THORNTHWAITE'S MOISTURE INDEX AS A MEASURE OF THE INTENSITY TO WHICH HARVESTED CROPLAND IS DEVOTED TO CORN UNDER NATURAL CLIMATIC CONDITIONS

by

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THORNTHWAITE'S MOISTURE INDEX AS A MEASURE OF THE INTENSITY TO WHICH HARVESTED CROPLAND IS DEVOTED TO CORN UNDER NATURAL CLIMATIC CONDITIONS

ABSTRACT: Moisture has long been identified as one of the major limiting factors in the distribution of agricultural land use practices. However, the importance of any environmental element can only be determined by considering how it is affected by its relationship with other elements of the environment. Thornthwaite's moisture index attempts to measure the moisture conditions of an area as they are controlled by other environmental conditions. Through analysis of variance, this study seeks to determine whether Thornthwaite's moisture index can be used as a measure of the intensity to which harvested cropland is devoted to corn in the Corn Belt of the United States.

The natural environment of a plant is a dynamic and ever-changing complex of elements. All of these elements are in a state of constant variation. The rates of change in intensity of each, the time of their duration, and the extreme values reached by each all have a direct effect on the survival and productivity of a plant.[1]

Modern agriculture is concerned with using each parcel of land to its productive optimum. This requires an analysis of the several components which combine to determine the quality of a given site for agricultural production. The farmer then attempts to select the crops and production processes which will result in the highest possible level of production from his land.

THE PROBLEM

If one assumes that there is some environmental variable (or combination of variables) which is paramount in regulating the distribution of crops, the next step is to analyse those components of the environmental complex which appear to exercise this overriding control. This study attempts such an analysis. Its objective is to determine whether the spatial variation of moisture, when measured by Thornthwaite's moisture index, coincides with that of the intensity to which land is planted to corn in the Middle West.

LITERATURE REVIEW

Moisture is one of the major environmental factors which determines the kind of crops that can be grown in an area.[2] It is not only important as a reagent in photosynthesis, but is essential for turgidity, maintenance of leaf form and several of the other physiological movements of plants.[3] Its overall importance is well reflected in the fact that water alone accounts for 85 to 90 percent of the green weight of a plant.

There are several sources from which a plant may obtain its water requirements. These include the many aspects of atmospheric moisture such as precipitation, moisture held within the air (humidity), dew and the like, and soil moisture. However, the extent to which each of these is able to add to the moisture supply of a plant

depends on their relationship with other aspects of the environment such as temperature, length of the growing season, latitude, drainage, etc.[4]

Perhaps one of the more notable attempts to combine several of the more important environmental elements which affect the moisture available for plant growth into one meaningful measure is that by C. W. Thornthwaite. In 1955 Thornthwaite presented an index which combined temperature, precipitation, latitude, potential evapotranspiration, and total runoff into an index which reflects the moisture conditions at a given station for the period through which the variables are measured.[5] Although this new index was only a slight modification of the one Thornthwaite presented in 1948,[6] the latter was based on nearly five decades of research by various authors.[7]

Thornthwaite's moisture index is actually a combination of two of his other climatic indices. It is derived by subtracting his aridity index from his index of humidity. That is,

$$I_m = I_h - I_a = 100 \left(\frac{S}{PE} - \frac{D}{PE}\right)$$

where: I_m = moisture index
I_h = index of humidity
I_a = aridity index
S = moisture surplus (precipitation - actual evapotranspiration)
D = moisture deficit (potential evapotranspiration - actual evapotranspiration)
PE = potential evapotranspiration.

If one is interested in calculating only the moisture index, the above formula may be reduced to $I_m = 100 \left(\frac{ppn}{PE} - 1\right)$.[8] Positive values represent a moisture shortage. Although this new formulation of Thornthwaite's moisture index has been available for more than a decade, it has not been used in any climatological studies and has received only limited attention in climate classification.[9]

Thornthwaite's moisture index may be calculated for any station whose mean monthly temperature, latitude and monthly precipitation (in millimeters) is known. This data allows one to select values from several tables which are then introduced into nomograms for determining the actual and potential evapotranspiration of the station.[10] However, Thornthwaite Associates have published water balance data for selected stations throughout the world. This study analyses the 160 stations within the study area for which this published data is available.[11]

THE STUDY AREA

The area selected for testing Thornthwaite's moisture index as a measure of the intensity of land devoted to corn production is a composite of two descriptions of that area identified as the major corn producing region of the Middle West. It was delimited by using the outermost boundary created by combining those definitions of the Corn Belt by the Economic Research Service[12] and the Soil Conservation Service[13] of the United States Department of Agriculture. (see

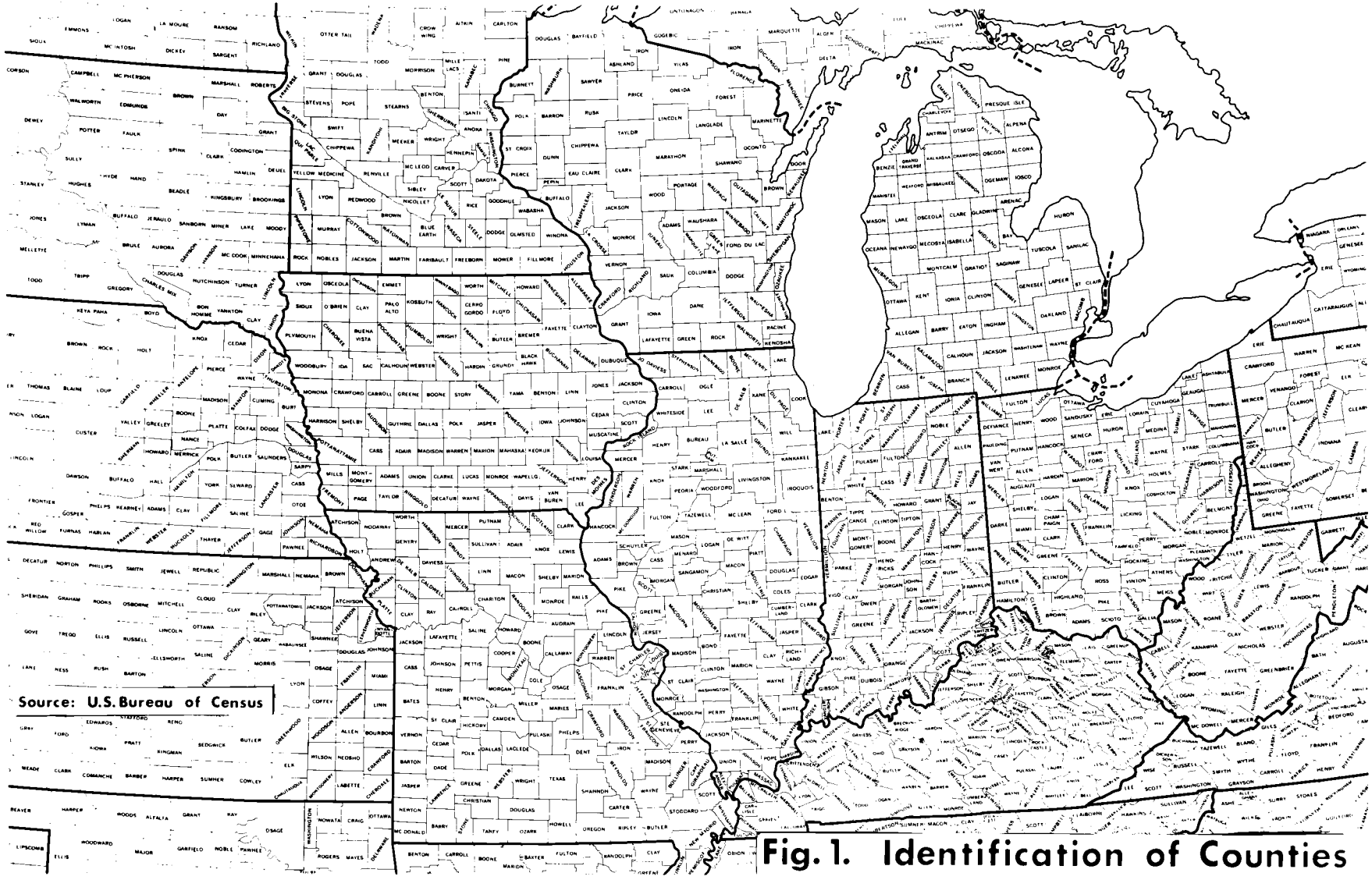


Fig. 1. Identification of Counties

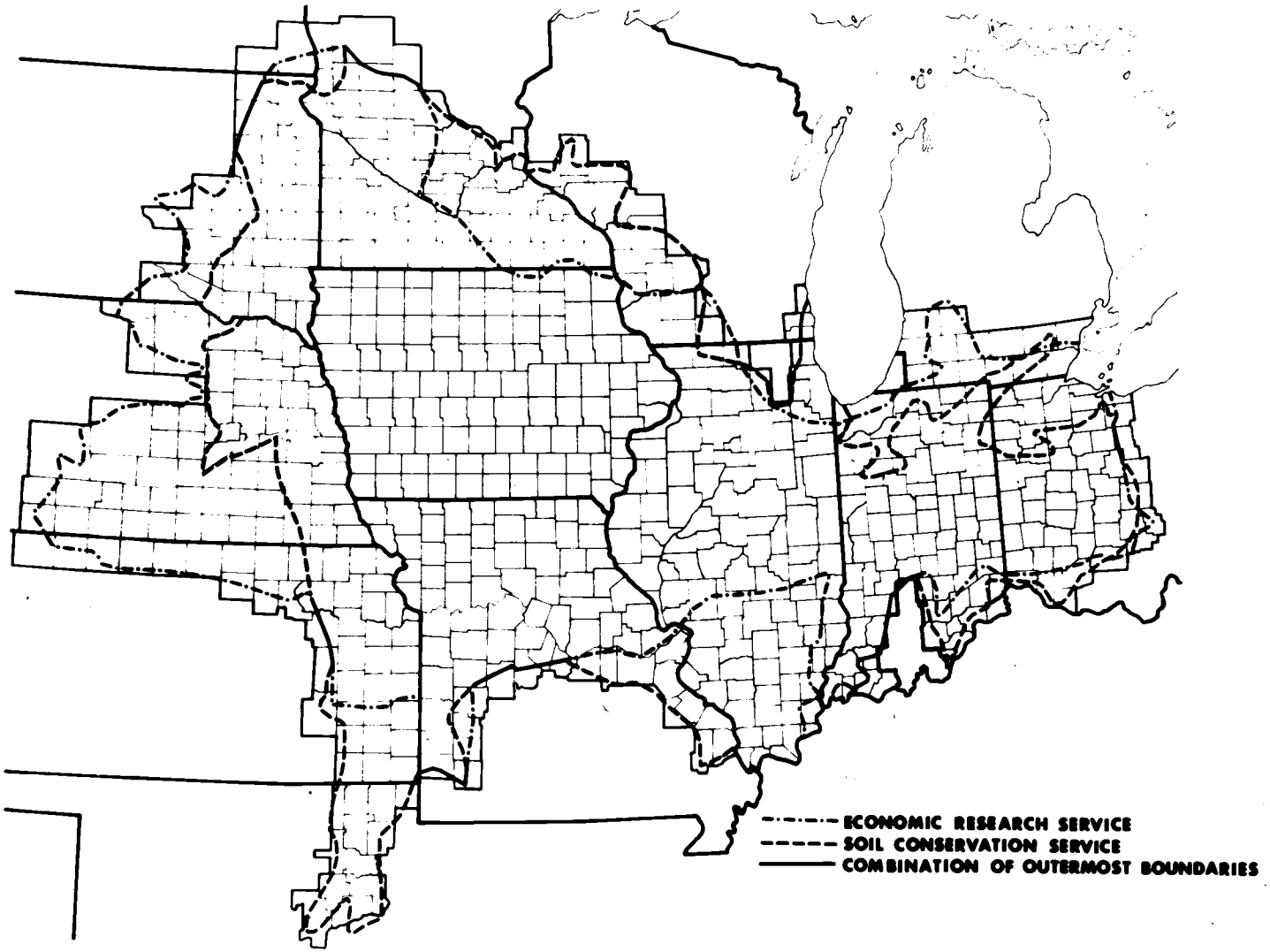
Fig. 2).[14] Since counties, of which there are 648 in the area thus delimited, were used as the basic areal data units, the final boundary encloses entire county units and does not divide them as do both of the above definitions.

ANALYSIS

The following analysis consists of three parts. First, it was necessary to determine the percent of harvested cropland devoted to corn in each of the 648 counties so that intensity classes could be formed. Next, Thornthwaite's moisture index was calculated for each county for which the necessary climatic data was available. Finally, each county with a moisture index was drawn from the three intensity groups and the means of the moisture indices of each of these groups compared through analysis of variance to determine whether the moisture indices vary as does the intensity to which land is devoted to corn within the study area.

Intensity of Harvested Cropland Devoted to Corn

In order to determine the percentage of harvested cropland devoted to corn, data was obtained from the Preliminary Reports of of the 1964 Census of Agriculture as to the total harvested acreage in each county, the acreage of corn harvested for all purposes, and the amount of harvested acreage that was under irrigation.[15] The percent of harvested cropland devoted to corn was calculated by dividing



Source: U.S.D.A.

Fig. 2. Derivation of Study Area Boundary

the second figure by the first.

The irrigation data was used as a control to exclude counties in which irrigation would compensate for deficit moisture conditions. A value greater than 30 percent for the ratio of irrigated acreage harvested to total acres harvested was considered sufficient to exclude that county from further calculations.[16] Nine counties were excluded in this manner. Table 1 lists the percentages for the amount of harvested acreage devoted to corn for the remaining 639 counties.

The mean and standard deviation were then calculated for the data on corn percentages. The mean being,

$$\mu = \frac{\sum_{i=1}^{N} x}{N}$$

where: μ = mean
x = an individual percentage
N = total number of counties

and, the standard deviation,

$$\sigma = \left(\frac{\sum_{i=1}^{N} x^2 - \frac{\left(\sum_{i=1}^{N} x\right)^2}{N}}{N} \right)^{1/2}$$

where: σ = standard deviation and x and N are as above.

Each county was then placed in one of three groups in the basis of the intensity of harvested cropland devoted to corn production

(Fig. 4). Low intensity corn producing counties were defined as those in which the ratio of corn to harvested acreage was less than one standard deviation below the mean; medium intensity as those in which this ratio was within one standard deviation about the mean; and, high intensity as those where the ratio was greater than one standard deviation above the mean. Figure 3 shows the method used in determining these boundary values.

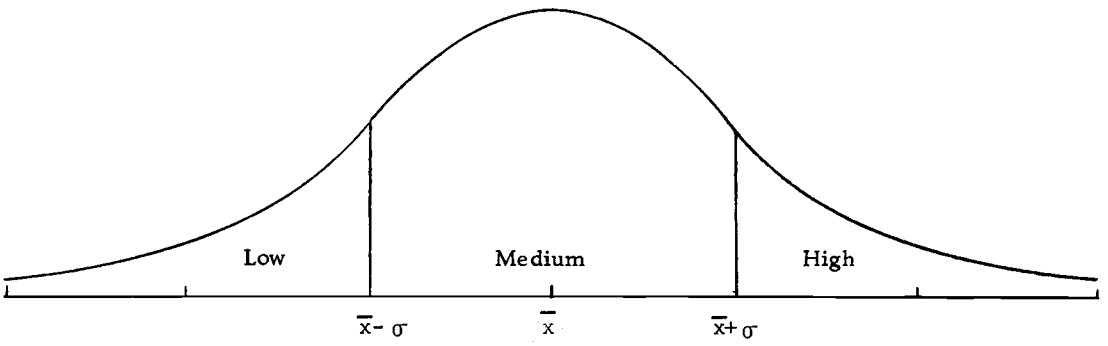
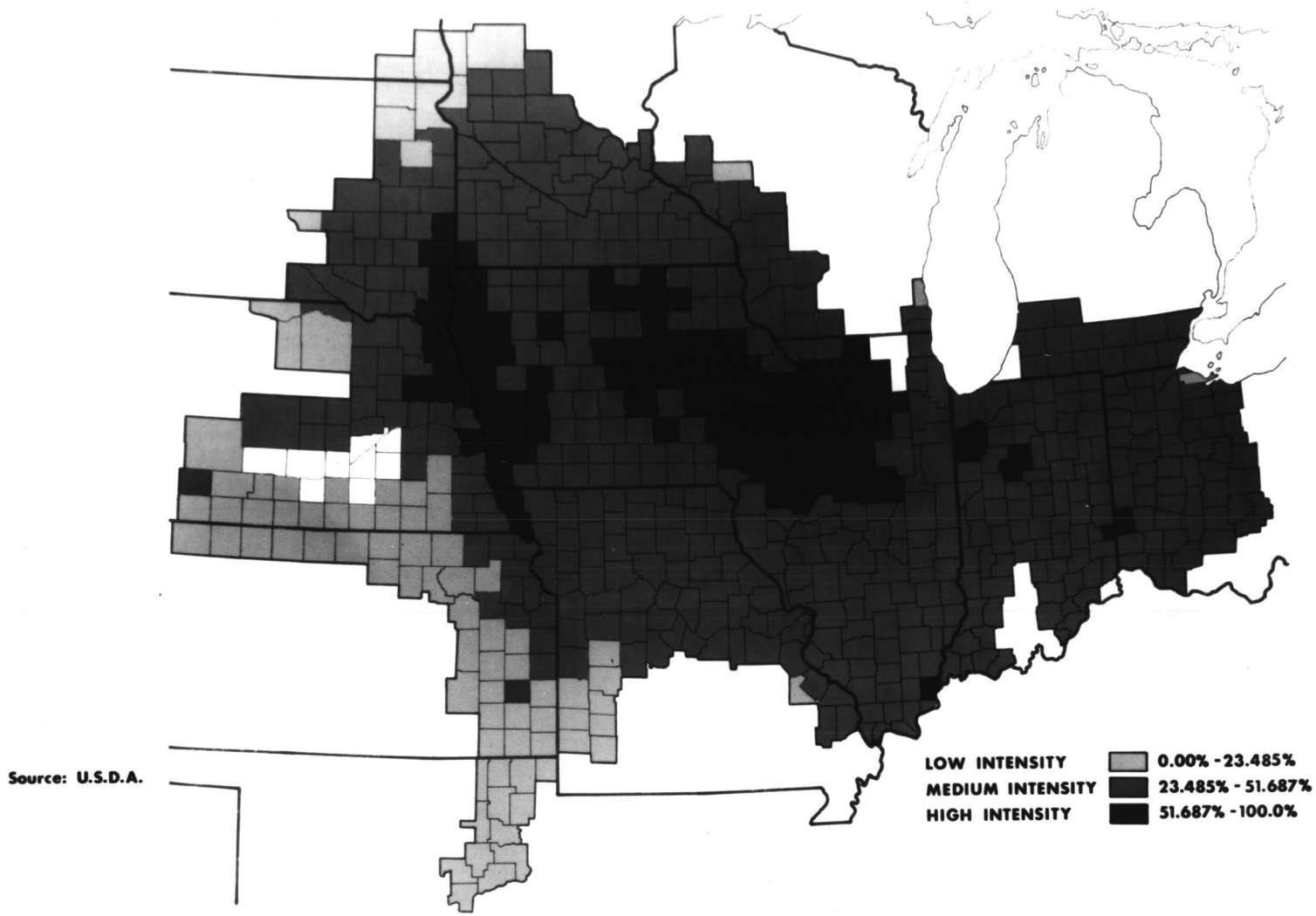


Fig. 3. Method of determining boundary values of land use intensity classes based on the percentage of harvested cropland devoted to corn.

Calculation of the Moisture Index

Thornthwaite's moisture index was then calculated for the 160 counties for which the necessary evapotranspiration data was available. This entailed the summation of the moisture indices for those months and portions of months contained within the mean $32^{o}F$ growing season for each station.[17] The formula for this calculation is:



Source: U.S.D.A.

Fig.4. Intensity of Harvested Cropland Devoted to Corn

$$I_m = 100 \sum_{i=a}^{b} \left(\frac{ppn}{PE} - 1\right)$$

where: I_m = moisture index
a = mean date of the last 32°F spring frost
b = mean date of the first 32°F fall frost
ppn = precipitation in millimeters
PE = potential evapotranspiration

Table 2 lists the stations in each county used for this calculation, the extreme dates of the 32°F frost-free season, and the value obtained for the moisture index when summed through this frost-free season. Figure 5 shows the areal variation of the moisture indices throughout the study area.

Analysis of Variance

The means of the moisture indices of each of the three intensity groups were then compared for equality through analysis of variance. This test tests the among-sample variance with the within-sample variance by comparing their ratio with Fisher's F-distribution.[18] A small value (near one) for this ratio infers that the variance within each sample is not significantly different enough from the variance between samples for them to be considered as representing populations with different means. Conversely, if the ratio is significantly greater than one,[19] it can be inferred that the samples were drawn from populations with different means. The formula for the analysis of variance test is:

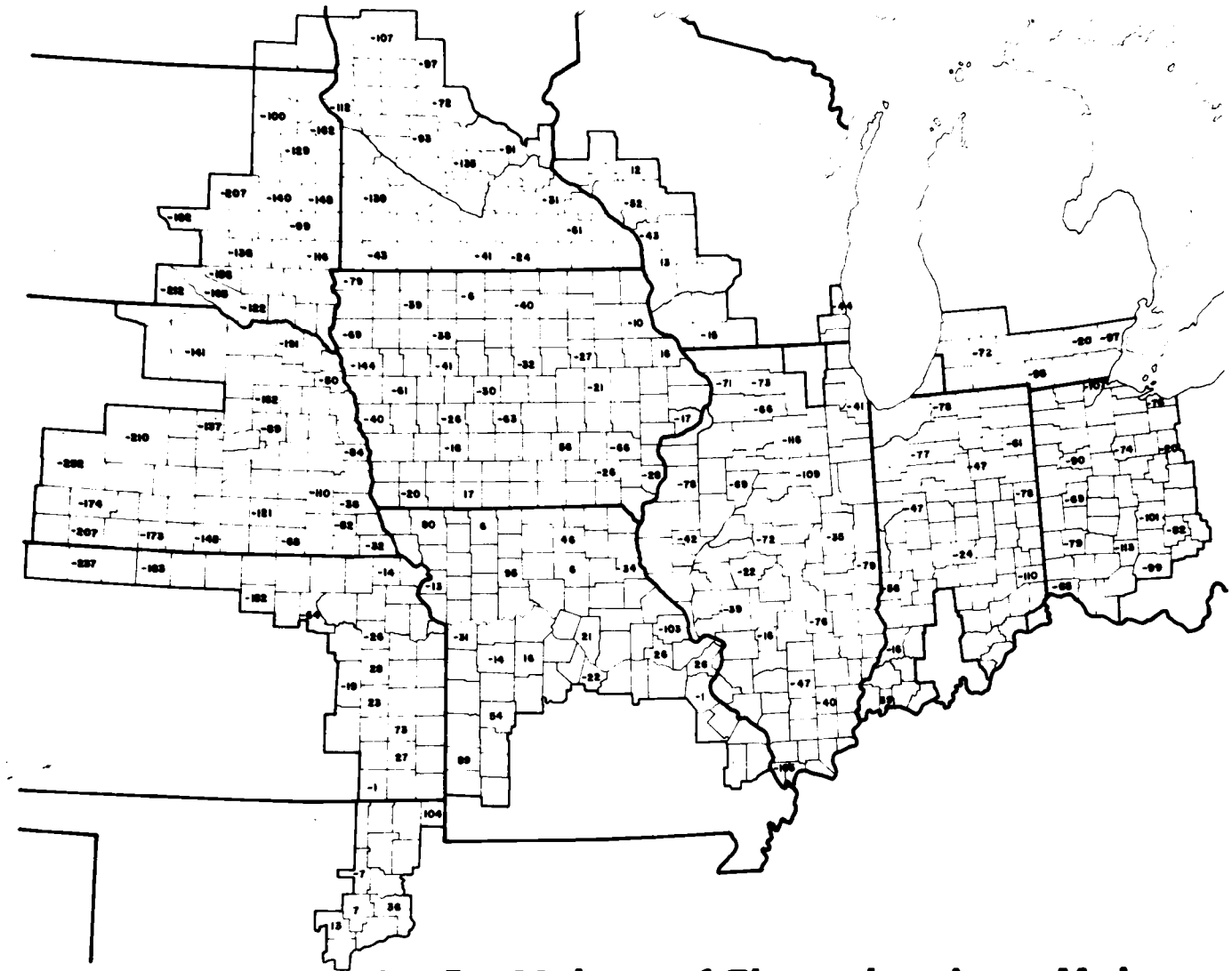


Fig. 5. Values of Thornthwaite's Moisture Index Summed Through the Mean Growing Season

$$F = \frac{n \sum_{i=1}^{k} (\bar{x}_i - \bar{\bar{x}})^2}{\frac{\sum_{i=1}^{kn} (x_i - \bar{\bar{x}})^2}{k(n-1)}} = \frac{\text{Among-sample variance}}{\text{Within-sample variance}}$$

where: n = total number of observations in all samples
k = number of samples
x = an individual moisture index
$\bar{x}_i$ = the mean of the i^{th} sample
$\bar{\bar{x}}$ = the mean of all sample means

This ratio follows the F-distribution with (k - 1) and k(n - 1) degrees of freedom.

RESULTS

The 639 counties which were retained for analysis were found to have a mean of 37.58 percent of their harvested cropland devoted to corn. The standard deviation of this data was 14.10 percent. This yielded the following boundaries for the intensity classes:

Low Intensity - 0.00% to 23.485%
Medium Intensity - 23.485% to 51.687%
High Intensity - 51.687% to 100.0%

These boundaries resulted in 86 counties being classed as low intensity, 457 as medium intensity and 96 as high intensity (Table 3).

With the exception of Ottawa County, Ohio, Milwaukee and Eau Claire counties, Wisconsin and St. Francois County, Missouri, the low intensity corn producing counties are located along the western margin of the study area. The majority of these are outside the

boundary of the Corn Belt as defined by the Soil Conservation Service.

With the sole exception of Hughes County, Nebraska, the medium intensity corn producing class is one contiguous unit which surrounds those areas of high intensity production.

The high intensity class shows a definite concentration throughout the central portion of the study area. One group follows the Missouri River from the southeast corner of South Dakota to the northwest corner of Missouri and extends into portions of Iowa and Nebraska. The largest single unit occurs in eastern Iowa and northwestern Illinois. Smaller units are found in Indiana and Ohio. An apparent anomaly occurs in southeastern Illinois where a high intensity county (Gallatin) falls along the boundary of the study area.

The nine counties which were excluded because of excessive irrigation form a contiguous unit in Nebraska which is bifurcated by the Platte River. The counties which comprise this group include Merrick, Polk, York, Hamilton, Clay, Hall, Buffalo, Kearney and Dawson.

The distribution of the intensity classes varies somewhat from what one would consider the theoretical situation to be. Ideally, each class (though it need not be a solid unit) should be entirely surrounded by the next lowest class. This is the case (with the above noted exception) for the high intensity counties, but, medium intensity

counties are found to lie along the boundary of the study area throughout most of its northern, eastern and southern extent. One would expect only low intensity counties adjoining the boundary line in a theoretical distribution.

There appears to be little or no logic in the distribution of the values obtained by the summation of Thornthwaite's moisture index through the mean 32°F growing season. Highly negative values occur along the western margin of the study area in portions of South Dakota, Nebraska and Kansas in the areas of low intensity corn production. But, these are compensated for by positive values in eastern Kansas, Oklahoma and west-central Missouri. Large differences in these values are also exhibited throughout the areas of medium and high intensity production. The greatest variation occurs in east-central Missouri where Lincoln County has an index of -103 and Warren County one of 26.

The analysis of variance test gave an F-value of 0.165 with 2 and 477 degrees of freedom. The tabled value of Fisher's F-distribution at 2 and 477 degrees of freedom is 1.00. Since the computed value is less than the theoretical, it must be concluded that there is no difference in the means of the moisture indices drawn from each of the three groups based on the intensity of harvested cropland devoted to corn.

CONCLUSIONS

In view of the value obtained through the test of analysis of variance it must be concluded that Thornthwaite's moisture index, when summed through the mean 32°F growing season, is not a good measure of the intensity to which harvested cropland is devoted to corn within the study area. This does not infer that this index is totally useless for this purpose. Perhaps some other summation (for the entire year or the 50°F growing season) would produce more meaningful results. However, under the conditions listed in this study, the index proves to be quite meaningless.

Also, it can not be assumed that moisture is not important in determining the distribution of corn production under natural climatic conditions. The fact that so much of the corn acreage in the western portion of the study area was irrigated immediately discounts this theory.[20]

Perhaps, as Billings has inferred, when considering the distribution of any plant, one must examine the myraid of environmental conditions which impose influences upon that plant.[21] Thornthwaite's moisture index considers only a very few of these variables, and then only in terms as to how they affect the moisture available for plant growth. However, the onerous task required to satisfy Billings' approach far exceeds the limits of this paper.

FOOTNOTES

1 R.F. Daubenmire, Plants and Environment (New York: John Wiley and Sons, 1959) p. 3.

2 Carroll P. Wilsie, Crop Adaptation and Distribution (San Francisco: W.H. Freeman, 1962) p. 133.

3 P.J. Kramer, "The Role of Water in the Physiology of Plants," Advances in Agronomy, Vol. 11 (1959) pp. 51-70.

4 W.D. Billings, "The Environmental Complex in Relation to Plant Growth and Distribution," Quarterly Review of Biology, Vol. 27 (September, 1952) pp. 251-264.

5 C.W. Thornthwaite and J.R. Mather, "The Water Balance," Drexell Institute Publications in Climatology, Vol. 8, No. 1 (1955).

6 C.W. Thornthwaite, "An Approach Toward a Rational Classification of Climate," Geographical Review, Vol. 38 (January, 1948) pp. 75-81.

7 For a review of the moisture studies prior to the development of Thornthwaite's moisture index see, Thornthwaite, op. cit., footnote 6, pp. 73-75.

8 For the logic behind this reduction see, Douglas B. Carter and John R. Mather, "Climatic Classification for Environmental Biology," C.W. Thornthwaite Associates Publications in Climatology, Vol. 19, No. 4 (1966) p. 323.

9 Ibid.

10 For a detailed description of the method used to determine these values see, Thornthwaite and Mather, op. cit., footnote 5.

11 C.W. Thornthwaite Associates, "Average Climatic Water Balance Data of the Continents," Publications in Climatology, Vol. 17, No. 3, Part 7 (1964).

12 Economic Research Service, Map of Generalized Types of Farming in the United States (Washington, D.C.: Government Printing Office, 1965).

14 Figure 1 is to be used with this and each of the following maps for determining the names of the counties within the study area.

15 This data was placed on computer punchcards and all of the calculations which follow were done on an IBM 350 computer.

16 In a preliminary study with Nebraska data it was found that in counties where more than 30 percent of the harvested acreage was irrigated a significantly greater amount of land was devoted to corn than in those counties for which this ratio was less than 30 percent.

17 This follows the work of Kimball, Went and others (see bibliography) who consider there to be a temperature period during which other environmental elements exert their greatest influence upon plants.

18 See, Jerome C.R. Li, Statistical Inference I (Ann Arbor: Edwards Brothers, 1964) p. 184 for the theory behind this test.

19 Tables are available which give the critical values of the F-distribution. For example see, Li, op. cit.

20 See, Nebraska Department of Agriculture and Inspection, Nebraska Agricultural Statistics Annual Report 1964 (Lincoln: State-Federal Division of Agricultural Statistics, 1966).

21 Billings, op. cit.

APPENDIX

BIBLIOGRAPHY

1. W.D. Billings, "The Environmental Complex in Relation to Plant Growth and Distribution," Quarterly Review of Biology, Vol. 27 (September, 1952) pp. 251-264.

2. Douglas B. Carter and John R. Mather, "Climatic Classification for Environmental Biology," C.W. Thornthwaite Associates Publications in Climatology, Vol. 19, No. 4 (1966).

3. R.F. Daubenmire, Plants and Environment (New York: John Wiley and Sons, 1959).

4. Economic Research Service, Map of Generalized Types of Farming in the United States (Washington, D.C.: Government Printing Office, 1949).

5. M.H. Kimball, "Plantclimates of California," California Agriculture, Vol. 13 (May, 1959) pp. 7-12.

6. P.J. Kramer, "The Role of Water in the Physiology of Plants," Advances in Agronomy, Vol. 11 (1959) pp. 51-70.

7. Jerome C.R. Li, Statistical Inference I (Ann Arbor: Edwards Brothers, 1964).

8. J.R. Mather, "The Climatic Water Balance," C.W. Thornthwaite Associates Publications in Climatology, Vol. 14, No. 3 (1961).

9. Nebraska Department of Agriculture and Inspection, Nebraska Agricultural Statistics Annual Report 1964 (Lincoln: State-Federal Division of Agricultural Statistics, 1966).

10. Soil Conservation Service, Land Resource Regions and Major Land Resource Areas of the United States, Agricultural Handbook No. 296 (Washington, D.C.: Government Printing Office, 1965).

11. C.W. Thornthwaite, "The Climates of North America According to a New Classification," Geographical Review, Vol. 21 (October, 1931) pp. 633-656.

12. _____, "An Approach Toward A Rational Classification of Climate," Geographical Review, Vol. 38 (January, 1948) pp. 75-81.

13. _____, "A Re-Examination of the Concept and Measurement of Potential Evapotranspiration," Johns Hopkins University Publications in Climatology, Vol. 7, No. 1 (1954) pp. 200-210.

14. _____ and J.R. Mather, "The Water Balance," Drexell Institute Publications in Climatology, Vol. 8, No. 1 (1955).

15. C.W. Thornthwaite Associates, "Average Climatic Water Balance Data of the Continents," Publications in Climatology, Vol. 17, No. 3, Part 7 (1964).

16. U.S. Bureau of the Census, Map of County Boundaries as of April 1, 1960 (Washington, D.C.: Government Printing Office, 1960).

17. U.S. Bureau of the Census, 1964 Census of Agriculture Preliminary Reports (Washington, D.C.: Government Printing Office, 1966).

18. U.S. Weather Bureau, Climatography of the United States No. 60 (Washington, D.C.: Government Printing Office, 1959).

19. F.W. Went, "The Response of Plants to Climate," Science, Vol. 112 (October, 1950) pp. 489-494.

20. Carroll P. Wilsie, Crop Adaption and Distribution (San Francisco: W.H. Freeman, 1962).

Table 1.——Percent of Total Harvested Acreage Devoted to Corn (Total harvested acreage/acres of corn harvested)

State	County	Percent	State	County	Percent
Illinois			Illinois (cont.)		
	ADAMS	44.126495		JASPE	29.616501
	ALEXA	29.446198		JEFFE	27.103012
	BOND	35.839569		JERSE	44.187378
	BOONE	53.454575		JO DA	42.789536
	BROWN	41.458344		JOHNS	37.295135
	BUREA	62.592407		KANE	58.133820
	CALHO	51.913940		KANKA	49.154221
	CARRO	55.859314		KENDA	59.588272
	CASS	43.579849		KNOX	59.537659
	CHAMP	46.623032		LAKE	31.626587
	CHRIS	42.324921		LAWRE	42.810684
	CLARK	38.520157		LA SA	57.143646
	CLAY	24.814682		LEE	54.374893
	CLINT	36.330032		LIVIN	51.579666
	COLES	47.559921		LOGAN	47.895721
	COOK	35.422729		MACON	45.215683
	CRAWF	33.371674		MACOU	42.788391
	CUMBE	38.602325		MADIS	30.420944
	DE KA	60.234360		MARIO	26.827866
	DE WI	48.998322		MARSH	55.595367
	DOUGL	49.155609		MASON	42.846603
	DU PA	46.782272		MASSA	36.568069
	EDGAR	47.607727		MC DO	56.020294
	EDWAR	44.320938		MC LE	55.370438
	EFFIN	35.881958		MENAR	46.731461
	FAYET	32.217316		MERCE	65.650284
	FORD	48.305069		MONRO	39.692810
	FRANK	28.476624		MONTG	41.104385
	FULTO	56.026703		MORGA	44.629684
	GALLA	60.313721		MOULT	44.849258
	GREEN	49.041992		OGLE	56.030869
	GRUND	51.472351		PEORI	51.395386
	HAMIL	29.200607		PERRY	30.444489
	HANCO	47.477036		PIATT	44.834671
	HARDI	34.079468		PIKE	50.308701
	HENDE	59.402100		POPE	33.296600
	HENRY	60.880112		PULAS	28.053879
	IROQU	47.370209		PUTNA	58.274139
	JACKS	39.793365		RANDO	37.089386

Table 1. cont.

State	County	Percent
Illinois (cont.)		
	RICHL	31.417786
	ROCK	61.405807
	SALIN	41.094254
	SANGA	45.705750
	SCHUY	45.082977
	SCOTT	44.780991
	SHELB	43.783997
	STARK	60.881699
	ST. C	31.180695
	STEPH	48.346451
	TAZEW	54.983902
	UNION	41.131149
	VERMI	43.938568
	WABAS	44.219101
	WARRE	65.716248
	WASHI	25.715256
	WAYNE	29.816605
	WHITE	43.717133
	WHITE	62.216324
	WILL	46.333527
	WILLI	35.197876
	WINNE	53.444595
	WOODF	60.422943
Indiana		
	ADAMS	34.168228
	ALLEN	34.106613
	BARTH	45.682892
	BLACK	34.400330
	BOONE	47.636459
	BROWN	47.304001
	CARRO	55.196030
	CASS	51.811539
	CLARK	30.955765
	CLAY	40.219025
	CLINT	51.427261
	DAVIE	44.815140
	DEARB	28.457581
	DECAT	46.669861
	DE KA	32.587555
	DELAW	40.499084
	ELKHA	44.370270
Indiana (cont.)		
	FAYET	50.509369
	FLOYD	26.441895
	FOUNT	44.096893
	FRANK	47.971573
	FULTO	45.680069
	GIBSO	50.321930
	GRANT	40.433472
	GREEN	43.417709
	HAMIL	42.877365
	HANCO	40.726196
	HENDR	44.942917
	HENRY	42.753860
	HOWAR	47.438034
	HUNTI	36.069443
	JACKS	38.976044
	JASPE	52.812347
	JAY	30.485275
	JEFFE	28.679672
	JENNI	31.160263
	JOHNS	43.786987
	KNOX	49.169235
	KOSCI	47.294495
	LAKE	47.189056
	LA PO	43.971954
	MADIS	41.129074
	MARIO	36.327194
	MARSH	45.732422
	MIAMI	46.939972
	MONTG	51.315765
	MORGA	45.704514
	NEWTO	52.620514
	NOBLE	42.794952
	OWEN	32.273071
	PARKE	48.706131
	PIKE	43.534027
	PORTE	44.030563
	POSEY	49.546432
	PULAS	45.192642
	PUTNA	48.081863
	RANDO	38.213196
	RIPLE	29.584824
	RUSH	51.249954

Table 1. cont.

State	County	Percent
Indiana (cont.)		
	SCOTT	24.342682
	SHELB	45.554825
	SPENC	37.009644
	STARK	47.927094
	ST. J	43.569839
	STUEB	40.216339
	SULLI	33.141342
	TIPPE	47.197952
	TIPTO	44.784195
	UNION	55.372803
	VANDE	46.420746
	VERMI	49.383209
	VIGO	44.335922
	WABAS	44.021698
	WARRE	41.548325
	WARRI	36.157257
	WASHI	37.105515
	WAYNE	47.607330
	WELLS	36.365585
	WHITE	48.760284
	WHITL	39.403366
Iowa		
	ADAIR	44.853607
	ADAMS	44.755341
	ALLAM	40.750214
	APPAN	33.285843
	AUDUB	54.161331
	BENTO	54.986404
	BLACK	53.340622
	BOONE	49.655029
	BREME	49.854324
	BUCHA	51.785217
	BUENA	50.154358
	BUTLE	54.844223
	CALHO	44.845642
	CARRO	52.973663
	CASS	53.634872
	CEDAR	57.372620
	CERRO	54.892181
	CHERO	52.632370
Iowa (cont.)		
	CHICK	51.859619
	CLARK	36.908691
	CLAY	50.617920
	CLAYT	45.976547
	CLINT	59.110886
	CRAWF	47.544647
	DALLA	49.739914
	DAVIS	36.027649
	DECAT	35.599701
	DELAW	51.943939
	DES M	54.204803
	DICKI	51.621231
	DUBUQ	45.593796
	EMMET	50.365158
	FAYET	48.298523
	FLOYD	53.209549
	FRANK	46.959610
	FREMO	58.361526
	GREEN	50.807205
	GRUND	55.505600
	GUTHR	46.540482
	HAMIL	52.681305
	HANCO	51.827301
	HARDI	54.638397
	HARRI	54.520981
	HENRY	55.219315
	HOWAR	43.798691
	HUMBO	50.854919
	IDA	53.085419
	IOWA	53.043259
	JACKS	47.902100
	JASPE	54.349350
	JEFFE	42.969528
	JOHNS	53.817413
	JONES	55.671616
	KEOKU	50.611801
	KOSSU	49.231125
	LEE	50.162827
	LINN	54.510498
	LOUIS	55.842957
	LUCAS	35.853668

Table 1. cont.

State	County	Percent	State	County	Percent
Iowa (cont.)			Kansas		
	LYON	54.131943		ALLEN	24.509445
	MADIS	44.769058		ANDER	20.106689
	MAHAS	51.875656		ATCHI	28.391663
	MARIO	48.979507		BOURB	22.438461
	MARSH	55.581955		BROWN	39.267624
	MILLS	57.342163		CHERO	12.717592
	MITCH	52.552704		CLAY	10.465258
	MONON	54.132797		CLOUD	8.446890
	MONRO	36.874313		COFFE	14.398109
	MONTG	53.462189		CRAWF	19.091949
	MUSCA	53.666016		DECAT	4.361275
	O BRI	49.863068		DONIP	43.590439
	OSCEO	51.451920		DOUGL	25.346420
	PAGE	51.412659		FRANK	19.684921
	PALO	49.597305		GREEN	9.251362
	PLYMO	53.273209		JACKS	19.997086
	POCAH	57.793106		JEFFE	29.063431
	POLK	51.143250		JEWEL	6.498343
	POTTA	56.010223		JOHNS	23.679489
	POWES	49.867447		LABET	12.117612
	RINGG	36.180405		LEAVE	29.171005
	SAC	50.636261		LINN	25.060822
	SCOTT	72.637604		LYON	15.180498
	SHELB	54.149536		MARSH	12.683898
	SIOUX	57.920578		MIAMI	25.103790
	STORY	53.538818		MONTG	13.843816
	TAMA	51.762863		NEMAH	31.254623
	TAYLO	39.385864		NEOSH	21.787964
	UNION	43.372086		NORTO	3.221268
	VANBU	37.022583		OSAGE	15.650964
	WAPEL	42.313980		PHILL	3.261211
	WARRE	44.966309		POTTA	14.302557
	WASHI	54.392273		RAWLI	2.277858
	WAYNE	33.707809		REPUB	18.046219
	WEBST	45.445938		RILEY	11.773020
	WINNE	51.894882		SHAWN	23.820404
	WINNE	45.416992		SMITH	4.387011
	WOODB	54.018524		WABAU	10.085570
	WORTH	49.668777		WASHI	8.953291
	WRIGH	50.701370		WILSO	17.871536
				WOODS	11.105716
				WYAND	25.160217

Table 1. cont.

State	County	Percent
North Dakota		
	RICHL	16.661087
	SARGE	12.443334
Michigan		
	ALLEG	36.694427
	BARRY	33.743958
	BERRI	23.326233
	BRANC	45.911469
	CALHO	41.033142
	CASS	42.623871
	HILLS	43.048874
	JACKS	38.141464
	KALAM	40.118210
	LENAW	40.861679
	MONRO	30.747635
	ST. J	41.430191
	VAN B	33.113922
	WASHT	37.040344
	WAYNE	24.402679
Minnesota		
	BIGST	32.105087
	BLUE	44.754761
	BROWN	44.320740
	CARVE	43.488861
	CHIPP	43.030212
	COTTO	48.512985
	DAKOT	35.514206
	DODGE	36.485535
	DOUGL	28.479370
	FARIB	45.097260
	FILLM	41.217316
	FREEB	45.736313
	GOODH	32.253860
	GRANT	25.156906
	HENNE	36.154388
	HOUST	37.345062
	JACKS	51.633865
	KANDI	41.028809
	LAC Q	39.401260
	LE SU	39.647614
Minnesota (cont.)		
	LINCO	42.162735
	LYON	51.345825
	MARTI	53.487366
	MC LE	40.108246
	MEEKE	38.710175
	MOWER	39.643524
	MURRA	49.459595
	NOBLE	49.539948
	OLMST	39.453476
	OTTER	22.828461
	PIPES	49.437302
	POPE	33.492722
	RAMSE	28.811584
	REDWO	46.566101
	RENVI	42.264481
	RICE	39.912186
	ROCK	54.447098
	SCOTT	40.844528
	SIBLE	40.798859
	STEAR	34.996140
	STEEL	42.390732
	STEVE	39.059189
	SWIFT	39.321289
	TODD	32.673767
	TRAVE	19.784317
	WABAS	33.541031
	WASEC	46.163635
	WASHI	34.084015
	WATON	50.983871
	WILKI	10.633242
	WINON	35.661713
	WRIGH	40.940323
	YELLO	45.718704
Missouri		
	ADAIR	27.230194
	ANDRE	34.308517
	ATCHI	66.299942
	AUDRA	31.319946
	BARTO	19.838425
	BATES	27.752670

Table 1. cont.

State	County	Percent	State	County	Percent
Missouri (cont.)			Missouri (cont.)		
	BENTO	26.460892		MONRO	29.713516
	BOLLI	29.295151		MONTG	34.689438
	BOONE	29.846909		MORGA	30.363770
	BUCHA	30.298294		NODAW	39.916489
	CALLA	31.437943		OSAGE	33.589294
	CAPE	35.974976		PERRY	39.274612
	CARRO	36.992371		PETTI	35.908722
	CASS	33.863068		PIKE	40.582565
	CEDAR	20.622696		PLATT	33.829834
	CHADW	29.279953		PUTNA	25.091293
	CHARI	35.410080		RALLS	28.781052
	CLARK	41.775742		RANDO	30.357346
	CLAY	40.057983		RAY	42.223267
	CLINT	34.104782		SALIN	47.485626
	COLE	30.149307		SCHUY	27.479935
	COOPE	41.156326		SCOTL	33.912598
	DADE	20.634613		SHELB	32.148422
	DAVIE	28.265076		ST. C	37.229996
	DE KA	29.963135		ST. C	19.317642
	FRANK	35.512253		ST. F	21.550064
	GASCO	32.800293		ST. L	29.376862
	GENTR	28.412827		STE.	40.412949
	GRUND	32.662704		SULLI	24.811646
	HARRI	29.005249		VERNO	21.972900
	HENRY	20.908722		WARRE	36.632492
	HOLT	55.253815		WORTH	26.550476
	HOWAR	44.896042			
	JACKS	38.965881	Nebraska		
	JASPE	20.200256		ADAMS	18.784485
	JEFFE	29.275894		ANTEL	48.324524
	JOHNS	28.497314		BOONE	35.857620
	KNOX	29.058289		BOYD	24.674728
	LAFAY	44.156738		BUFFA	36.666397
	LAWRE	16.571518		BURT	55.025497
	LEWIS	38.161575		BUTLE	36.545227
	LINCL	42.398285		CASS	36.681564
	LINN	27.368469		CEDAR	48.124619
	LIVIN	30.084244		CLAY	18.368942
	MACON	27.290421		COLFA	44.059036
	MARIO	34.825653		COMIN	55.361938
	MERCE	26.159241		CUSTE	30.597839
	MONIT	35.629349			

Table 1. cont.

State	County	Percent	State	County	Percent
Nebraska (cont.)			Nebraska (cont.)		
	DAWSO	41.962540		SHERM	28.001373
	DIXON	55.873749		STANT	53.271408
	DODGE	47.290680		THAYE	13.106930
	DOUGL	64.803970		THURS	51.925980
	FILLM	21.073853		VALLE	33.114075
	FRANK	20.128769		WASHI	50.638763
	FRONT	12.277770		WAYNE	51.371826
	FURNA	14.927279		WEBST	12.897921
	GAGE	18.147949		WHEEL	9.390455
	GREEL	33.596100		YORK	39.344193
	GOSPE	22.145599			
	HALL	54.555649	Ohio		
	HAMIL	39.919556		ALLEN	35.699753
	HARLA	13.982814		AUGLA	35.842300
	HAYES	23.819885		BROWN	27.821976
	HITCH	14.088613		BUTLE	48.002472
	HOLT	11.361634		CHAMP	43.203369
	HOWAR	33.987793		CLARK	44.233582
	JEFFE	12.194276		CLERM	27.716187
	JOHNS	30.513458		CLINT	49.729279
	KEARN	32.676865		CRAWF	36.877075
	KEYA	6.365078		DARKE	41.496216
	KNOX	37.964462		DEFIA	25.121078
	LANCA	13.412309		DELAW	35.676605
	LINCO	17.834473		ERIE	31.164688
	MADIS	46.708618		FAIRF	40.051300
	MERRI	54.219818		FAYET	42.007935
	NANCE	29.569031		FRANK	36.087738
	NEMAH	44.756958		FULTO	45.642303
	NUCKO	15.822714		GREEN	51.454285
	OTOE	39.742722		HAMIL	50.282883
	PAWNE	24.429886		HANCO	37.031845
	PIERC	49.937164		HARDI	36.384933
	PLATT	34.431549		HENRY	34.770538
	POLK	32.473633		HIGHL	38.719376
	RED W	15.827256		HOCKI	32.695374
	RICHA	47.752213		HURON	29.394730
	ROCK	1.580793		KNOX	35.817978
	SALIN	19.306824		LOGAN	34.851517
	SARPY	60.624817		LICKI	34.086029
	SAUND	43.254333		LUCAS	26.723602
	SEWAR	27.874313		MADIS	41.725555

Table 1. (cont.)

State	County	Percent
Ohio (cont.)		
	MARIO	40.415421
	MERCE	35.983002
	MIAMI	44.104706
	MONTG	45.477402
	MORRO	30.594055
	OTTAW	15.885091
	PAULD	27.175781
	PERRY	28.880753
	PICKA	45.164261
	PREBL	54.641663
	PUTNA	31.057693
	RICHL	28.581741
	ROSS	43.644836
	SANDU	31.224640
	SENEC	33.372070
	SHELB	34.297592
	UNION	36.567734
	VAN W	32.490936
	WARRE	42.077072
	WILLI	33.602539
	WOOD	33.414108
	WYAND	37.324127
Oklahoma		
	CRAIG	4.604335
	HUGHE	6.637018
	MAYES	5.227081
	MC IN	5.100485
	MUSKO	3.924349
	NOWAT	6.845325
	OKFUS	5.464095
	OKMUL	6.135866
	OTTAW	5.446508
	ROGER	4.312735
	TULSA	5.123413
	WAGON	4.638718
	WASHI	4.499737
South Dakota		
	AUROR	32.576721
	BEADL	27.383820
South Dakota (cont.)		
	BON H	44.959518
	BROOK	44.659363
	BUFFA	15.738695
	CHARL	33.261292
	CLARK	23.835144
	CLAY	53.166595
	CODIN	16.397232
	DAVIS	40.658401
	DAY	11.826658
	DEVEE	28.420670
	DOUGL	42.783188
	GRANT	26.299362
	GREGO	27.042328
	HAMLI	31.845932
	HANSO	44.471344
	HUTCH	47.254288
	JERAU	24.744202
	KINGS	38.352005
	LAKE	50.952667
	LINCO	54.817932
	MARSH	18.820663
	MC CO	50.160614
	MINER	36.260574
	MINNE	56.257294
	MOODY	53.580368
	ROBER	21.081818
	SANBO	34.024002
	TURNE	51.415451
	UNION	50.680542
	YANKT	50.746185
Wisconsin		
	BUFFA	28.476959
	CRAWF	25.521072
	DUNN	28.001144
	EAU C	21.942474
	GRANT	36.442963
	GREEN	35.498047
	IOWA	33.012161
	JACKS	26.664856
	KENOS	35.506592

Table 1. cont.

State	County	Percent
Wisconsin (cont.)		
	LA CR	33.533905
	LAFAY	40.891464
	MILWA	19.591919
	MONRO	25.489929
	PEPIN	27.869873
	PIERC	30.972412
	RACIN	33.919235
	RICHL	26.159607
	SAUK	32.821259
	TREMP	26.448181
	VERNO	23.765457

Table 2. — Extreme Dates of the Mean 32°F Growing Season and Values of Thornthwaite's Moisture Index Summed Through This Growing Season for Selected Stations in the Study Area

City	County	Mean Date of Last Spring Frost	Mean Date of First Fall Frost	Moisture Index
Illinois				
Cairo	Alexander	April 29	November 1	-165
Carlinville	Macoupin	April 22	October 17	-39
Chicago	Cook	April 19	October 28	-41
Dixon	Lee	May 3	October 6	-66
Effingham	Effingham	April 22	October 15	-76
Greenville	Bond	April 18	October 25	-18
Harrisburg	Saline	April 16	October 19	-40
La Salle	La Salle	May 1	October 9	-116
Lincoln	Logan	April 29	October 15	-72
Monmouth	Warren	April 25	October 16	-78
Mount Carroll	Carroll	May 7	October 3	-71
Mt. Vernon	Jefferson	April 15	October 19	-47
Paris	Edgar	April 29	October 18	-79
Peoria	Peoria	April 22	October 16	-69
Pontiac	Livingston	April 24	October 18	-109
Rockford	Ogle	May 6	October 6	-73
Rushville	Schuyler	April 19	October 20	-42
Springfield	Sangamon	April 8	October 30	-22
Urdana	Champaign	April 23	October 21	-35
Indiana				
Brookville	Franklin	May 5	October 6	-110
Evansville	Vanderburgh	April 2	November 4	39
Fort Wayne	Allen	April 24	October 20	-61
Indianapolis	Marion	April 17	October 27	-24
Lafayette	Tippecanoe	April 27	October 12	-47
Sacamonia	Jay	May 8	October 7	-75
South Bend	St. Joseph	May 3	October 16	-76
Terra Haute	Vigo	April 11	October 28	-38
Vincennes	Knox	April 14	October 23	-15
Wabash	Wabash	May 4	October 11	-47
Winamac	Pulaski	May 4	October 12	-77
Iowa				
Algona	Kossuth	April 15	October 19	-6
Ames	Boone	May 1	October 9	-30
Belle Plaine	Benton	May 3	October 5	-21
Burlington	Des Moines	April 20	October 16	-28
Clarinda	Page	April 30	October 10	-20
Davenport	Scott	April 12	October 24	-17
Denison	Crawford	May 5	October 4	-61
Des Moines	Polk	April 20	October 19	-53

Table 2. cont.

City	County	Mean Date of Last Spring Frost	Mean Date of First Fall Frost	Moisture Index
Iowa (cont.)				
Dubuque	Dubuque	April 19	October 19	18
Fairfield	Jefferson	April 29	October 10	-29
Greenfield	Adair	April 29	October 10	-16
Guthrie Center	Guthrie	May 3	October 6	-26
Inwood	Lyon	May 10	September 28	-79
Iowa Falls	Hardin	May 4	October 2	-32
Le Mans	Plymouth	May 7	October 2	-69
Logan	Harrison	May 1	October 9	-40
Mason City	Cerro Gordo	May 8	October 3	-40
Mount Ayr	Ringgold	April 30	October 13	17
Oskaloosa	Mahaska	April 28	October 11	56
Pocahontas	Pocahontas	May 7	October 4	-38
Post Ville	Clayton	May 6	October 4	-10
Rockwell City	Calhoun	May 5	October 9	-41
Sioux City	Woodbury	April 28	October 12	-144
Spencer	Clay	May 9	October 3	-59
Washington	Washington	May 4	October 4	-56
Waterloo	Black Hawk	April 26	October 9	-27
Kansas				
Burlington	Coffey	April 15	October 23	23
Chanute	Neosho	April 10	October 25	27
Concordia	Cloud	April 16	October 24	-152
Emporia	Lyon	April 19	October 22	-19
Horton	Brown	April 22	October 17	-14
Independence	Montgomery	April 14	October 26	-1
Iola	Allen	April 9	October 26	73
Manhattan	Riley	April 23	October 16	-64
Oberlin	Decator	May 8	October 2	-237
Ottawa	Franklin	April 17	October 23	28
Phillipsburg	Phillips	April 26	October 15	-183
Topeka	Shawnee	April 9	October 26	-26
Michigan				
Ann Arbor	Washtenaw	May 2	October 17	-80
Detroit	Wayne	April 25	October 23	-97
Eau Claire	Berrien	May 4	October 22	-33
Hillsdale	Hillsdale	May 11	October 4	-93
Kalamazoo	Kalamazoo	May 9	October 9	-72
Minnesota				
Albert Lea	Freeborn	May 3	October 6	-24
Beardsley	Bigstone	May 17	September 23	-112
Fergus Falls	Otter Tail	May 13	September 25	-107

Table 2. cont.

City	County	Mean Date of Last Spring Frost	Mean Date of First Fall Frost	Moisture Index
Minnesota (cont)				
Hutchinson	McLeod	May 13	September 29	-135
Long Praire	Todd	May 16	September 23	-97
Minneapolis - St. Paul	Hennepin	April 30	October 13	-91
Red Wing	Goodhue	May 2	October 11	-31
Rochester	Olmstead	May 15	September 29	-51
St. Cloud	Stearns	May 9	September 29	-72
Tracey	Lyon	May 8	October 6	-139
Willmar	Kandiyohi	May 8	September 29	-93
Winnebago	Faribault	May 7	October 6	-41
Worthington	Nobles	May 7	October 4	-43
Missouri				
Appleton City	St. Clair	April 12	October 24	54
Bethany	Harrison	April 26	October 11	6
Chillicothe	Livingston	April 19	October 15	95
Columbia	Boone	April 9	October 24	21
Elsberry	Lincoln	April 24	October 11	-103
Hannibal	Marion	April 11	October 23	-34
Jackson	Cape Girardeau	April 16	October 16	-1
Jefferson City	Cole	April 13	October 20	-22
Kansas City	Jackson	April 5	October 31	-31
Kirksville	Adair	April 21	October 19	46
La Mar	Barton	April 13	October 24	89
Macon	Macon	April 19	October 17	6
Maryville	Novaway	April 22	October 13	80
St. Joseph	Buchanan	April 8	October 28	-13
St. Louis	St. Louis	April 2	November 8	26
Sedalia	Pettis	April 13	October 22	16
Warrensburg	Johnson	April 12	October 25	-14
Warrenton	Warren	April 16	October 21	26
Nebraska				
Alma	Harlan	May 5	October 3	-173
Broken Bow	Custer	May 11	September 26	-210
Columbus	Platte	May 1	October 8	-89
Curtis	Frontier	May 8	September 30	-174
Ewing	Holt	May 10	October 1	-141
Fairbury	Jefferson	April 25	October 15	-68
Fairmont	Fillmore	May 5	October 7	-121
Falls City	Richardson	April 26	October 9	-32
Gothenburg	Dawson	May 9	October 2	-185
Grand Island	Hall	April 29	October 6	-141
Greeley	Greeley	April 29	September 30	-137

Table 2. cont.

City	County	Mean Date of Last Spring Frost	Mean Date of First Fall Frost	Moisture Index
Nebraska (cont)				
Hartington	Cedar	May 3	October 7	-191
Kearney	Buffalo	May 1	October 6	-127
Lincoln	Lancaster	April 20	October 17	-110
Mc Cook	Red Willow	May 3	October 6	-207
Nebraska City	Otoe	April 26	October 13	-38
Norfolk	Madison	May 4	October 3	-152
North Platte	Lincoln	April 30	October 7	-252
Omaha	Douglas	April 14	October 20	-84
Osceola	Polk	May 1	October 7	-94
Red Cloud	Webster	May 1	October 4	-145
Tecumseh	Johnson	April 25	October 7	-52
Walthill	Thurston	May 5	October 4	-50
Ohio				
Chillicothe	Ross	April 25	October 15	-99
Cincinnati	Hamilton	April 15	October 25	-65
Columbus	Franklin	April 17	October 30	-101
Dayton	Montgomery	April 19	October 25	-79
Lancaster	Fairfield	May 7	October 5	-82
Lima	Allen	May 3	October 11	-90
Mansfield	Richland	May 9	October 6	-20
Sandusky	Erie	April 17	October 30	-76
Sidney	Shelby	May 1	October 12	-69
Toledo	Lucas	April 24	October 25	-107
Upper Sandusky	Wyandot	May 4	October 7	-74
Washington C.H.	Fayette	April 28	October 12	-113
Oklahoma				
Miami	Ottawa	April 4	October 27	104
Muskogee	Muskogee	March 31	November 1	36
Okemah	Okfuskee	March 30	November 15	13
Okmulgee	Okmulgee	April 1	October 30	7
Tulsa	Tulsa	March 31	November 2	-7
South Dakota				
Academy	Charles Mix	May 11	September 26	-165
Armour	Douglas	May 8	September 30	-156
Brookings	Brookings	May 13	September 27	-148
De Smet	Kingsbury	May 11	September 25	-140
Cannvalley	Buffalo	May 8	September 28	-182
Gregory	Gregory	May 5	October 2	-212
Huron	Beadle	May 4	September 30	-207
Milbank	Grant	May 7	September 30	-162
Mitchell	Davison	May 5	October 1	-136

Table 2. cont.

City	County	Mean Date of Last Spring Frost	Mean Date of First Fall Frost	Moisture Index
South Dakota (cont)				
Sioux Falls	Minnehaha	May 5	October 3	-116
Tyndall	Bon Homme	May 3	October 3	-122
Watertown	Codington	May 17	September 27	-128
Webster	Day	May 18	September 23	-100
Wentworth	Lake	May 14	September 29	-99
Wisconsin				
Blair	Trempealeau	May 19	September 24	-52
Darlington	Lafayette	May 12	September 29	-15
Eau Claire	Eau Claire	May 5	October 4	12
La Crosse	La Crosse	May 1	October 8	-43
Milwaukee	Milwaukee	April 20	October 25	-44
Virogua	Vernon	May 6	October 5	13

Table 3.— Intensity Classes

	State County	Percent Cropland Planted to Corn[a]	Moisture Index[b]
Low Intensity	0.0 TO 23.485 PERCENT		
	KS ANDER	20.107	0
	KS BOURB	22.438	0
	KS CHERO	12.718	0
	KS CLAY	10.465	0
	KS CLOUD	8.447	-152
	KS COFFE	14.398	23
	KS CRAWF	19.092	0
	KS DECAT	4.361	-237
	KS FRANK	19.685	28
	KS GREEN	9.251	0
	KS JACKS	19.997	0
	KS JEWEL	6.498	0
	KS LABET	12.118	0
	KS LYON	15.180	-19
	KS MARSH	12.684	0
	KS MONTG	13.844	-1
	KS NEOSH	21.788	27
	KS NORTO	3.221	0
	KS OSAGE	15.651	0
	KS PHILL	3.261	-183
	KS POTTA	14.303	0
	KS RAWLI	2.278	0
	KS REPUB	18.046	0
	KS RILEY	11.773	-64
	KS SMITH	4.387	0
	KS WABAU	10.086	0
	KS WASHI	8.953	0
	KS WILSO	17.872	0
	KS WOODS	11.106	0
	MG BERRI	23.326	-33
	MN OTTER	22.828	-107
	MN TRAVE	19.784	0
	MN WILKI	10.633	0
	MS BARTO	19.838	0
	MS CEDAR	20.623	0
	MS DADE	20.635	0
	MS HENRY	20.909	0
	MS JASPE	20.200	-14
	MS LAWRE	16.572	-103
	MS ST. C	19.318	26
	MS ST. F	21.550	0

Table 3. cont.

State County	Percent Cropland Planted to Corn[a]	Moisture Index[b]
Low Intensity (cont.)		
MS VERNO	21.973	0
NB ADAMS	18.784	0
NB FILLM	21.074	-174
NB FRANK	20.129	0
NB FRONT	12.278	0
NB FURNA	14.927	-137
NB GAGE	18.143	0
NB GOSPE	22.146	0
NB HARLA	13.983	0
NB HITCH	14.089	0
NB HOLT	11.362	-68
NB JEFFE	12.194	0
NB KEYA	6.365	-110
NB LANCA	13.412	-152
NB LINCO	17.834	0
NB NUCKO	15.823	0
NB RED W	15.827	0
NB ROCK	1.581	0
NB SALIN	19.307	0
NB THAYE	13.107	0
NB WEBST	12.898	0
NB WHEEL	9.390	0
ND RICHL	16.661	-90
ND SARGE	12.443	0
OH OTTAW	15.885	0
OK CRAIG	4.604	0
OK HUGHE	6.637	0
OK MAYES	5.227	0
OK MC IN	5.100	0
OK MUSKO	3.924	36
OK NOWAT	6.845	0
OK OKFUS	5.464	13
OK OKMUL	6.136	7
OK OTTAW	5.447	104
OK ROGER	4.313	0
OK TULSA	5.123	-7
OK WAGON	4.639	0
OK WASHI	4.500	0
SD BUFFA	15.739	-182
SD CODIN	16.397	-128
SD DAY	11.827	-100

Table 3. cont.

State County	Percent Cropland Planted to Corn[a]	Moisture Index[b]
Low Intensity (cont.)		
SD MARSH	18.821	0
SD ROBER	21.082	0
WS EAU C	21.942	12
WS MILWA	19.592	-44
Medium Intensity 23.485TO 51.687PERCENT		
IL ADAMS	44.126	0
IL ALEXA	29.446	-165
IL BOND	35.840	-18
IL BROWN	41.458	0
IL CASS	43.580	0
IL CHAMP	46.623	-35
IL CHRIS	42.325	0
IL CLARK	38.520	0
IL CLAY	24.815	0
IL CLINT	36.330	0
IL COLES	47.560	0
IL COOK	35.423	-41
IL CRAWF	33.372	0
IL CUMBE	38.602	0
IL DE WI	48.998	0
IL DOUGL	49.156	0
IL DU PA	46.782	0
IL EDGAR	47.608	-79
IL EDWAR	44.321	0
IL EFFIN	35.882	-76
IL FAYET	32.217	0
IL FORD	48.305	0
IL FRANK	28.477	0
IL GREEN	49.042	0
IL GRUND	51.472	0
IL HAMIL	29.201	0
IL HANCO	47.477	0
IL HARDI	34.079	0
IL IROQU	47.370	0
IL JACKS	39.793	0
IL JASPE	29.617	0
IL JEFFE	27.103	-47
IL JERSE	44.187	0

Table 3. cont.

State County	Percent Cropland Planted to Corn[a]	Moisture Index[b]
Medium Intensity (cont.)		
IL JO DA	42.790	0
IL JOHNS	37.295	0
IL KANKA	49.154	0
IL LAKE	31.627	0
IL LAWRE	42.811	0
IL LIVIN	51.580	-109
IL LOGAN	47.896	-72
IL MACON	45.216	0
IL MACOU	42.788	-39
IL MADIS	30.421	0
IL MARIO	26.828	0
IL MASON	42.847	0
IL MASSA	36.568	0
IL MENAR	46.731	0
IL MONRO	39.693	0
IL MONTG	41.104	0
IL MORGA	44.630	0
IL MOULT	44.849	0
IL PEORI	51.395	-69
IL PERRY	30.444	0
IL PIATT	44.835	0
IL PIKE	50.309	0
IL POPE	33.297	0
IL PULAS	28.054	0
IL RANDO	37.089	0
IL RICHL	31.418	0
IL SALIN	41.094	-40
IL SANGA	45.706	-22
IL SCHUY	45.083	-42
IL SCOTT	44.781	0
IL SHELB	43.784	0
IL ST. C	31.181	0
IL STEPH	48.346	0
IL UNION	41.131	0
IL VERMI	43.939	0
IL WABAS	44.219	0
IL WASHI	25.715	0
IL WAYNE	29.817	0
IL WHITE	43.717	0
IL WILL	46.334	0
IL WILLI	35.198	0

Table 3. cont.

State County	Percent Cropland Planted to Corn[a]	Moisture Index[b]
Medium Intensity (cont.)		
IN ADAMS	34.168	0
IN ALLEN	34.107	-61
IN BARTH	45.683	0
IN BLACK	34.400	0
IN BOONE	47.636	0
IN BROWN	47.304	0
IN CLARK	30.956	0
IN CLAY	40.219	0
IN CLINT	51.427	0
IN DAVIE	44.815	0
IN DEARB	28.458	0
IN DECAT	46.670	0
IN DE KA	32.588	0
IN DELAW	40.499	0
IN ELKHA	44.370	0
IN FAYET	50.509	0
IN FLOYD	26.442	0
IN FOUNT	44.097	0
IN FRANK	47.972	-110
IN FULTO	45.680	0
IN GIBSO	50.322	0
IN GRANT	40.433	0
IN GREEN	43.418	0
IN HAMIL	42.877	0
IN HANCO	40.726	0
IN HENDR	44.943	0
IN HENRY	42.754	0
IN HOWAR	47.438	0
IN HUNTI	36.069	0
IN JACKS	38.976	0
IN JAY	30.485	-75
IN JEFFE	28.680	0
IN JENNI	31.160	0
IN JOHNS	43.787	0
IN KNOX	49.169	-15
IN KOSCI	47.294	0
IN LAKE	47.189	0
IN LA PO	43.972	0
IN MADIS	41.129	0
IN MARIO	36.327	-24
IN MARSH	45.732	0

Table 3. cont.

State County	Percent Cropland Planted to Corn[a]	Moisture Index[b]
Medium Intensity (cont.)		
IN MIAMI	46.940	0
IN MONTG	51.316	0
IN MORGA	45.705	0
IN NOBLE	42.795	0
IN OWEN	32.273	0
IN PARKE	48.706	0
IN PIKE	43.534	0
IN PORTE	44.031	0
IN POSEY	49.546	0
IN PULAS	45.193	-77
IN PUTNA	48.082	0
IN RANDO	38.213	0
IN RIPLE	29.585	0
IN RUSH	51.250	0
IN SCOTT	24.343	0
IN SHELB	45.555	0
IN SPENC	37.010	0
IN STARK	47.927	0
IN ST. J	43.570	-76
IN STUEB	40.216	0
IN SULLI	33.141	0
IN TIPPE	47.198	-47
IN TIPTO	44.784	0
IN VANDE	46.421	39
IN VERMI	49.383	0
IN VIGO	44.336	-38
IN WABAS	44.022	-47
IN WARRE	41.548	0
IN WARRI	36.157	0
IN WASHI	37.106	0
IN WAYNE	47.607	0
IN WELLS	36.366	0
IN WHITE	48.760	0
IN WHITL	39.403	0
IA ADAIR	44.854	-16
IA ADAMS	44.755	0
IA ALLAM	40.750	0
IA APPAN	33.286	0
IA BOONE	49.655	-30
IA BREME	49.854	0
IA BUENA	50.154	0

Table 3. (cont.)

State County	Percent Cropland Planted to Corn[a]	Moisture Index[b]
Medium Intensity (cont.)		
IA CALHO	44.846	-41
IA CLARK	36.909	0
IA CLAY	50.618	-59
IA CLAYT	45.977	-10
IA CRAWF	47.545	-61
IA DALLA	49.740	0
IA DAVIS	36.028	0
IA DECAT	35.600	0
IA DICKI	51.621	0
IA DUBUQ	45.594	18
IA EMMET	50.365	0
IA FAYET	48.299	0
IA FRANK	46.960	0
IA GREEN	50.807	0
IA GUTHR	46.540	-26
IA HOWAR	43.799	0
IA HUMBO	50.855	0
IA JACKS	47.902	0
IA JEFFE	42.970	-29
IA KEOKU	50.612	0
IA KOSSU	49.231	-6
IA LEE	50.163	0
IA LUCAS	35.854	0
IA MADIS	44.769	0
IA MARIO	48.980	0
IA MONRO	36.874	0
IA O BRI	49.863	0
IA OSCEO	51.452	0
IA PAGE	51.413	-20
IA PALO	49.597	0
IA POLK	51.143	-38
IA POWES	49.867	0
IA RINGG	36.180	17
IA SAC	50.636	0
IA TAYLO	39.386	0
IA UNION	43.372	0
IA VANBU	37.023	0
IA WAPEL	42.314	0
IA WARRE	44.966	0
IA WAYNE	33.708	0
IA WEBST	45.446	0

Table 3. cont.

State County	Percent Cropland Planted to Corn[a]	Moisture Index[b]
Medium Intensity (cont.)		
IA WINNE	45.417	0
IA WORTH	49.669	0
IA WRIGH	50.701	0
KS ALLEN	24.509	73
KS ATCHI	28.392	0
KS BROWN	39.268	-14
KS DONIP	43.590	0
KS DOUGL	25.346	0
KS JEFFE	29.063	0
KS JOHNS	23.679	0
KS LEAVE	29.171	0
KS LINN	25.061	0
KS MIAMI	25.104	0
KS NEMAH	31.255	0
KS SHAWN	23.820	-26
KS WYAND	25.160	0
MG ALLEG	36.694	0
MG BARRY	33.744	0
MG BRANC	45.911	0
MG CALHO	41.033	0
MG CASS	42.624	0
MG HILLS	43.049	-93
MG JACKS	38.141	0
MG KALAM	40.118	-72
MG LENAW	40.862	0
MG MONRO	30.748	0
MG ST. J	41.430	0
MG VAN B	33.114	0
MG WASHT	37.040	-80
MG WAYNE	24.403	-97
MN BIGST	32.105	-112
MN BLUE	44.755	0
MN BROWN	44.321	0
MN CARVE	43.489	0
MN CHIPP	43.030	0
MN COTTO	48.513	0
MN DAKOT	35.514	0
MN DODGE	36.486	0
MN DOUGL	28.479	0
MN FARIB	45.097	-41
MN FILLM	41.217	0

Table 3. cont.

	State County	Percent Cropland Planted to Corn[a]	Moisture Index[b]
Medium Intensity (cont.)			
	MN FREEB	45.736	-24
	MN GOODH	32.254	-31
	MN GRANT	25.157	0
	MN HENNE	36.154	-91
	MN HOUST	37.345	0
	MN JACKS	51.634	0
	MN KANDI	41.029	-93
	MN LAC Q	39.401	0
	MN LE SU	39.648	0
	MN LINCO	42.163	0
	MN LYON	51.346	-139
	MN MC LE	40.108	-135
	MN MEEKE	38.710	0
	MN MOWER	39.644	0
	MN MURRA	49.460	0
	MN NOBLE	49.540	-43
	MN OLMST	39.453	-51
	MN PIPES	49.437	0
	MN POPE	33.493	0
	MN RAMSE	28.812	0
	MN REDWO	46.566	0
	MN RENVI	42.264	0
	MN RICE	39.912	0
	MN SCOTT	40.845	0
	MN SIBLE	40.799	0
	MN STEAR	34.996	-72
	MN STEEL	42.391	0
	MN STEVE	39.059	0
	MN SWIFT	39.321	0
	MN TODD	32.674	-97
	MN WABAS	33.541	0
	MN WASEC	46.164	0
	MN WASHI	34.084	0
	MN WATON	50.984	0
	MN WINON	35.662	0
	OH LOGAN	34.852	0
	OH LICKI	34.086	0
	MN WRIGH	40.940	46
	MN YELLO	45.719	0
	MS ADAIR	27.230	0
	MS ANDRE	34.309	0

Table 3. cont.

	State County	Percent Cropland Planted to Corn[a]	Moisture Index[b]
Medium Intensity (cont.)			
	MS AUDRA	31.320	0
	MS BATES	27.753	0
	MS BENTO	26.461	21
	MS BOLLI	29.295	-13
	MS BOONE	29.847	0
	MS BUCHA	30.298	-1
	MS CALLA	31.438	0
	MS CAPE	35.975	0
	MS CARRO	36.992	0
	MS CASS	33.863	0
	MS CHADW	29.280	0
	MS CHARI	35.410	0
	MS CLARK	41.776	0
	MS CLAY	40.058	-22
	MS CLINT	34.105	0
	MS COLE	30.149	0
	MS COOPE	41.156	0
	MS DAVIE	28.265	0
	MS DE KA	29.963	0
	MS FRANK	35.512	0
	MS GASCO	32.800	0
	MS GENTR	28.413	6
	MS GRUND	32.663	0
	MS HARRI	29.005	0
	MS HOWAR	44.896	0
	MS JACKS	38.966	0
	MS JEFFE	29.276	0
	MS JOHNS	28.497	0
	MS KNOX	29.058	0
	MS LAFAY	44.157	0
	MS LEWIS	38.162	0
	MS LINCL	42.398	95
	MS LINN	27.368	6
	MS LIVIN	30.084	-34
	MS MACON	27.290	0
	MS MARIO	34.826	0
	MS MERCE	26.159	0
	MS MONIT	35.629	0
	MS MONRO	29.714	0
	MS MONTG	34.689	80
	MS MORGA	30.364	0

Table 3. cont.

State County	Percent Cropland Planted to Corn[a]	Moisture Index[b]
Medium Intensity (cont.)		
MS NODAW	39.916	0
MS OSAGE	33.589	16
MS PERRY	39.275	0
MS PETTI	35.909	0
MS PIKE	40.583	0
MS PLATT	33.830	0
MS PUTNA	25.091	0
MS RALLS	28.781	0
MS RANDO	30.357	0
MS RAY	42.223	0
MS SALIN	47.486	0
MS SCHUY	27.480	0
MS SCOTL	33.913	0
MS SHELB	32.148	0
MS ST. C	37.230	0
MS ST. L	29.377	0
MS STE.	40.413	0
MS SULLI	24.812	26
MS WARRE	36.632	0
MS WORTH	26.550	0
NB ANTEL	48.325	0
NB BOONE	35.858	-127
NB BOYD	24.675	0
NB BUTLE	36.545	-191
NB CASS	36.682	0
NB CEDAR	48.125	0
NB COLFA	44.059	-210
NB CUSTE	30.598	0
NB DODGE	47.291	-121
NB GREEL	33.596	-141
NB HAYES	23.820	-141
NB HOWAR	33.988	-52
NB JOHNS	30.513	0
NB KNOX	37.964	-252
NB MADIS	46.709	0
NB NANCE	29.569	0
NB NEMAH	44.757	-38
NB OTOE	39.743	0
NB PAWNE	24.430	-89
NB PIERC	49.937	-94
NB PLATT	34.432	-207

Table 3. cont.

State County	Percent Cropland Planted to Corn[a]	Moisture Index[b]
Medium Intensity (cont.)		
NB RICHA	47.752	0
NB SAUND	43.254	0
NB SEWAR	27.874	0
NB SHERM	28.001	0
NB VALLE	33.114	0
NB WASHI	50.639	-145
NB WAYNE	51.372	0
OH ALLEN	35.700	0
OH AUGLA	35.842	0
OH BROWN	27.822	0
OH BUTLE	48.002	0
OH CHAMP	43.203	0
OH CLARK	44.234	0
OH CLERM	27.716	0
OH CL INT	49.729	0
OH CRAWF	36.877	0
OH DARKE	41.496	0
OH DEFIA	25.121	-76
OH DELAW	35.677	0
OH ERIE	31.165	-113
OH FAIRF	40.051	-82
OH FAYET	42.008	0
OH FRANK	36.088	0
OH FULTO	45.642	-65
OH GREEN	51.454	0
OH HAMIL	50.283	0
OH HANCO	37.032	0
OH HARDI	36.385	0
OH HENRY	34.771	0
OH HIGHL	38.719	0
OH HOCKI	32.695	54
OH HURON	29.395	0
OH KNOX	35.818	0
OH LUCAS	26.724	-107
OH MADIS	41.726	0
OH MARIO	40.415	0
OH MERCE	35.983	0
OH MIAMI	44.105	0
OH MONTG	45.477	-79
OH MORRO	30.594	0
OH PAULD	27.176	0

Table 3. cont.

State County	Percent Cropland Planted to Corn[a]	Moisture Index[b]
Medium Intensity (cont.)		
OH PERRY	28.881	0
OH PICKA	45.164	0
OH PUTNA	31.058	0
OH RICHL	28.582	-20
OH ROSS	43.645	-99
OH SANDU	31.225	0
OH SENEC	33.372	0
OH SHELB	34.298	-69
OH UNION	36.568	0
OH VAN W	32.491	0
OH WARRE	42.077	0
OH WILLI	33.603	0
OH WOOD	33.414	0
OH WYAND	37.324	-74
SD AUROR	32.577	0
SD BEADL	27.384	-207
SD BON H	44.960	-122
SD BROOK	44.659	-148
SD CHARL	33.261	-165
SD CLARK	23.835	0
SD DAVIS	40.658	-136
SD DEVEE	28.421	0
SD DOUGL	42.783	-156
SD GRANT	26.299	-162
SD GREGO	27.042	-212
SD HAMLI	31.846	0
SD HANSO	44.471	0
SD HUTCH	47.254	0
SD JERAU	24.744	0
SD KINGS	38.352	-140
SD LAKE	50.953	-99
SD MC CO	50.161	0
SD MINER	36.261	0
SD SANBO	34.024	0
SD TURNE	51.415	0
SD UNION	50.681	0
SD YANKT	50.746	0
WS BUFFA	28.477	0
WS CRAWF	25.521	0
WS DUNN	28.001	0
WS GRANT	36.443	0

Table 3. cont.

	State County	Percent Cropland Planted to Corn[a]	Moisture Index[b]
Medium Intensity (cont.)			
	WS GREEN	35.498	0
	WS IOWA	33.012	0
	WS JACKS	26.665	0
	WS KENOS	35.507	0
	WS LA CR	33.534	-43
	WS LAFAY	40.891	-15
	WS MONRO	25.490	0
	WS PEPIN	27.870	0
	WS PIERC	30.972	0
	WS RACIN	33.919	0
	WS RICHL	26.160	0
	WS SAUK	32.821	0
	WS TREMP	26.448	-52
	WS VERNO	23.765	13
High Intensity	51.687TO 100.0 PERCENT		
	IL BOONE	53.455	0
	IL BUREA	62.592	0
	IL CALHO	51.914	0
	IL CARRO	55.859	-71
	IL DE KA	60.234	0
	IL FULTO	56.027	0
	IL GALLA	60.314	0
	IL HENDE	59.402	0
	IL HENRY	60.880	0
	IL KANE	58.134	0
	IL KENDA	59.588	0
	IL KNOX	59.538	0
	IL LA SA	57.144	-116
	IL LEE	54.375	-66
	IL MARSH	55.595	0
	IL MC DO	56.020	0
	IL MC LE	55.370	0
	IL MERCE	65.650	0
	IL OGLE	56.031	-73
	IL PUTNA	58.274	0
	IL ROCK	61.406	0
	IL STARK	60.882	0
	IL TAZEW	54.984	0
	IL WARRE	65.716	-78

Table 3. cont.

State County	Percent Cropland Planted to Corn[a]	Moisture Index[b]
High Intensity (cont.)		
IL WHITE	62.216	0
IL WINNE	53.445	0
IL WOODF	60.423	0
IN CARRO	55.196	0
IN CASS	51.812	0
IN JASPE	52.812	0
IN NEWTO	52.621	0
IN UNION	55.373	0
IA AUDUB	54.161	0
IA BENTO	54.986	-21
IA BLACK	53.341	-27
IA BUCHA	51.785	0
IA BUTLE	54.844	0
IA CARRO	52.974	0
IA CASS	53.635	0
IA CEDAR	57.373	0
IA CERRO	54.892	-40
IA CHERO	52.632	0
IA CHICK	51.860	0
IA CLINT	59.111	0
IA DELAW	51.944	0
IA DES M	54.205	-28
IA FLOYD	53.210	0
IA FREMO	58.362	0
IA GRUND	55.506	0
IA HAMIL	52.681	0
IA HANCO	51.827	0
IA HARDI	54.638	-32
IA HARRI	54.521	-40
IA HENRY	55.219	0
IA IDA	53.085	0
IA IOWA	53.043	0
IA JASPE	54.349	0
IA JOHNS	53.817	0
IA JONES	55.672	0
IA LINN	54.510	0
IA LOUIS	55.843	0
IA LYON	54.132	-79
IA MAHAS	51.876	56
IA MARSH	55.582	0
IA MILLS	57.342	0

Table 3. cont.

State County	Percent Cropland Planted to Corn[a]	Moisture Index[b]
High Intensity (cont.)		
IA MITCH	52.553	0
IA MONON	54.133	0
IA MONTG	53.462	0
IA MUSCA	53.666	0
IA PLYMO	53.273	-69
IA POCAH	57.793	0
IA POTTA	56.010	0
IA SCOTT	72.638	-17
IA SHELB	54.150	0
IA SIOUX	57.921	0
IA STORY	53.539	0
IA TAMA	51.763	0
IA WASHI	54.392	-56
IA WINNE	51.895	0
IA WOODB	54.019	-144
MN MARTI	53.487	0
MN ROCK	54.447	0
MS ATCHI	66.300	89
MS HOLT	55.254	-31
NB BURT	55.025	0
NB COMIN	55.362	-185
NB DIXON	55.874	-84
NB DOUGL	64.804	0
NB SARPY	60.625	0
NB STANT	53.271	-50
NB THURS	51.926	0
OH PREBL	54.642	0
SD CLAY	53.167	0
SD LINCO	54.818	0
SD MINNE	56.257	-116
SD MOODY	53.580	0

[a] $\frac{\text{Acres of Corn Harvested}}{\text{Total Acres Harvested}}$

[b] Summed through the mean 32°F growing season