |
| Sioux Falls | Sept 27 | Oct 1 | Oct 9 | Oct 23 |

**Table 8. Fall Dates Before Which There Is the Given Likelihood of a Temperature of 34° F. or Lower**

| Station | 40% | 30% | 20% | 10% | 5% |
|---|---|---|---|---|---|
| Aberdeen | Sept 17 | Sept 14 | Sept 10 | Sept 5 | Sept 1 |
| Academy | Sept 20 | Sept 17 | Sept 13 | Sept 8 | Sept 4 |
| Brookings | Sept 16 | Sept 13 | Sept 8 | Sept 4 | Aug 30 |
| Camp Crook | Sept 10 | Sept 7 | Sept 3 | Aug 28 | Aug 25 |
| Cottonwood | Sept 15 | Sept 13 | Sept 8 | Sept 3 | Aug 30 |
| Eureka | Sept 9 | Sept 5 | Sept 1 | Aug 28 | Aug 29 |
| Highmore | Sept 17 | Sept 14 | Sept 10 | Sept 5 | Sept 1 |
| Milbank | Sept 20 | Sept 17 | Sept 13 | Sept 8 | Sept 4 |
| Mitchell | Sept 21 | Sept 18 | Sept 14 | Sept 8 | Sept 4 |
| Oelrichs | Sept 15 | Sept 12 | Sept 8 | Sept 2 | Aug 29 |
| Redfield | Sept 16 | Sept 13 | Sept 9 | Sept 4 | Aug 30 |
| Sioux Falls | Sept 24 | Sept 21 | Sept 17 | Sept 12 | Sept 8 |

**Table 9. Fall Dates Before Which There Is the Given Likelihood of a Temperature of 32° F. or Lower**

| Station | 40% | 30% | 20% | 10% | 5% |
|---|---|---|---|---|---|
| Aberdeen | Sept 21 | Sept 17 | Sept 14 | Sept 8 | Sept 4 |
| Academy | Sept 25 | Sept 22 | Sept 18 | Sept 12 | Sept 8 |
| Brookings | Sept 21 | Sept 18 | Sept 14 | Sept 9 | Sept 4 |
| Camp Crook | Sept 15 | Sept 12 | Sept 8 | Sept 3 | Aug 29 |
| Cottonwood | Sept 18 | Sept 15 | Sept 11 | Sept 6 | Sept 1 |
| Eureka | Sept 12 | Sept 8 | Sept 6 | Sept 1 | Aug 27 |
| Highmore | Sept 22 | Sept 19 | Sept 15 | Sept 10 | Sept 5 |
| Milbank | Sept 24 | Sept 21 | Sept 17 | Sept 12 | Sept 7 |
| Mitchell | Sept 27 | Sept 24 | Sept 20 | Sept 15 | Sept 10 |
| Oelrichs | Sept 17 | Sept 14 | Sept 10 | Sept 5 | Sept 1 |
| Redfield | Sept 21 | Sept 18 | Sept 14 | Sept 9 | Sept 4 |
| Sioux Falls | Sept 28 | Sept 25 | Sept 21 | Sept 16 | Sept 11 |

Table 10. Fall Dates Before Which There Is the Given Likelihood of a Temperature of 28° F. or Lower

| Station | 40% | 30% | 20% | 10% | 5% |
|---|---|---|---|---|---|
| Aberdeen | Sept 28 | Sept 24 | Sept 21 | Sept 16 | Sept 12 |
| Academy | Oct 4 | Oct 1 | Sept 27 | Sept 22 | Sept 18 |
| Brookings | Sept 29 | Sept 26 | Sept 22 | Sept 17 | Sept 12 |
| Camp Crook | Sept 24 | Sept 21 | Sept 17 | Sept 12 | Sept 7 |
| Cottonwood | Sept 29 | Sept 26 | Sept 22 | Sept 17 | Sept 12 |
| Eureka | Sept 25 | Sept 22 | Sept 18 | Sept 13 | Sept 8 |
| Highmore | Sept 29 | Sept 26 | Sept 22 | Sept 17 | Sept 12 |
| Milbank | Oct 4 | Oct 1 | Sept 27 | Sept 22 | Sept 17 |
| Mitchell | Oct 5 | Oct 2 | Sept 28 | Sept 23 | Sept 18 |
| Oelrichs | Sept 28 | Sept 25 | Sept 21 | Sept 16 | Sept 11 |
| Redfield | Sept 30 | Sept 27 | Sept 23 | Sept 18 | Sept 13 |
| Sioux Falls | Oct 6 | Oct 3 | Sept 29 | Sept 24 | Sept 19 |

Table 11. Fall Dates Before Which There Is the Given Likelihood of a Temperature of 24° F. or Lower

| Station | 40% | 30% | 20% | 10% | 5% |
|---|---|---|---|---|---|
| Aberdeen | Oct 8 | Oct 4 | Oct 1 | Sept 25 | Sept 21 |
| Academy | Oct 15 | Oct 12 | Oct 8 | Oct 3 | Sept 28 |
| Brookings | Oct 8 | Oct 5 | Oct 1 | Sept 25 | Sept 21 |
| Camp Crook | Oct 2 | Sept 29 | Sept 25 | Sept 20 | Sept 15 |
| Cottonwood | Oct 9 | Oct 6 | Oct 2 | Sept 27 | Sept 22 |
| Eureka | Oct 3 | Sept 20 | Sept 26 | Sept 21 | Sept 16 |
| Highmore | Oct 9 | Oct 6 | Oct 2 | Sept 27 | Sept 22 |
| Milbank | Oct 12 | Oct 9 | Oct 5 | Sept 30 | Sept 25 |
| Mitchell | Oct 16 | Oct 13 | Oct 9 | Oct 4 | Sept 29 |
| Oelrichs | Oct 7 | Oct 4 | Sept 30 | Sept 25 | Sept 20 |
| Redfield | Oct 8 | Oct 5 | Oct 1 | Sept 26 | Sept 21 |
| Sioux Falls | Oct 20 | Oct 17 | Oct 13 | Oct 8 | Oct 3 |

## Summary

Four categories of freeze temperature data have been analyzed for 12 South Dakota weather observation stations. These are 34° F. or lower, 32° F. or lower, 28° F. or lower, and 24° F. or lower.

To be successful, farming operations must be planned on the basis of temperature during seeding and harvesting periods. Ordinarily a farmer will not wish to assume a risk greater than one in ten for general farming operations. In case of valuable crops from which a high return might be expected from early maturity a farmer might be justified in assuming a risk higher than 10 percent on a part of his acreage.

By making use of these freeze data a farmer will be able to determine as well as to minimize his risk from damaging low temperatures while making full use of the growing season.

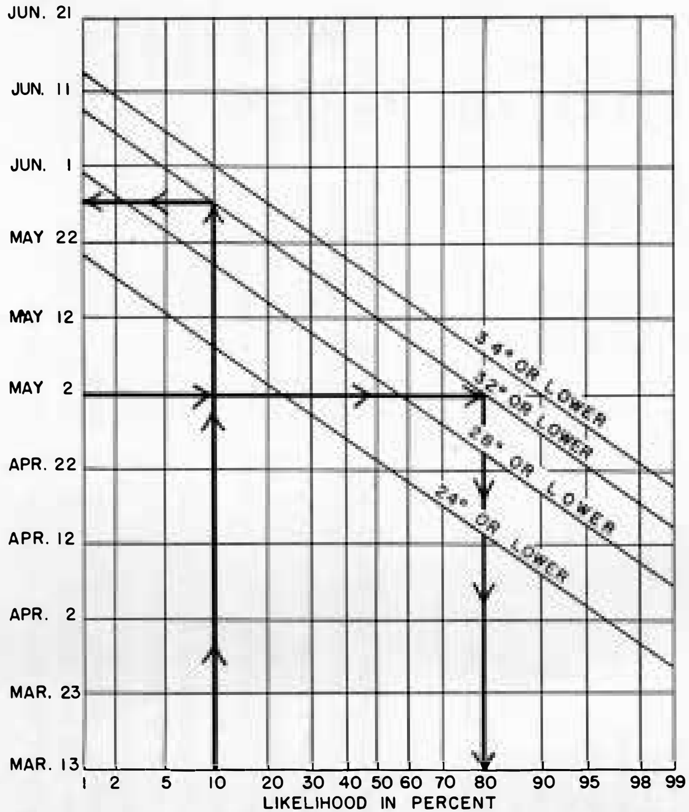



Fig. 3. ABERDEEN, South Dakota—Likelihood of freeze temperatures occuring on any date in the spring

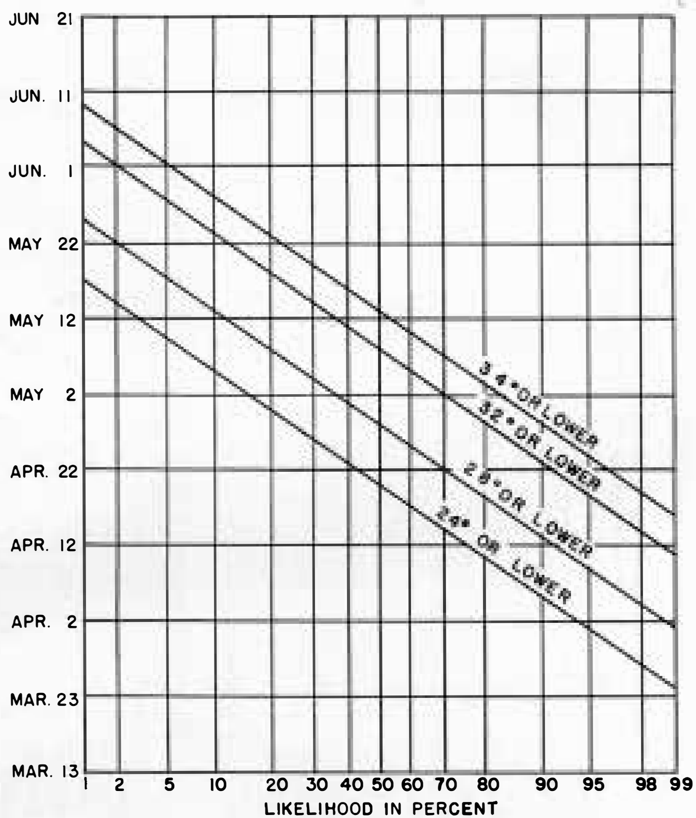



Fig. 4. ACADEMY, South Dakota—Likelihood of freeze temperatures occurring on any date in the spring

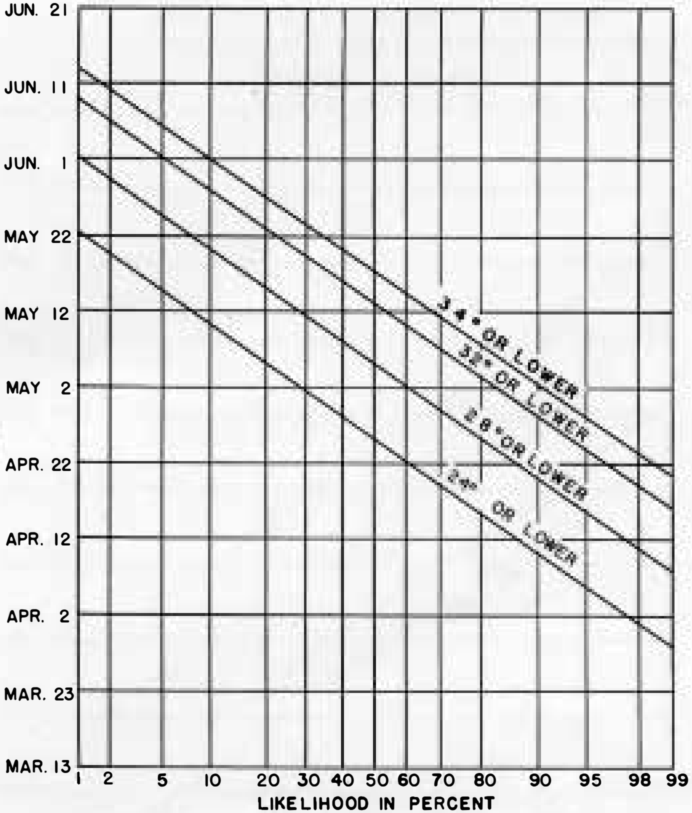



Fig. 5. BROOKINGS, South Dakota—Likelihood of freeze temperatures occurring on any date in the spring

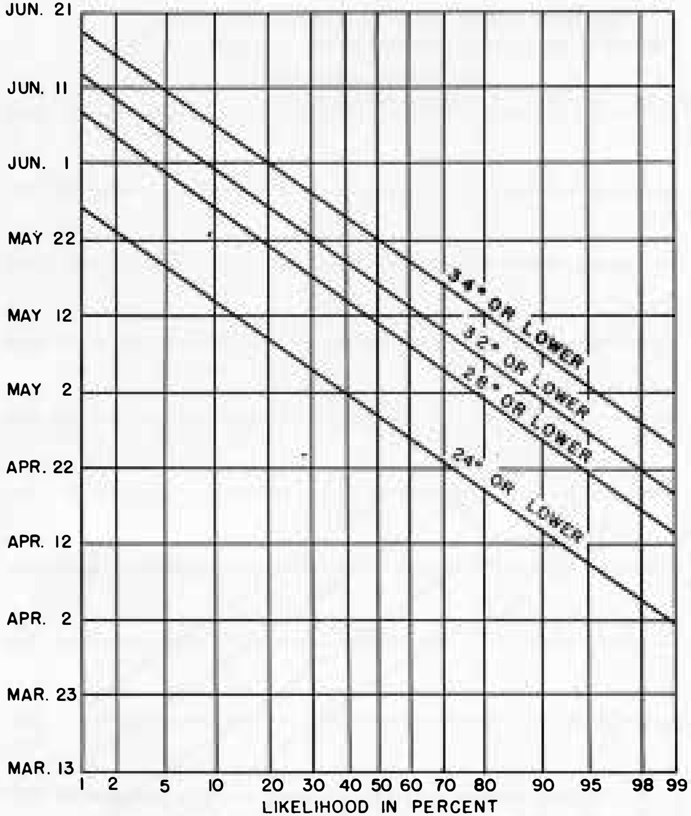



Fig. 6. CAMP CROOK, South Dakota—Likelihood of freeze temperatures occurring on any date in the spring

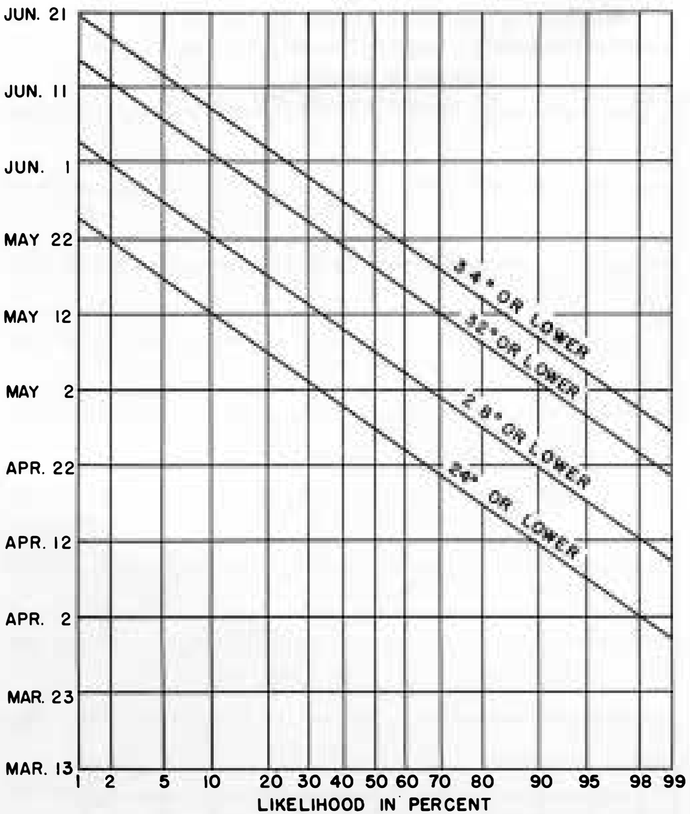



Fig. 7. COTTONWOOD, South Dakota—Likelihood of freeze temperatures occurring on any date in the spring

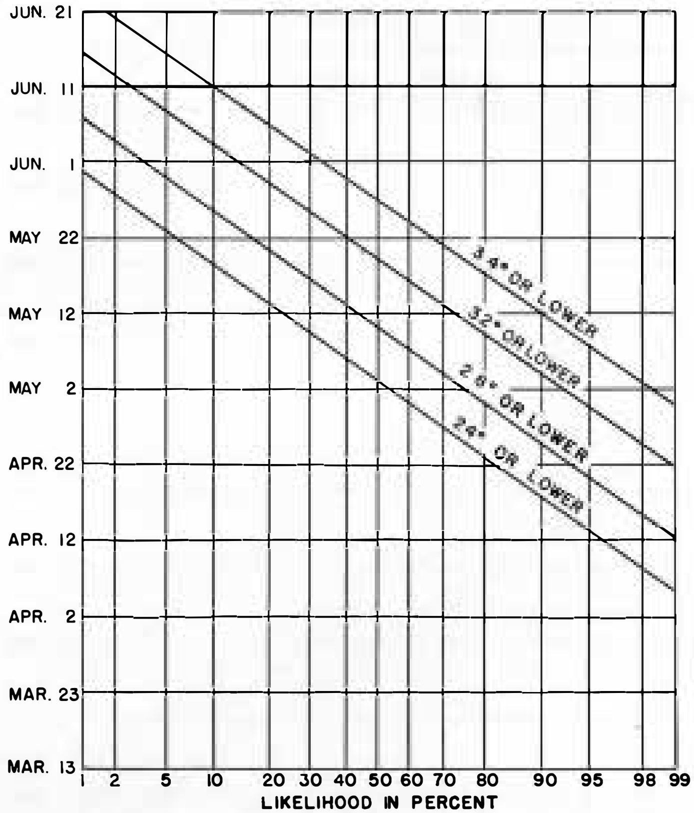



Fig. 8. EUREKA, South Dakota—Likelihood of freeze temperatures occurring on any date in the spring

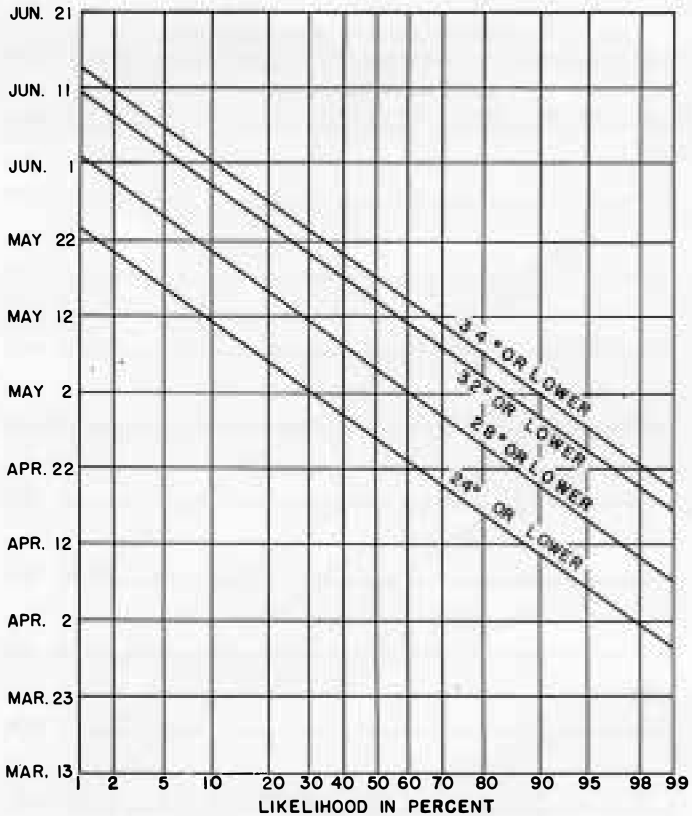



Fig. 9. HIGHMORE, South Dakota—Likelihood of freeze temperatures occurring on any date in the spring

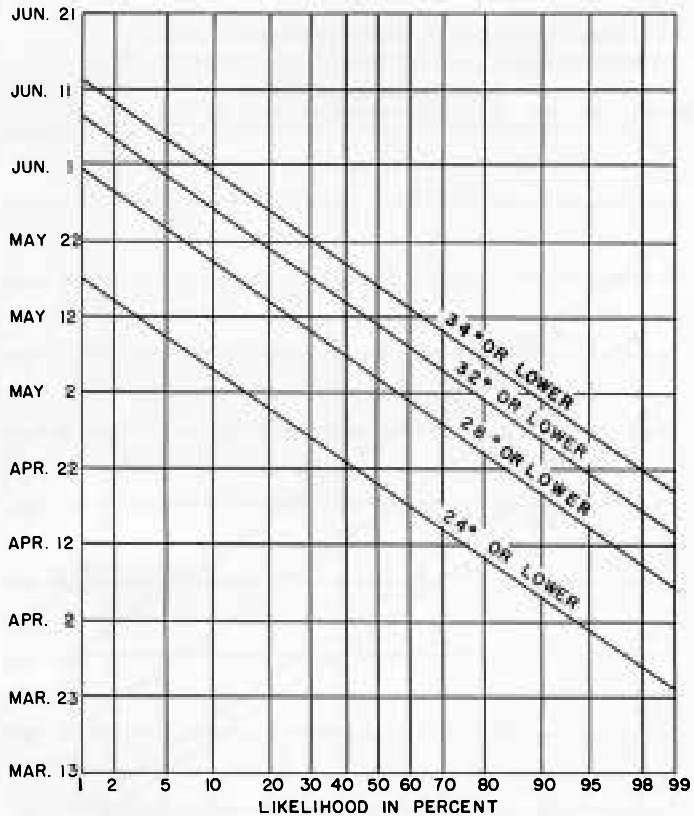



Fig. 10. MILBANK, South Dakota—Likelihood of freeze temperatures occurring on any date in the spring

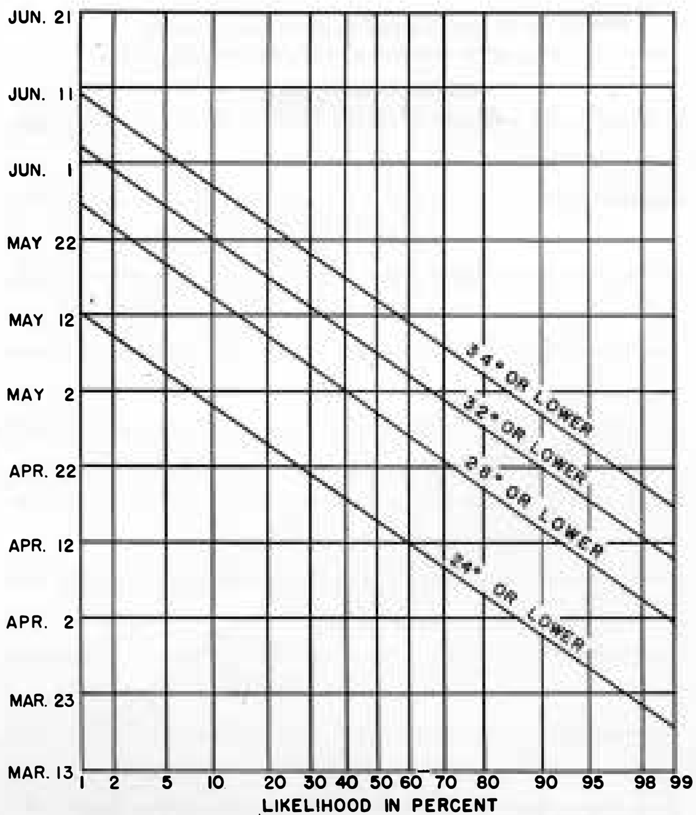



Fig. 11. MITCHELL, South Dakota—Likelihood of freeze temperatures occurring on any date in the spring

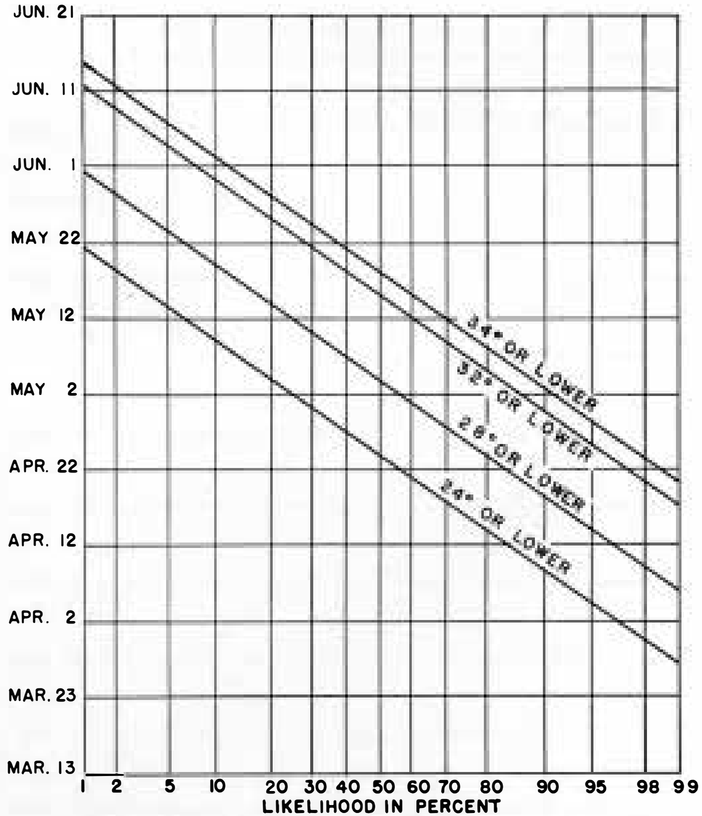



Fig. 12. OELRICHS, South Dakota—Likelihood of freeze temperatures occurring on any date in the spring

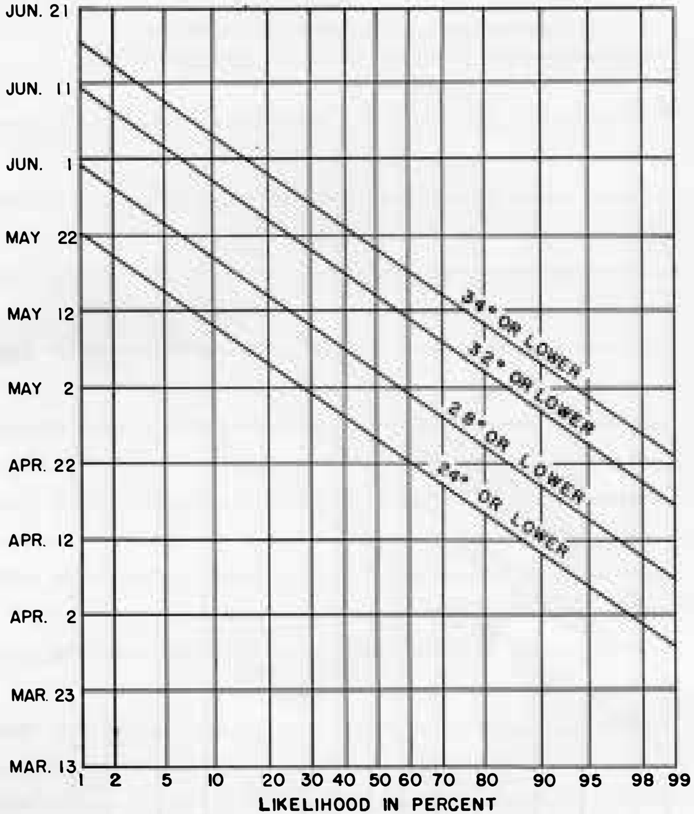



**Fig. 13. REDFIELD,** South Dakota—Likelihood of freeze temperatures occurring on any date in the spring

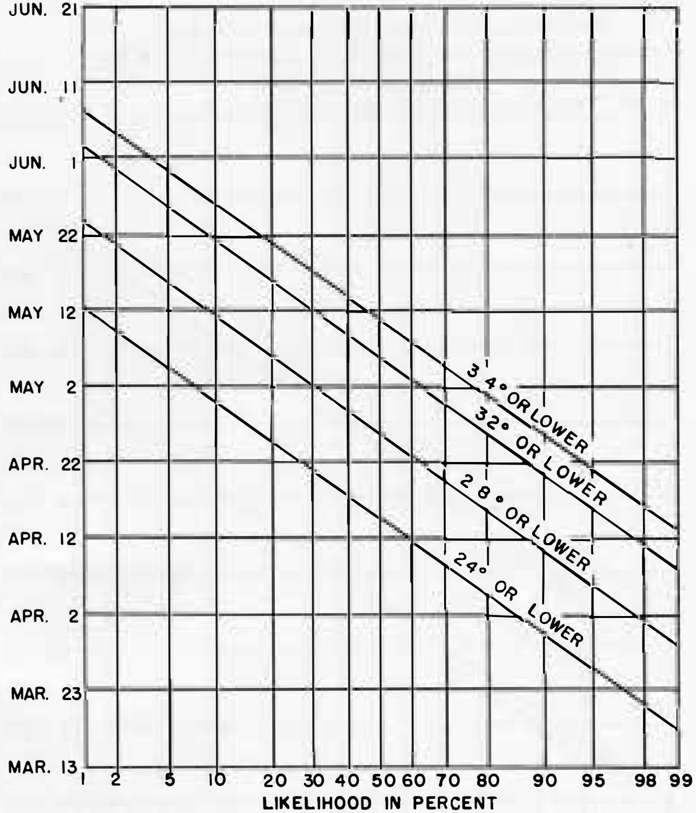



**Fig. 14. SIOUX FALLS,** South Dakota—Likelihood of freeze temperatures occurring on any date in the spring

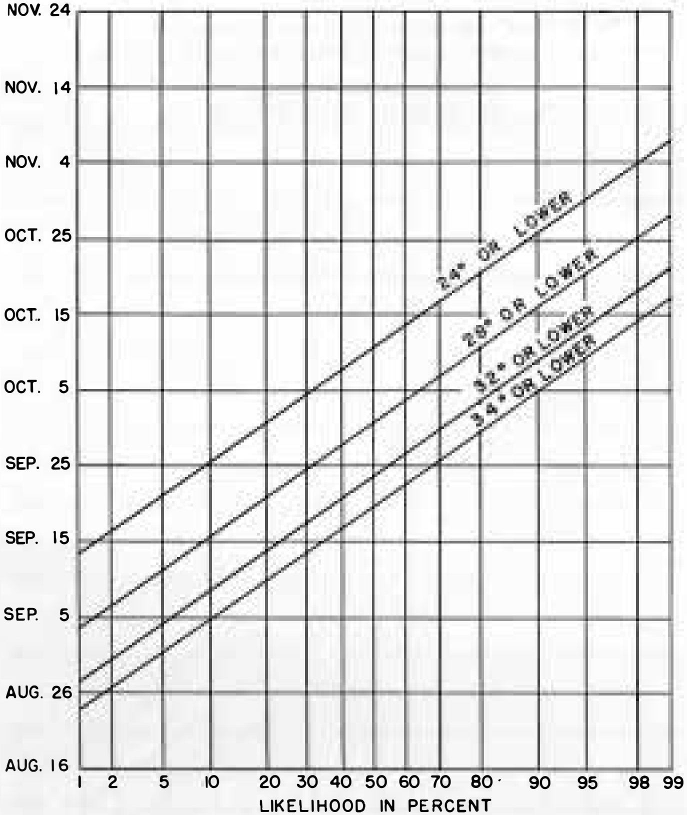



**Fig. 15. ABERDEEN, South Dakota—Likelihood of freeze temperatures occurring on any date in the fall**

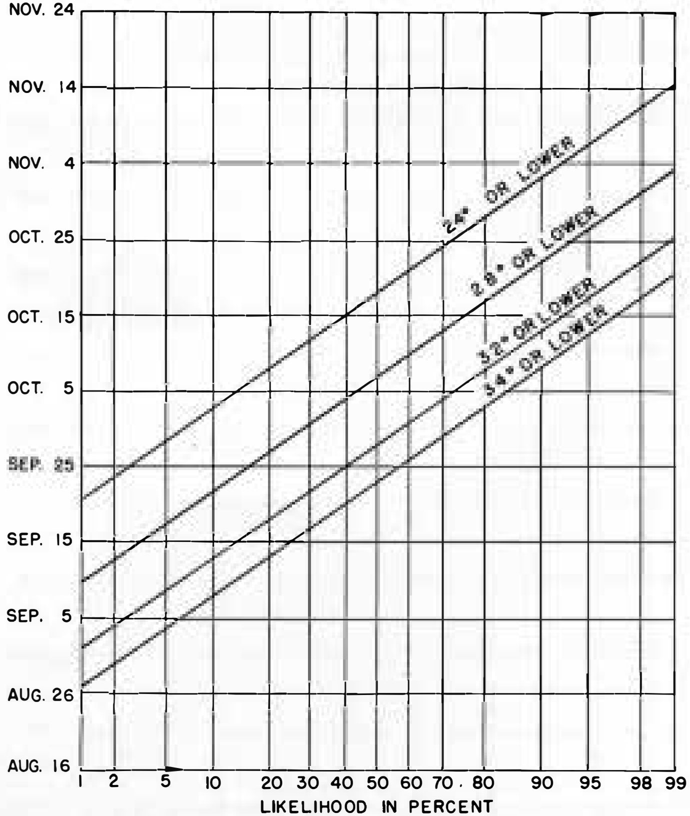



**Fig. 16. ACADEMY, South Dakota—Likelihood of freeze temperatures occurring on any date in the fall**

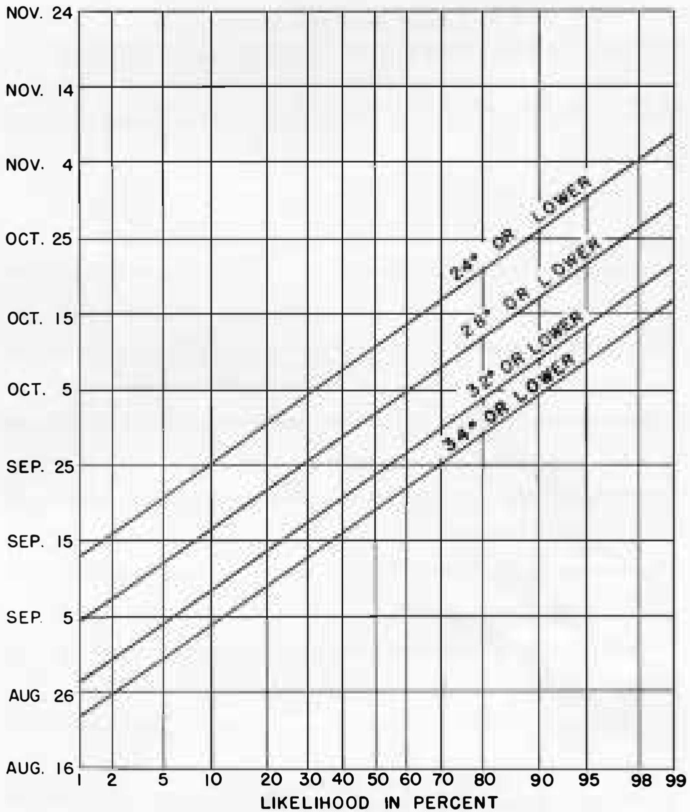



Fig. 17. BROOKINGS, South Dakota—Likelihood of freeze temperatures occurring on any date in the fall

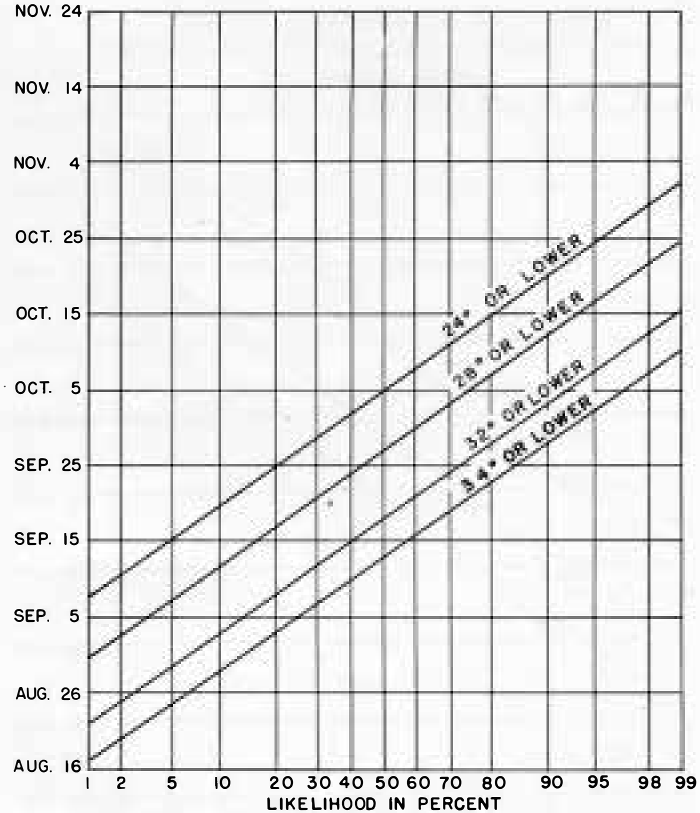



Fig. 18. CAMP CROOK, South Dakota—Likelihood of freeze temperatures occurring on any date in the fall

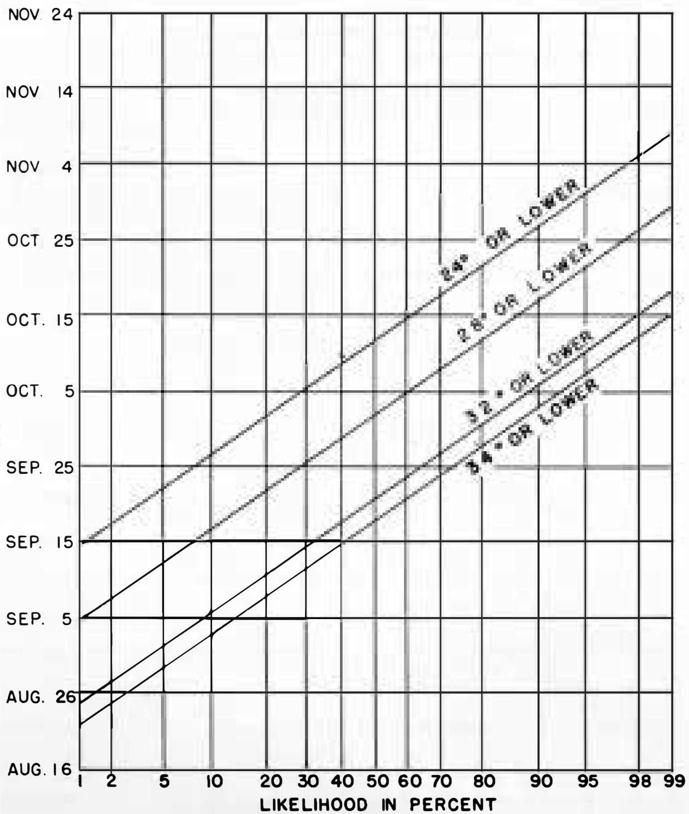



Fig. 19. COTTONWOOD, South Dakota—Likelihood of freeze temperatures occurring on any date in the fall

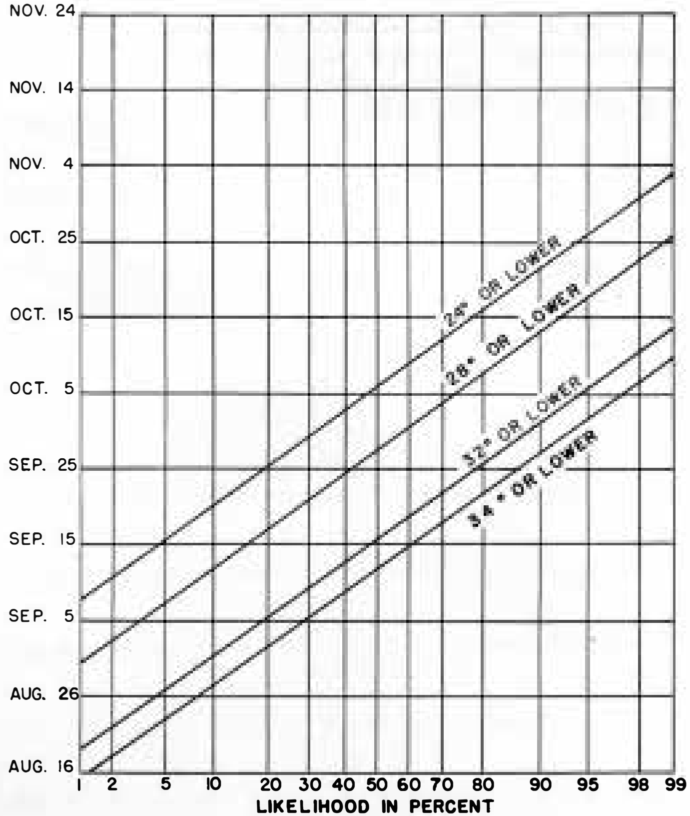



Fig. 20. EUREKA, South Dakota—Likelihood of freeze temperatures occurring on any date in the fall

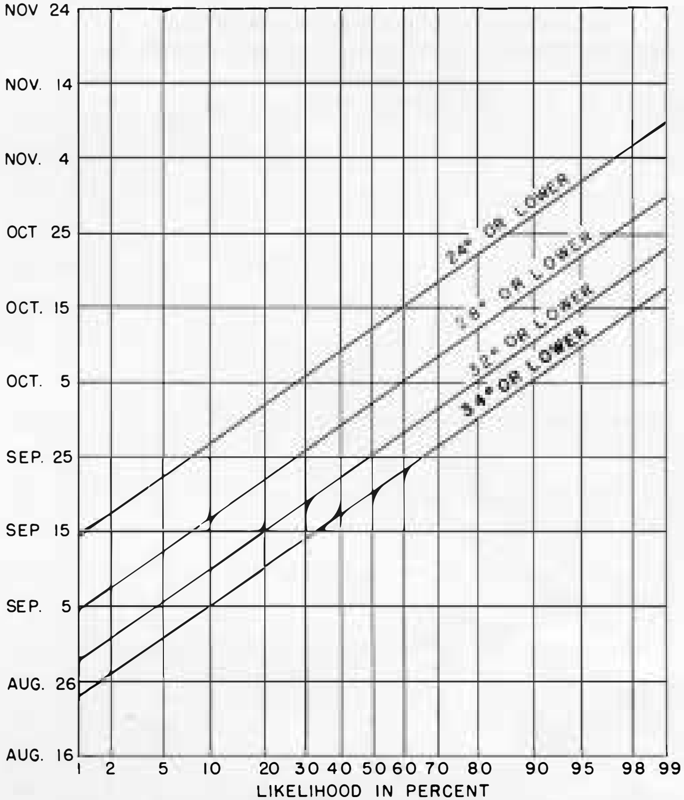



Fig. 21. HIGHMORE, South Dakota—Likelihood of freeze temperatures occurring on any date in the fall

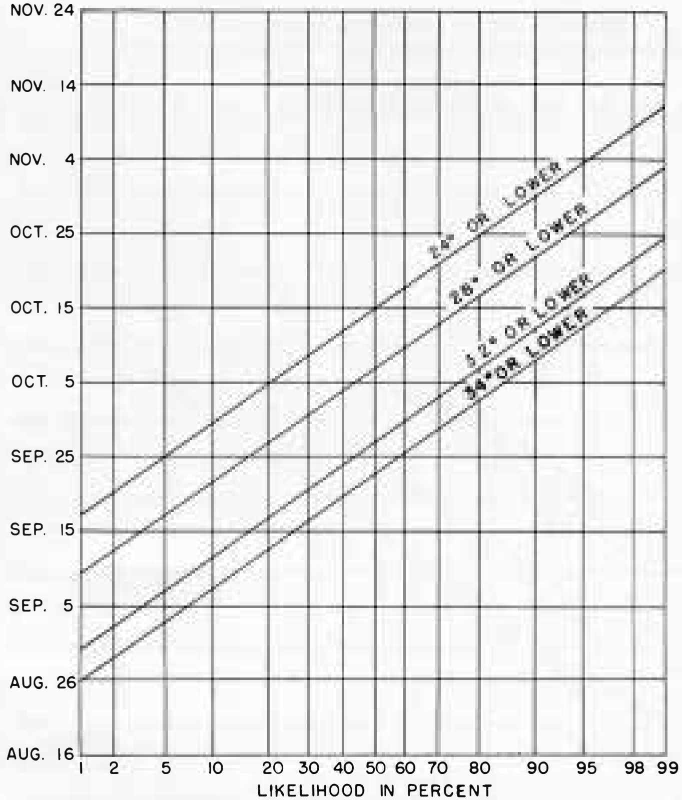



Fig. 22. MILBANK, South Dakota—Likelihood of freeze temperatures occurring on any date in the fall

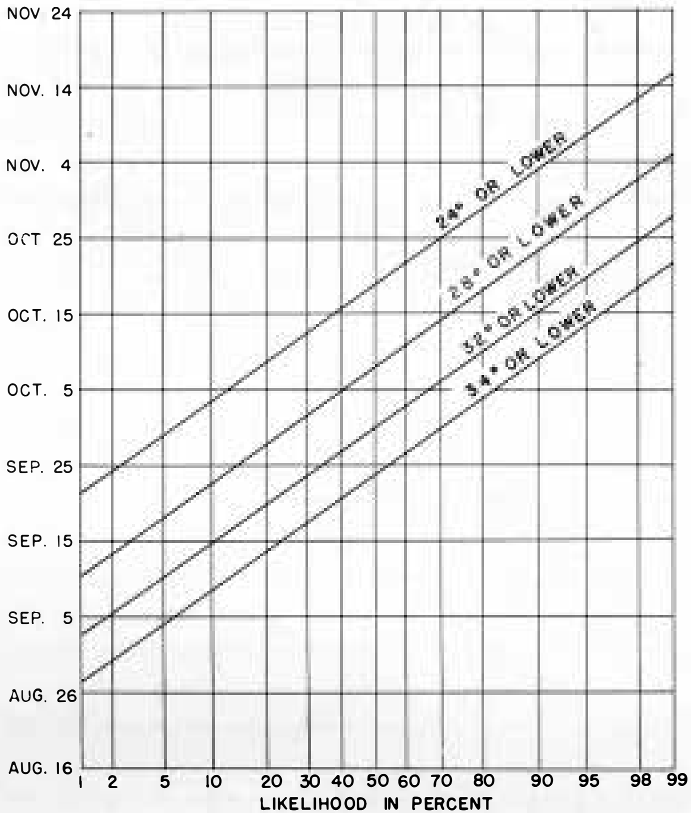



Fig. 23. MITCHELL, South Dakota—Likelihood of freeze temperatures occurring on any date in the fall

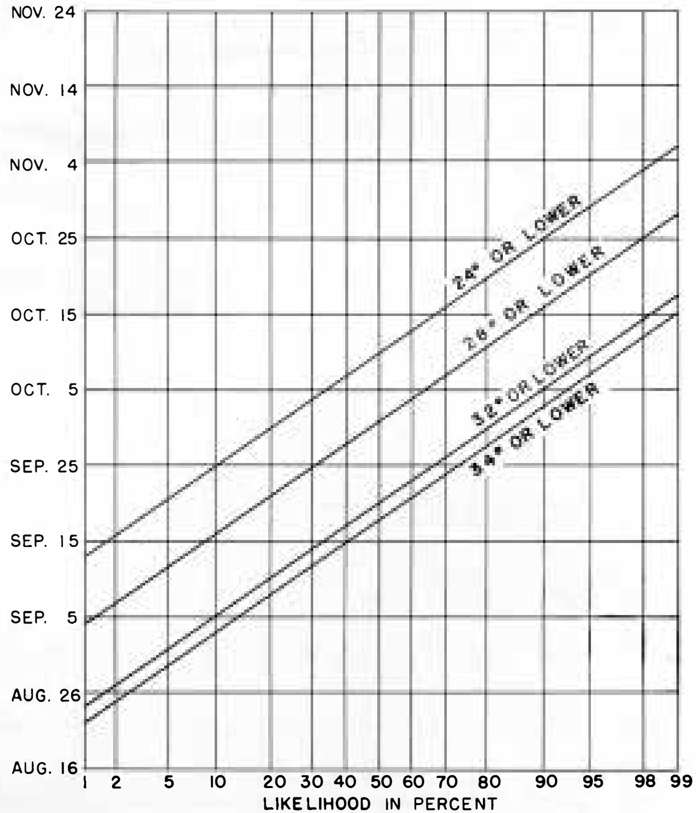



Fig. 24. OELRICHS, South Dakota—Likelihood of freeze temperatures occurring on any date in the fall

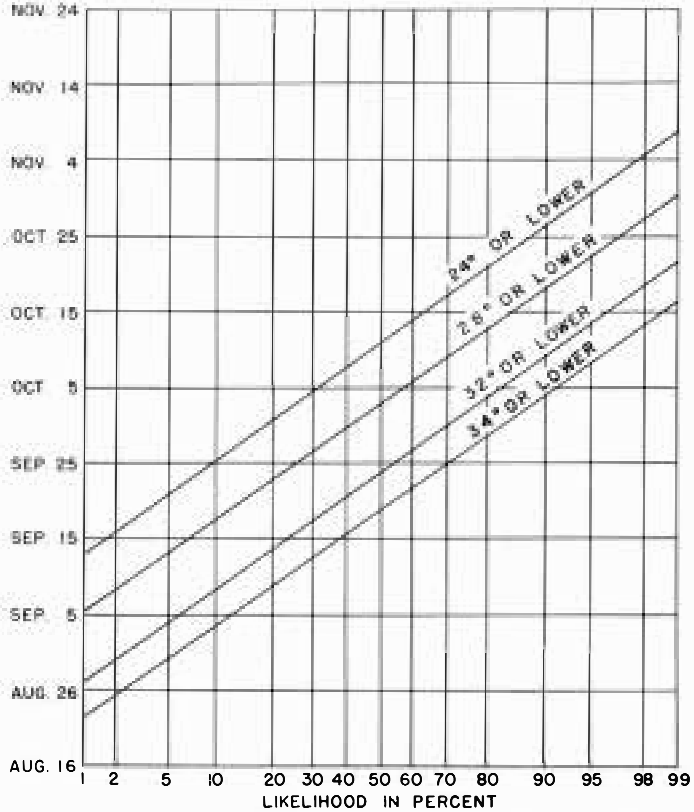



Fig. 25. REDFIELD, South Dakota—Likelihood of freeze temperatures occurring on any date in the fall

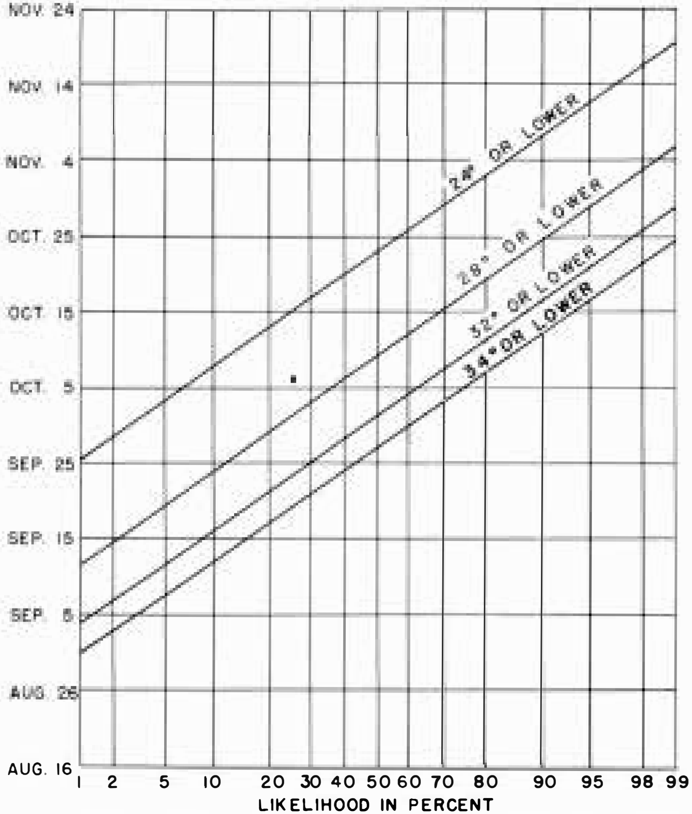



Fig. 26. SIOUX FALLS, South Dakota—Likelihood of freeze temperatures occurring on any date in the fall