226

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PREDICTION OF FLUCTUATIONS IN CROP-HAIL LOSS DATA

by

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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

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GLOSSARY OF TERMS

Amplitude	The peak value of a periodicity from its mean (zero). (See Figure 7.)
Bandpass	A method to extend the periodicities into the future involving use of the given harmonic number, phase point, and amplitude for each significant periodicity found and then by combining all the extended periodicities with the mean value, to get predicted values. (See Figure 7 and discussion.)
Cosine wave	A graphical representation of the cosine function with the values of cosine function as ordinates (y coordinates) against the value of the angle as abscissas (x coordinates).
Cycle	A series of events that recur regularly.
End Effect	The dampening (reduction) of the amplitude of filter outputs at the beginning and ending of the data series. (See Figures 13 and 14.)
Filter	A set of symmetrical weights designed to separate a particular periodicity from other periodicities in a time series data set.
Filter Method (Technique)	A moving average type calculation with symmetrical weights applied to any significant periodicity to filter out (suppress) all other periodicities with other wavelengths. These filtered outputs can be extended into the future with the knowledge of amplitudes, wavelengths, and phase points occurring near the end of the record.
Filter Output	The output (a set of values) that is generated with the application of a filter, for any particular periodicity, to a time series data set. (See Figures 8 and 9.)
Harmonic Number	The number of times any particular periodicity is repeated in the series. Thus, it is the data record length divided by wavelength.
Histogram	Graphic representation of the observations in to different classes by bars or rectangles.
Mean	In this report the mean of a data series is the arithmetic average of the series.

Median	A value that is half way between the smallest and largest value of a data series.
Mode	The mode is the most frequently occurring value in a data series-
Noise	Random variation without any pattern.
Non-Integer Spectra	The spectral analysis with the capability to search for periodicities with wavelengths for which the record length is not a multiple, as well as with wavelengths for which the record length is a multiple.
Periodicity (Harmonic)	A waveform which moves around a zero mean value and in which the period of time between successive maxima and minima is nearly constant — throughout the data record length.
Phase Angle	Phase point expressed in degrees.
Phase Point	The point in time at which the harmonic (waveform) reaches the first maximum following the time of the first observation. (See Figure 7.)
Quartiles	After a data series has been arranged from low to high or vice versa, quartiles are groups of data each containing 25 percent of the values arranged according to size.
Significant Periodicities	Periodicities with too or more wavelengths, but not longer than one-fourth of the record length, and having amplitudes greater than would be expected from random variation. For example, greater than the 10 percent level of statistical significance which signifies odds are 10 to 1 that the periodicity was not due to chance alone.
Sine Wave	A graphical representation of the sine function with the values of sine function as ordinates (y coordinates) against the values of the angle as abscissas (x coordinates).
Spectrum	A decomposition of total variation in a data series showing the portion of the total variation attributed to each periodicity.
Spectral Analysis	A time series data analysis technique that has the capability to search for all the periodicities with different wavelengths in a data series.
Spectral Peaks	A sharp peak in the spectrum of the series indicating *a* periodicity at its appropriate wavelength.

Synthesis	Estimation of data point with the selected periodicities.
Time Series	A set of data (loss costs) arranged in sequence according to their time (year) of observation or occurrence.
Trend	Direction (either upward or downward).
Wave Length	The period of time between successive maxima or successive minima of a periodicity. (See Figure 7.)

INTRODUCTION

The Illinois State Water Survey performed a study of historical hail loss and rainfall variations for the Association during 1975-1977. The encouraging results, particularly on the statistical behavior of the past annual loss cost data, led to a subsequent 2-year research effort. This latest research project (1978-79) was designed to develop methods for estimating future loss cost values for 22 states and the principal hail loss districts in them (Fig.

Prediction of the weather, be it hail, rain, or temperature, for one or more years in the future is extremely difficult. Considerable research into such predictions is now being launched in the nation, based largely on statistical techniques. Basically, we know too little about the physical factors that create climate to perform such predictions, at least on a physical basis. Our statistically-oriented research for CHIAA has been at the frontier of this new area of research. The methods employed yield annual loss cost values for one up to five years ahead, but we do not consider the magnitudes to be the test of our method. Rather, we believe a reasonable product to be the prediction of trends and averages expected over the next one to five years.

These expectations were in line with applications envisioned by CHIAA for the insurance industry. Basically, rate setting, done for most states once every 3 to 5 years, has hinged on past experience. If, in the next 3 to 5 years, the experience of the past few years is expected to change (up or down from a flat unchanging mean loss cost, or the cessation of a decided up or down trend), then it will be useful in decisions as to the timing and magnitude of the proposed rate changes. A secondary application envisioned from the research was related to the possible forecast of years of extremely high or low costs in the next 5 years.

Use of the methods developed on this project, and the user assessment of the trial predictions made and evaluated herein should be done with respect to two key concepts.

One important concept for users of the results is to realize that the predictive methodology that has been evolved is still not finalized. The research is truly pioneering and future results should be monitored and used to consider improvements in the method. Predictions for future years should be generated each year using the latest year of experience.

A second concept that is critical to the statistical methodology we have evolved is the belief that the extra-terrestrial forces that control our climate (largely through oceanic influences) have rhythmic (non-random) pulsations and these are found in our climate. The sun is the major force driving our weather system and hence in determining the earth's climate. This solar influence, coupled with earth's rotation and the position and amount of the land and water mass, all interact in determining our climate. Much of the sun's energy is stored in our oceans, which cover 80% of the earth, and hence the oceans become major determinants of our air masses and hence our weather. Since the moon has a known major influence on the ocean tides, it too exerts some influence on weather and ultimately the climate.

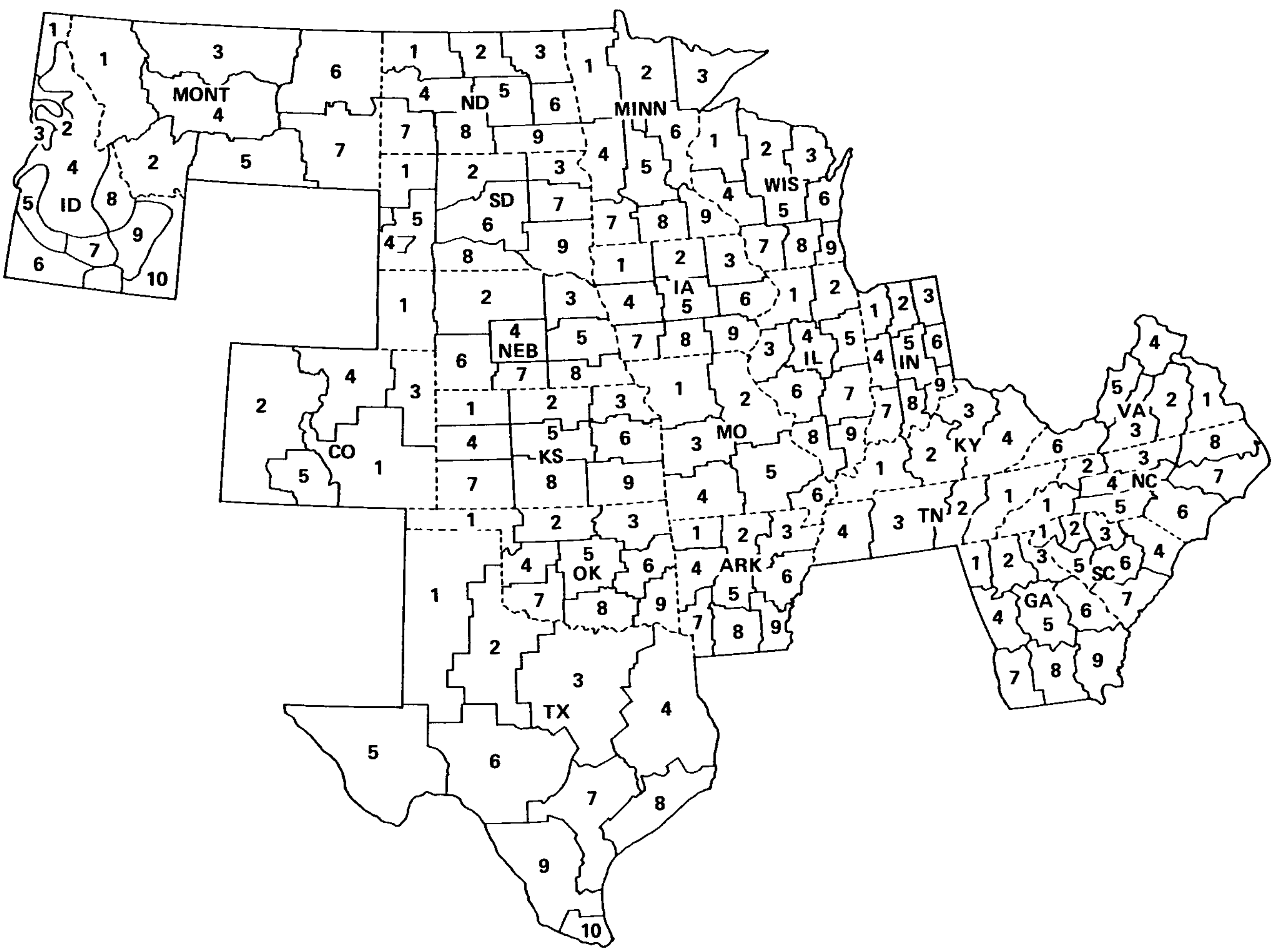


Figure 1. Data Map of Crop Hail Insurance Actuarial Association Loss Cost Values for 22 States and their Principal Hail Loss Districts for 1948-1978.

Man has long suspected there were periodicities in his weather and climate. The major cycle, of course, is the annual cycle. Since the mid 19th century there have been many claims of influence of solar activity or cycles on the climate. Arguments have raged over whether the sunspot cycle (recognized as a period generally of 22 years composed of two 11-year cycles of minimum and maximum sunspot frequencies) was associated with similar weather cycles on earth. It should be noted that sunspot cycles were often not at perfect 11-year intervals, being as short as 8.2 years at times. The sunspot concept received support because past severe U.S. droughts occurred about 22 years apart (1890, 1913, 1934, 1954). Tree rings spanning 1000 years were recently analyzed and revealed a growth periodicity closely corresponding with the sunspot frequency and hence these findings represent a strong new reason for believing the solar cycle is strongly involved in weather. Very recent results also argue that the 22-year solar cycle is not due to sunspots but rather is due to an 11-year fluctuation in the solar luminosity. Regardless, solar behavior reveals there are solar cycles and there is considerable evidence that these influence the weather and hence the climate of the earth.

The moon also has influences on the earth and our oceans. The moon moves in declination about the plane of the ecliptic with a period of 18.7 years. This induces an ocean tide with the simplest possible mode of oscillation, namely a movement of the general mass of ocean water from the equator to the poles and back, with a period 18.7 years. When the water is at the Poles it is cooled, and when at the Equator it is heated; hence, an 18.7-year period appears in ocean temperatures (which in turn affect air masses that move over the land area).

It is important to realize just how these sets of pulsations in the sun and moon can be combined to yield other pulsations. Combining the 18.7-year lunar period and the 11-year solar period yields a "beat" frequency of 6.9 years (1/18.7 + 1/11 = 1/6.9 years). Certain other known cycles that could affect the weather include the longitude of the moon, the lunar and solar perigees, and longitude of the moon's node. There are at least 17 possible lunar variables and 4 solar variables (and their various combinations) that can yield a wide variety of cycles of different length.

This project required a considerable data evaluation and manipulation effort. A schematic (Fig. la) outlines of the data analysis steps from the data evaluation stage through the predictions. Since the prediction method was dependent on the fluctuations in the past data, the past data had to be as consistent and correct, from a sampling viewpoint, as possible. Factors possibly affecting the consistency of past loss cost values were identified as crop variety changes, shifts in crop types, and unknown variations in placement or extent of insurance coverage. An objective procedure for evaluating past county loss cost data was evolved by CHIAA staff and used to develop the crop district and state data base for the 1948-1976 period.

This report first discusses this data evaluation effort. This is followed by a section treating the research on the estimation (prediction) procedures. Discussed are various exploratory analyses of periodicities in the historical data. This is followed by a discussion of the two prediction techniques employed: the use of mathematical filters and the use of the "bandpass"

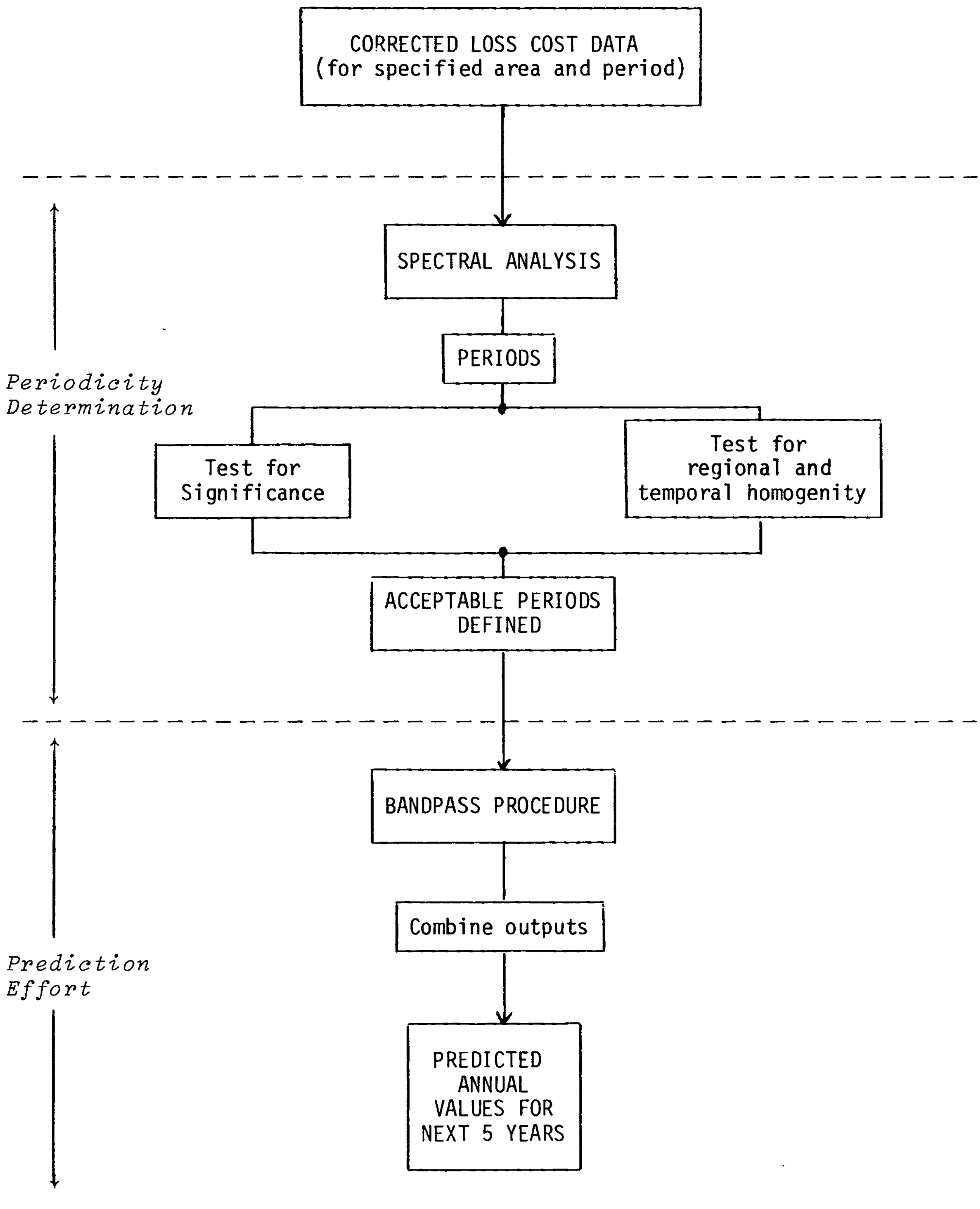


Figure 1a. Schematic of Data Analyis Steps.

approach in treating the spectral features of past records. This section then focuses on the extensive studies of Kansas data where we investigated differences in the two prediction techniques and chose bandpass over filtering for further predictions in a 21-state area. Results derived from shorter (1948-73) and longer (1924-1973) Kansas and North Dakota records are compared.

The third major section of the report presents the 21-state area spectral and bandpass prediction results. This includes the tables and graphs that display the results obtained for predictions in each district, for each state, and for various regions for periods of 1 up to 5 years ahead. The predicted test period was 1974-1978.

The final section summarizes these results, and offers recommendations for the future use of the methodology.

DATA AND ITS PREPARATION

The analysis was pursued using the CHIAA loss cost and liability data (from CHIAA 802 summaries) for 22 states (Arkansas, Colorado, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Carolina, Oklahoma, North Dakota, South Dakota, South Carolina, Tennessee, Kentucky, Texas, Virginia, Wisconsin). Most of these states have combination crops data (two or more crops), and several crops were analyzed separately. Nebraska has loss cost data for combination crops and also for corn and wheat separately. Two crop data sets were also analyzed for Kansas, North Dakota, and Texas.

The evaluation of the data as to its quality began at the county level. The counties were used in the analysis if they had $2 million or more total liability accummulated over the period 1948-1978 and if they had liability data for at least two thirds (21 years) of the years in the 31 year analysis period. When at least two thirds of the counties in a climatological division so qualified, the division was included in the analysis. In those cases, the county liabilities and losses were each summed for the climatological division. The division totals of liability and loss were then used to derive the division loss cost values (loss divided by liability times 100). After this process of evaluation, the final areas with data that were used in the statistical analysis were identified as shown in Figure 2, for combination crops and in Figure 3 for single crops. All of the 22 states with the expection of Tennessee had one or more districts with qualifying data.

To obtain state loss cost data, the data from the counties that had been judged to qualify (county liabilities and losses) were summed within each state and the state totals of liability and loss were used to construct state loss cost data. Only Illinois, Iowa, Kansas, and North Dakota had loss cost data for all their divisions. The rest of the states have data from only part of their divisions. If any state had several adjacent divisions of data (at least two), then "area" (substate) loss cost values were constructed in a similar way to the state loss cost values. The same procedure of data preparation was used for the Kansas combination crops, Kansas wheat, and the North Dakota wheat and barley data for the longer period, 1924-1978.

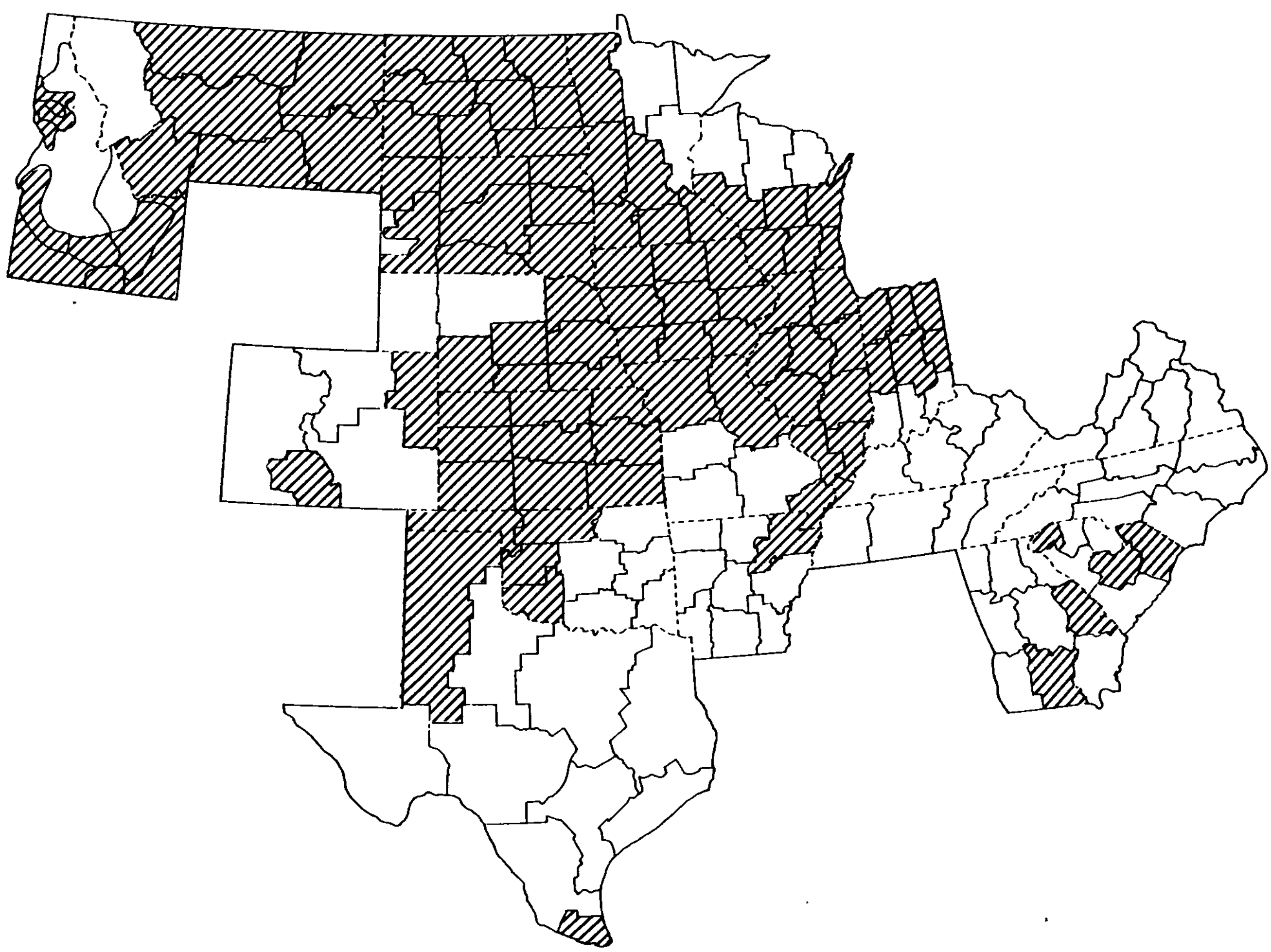


Figure 2. Data Map of Districts for Loss Cost Values for Combination Crops During 1948-1978.

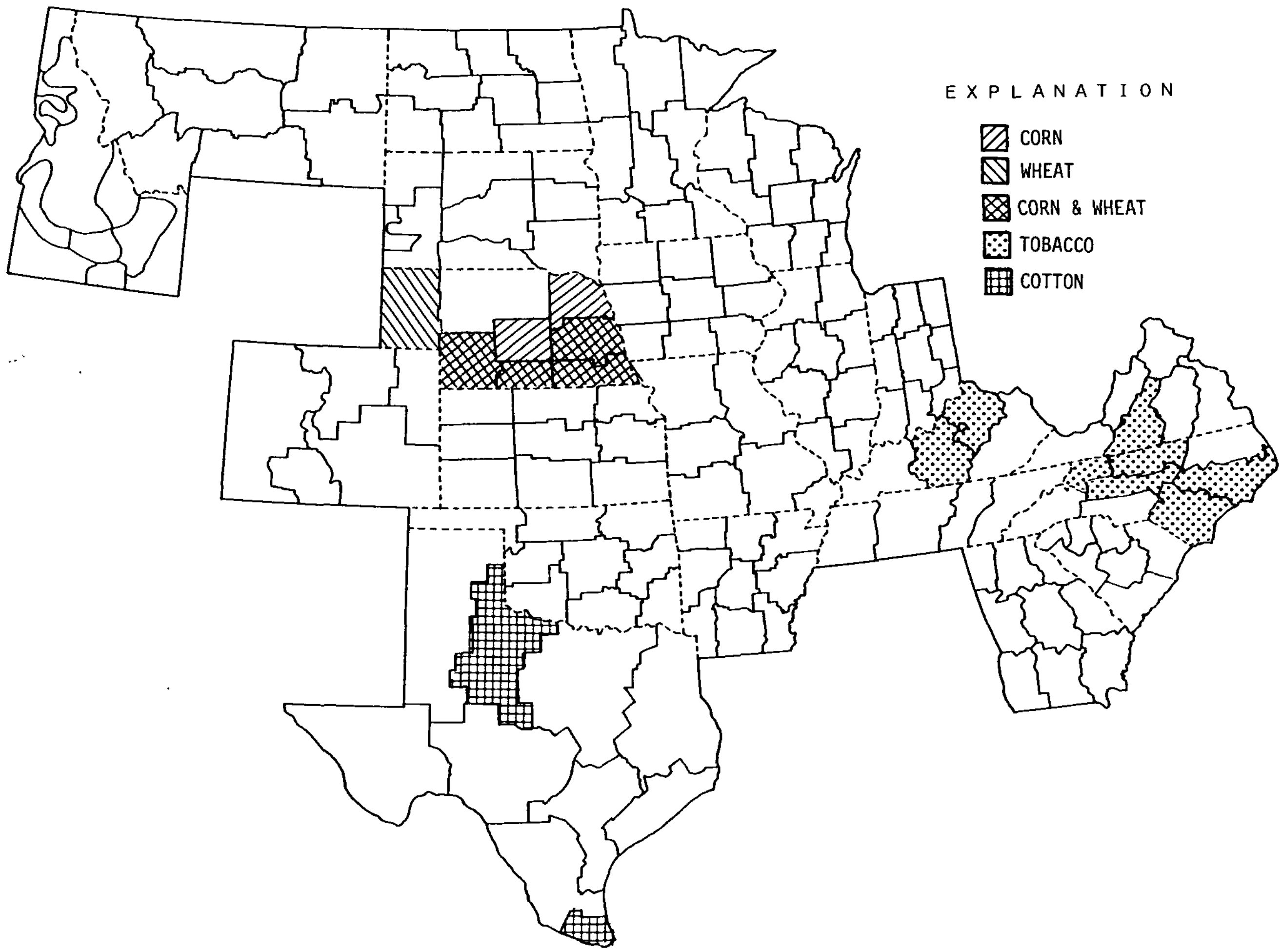


Figure 3. Data Map of Districts for Loss cost Values from Single Crops During 1948-1978.

SPECTRAL ANALYSIS PROCEDURES

Time series data analysis techniques were used to search for predictive power in the crop-hail loss cost data. The first step in predicting with time series analysis techniques involves a search for periodicities (nonrandom fluctuations or oscillations) in the historical loss cost data. Periodicities, if present, represent potential predictive power for anticipated variations in loss cost trends (up and down) during a future time period (1 to 5 years for this study). The schematic of the overall analysis and prediction technique used in this study (Fig. la) reveals the two basic steps: 1) the periodicity determination using spectral analyses, and 2) the prediction effort described in the next major section.

Nonrandom fluctuations in loss cost are assumed due to conditions (terrestrial, extraterrestrial, atmospheric etc.) that influence the occurrence of hail over a large area (several adjacent districts) in a similar manner. Integration of the hail experience (or loss) over time and space (summing over a crop exposure season and averaging over a large area) is necessary to reduce, or filter, the random component in individual hail events. Random components interfere with possible identification of periodicities.

A pertinent question the research faced was that of how much integration was required. It was, therefore, assumed that adjacent district average records should have similar temporal characteristics (annual trends) which would become evident in the spectra and correlations among district data within a state (or region) of similar size. Any fluctuations without some regional homogeneity were considered random events. Thus, while individual hailstorms appear rather random in their occurrence in space and time, the forces which produce hail have to vary regionally from season-to-season if periodicities are to be a reality in historical loss cost data. The establishment of periodicities in the historical data provide the basis for trend predictions, assuming periodicities will continue into the future with similar wavelength and amplitude.

Non-integer Spectral Algorithm

A search for periodicities was accomplished with a non-integer spectral analysis algorithm developed by Schickedanz and Bowen (1977). The algorithm is a set of computer instructions designed to test the "goodness of fit" of sine and cosine waveforms to historical data. This spectral analysis technique was employed because it is capable of performing a very thorough search for periodicities. The non-integer feature permits a search for wavelengths for which the observation period is not a multiple, as well as for those wavelengths for which the observation period is a multiple. Wavelengths resolvable to 0.1 year were searched for. Figure 4 shows a sample of many waveforms which were correlated with loss cost in the search for periodicities.

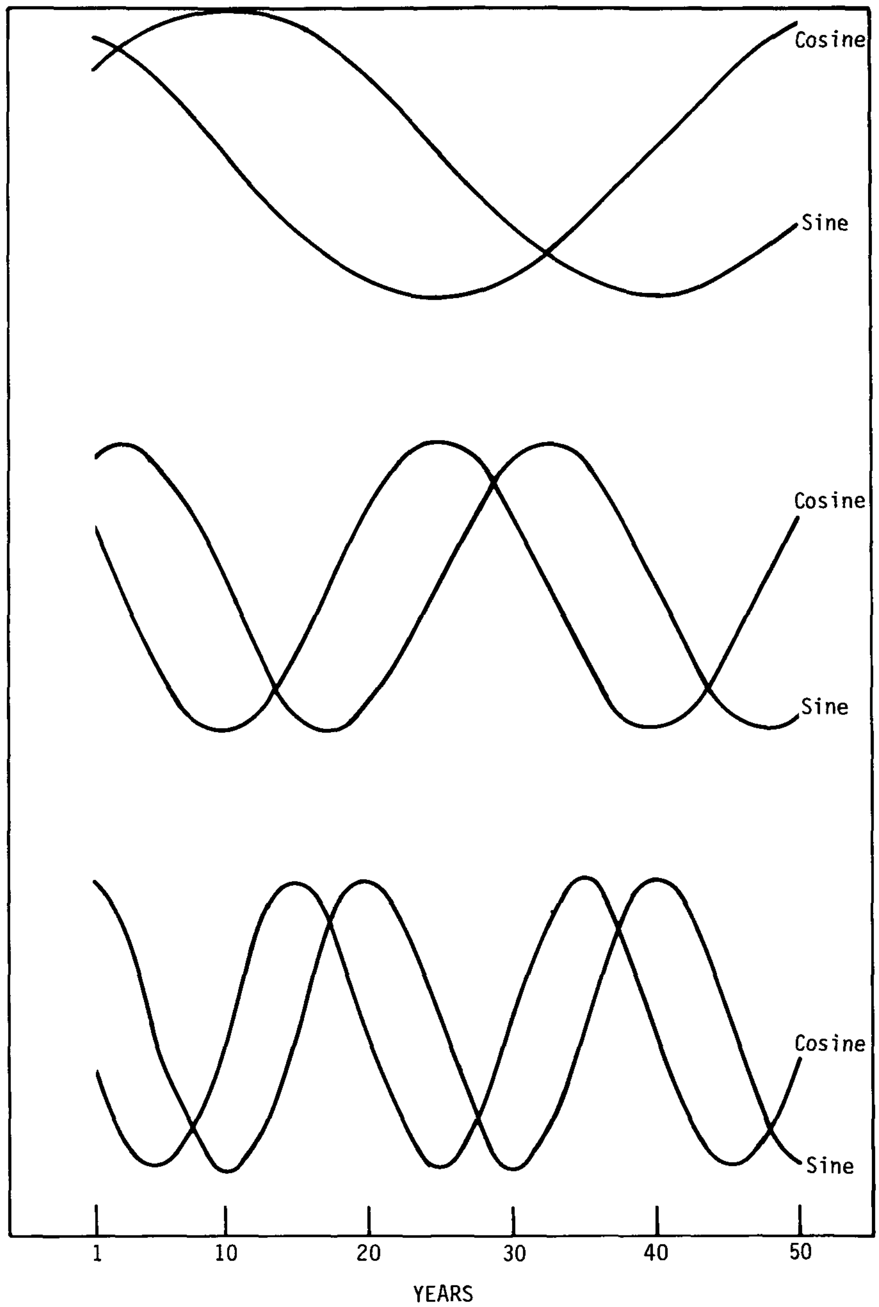


Figure 4. Example of Harmonics Used as Predictor Variables in Multiple Regression with Loss Cost.

Analysis Using 50-Year Records (1924-1973)

Spatial Spectral Variation - Kansas All Crops. The loss cost data for Kansas (all crops combined) were considered prime data for many exploratory analyses. Kansas climatological district records were the longest (1924-1978) and most reliable observations available. Hence, Kansas for the 50-year period 1924 through 1973 and data for each Kansas district (9 in all) were subjected to a spectrum analysis, 1) to search for significant periodicities, and 2) to determine the degree of areal coherence across the state. Spectral coherence for one or more periodicities from adjacent districts is considered a very important condition for the establishment of a potential prediction technique with periodicities as predictors. The 5-year (1974-1978) record was excluded and saved for later independent (prediction) comparisons.

The multiple correlation between loss cost and the sine and cosine waveforms was the statistic employed to determine evidence of a spectral peak or periodicity. The spectral analysis program determined a correlation for loss cost with each waveform.

These correlations were plotted versus the period (wavelength) of the waveforms. Only periods from 2 years to 12 years are displayed in Figure 5 for each of the 9 Kansas districts and for the state average, as a visual representation of spectral outputs. Periods shorter than 2 years are not resolvable with annual data. The resolution of periodicities longer than 12 years is questionable from base records no longer than 50 years. Experimentation with the non-integer program suggested a data record length of 4 to 5 times the period of an oscillation is needed for accurate determination of the period. Thus, the resolution of periodicities greater than 12 years is not considered reliable from observation periods of 50 years.

Examination of the district spectra (Fig. 5a-i) reveals many peaks in the correlation traces between 2 and 6 years. Hence, a procedure was needed to select the more meaningful peaks (periods) and to reject those less meaningful. The 10 percent level of statistical significance was selected as a guideline for accepting a periodicity. With a 50-year record, a correlation of 0.30 is needed at the 10 percent level for statistical significance (odds are 1 in 10 that the peak is real rather than a chance variation). Another expression of the importance of a periodicity chosen in this manner is to realize that the square of the correlation represents that portion of the variance of the annual loss cost observations for the 50-year sampling (measurement) period. For example, a correlation of 0.30 accounts for 9 percent of the loss cost variation. Most districts had periodicities with correlations which approached and exceeded this rather moderate level of statistical significance.

Correlation plots such as in Figure 5 were examined for evidence of periodic variations which had similar frequency of occurrence in adjacent districts. Intuitively, spatial frequency coherence should strengthen the argument for using periodic waveforms as predictors for values of district and larger (combined districts) areas. Spatial frequency coherence does not prove the loss cost experience over adjacent districts is varying with similar causative forces. However, such an areal condition is evidence that periodicities exist in the data system. It was difficult to discern spatial coherence from the correlation plots; consequently, a tabulation was made.

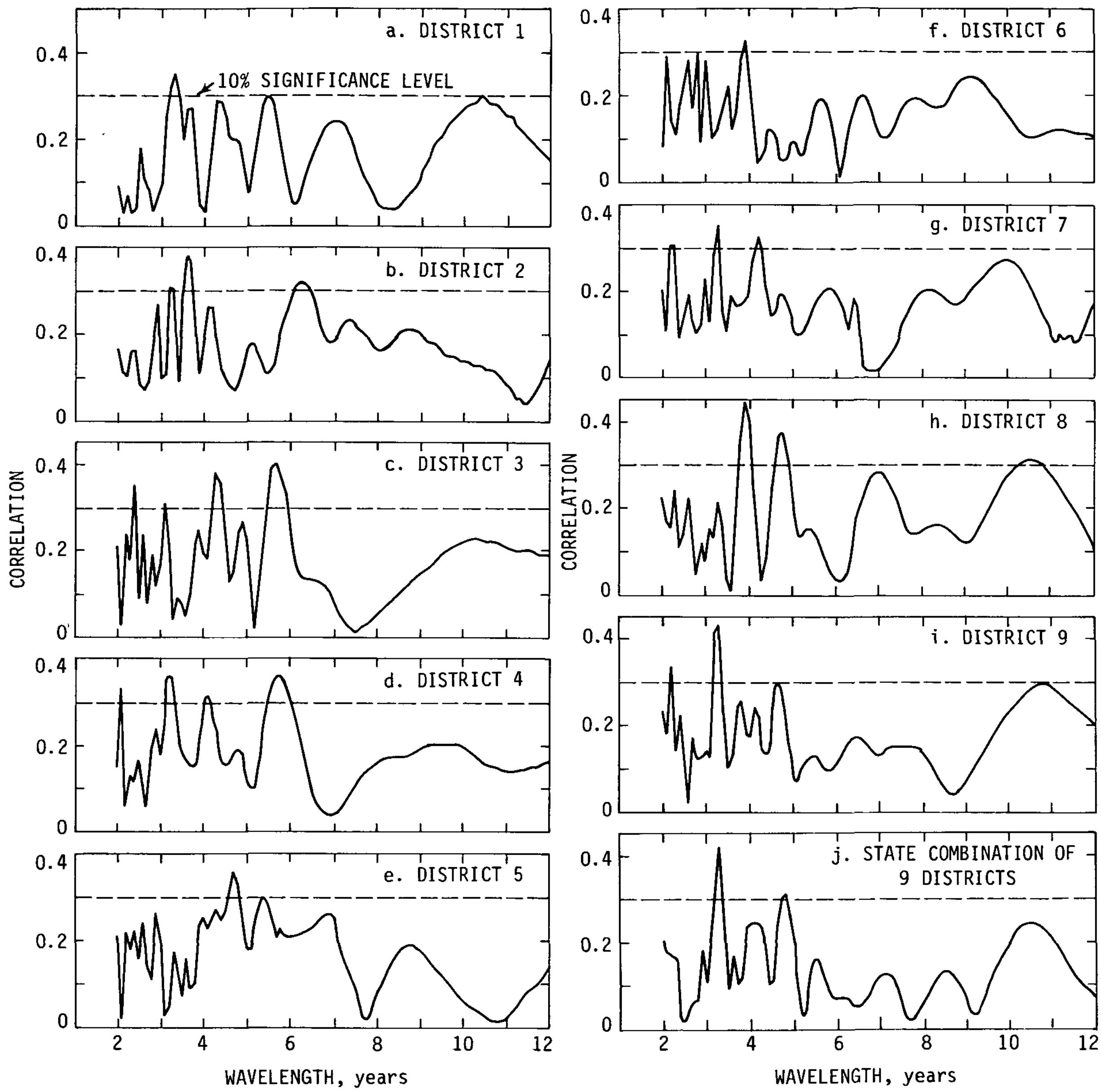


Figure 5. Multiple Correlation Plots of Harmonics with Kansas All Crops Loss Cost, 1924-1973.

Waveforms with correlation near 0.30 with loss costs are tabulated in Table 1. The tabulation is a way to classify the more consistent oscillations. Periodicities recorded to the nearest tenth of a year are shown along with their correlation coefficients. Those with lesser correlations with the loss cost variable are not considered useful as potential predictors. Periodicity categories in columns 2 (3.0-3.9 year range) and 3 (4.0 to 4.9 years) of Table 1 have the most consistent or coherent wavelengths for the "all crops" over the nine Kansas districts. Other sample periodicities exhibit very little repetition, or coherence, among districts. For example, note that district 2 (Kansas all crops) has a 6.2-year period that exceeds the 0.30 correlation, but such a period does not appear in the other eight districts.

All qualifying county loss cost experiences were combined to obtain annual state average loss costs. Averaging over an area offered the possibility of filtering out some random fluctuations that hinder the identification of rhythmic variations. Multiple correlations (spectral analysis) for waveforms of 2 through 12 years for Kansas are presented in Figure 5j. A visual comparison with the 9 individual district plots indicates some filtering or smoothing may have been achieved. Only two periods, a 4.8-year and a 3.3-year, exceed the 0.30 correlation (accepted 10% significance level). These two periodicities evidently reflect the district fluctuations in the 3.0 to 3.9 and 4.0 to 4.9-year periods tabulated in Table 1. Thus, it appears these are the dominate nonrandom fluctuations in the Kansas all crops data.

Spatial Spectral Variations - Kansas Wheat. The same spectral analysis discussed above was done for Kansas wheat data, the major crop in the state. Limiting the data sampling to this crop, and to one portion of the hail season, could remove variations which may obstruct the identification of certain nonrandom fluctuations. Those periodicities in the wheat data which approach and exceed the 10 percent significance level are listed in Table 1. The spectral picture is similar to that for the all crops spectra (Table 1). The periodicities from 3 to 5 years are the most coherent in both data sets. Importantly, this is the range of periodicity that should be most important for making the 3-year to 5-year predictions which are desired by CHIAA for rate review procedures.

Spatial Spectral Variation - North Dakota Wheat and Barley. Spectra for North Dakota wheat and barley were also calculated and periodicities qualifying statistically are tabulated in Table 1. The predominate periodicities are in the vicinity of 3.9 and 2.8 years as shown in columns 1 and 2 of the table. Note that the periodicities in the 2.0-2.9-year range appear in all but the two southeastern most districts (#6 and 9).

The 3.9-year period for the combined (state) district data of the state is about midway between the 3.3- and 4.7-year periods of the Kansas wheat loss cost data, but it does fall in the same 3.0-3.9 class with the 3.3-year Kansas periodicity. The 2.8-year period in North Dakota is 0.5 year less than the 3.3-year period in the combined district data for Kansas. Therefore it is in closer agreement with results of 5 Kansas districts in the 2.0-2.9 class. North Dakota data had no state value to compare with the Kansas statewide 4.7-year period.

Table 1. Loss Cost Periodicities for Kansas and North Dakota based on 1924-1973 data[1].

Periodicities (Years) within 1-year intervals

Dist.	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	8.0-8.9	10.0-10.9
				Kansas (All Crops)			
1		3.3	4.3	5.4			10.4
		.35	.38	.30			.30
2		3.2 3.6			6,.2		
		.31 .38			.32		
3	2.4	3.1	4.3	5.7			
	.35	.31	.38	.40			
4	2.1	3.2	4.1	5.7			
	.33	.36	.31	.36			
5			4.7	5.4			
			.36	.30			
6	2.8	3.9					
	.30	.32					
7	2.2	3.3	4.2				
	.30	.35	.32				
8		3.9	4.7				10.5
		.45	.37				.31
9	2.2	3.3	4.6				10.8
	.33	.43	.30				.30
State[2]		3.3	4.8				
		.42	.31				
Dist.				Kansas (Wheat)			
1		3.3	4.3	5.4			
		.35	.31	.31			
2		3.2 3.6			6,.3		
		.32 .39			.36		
3		3.1	4.3 4.9	5.7			
		.35	.32 .37	.30			
4	2.1	3.3	4.0	5.7			
	.32	.41	.33	.31			
5			4.7	5.4			
			.36	.30			
6							
7		3.3	4.2				
		.34	.30				
8		3.9	4.7				10.5
		.45	.37				.31
9	2.2	3.3					10.9
	.33	.43					.30
State[2]		3.3	4.7				
		.42	.33				

[1] The first row for each district is the period, and the second (bottom) now shows the correlation of the periodicity with loss cost data.

[2] Obtain by an analysis after combining county data.

Table 1 (Continued)

Periodicities (Years) within 1-year intervals

Dist.	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	8.0-8.9	10.0-10.9
			North Dakota (Wheat and Barley)				
1	2.5		4.0 4.6				
	.31		.42 .31				
2	2.4	3.1 3.8					
	.42	.30 .34					
3	2.7	3.5	4.5				
	.32	.34	.31				
4	2.9	3.9			6.8		
	.35	.30			.35		
5	2.5	3.0			6.9		10.3
	.31	.30			.33		.36
6					6.0	8.4	
					.32	.35	
7	2.8				6.9	8.8	
	.34				.44	.33	
8	2.0	3.0					
	.32	.34					
9		3.8		5.5			
		.31		.34			
State	2.8	3.9					
	.32	.30					

Table la. Lost Cost Periodicities for Kansas and North Dakota Based on 1948-1973 Data(1)

Periodicities (Years) within 1-year intervals

Districts	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9
		Kansas (All Crops)			
1		3.2 .52	4.5 .51	–	6.8^+ .40
2		3.5 .44			–
3	2.3 .42	-	4.2 .45	5.7 .57	
4	–	3.3 .56	–	5.4 .44	
5			4.8 .47	–	
6	2.2 2.5 .42 .44	3.7 .43			
7	2.3 .44	3.3 .42	4.2 .48		
8	2.3+ .56	3.2 3.9 .44 .46	–		
9	2.0 2.4 .43 .43	3.2 3.9 .51 .42	–		
State(2)		3.3 0.57	-		

(1)The first row for each district is the period, and the following row shows the correlation of the periodicity with loss cost data.

(2)Obtained by an analysis after combining county data.

⁻ Periodicities were significant in the 50-year record but were non-significant in the 26-year record.

$^+$ Periodicities which were significant in the 26-year record and non-significant in the 50-year record.

Table la (continued).

Districts	Periodicities (Years) within 1-year intervals 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9
		Kansas (Wheat)			
1		3.2 .52	4.5 .53	-	
2		3.0 3.5 .40 .46			-
3			—		
4	-	3.3 .62	-	5.1 .44	
5			4.8 .47	—	
6	2.2^{+} .41				
7	2.3^{+} .44	3.3 .41	4.1 .43		
8	2.3^{+} .54	3.2 3.9 .44 .47	—		
9	2.4 .43	3.2 3.8 .52 .41			
State[2]		3.3 .55	4.0 .46		
		North Dakota (Wheat & Barley)			
1	-	3.7^{+} .41	-		
2	—	3.1 3.9 .55 .40			
3	—	3.4 .42	—		
4	2.9 .53	—			—
5	2.4 2.9 .43 .44	—			—
6					6.5 .56
7	2.1 .42				—
8	2.9 .50	—			
9	2.5 .40	—		5.6 .43	
State[2]	-	3.5 .40			

Temporal Spectral Variation

Thus far, the analysis presentation has been confined to a search for periodicities and a review of their spatial coherence. Temporal, as well as spatial, variation is pertinent to a prediction approach that uses periodicities since predictions will be made on the assumption that the periodic functions of the past continue into the future.

Temporal variation was determined initially by analyzing 20-year sampling periods of Kansas loss cost for combination crop data. The analysis began with the 1924 through 1943 period for the all crops data series and proceeded through the 55-year record in a "sliding fashion" with 20-year periods determined by dropping the first year and picking up the next year. A 20-year period was used in this moving spectral analysis in order a) to search for temporal variation in 2 through 5-year periodicities, and b) because 20 years is considered the necessary record length from which periodicities of up to 5 years in wavelength can be determined with reasonable accuracy.

A tabulation of the stronger periodicities from 2- to 5-year periods resulting from the moving analysis is presented in Tables 2, 3, and 4. The periods (wavelengths) in Table 2 basically represent variations (3.1 to 3.6 years) around the 3.3-year Kansas average wavelength for 1924-1973 (last line of Table 2). The 3.3-year wavelength was determined from a combination of all 9 Kansas districts for a single, 1924-1973 data period. This wavelength has the best correlation (R = 0.43) of any periodicity with Kansas average 1924-1973 data and must be considered as having the most prediction potential contained in the state's historical record. The short term prediction potential of a periodicity should be inversely proportional to its temporal variation. Considerable repeatability of the approximate 3.3-year periodicity is demonstrated in Table 2. The wavelength varies slowly and seldom changes more than 0.1-year as the 20-year sample moves along through the 55-year record. Most of the correlations either approach or exceed the 10 percent level of significance (0.49) required for 20-year samples. The amplitude of a periodicity is another important characteristic, as shown in Table 2. It varies directly with the correlation coefficient and represents the change in the loss cost ratio as the wave progresses through its wavelength.

Sample 20-year periodicities, which represent variation around the Kansas 4.8-year periodicity, are shown in Table 3. These are considerably more variable in sequential observation periods than those reported in Table 2 for the 3.3-year period. Variations of 0.1-year up to 1.3-years occurred in the 20-year samples of the 50-year period. Some of the variation is due to random data variation. However, a change of 1 year suggests instability in a periodicity that may render it useless as predictor. Correlations associated with these 20-year samples are generally small prior to the 1951-1970 period sample. Analysis of the last eight 20-year samples in Table 3 demonstrate temporal coherence and signficant correlations. This suggests a 4.3-year periodicity may be a useful predictor for the immediate future. Periodicities of Table 3 are contributory to the 4.8-year average oscillation of the Kansas 50-year all crops record (as shown in Table 1).

There is in Kansas also a third periodicity which is approximately 2.0 year (Table 4). This 2-year period indicates a change in trend since the previous year relationships. That is, if last years value was up, this year's value would be down. This period has no average, or counterpart, in the

Table 2. Moving spectral outputs around a 3.3-year period based on annual loss cost (Kansas all crops data).

Sample No.	Years	R*	Period	Amplitude	Phase
1	1924-1943	.47	3.6	1.44	1.11
2	1925-1944	.43	3.5	1.29	0.43
3	1926-1945	.47	3.6	1.51	-1.10
4	1927-1946	.54	3.5	1.71	-1.72
5	1928-1947	.44	3.5	1.37	0.91
6	1929-1948	.38	3.3	1.10	0.46
7	1930-1949	.41	3.4	1.23	-0.81
8	1931-1950	.41	3.4	1.22	1.60
9	1932-1951	.43	3.3	1.40	0.68
10	1933-1952	.49	3.2	1.58	0.03
11	1934-1953	.52	3.1	1.58	-0.48
12	1935-1954	.45	3.1	1.33	-1.45
13	1936-1955	.58	3.3	1.64	-0.01
14	1937-1956	.69	3.1	1.87	-0.30
15	1938-1957	.66	3.2	1.72	1.58
16	1939-1958	.68	3.2	1.80	0.55
17	1940-1959	.70	3.2	1.95	-0.46
18	1941-1960	.67	3.2	1.70	-1.41
19	1942-1961	.65	3.2	1.64	0.77
20	1943-1962	.59	3.2	1.46	-0.18
21	1944-1963	.65	3.3	1.61	-1.56
22	1945-1964	.65	3.4	1.61	0.45
23	1946-1965	.62	3.5	1.40	-0.96
24	1947-1966	.61	3.5	1.39	1.58
25	1948-1967	.55	3.2	1.35	1.15
26	1949-1968	.54	3.2	1.30	0.15
27	1950-1969	.54	3.2	1.27	-0.93
28	1951-1970	.53	3.2	1.23	1.24
29	1952-1971	.51	3.3	1.30	0.10
30	1953-1971	.58	3.2	1.47	-0.48
31	1954-1973	.57	3.2	1.46	-1.43
32	1955-1974	.59	3.3	1.51	0.42
33	1956-1975	.58	3.3	1.48	-0.59
34	1957-1976	.56	3.3	1.39	-1.58
35	1958-1977	.58	3.3	1.47	0.67
36	1959-1978	.56	3.2	1.40	-0.01
	1924-1973	.43	3.3	1.22	-1.44

*A multiple correlation (R) of .49 is required for significance at 10% level for 20-year samples.

Table 3. Moving spectral outputs around a 4.8-year period based on annual loss cost (Kansas all crops data).

Sample No.	Years	R*	Period	Amplitude	Phase
1	1924-1943	.39	4.8	1.18	.37
2	1925-1944	.37	5.0	1.12	-1.33
3	1926-1945	.36	5.4	1.07	2.39
4	1927-1946	.32	5.4	1.03	1.55
5	1928-1947	.36	4.7	1.11	1.24
6	1929-1948	.30	4.6	0.85	0.78
7	1930-1949	.28	4.9	0.83	-0.68
8	1931-1950	.28	4.8	0.83	-1.37.
9	1932-1951	.31	4.2	1.01	-1.02
10	1933-1952	.28	4.1	0.89	-1.80
11	1934-1953	.34	4.5	1.03	0.23
12	1935-1954	.43	4.3	1.26	-0.28
13	1936-1955	.46	4.2	1.31	-0.93
14	1937-1956	.38	4.1	1.05	-1.77
15	1938-1957	.36	4.2	0.93	0.97
16	1939-1958	.40	4.1	1.06	0.11
17	1940-1959	.32	4.0	0.89	-0.65
18	1941-1960	.27	3.9	0.69	-1.47
19	1942-1961	.26	3.9	0.65	1.40
20	1943-1962	---	---	----	----
21	1944-1963	---	---	----	----
22	1945-1964	---	---	----	----
23	1946-1965	.27	4.8	0.63	2.39
24	1947-1966	.29	4.8	0.65	1.31
25	1948-1967	.34	5.8	0.83	-2.87
26	1949-1968	.41	5.5	0.99	2.60
27	1950-1969	.46	5.2	1.09	2.35
28	1951-1970	.51	3.9	1.20	0.50
29	1952-1971	.57	4.2	1.46	-1.29
30	1953-1972	.55	4.2	1.39	-1.86
31	1954-1973	.64	4.4	1.63	0.22
32	1955-1974	.68	4.3	1.75	-0.19
33	1956-1975	.70	4.3	1.78	-1.55
34	1957-1976	.66	4.3	1.64	1.66
35	1958-1977	.57	4.4	1.44	0.44
36	1959-1978	.57	4.5	1.43	-0.73
	1924-1973	.31	4.8	0.91	0.22

*A multiple correlation (R) of .49 is required for significance at the 10% level for 20-year samples.

Table 4. Moving spectral outputs around a 2.1-year period based on annual loss cost (Kansas all crops data).

Sample No.	Years	R*	Period	Amplitude	Phase
1	1924-1943	---	---	----	----
2	1925-1944	---	---	----	----
3	1926-1945	.32	2.0	1.01	0.50
4	1927-1946	.26	2.0	0.82	-0.50
5	1928-1947	.45	2.0	1.40	0.50
6	1929-1948	---	---	----	----
7	1930-1949	.30	2.0	0.91	0.50
8	1931-1950	.33	2.0	0.98	-0.50
9	1932-1951	.44	2.0	1.42	0.50
10	1933-1952	.48	2.0	1.53	-0.50
11	1934-1953	.42	2.0	1.29	0.50
12	1935-1954	.42	2.0	1.23	-0.50
13	1936-1955	.48	2.0	1.37	0.50
14	1937-1956	.55	2.1	1.50	0.36
15	1938-1957	.55	2.0	1.45	0.50
16	1939-1958	.53	2.1	1.42	0.56
17	1940-1959	.52	2.1	1.45	-0.38
18	1941-1960	.51	2.1	1.28	0.58
19	1942-1961	.52	2.1	1.31	-0.40
20	1943-1962	.60	2.1	1.49	0.77
21	1944-1963	.61	2.1	1.52	-0.22
22	1945-1964	.55	2.0	1.35	0.50
23	1946-1965	.48	2.1	1.09	-0.20
24	1947-1966	.48	2.2	1.10	0.59
25	1948-1967	.51	2.3	1.26	-0.79
26	1949-1968	.44	2.0	1.06	0.50
27	1950-1969	.38	2.0	0.91	-0.50
28	1951-1970	.35	2.0	0.81	0.50
29	1952-1971	.35	2.3	0.88	-0.44
30	1953-1972	.34	2.3	0.86	0.75
31	1954-1973	.38	2.3	0.97	-0.11
32	1955-1974	.38	2.3	0.97	-1.10
33	1956-1975	.34	2.3	0.86	0.18
34	1957-1976	.32	2.2	0.79	-0.29
35	1958-1977	.35	2.1	0.88	-0.90
36	1959-1978	.35	2.1	0.88	0.21

*A multiple correlation (R) of .49 is required for significance at the 103 level for 20-year samples.

Kansas 50-year analysis (Table 1) and for some of the early 20-year samples, there is no evidence of a 2-year oscillation. For this periodicity, there are only two computed points available for defining the projected sine wave. Therefore, its potential as a predictor is probably limited. Next year's trend can be predicted as accurately by the simpler method of predicting one year in advance by using the median and the previous year's loss cost (Schickedanz, Reddy, and Changnon, 1977).

Summary of Spectral Analyses of 1924-1973 Data

The periodic data of the long state records (1924-1973) shown in Table 1 were summarized graphically in frequency diagrams, Figure 6. This presentation disregards the temporal and spatial variations discussed in the prior sections. The figure simply shows a count of the periodicities over the nine districts of each state (Kansas and North Dakota) after grouping into arbitrary 1-year classes. These frequency plots indicate the range of periodicities which contain the greatest potential predictive power. Kansas wheat and Kansas all crops have very similar histograms with the greater number of periodicities being in the 3.0- through 4.9-year range. The 3.0- through 3.9-year interval contains the greatest number of periodicities in all three state diagrams. Figure 6 supports the hypothesis that some predictive skill should be attained with proper use of sample periodicities in the 3.0-year through 4.9-year range in Kansas and North Dakota.

Comparative Spectral Analysis Using 26-Year Records (1948-1973)

The 50-year data records which were analyzed and discussed in previous sections of this report were only available for Kansas and North Dakota. Data for a much larger 21-state analysis were available only for a 26-year period (1948-1973), with the 5-year period (1974-1978) being saved for independent prediction verification. Consequently, spectral analyses for the 26-year period were duplicated as nearly as possible in order to determine whether the same periodicities found in the longer record were also in the shorter record.

Periodicities which were significant at the 10% level are tabulated in Table la for Kansas all crops, Kansas wheat, and North Dakota wheat and barley. For the shorter record (26 years instead of 50 years for the longer record) a minimum correlation of 0.40 is required for entry of a periodicity in Table la, compared with a correlation of 0.30 required for entry of a periodicity from the long record into Table 1. Magnitude of the correlation coefficient required for significance is inversely proportional to the record length. Also, the record length (26 years) was to short to allow accurate determination of periodicities with wavelengths greater than the 6.0 to 6.9 class. Consequently, the 8.0-8.9 and 10.0-10.9 periodicity classes of Table 1 were omitted from Table la

A smaller number of significant periodicities were found in the sorter data record. Kansas all crops had eight less significant district periodicities (marked with a - in Table la) and two new entries (marked with a + in Table la). The significant 4.8-year periodicity in the Kansas state all crops data analysis for the long record was not significant in the shorter data record. Other periodicity gains and losses are marked with + and - in

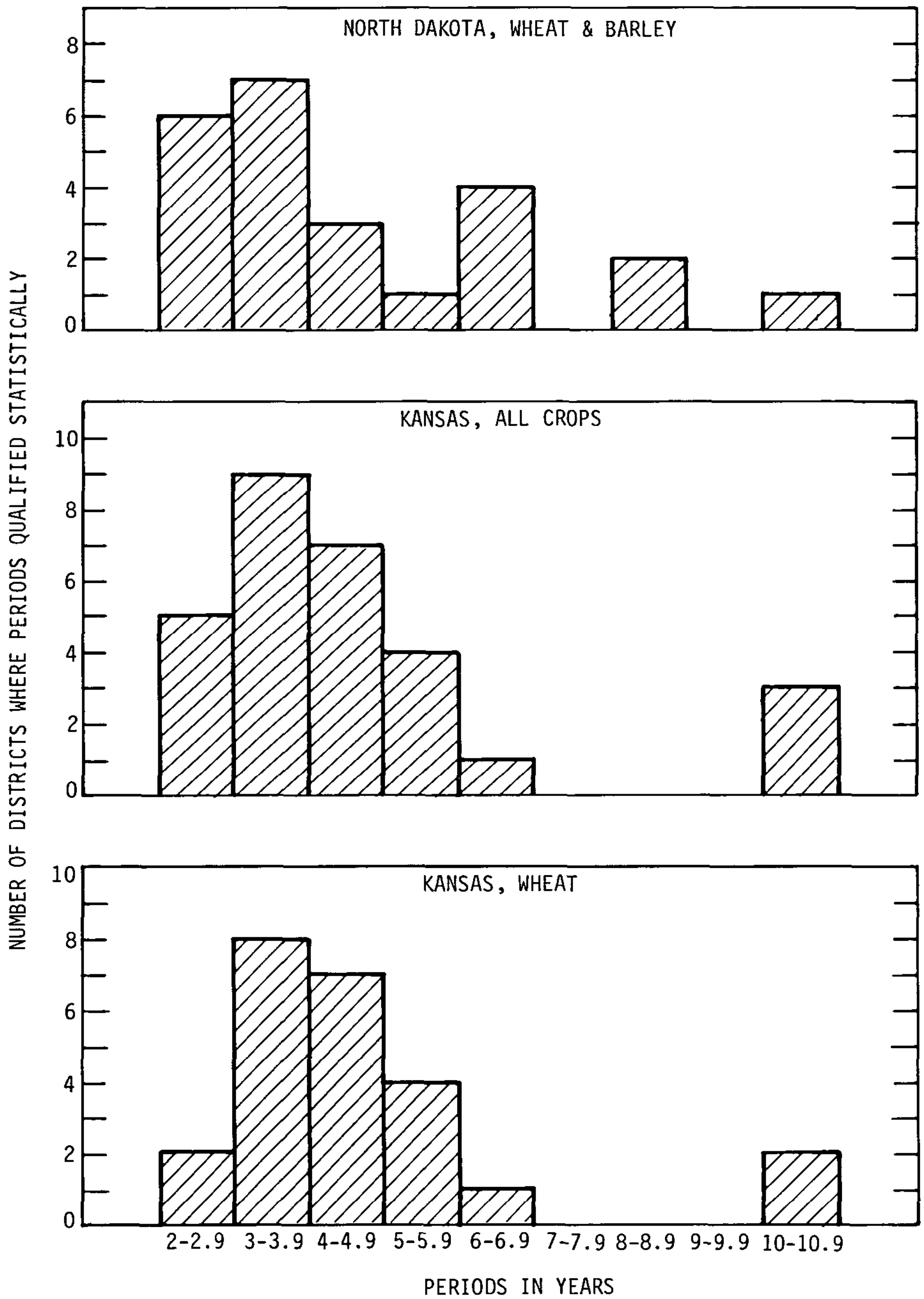


Figure 6. Frequency Histograms of the Number of Districts Having Various Periodicities in 1924-1973 Loss Cost Data Sample.

the Kansas wheat and North Dakota wheat and barley tabulations of Table la. Seldom were periodicities exactly the same wavelength in the two data records (long and short). However, the 3.3-year periodicity in the Kansas state data is very significant in both long and short records.

In summary, the 1948-1973 data record contained fewer and generally different periodicities than were found in the 1924-1973 record. Predictions, based on the two data bases, for the future 1974-1978 years will be different. These differences are presented and discussed in a later section (Comparison of Prediction Results from 1924-1973 and 1948-1973 Records) of this report.

COMPARISON OF TWO PREDICTION METHODS

During the initial portion of the prediction study, two prediction methods were considered. Due to the volume of data analysis (108 districts) under consideration, the project leaders, Changnon and Neill, of the Water Survey, and Fosse of CHIAA agreed to compare the skill of each method on common data and to select one for the remainder of the analysis. Kansas all crops data sets for 1924-1973 and for 1948-1973 were used for this comparison.

The two prediction methods are referred to as "bandpass" and "filters." Both methods utilize the periodicity results of a spectral analysis of historical data. Periodicities, which explained a statistically significant portion of the variance of the data, were used as predictors in each method. However, the manner in which the two methods use the significant periodicities differs.

Prediction with the Bandpass Method

The bandpass method utilized an empirical equation for extrapolating a periodicity into future years. The manner in which the bandpass method obtains a predicted annual loss cost ratio is described with the aid of Figure 7. This figure illustrates the determination of annual all crops loss cost ratios in Kansas for the prediction years 1974-1978 using the two significant periodicities, 3.3 and 4.8 years shown in Table 1.

The method requires, 1) the amplitude, 2) period (wavelength), 3) phase point, 4) harmonic number, and 5) the number of years (the number of years in the analysis period plus the number of years to be predicted) as input. The first four of these quantities come from a spectral analysis. The amplitude, period, and phase point are illustrated for the 4.8-year periodicity in Figure 7a. In theory, the estimated loss cost curve is a smooth and regular oscillation (dashed line of Figure 7a). However, with annual observations, the bandpass formula can only determine values at one year intervals on the smooth curve as shown by the less regular solid line.

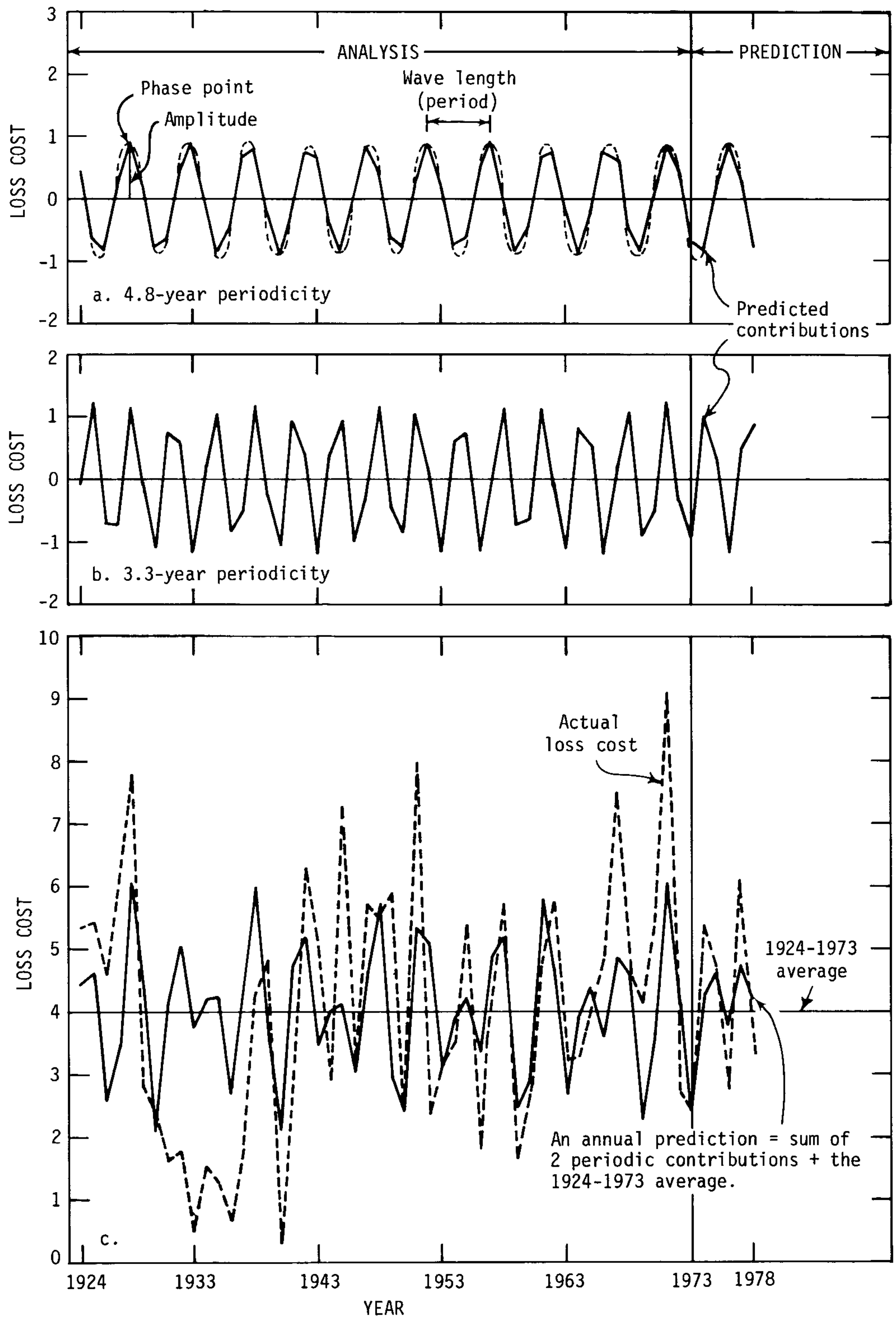


Figure 7. Bandpass Predictions for 1974-1978 Based on Kansas All Crops Loss Cost, 1924-1973.

Corresponding annual computed loss cost values (contributions) for each periodicity (Figure 7a and 7b) were added algebraically. Each of these sums was added to the average loss cost for the data analysis period (1924-1973) to obtain a reconstruction of the prediction basis data and to obtain five independent annual loss cost predictions (solid line connecting points in Figure 7c).

These summations provide an estimated loss cost for each year of the data analysis and a predicted loss cost for each of five years into the future. This prediction is illustrated in Figure 7 for Kansas. The figure also shows the actual hail loss cost experience for the state of Kansas for 1924 through 1978. The period from 1924 through 1973 was the data analysis period (prediction basis period) used in a search for significant periodicities which were used as predictors. The 1974 through 1978 record was saved for verification of the predictions. A good trend comparison is evident for the predicted values. A similar analysis was performed for the shorter Kansas record, 1948 through 1973, and a comparison of results with those for 1924-1973 are presented later. Trend predictions and numerical (quantitative) prediction results are shown for all 9 districts in Table 5 and Table 6, respectively. The values are discussed later as results of the two prediction techniques are compared.

Prediction with the Filtering Method

The other prediction method investigated involved mathematical filters. The term "filtering" is from electrical engineering and has the same general connotation and usage here. A filter is designed to suppress most periodicities (or frequencies) except the designated frequency it is designed to "pass". Values which are computed during a filtering operation will be referred to as a filter output. Filter testing was also performed on the Kansas data (both long and shorter records).

The procedure for determining a filter output is described with the aid of Figure 8. Figure 8a is a time series plot of Kansas all crops loss cost data for each year, 1924 through 1973. A filter for a 3.3-year periodicity (a periodicity determined from the spectral analysis see Table 1) was applied to the data for the period 1924 through 1973. A plot of the digital values of the 3.3-year filter is shown in Figure 8b. All filters used in this study were symmetrical around a vertical central value with 17 points to the left and 17 points to the right of center. In the vertical, the 35 points vary above and below zero. Points above the zero line are positive, in the algebraic sense, and those below zero are negative. In the Figure 8 illustration, the loss cost value for the year 1924 is positioned over the center filter value. The individual 3.3-year filter output value for 1924 is plotted directly below in Figure 8c. The digital value of the filter output with the data in this position, with respect to the filter, is the sum of products of the corresponding 35 filter and loss cost values. The entire filter output shown in Figure 8c is obtained by matching each loss cost data point with the center filter value, and repeating the multiply and sum computations. A filter output is similar to a moving correlation as the filter is systematically moved to the right along the data. In effect, the loss cost time series serves as an input to the filter, and the output is a new time series which becomes an input for the next step of the prediction process.

Table 5. Comparison of yearly predicted trends with actual trends using bandpass method with Kansas all crops, 1924-1973.

Trends, Up (U) or Down (D) with predicted on left and actual on right for each year

Districts	1974	1975	1976	1977	1978	%Correct	
			Kansas (all crops)				
1(NW)	U/U	U/U	D/D	*U/U	*U/D	88	80
2(NC)	U/U	D/U	U/U	U/U	*D/D	60	40
3(NE)	*D/U	U/D	*D/U	*U/D	D/D	20	100
4(WC)	U/U	D/D	*U/U	*D/D	*U/D	80	60
5(C)	U/U	U/D	U/D	D/U	D/U	20	20
6 (EC)	*U/D	D/U	*D/D	U/U	D/D	60	60
7(SW)	U/U	D/D	D/D	D/U	U/D	60	60
8(SC)	U/U	U/D	*D/D	D/U	U/D	40	40
9(SE)	U/D	U/D	D/D	U/U	*U/D	40	80
Percent Correct	89 67	67 33	44 67	44 56	56 33	51	60
State[1] Value	U/U	*U/D	D/D	U/U	*D/D	80	80

[1] Obtained from an analysis after combining county data.

*An asterisk by U and D signifies trend prediction obtained from 1948-1973 data were different than prediction from 1924-1973 data, otherwise prediction from both data sets agree. Underlined percentages are for predictions from 1948-1973 data.

Trends, Up (U) or Down (D) with predicted on left and actual on right for each year

Districts	1974	1975	1976	1977	1978	%Correct	
		Kansas (wheat)					
1(NW)	U/U	*U/U	D/D	U/U	U/U	100	60
2(NC)	U/U	D/U	D/D	U/U	D/D	80	80
3(NE)	D/U	U/D	D/U	D/D	U/D	20	60
4(WC)	U/U	D/U	D/D	U/U	*U/U	80	20
5(C)	U/U	U/D	U/D	D/U	D/U	20	100
6(EC)	No significant periodicties for prediction					-	-
7(SW)	U/U	D/U	D/D	U/U	U/D	60	60
8(SC)	U/U	*U/D	*D/D	D/U	U/D	40	40
9(SE)	D/D	*U/D	D/D	U/U	D/D	80	100
Percent Correct	100 87	38 12	75 75	75 75	38 50	60	65
State[1] Value	U/U	*U/U	D/D	U/U	U/D	80	60

(1) Obtained from an analysis after combining county data.

Table 5. Continued

Trends, Up (U) or Down (D) with predicted on left and actual on right for each year

Districts	1974	1975	1976	1977	1978	%Correct	
		North DakotaL (wheat and barley)					
1(NW)	*D/U	U/U	*U/D	D/D	*D/U	40	100
2 (NC)	D/D	D/D	U/U	D/U	*U/D	60	80
3(NE)	D/D	*U/D	U/U	D/D	*U/U	80	60
4(WC)	U/U	U/U	D/U	U/D	*U/D	40	60
5(C)	U/U	D/D	U/U	*U/U	U/D	80	60
6 (EC)	D/U	*U/D	U/U	U/U	*D/D	60	60
7(SW)	*U/D	*D/U	*U/D	U/U	D/D	40	100
8(SC)	*D/U	U/D	D/U	*D/U	U/D	0	40
9(SE)	D/D	U/D	*U/D	*D/U	D/D	40	80
Percent Correct	89 55	78 44	78 55	67 55	56 44	49	73
State[1] Value	U/U	D/D	*D/U	U/U	D/D	80	100

[1] Obtained from an analysis after combining county data.

Table 5a. Comparison of yearly predicted trends with actual trends using bandpass method for Kansas all crops, 1948-1973.

Trends, Up (U) or Down (D) with predicted on left and actual on right for each year

Districts	1974	1975	1976	1977	1978	%Correct
1(NW)	U/U	U/U	D/D	D/U	D/D	80
2(NC)	U/U	D/U	D/U	U/U	U/D	40
3(NE)	U/U	D/D	U/U	D/D	D/D	100
4(WC)	U/U	D/D	D/U	U/D	D/D	60
5(C)	U/U	U/D	U/D	D/U	D/U	20
6 (EC)	D/D	D/U	U/D	U/U	D/D	60
7(SW)	U/U	D/D	D/D	D/U	U/D	60
8(SC)	U/U	D/D	U/D	D/U	U/D	40
9(SE)	U/D	D/D	D/D	U/U	D/D	80
Percent Correct	89	67	44	44	56	60
State Value(1)	U/U	D/D	D/D	U/U	U/D	80

(1)Obtained by an analysis based on combining of county data.

Table 6. Comparison of actual loss cost, predicted loss cost values from bandpass method using significant periodicities based on 1924-1973, and 3-year and 5-year mean values.

District	3-year						5-year					
	Mean 1971-73	Actual 1974-76	Predicted 1974-76	A-M	P-M	P/A%	Mean 1969-73	Actual 1974-78	Predicted 1974-78	A-M	P-M	P/A%
						Kansas (all crops) (1924-73)						
1 (NW)	7.03	7.62	6.87	0.59	-0.16	90	6.78	8.01	7.86	1.23	1.08	98
2 (NC)	3.83	2.59	4.49	-1.24	0.66	173	3.95	3.84	4.56	-0.11	0.61	119
3 (NE)	0.83	2.43	1.54	1.60	0.71	63	1.05	1.86	1.43	0.81	0.38	77
4 (WC)	8.80	7.97	7.76	-0.83	-1.04	97	7.75	7.66	7.56	-0.09	-0.19	99
5 (C)	7.78	4.60	4.26	-3.18	-3.52	93	7.08	5.43	3.52	-1.65	-3.56	65
6(EC)	3.10	1.39	1.34	-1.71	-1.76	96	2.87	2.18	1.52	-0.60	-1.26	70
7 (SW)	5.12	4.27	7.76	-0.85	2.64	182	5.05	4.15	7.15	-0.90	2.10	172
8 (SC)	4.01	5.37	3.39	1.36	-0.62	63	4.78	4.97	3.40	0.19	-1.38	68
9 (SE)	2.34	1.03	1.28	-1.31	-1.06	124	2.72	1.40	1.45	-1.32	-1.27	104
Average	4.76	4.14	4.30	-0.62	-0.46	109	4.66	4.39	4.27	-0.27	-0.39	97
State[1]	4.79	4.33	4.20	-0.46	-0.59	97	4.78	4.48	4.30	-0.30	-0.48	96

(1) Obtained by an analysis based on combining of county data.

- Underlined values represent comparable percentage obt:ained from using 1948--1973 data.

Table 6. Continued

District	3-year Mean (71-73)	3-year Actual (74-76)	3-year Predicted (74-76)	A-M	P-M	P/A%	5-year Mean (69-73)	5-year Actual (74-78)	5-year Predicted (74-78)	A-M	P-M	P/A%
						Kansas (wheat) (1924-73)						
1(NW)	5.67	5.73	8.13	0.06	2.46	142	5.57	6.64	8.11	1.07	2.54	122
2(NC)	3.69	2.30	4.07	-1.39	0.38	177	3.71	3.76	4.57	0.05	0.86	122
3(NE)	0.62	3.36	1.48	2.74	0.86	44	1.32	2.54	1.48	1.22	0.16	58
4(WC)	6.86	6.49	8.17	-0.37	1.31	126	6.09	6.32	8.89	0.23	2.80	141
5(C)	8.38	4.62	4.34	-3.76	-4.04	94	7.50	5.57	3.56	-1.93	-3.94	64
6(EC)	No significant	periodicities										
7(SW)	3.57	4.64	7.29	1.07	3.72	157	5.09	5.18	6.98	0.09	1.89	135
8(SC)	4.03	5.42	3.40	1.39	-0.63	63	4.80	4.79	3.41	-0.01	-1.39	71
9(SE)	2.83	1.45	1.01	-1.38	-1.82	70	3.00	1.48	1.45	-1.52	-1.55	98
Average	4.46	4.25	4.74	-0.20	0.28	142	4.63	4.53	4.81	-0.10	0.17	126
State[1]	4.79	4.21	4.73	-0.58	-0.06	115	4.94	4.55	4.47	-0.39	-0.47	111
						North Dakota (wheat & barley) (1924-73)						
1 (NW)	4.01	3.70	5.85	-0.31	1.84	158	3.24	3.38	5.63	0.14	2.39	167
2(NC)	3.34	1.80	3.09	-1.54	-0.25	172	4.03	4.29	3.29	0.26	-0.74	77
3(NE)	3.37	3.48	2.68	0.11	-0.69	77	3.36	3.37	2.46	0.01	-0.90	73
4(WC)	1.74	3.42	6.08	1.68	4.34	178	3.05	2.88	6.52	-0.17	3.47	226
5(C)	3.57	3.76	4.75	0.19	1.18	126	3.07	5.43	5.39	2.36	2.32	99
6 (EC)	3.17	2.64	3.06	-0.53	-0.11	116	2.62	3.09	3.22	0.47	0.60	104
7(SW)	7.38	5.65	6.35	-1.73	-1.03	112	7.44	6.10	8.07	-1.34	0.63	132
8(SC)	5.57	6.62	6.22	1.05	0.65	94	5.97	6.83	6.41	0.86	0.44	94
9(SE)	4.67	2.47	2.65	-2.20	-2.02	107	3.07	3.33	3.06	0.26	-0.01	92
Average	4.09	3.73	4.53	-0.36	0.43	131	3.98	4.30	4.89	0.32	0.91	122
State[1]	3.60	3.16	4.06	-0.44	0.46	131	3.35	3.59	3.88	0.24	0.53	124

[1]Obtained from an analysis after combining county data.

Table 6a. Comparison of actual loss cost, predicted loss cost values from bandpass method using significant periodicities based on Kansas all crop data for 1948-1973, and 3-year 5-year mean values.

District	3-year						5-year					
	Mean 1971-73	Actual 1974-76	Predicted 1974-76	A-M	P-M	P/A%	Mean 1969-73	Actual 1974-78	Predicted 1975-78	A-M	P-M	P/A%
1 (NW)	6.98	7.66	12.06	0.68	5.08	157	6.73	8.04	10.25	1.31	3.52	127
2 (NC)	3.84	2.59	4.15	-1.25	0.31	160	3.95	3.84	4.36	-0.11	0.41	114
3 (NE)	0.83	2.44	2.08	1.61	1.25	85	1.15	1.87	1.52	0.72	0.37	81
4 (WC)	8.80	7.97	6.94	-0.83	-1.86	87	7.75	7.66	10.81	-0.09	3.06	141
5 (C)	7.78	4.60	5.14	-3.18	-2.64	112	7.08	5.43	3.92	-1.65	-3.16	72
6 (EC)	3.10	1.39	1.37	-1.71	-1.73	99	2.78	2.18	1.44	-0.60	-1.34	66
7 (SW)	5.12	4.27	1.24	-0.85	4.12	216	5.05	4.15	7.89	-0.90	2.84	190
8 (SC)	4.01	5.37	4.19	1.36	0.18	78	4.78	4.97	4.24	0.19	-0.54	85
9 (SE)	2.34	1.45	1.86	-0.89	-0.48	128	2.72	1.40	2.44	-1.32	-0.28	174
Average	4.76	4.19	5.23	-0.56	0.47	125	4.67	4.39	5.21	0.27	0.53	117
Stated[(1)]	4.79	4.33	4.43	-0.46	-0.36	102	4.78	4.48	4.76	-0.30	-0.02	106

[(1)] Obtained by an analysis based on combining county data.

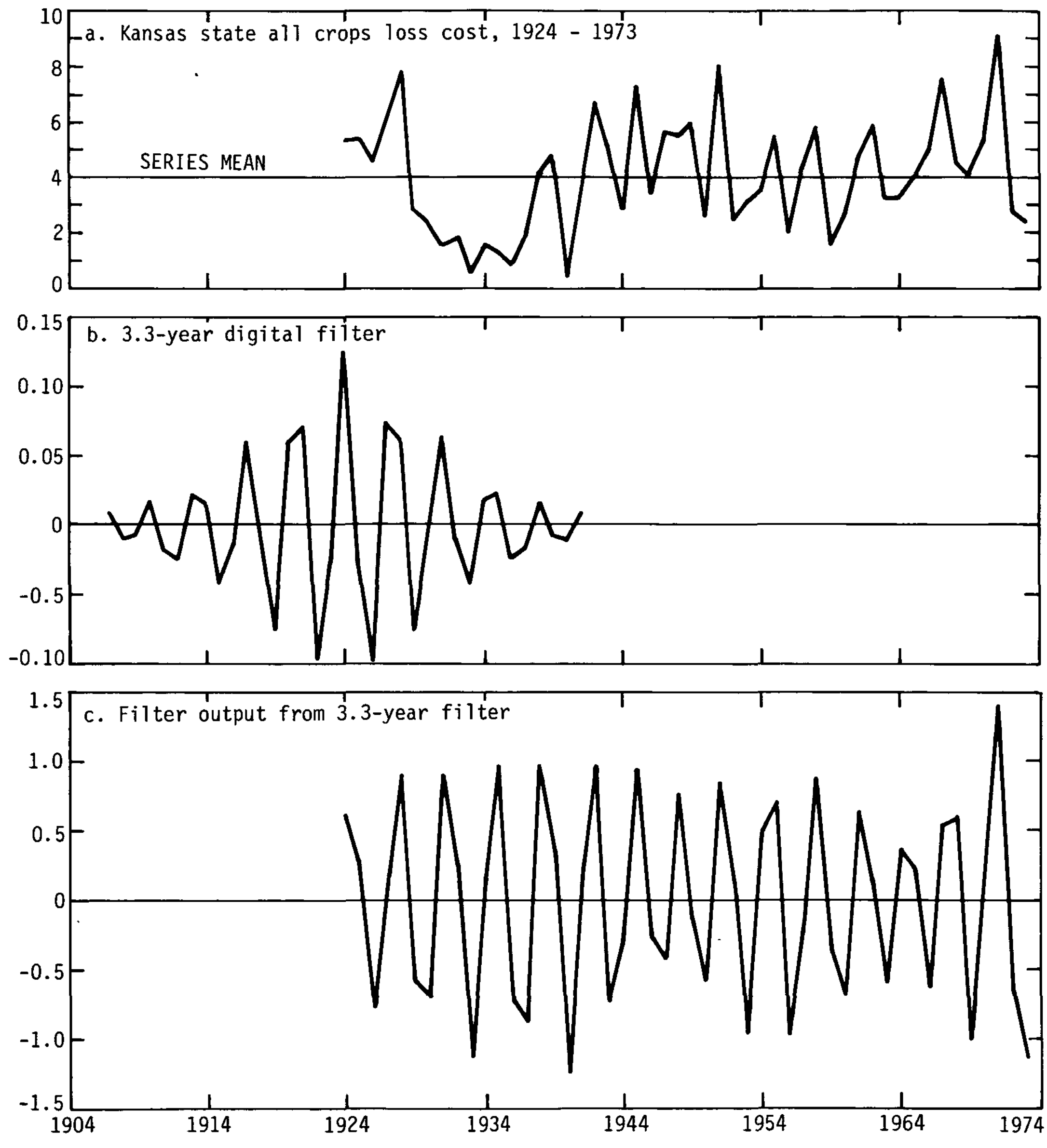


Figure 8. Illustration of a Filtering Operation Using Kansas All Crops Loss Cost and a 3.3-Year Digital Filter.

The entire filter prediction process was performed with a computer program package which was executed by an operator through a computer terminal with a cathode ray presentation and an on-line plotter. The operator requested a loss cost series from the computer data bank and called in the proper filter from a bank of 50 available filters. The filter output was computed as described above and plotted on the computer terminal screen (Fig. 9). The operator then selected a minimum of three points at the peaks and valleys of the filter output and near the end of an output record. These operator chosen points formed the basis for determining a sine wave which was projected back through filter output points and then projected forward for the desired number of years. At the time, the operator made a visual inspection of the "goodness-of-fit" of the sine wave to the data. The operator either retained (in the computer system) the estimated annual points on the sine wave, or elected to adjust the three basic points to try to obtain a better fitting sine wave.

A sine wave fit to the filter output of the 3.3-year periodicity is shown in Figure 10. Points A, B, C, D, and E represent the contribution of the 3.3-year periodicity to the predictions for years 1974 through 1978. If only one periodicity is used, these point values would be added to a mean value of the 1924-1973 period to finalize the yearly predictions. However, more than one significant periodicity was usually involved. In that case, the sum of contributions for all involved periodicities, plus a mean value, formed the yearly predictions.

Predictions for Kansas involving 4.8- and 3.3-year periodicities are presented in Figure 11. A good trend comparison is evident. Trend predictions and quantitative prediction results are tabulated in Tables 7 and 8.

Bandpass Versus Filter Rationale

Now that both bandpass and filtering prediction techniques have been described, differences in their rationales can be discussed and more easily understood. Both techniques are based on sample estimates of the three basic characteristics of cyclical variation; namely, amplitude, period, and phase point (often referred to as phase angle).

Bandpass utilized amplitude, period and phase point of significant periodicities determined during a spectral analysis. All three cyclical characteristics are based directly on the whole data analysis sample. Amplitude and period are analogous to averages for the whole sample, and the phase point determined is located near the beginning of a data record (Fig. 7).

The filtering technique utilizes the same significant cyclical tendencies but involves an intermediate step, namely that of determining a filter output from which the amplitude, period, and phase point sample estimates are determined. Amplitude, period, and phase for each significant periodicity are determined from approximately the last 2 peaks and valleys of a filter output. Therefore, a sample amplitude and period may be different than those utilized by bandpass since a filter output waveform often varies in amplitude and period during the period of record, note Figure 10 and Tables 2, 3, 4 of previous sections. The phase point, in case of the filter method, is located (or determined) at the last peak amplitude of the data record, instead of near the beginning in the bandpass approach.

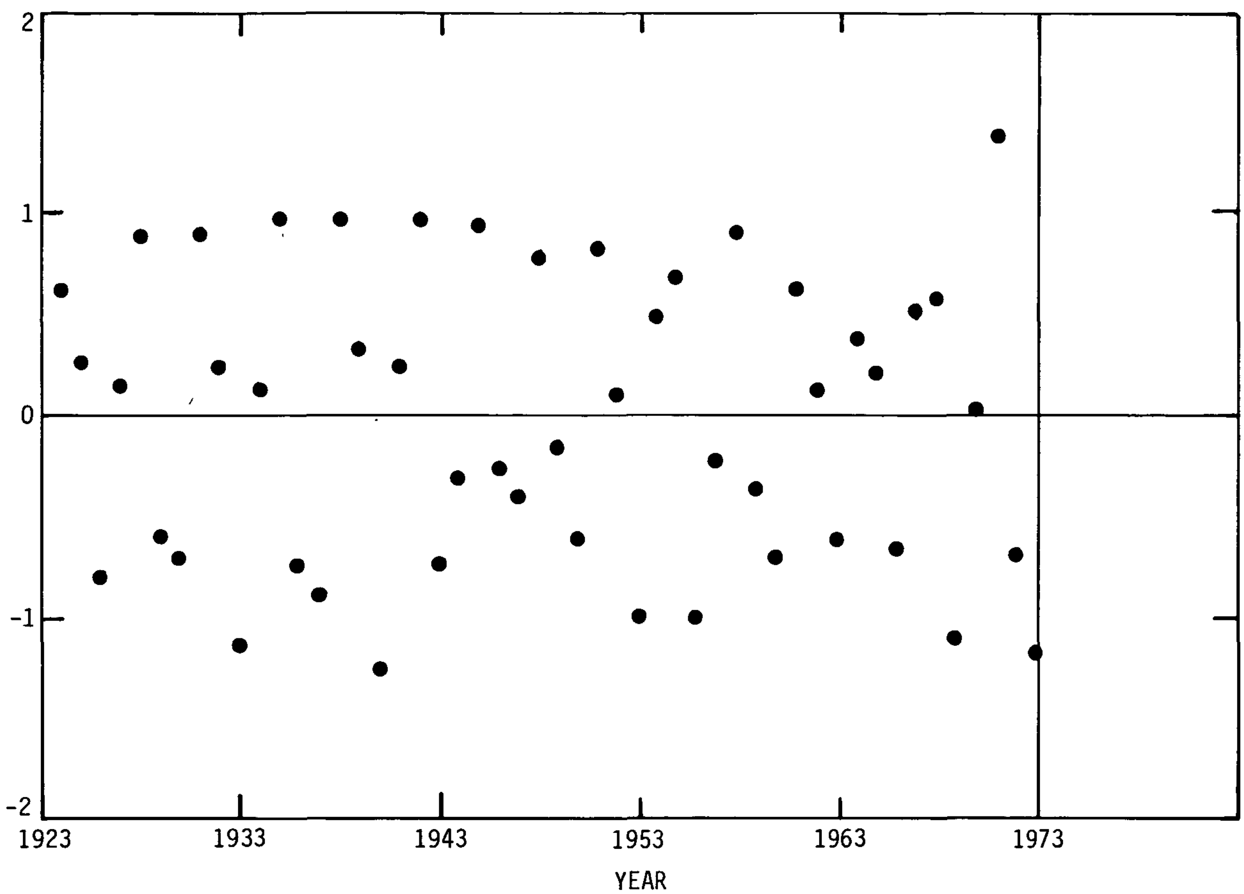


Figure 9. An Example of a Filter Output as it Appeared on Computer Terminal Cathode Ray Tube Using Kansas All Crops Loss Cost and a 3.3-Year Digital Filter.

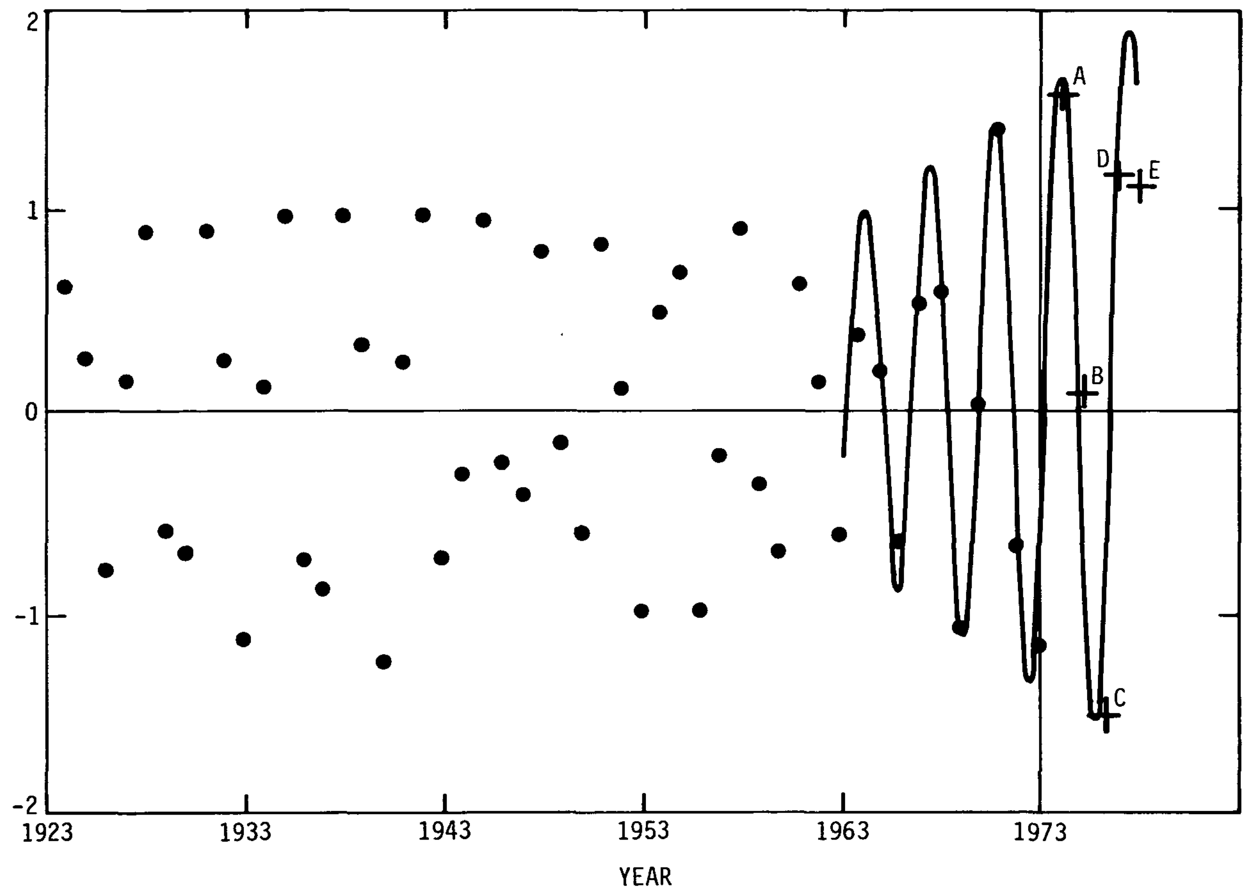


Figure 10. Best Fit of a Sine Wave to 3.3-Year Filter Output of Kansas All Crops Loss Cost, 1924-1973, and 5 Yearly Projections, A, B, C, D, and E.

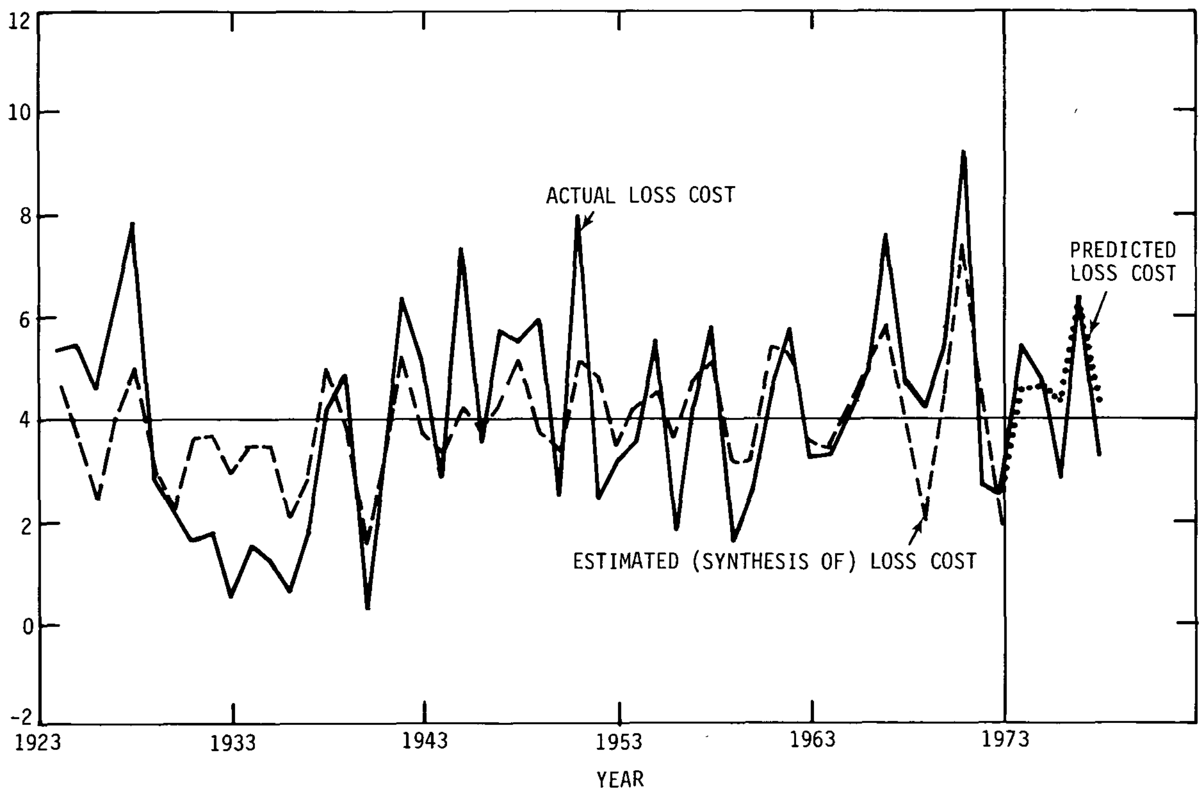


Figure 11. Predictions for Kansas Loss Cost, 1974-1978 Using the Filter Method with 3.3- and 4.8-Year Periodicities Based on 1924-1973 Data.

Table 7. Comparison of yearly predicted trends with actual trends using filter method for Kansas all crops, 1924-1973.

	Trends, Up (U) or Down (D) with predicted on left and actual on right for each year					
Districts	1974	1975	1976	1977	1978	% Correct
1(NW)	U/U	U/U	D/D	D/U	U/D	60
2(NC)	U/U	D/U	D/U	U/U	U/D	40
3(NE)	D/U	U/D	D/U	D/D	U/D	20
4(WC)	U/U	D/D	D/U	U/D	D/D	60
5(C)	U/U	U/D	U/D	D/U	D/U	20
6 (EC)	D/D	D/U	D/D	D/U	D/D	60
7(SW)	U/U	U/D	D/D	D/U	U/D	40
8(SC)	U/U	U/D	D/D	D/U	U/D	40
9(SE)	U/D	D/D	U/D	U/U	D/D	60
Percent Correct	78	33	44	33	33	44
State[1] Value	U/U	U/D	D/D	U/U	D/D	80

[1] Obtained from an analysis after combining county data.

Table 7a. Comparison of yearly predicted trends with actual trends using filter method for Kansas all crops, 1948-1973.

Districts	Trends, Up (U) or Down (D) with predicted on left and actual on right for each year										
	1974	1975	1976	1977	1978	%correct	1974	1975	1976	1977	1978
1 (NW)	U/U	U/U	D/D	D/U	D/D	80	93	118	216	57	164
2(NC)	U/U	D/U	D/U	U/U	U/D	40	265	82	53	60	126
3(NE)	U/U	D/D.	D/U	U/D	D/D	60	64	127	109	158	217
4(WC)	U/U	D/D	D/U	U/D	U/D	40	113	152	59	140	235
5(C)	U/U	U/D	U/D	D/U	D/U	20	47	172	326	42	- 18
6 (EC)	D/D	D/U	U/D	D/U	U/D	20	97	-.01	687	10	209
7(SW)	U/U	D/D	D/D	U/U	D/D	100	183	166	313	132	192
8(SC)	U/U	D/D	D/D	U/U	U/D	80	96	59	56	52	246
9(SW)	D/D	D/D	D/D	U/U	U/D	80	132	158	- 12	196	412
Percent Correct	100	67	44	44	33	58					
State Value[1]	U/U	D/D	D/D	U/U	U/D	80	109	110	112	81	188

[1]Obtained from an analysis after combining county data.

Table 8. Comparison of actual loss cost, predicted loss cost from filters using significant periodicities based on Kansas all crop data for 1924-1973 and 3-year and 5-year mean values.

District	3-Year						5-Year					
	Mean 1971-73	Actual 1974-76	Predicted 1974-76	A-M	P-M	P/A%	Mean 1969-73	Actual 1974-78	Predicted 1974-78	A-M	P-M	P/A%
1	7.03	7.62	8.31	0.59	1.28	109	6.78	8.01	7.71	1.23	0.93	96
2	3.83	2.59	3.84	-1.24	0.01	148	3.95	3.84	4.31	-0.11	0.36	112
3	0.83	2.43	1.75	1.60	0.92	72	1.05	1.86	1.50	0.81	0.45	81
4	8.80	7.97	7.22	-0.83	-1.58	91	7.75	7.66	8.26	-0.09	0.51	108
5	7.78	4.60	6.66	-3.18	-1.12	145	7.08	5.43	3.16	-1.65	-3.92	58
6	3.10	1.39	1.76	-1.71	-1.34	127	2.78	2.18	1.47	-0.60	-1.40	67
7	5.12	4.27	5.90	-0.85	0.78	138	5.05	4.15	5.26	-0.90	0.21	127
8	4.01	5.37	4.21	1.36	0.11	78	4.78	4.97	3.72	0.19	-1.06	75
9	2.34	1.45	1.65	-0.89	-0.69	114	2.72	1.40	1.82	-1.32	-0.90	130
Average	4.76	4.19	4.59	-0.57	- .17	110	4.66	4.39	4.13	-0.27	-0.53	94
Stated[1]	4.79	4.33	4.53	-0.46	-0.26	105	4.78	4.48	4.83	-0.30	0.05	109

[1] Obtained by an analysis after combining county data.

Table 8a. Comparison of actual loss cost, predicted loss cost from filters using significant periodicities based on Kansas all crop data for 1948-1974 and 3-year and 5-year mean values.

District	3-year						5-year					
	Mean 1971-73	Actual 1974-76	Predicted 1974-76	A-M	P-M	P/A%	Mean 1969-73	Actual 1974-78	Predicted 1974-78	A-M	P-M	P/A%
1 (NW)	7.03	7.62	9.40	0.59	2.37	123	6.78	8.01	8.53	1.23	1.75	106
2 (NC)	3.83	2.59	3.09	-1.24	-0.74	119	3.95	3.84	3.81	-0.11	-0.14	99
3 (NE)	0.83	2.43	2.20	1.60	1.37	91	1.05	1.86	2.01	0.81	0.86	108
4 (WC)	8.80	7.97	8.43	-0.83	-0.37	106	7.75	7.66	10.39	-0.09	2.64	136
5 (C)	7.78	4.60	6.98	-3.18	-0.80	152	7.08	5.43	4.71	-1.65	-2.57	83
6 (EC)	3.10	1.39	1.52	-1.71	-1.58	109	2.78	2.18	1.33	-0.60	-1.45	61
7 (SW)	5.12	4.27	8.41	-0.85	3.29	197	5.05	4.15	7.35	-0.90	2.30	177
8 (SC)	4.01	5.37	3.97	1.36	-0.04	74	4.78	4.97	4.28	0.19	-0.50	86
9 (SE)	2.34	1.45	1.81	-0.89	-0.53	125	2.72	1.40	2.52	-1.32	-0.20	180
Average	4.76	4.19	5.09	-0.57	0.33	121	4.66	4.39	4.97	-0.07	0.31	113
State [1]	4.79	4.33	4.77	-0.46	-0.02	110	4.78	4.48	5.10	-0.30	0.32	114

[1] Obtained from an analysiis after combining county data.

Thus, in the filter approach, emphasis is placed on the most recent and up-to-date data knowledge. The filtering approach and its associated manner of determining the amplitude, period, and phase are essentially an attempt to circumvent problems due to variable amplitudes and periods, and phase changes (waveforms damping out and reforming) which may occur earlier in the historical record. It is apparent that the filtering approach places a greater emphasis on periodic occurrences just before the prediction period starts, whereas bandpass is based more on representative periodic occurrences over long sample records. However, the success of any predictive system that uses cyclical tendencies is determined by whether the chosen periodicities reoccur during the forecast period.

Weakness of Filtering Method

Filtering has an inherent weakness for its application related to getting an accurate output at the beginning and ending of a time series record. Referring back to Figure 8, it is evident that as the filter is moved to the right along the data, 17 filter points will have passed beyond the right hand end (1973) of the data when the filtering process is completed. A dampening or some type of modification of the output waveform begins as the right end of the filter progresses beyond the observed data. In order for the filtering computation to run to completion, the data record is extended with 17 values equal to the mean of the data analysis period. Filtering theory for this type of application has not been developed to the state of being able to avoid this "end effect."

The anticipated attenuation on a filter output is illustrated through the use of some experimental data which were generated from four known harmonics (sine-cosine waves) with periods (wavelengths) of 4, 6, 12, and 24 years and with amplitudes of 3.0, 2.0, 1.0, and 0.5, respectively. The resulting experimental data series is presented in Figure 12 for a record length of 97 years. Filter outputs for 6-year and 12-year filters (two of the four cycles known to be in the data series) are shown in Figures 13 and 14, respectively. A "rounding" or dampening of the amplitude of both filter outputs is evident at the beginning and ending of each series. This "end effect" occurred as a result of the left half of the filter being applied to the data series mean value at the start of filtering, and the right half being applied to the mean as it moved past the data end on the right (latest year). The end effect is only critical on the right since this part of a filter output is emphasized in phase, amplitude, and period determinations.

The end effect pattern (Fig. 13) for the 6-year filter output for the 97-year data series is very similar at the beginning and the end. An examination of the end effect pattern for the 12-year filter output (Fig. 14) reveals some differences in dampening at the first of the output series, as compared to that at the last. An even greater difference between the beginning and ending effects occurred when the last two of the input data points were removed before filtering (Figs. 15 and 16). Thus, the end effect pattern is influenced by the data input series values and their amplitudes near the end of the series. The influence could be counteracted by the random component in a natural data series. Figure 8c may be a good example of this since an expanding pattern occurred instead of a dampening result. The end effect for filter outputs of geophysical, meteorological, agricultural and other types of data is not simple to evaluate.

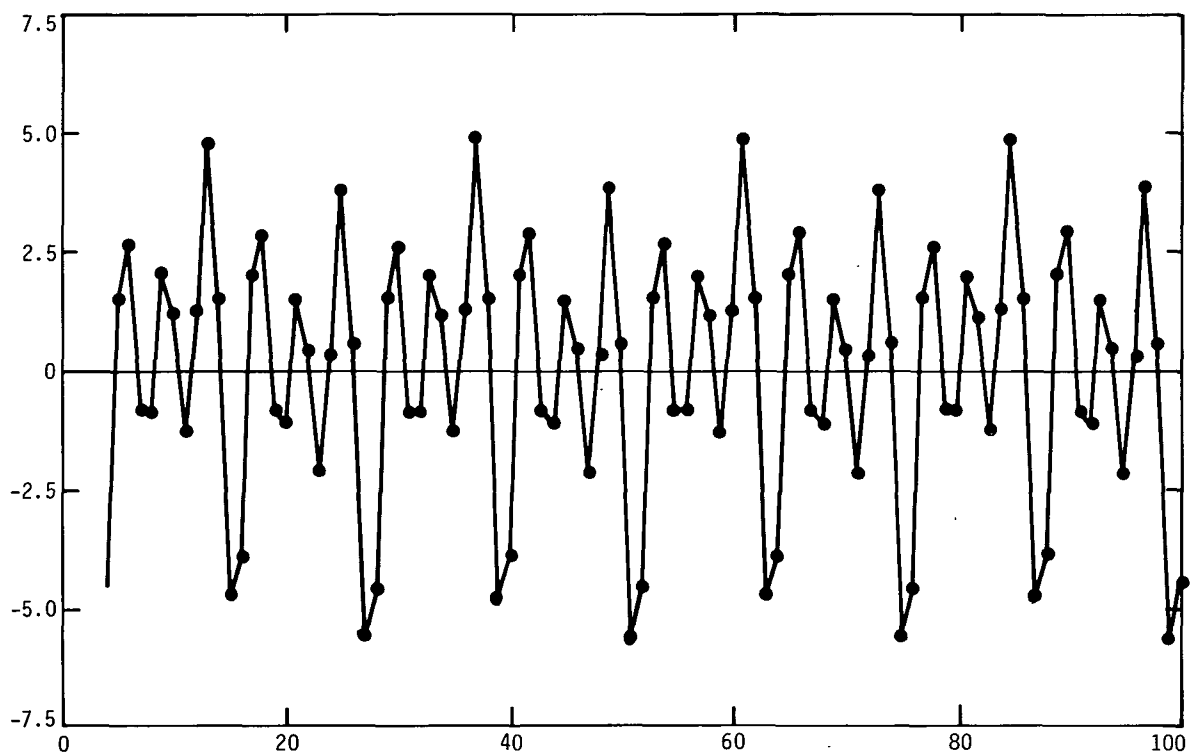


Figure 12. Experimental Data Series Generated from 4-, 6-, 12-, and 24-Year Cycles with Amplitudes of 3.0, 2.0, 1.0, and 0.5, respectively.

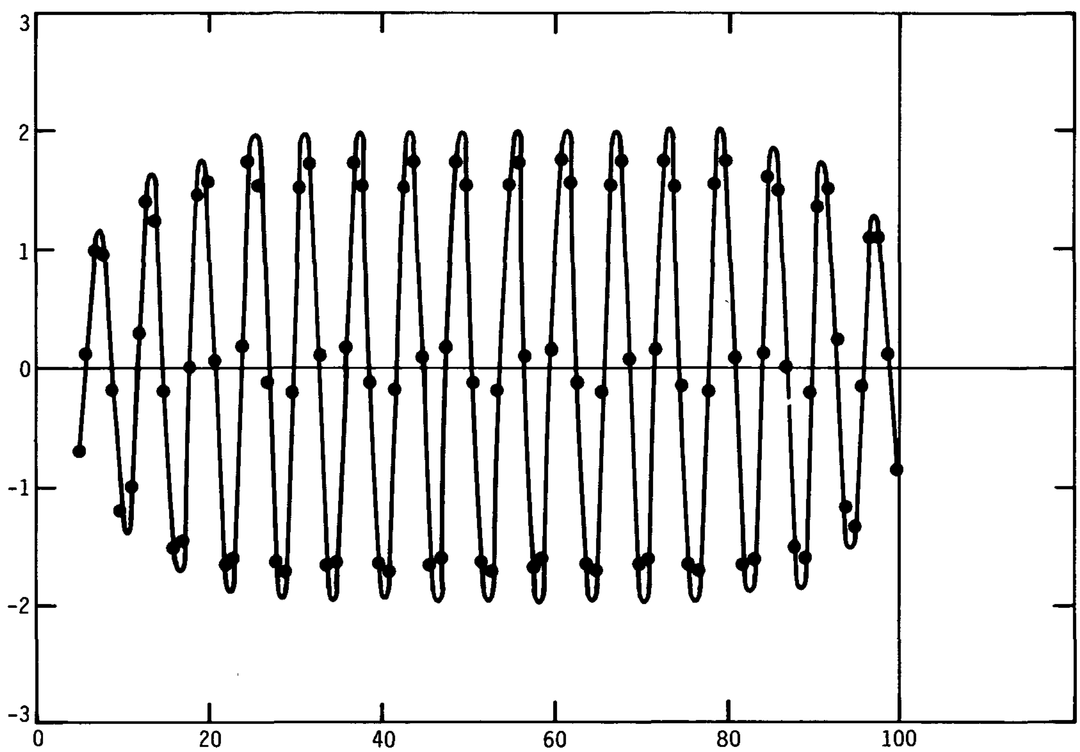


Figure 13. Filter Output of 6-Year Digital Filter Applied to Experimental Data of Figure 12.

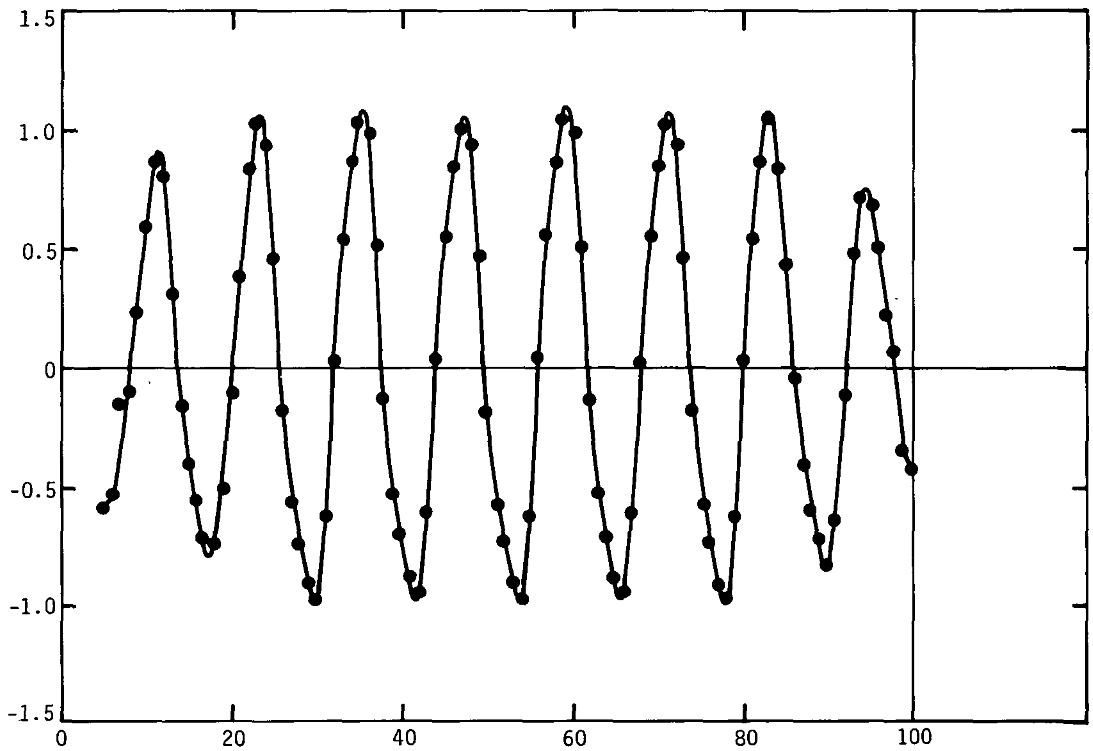


Figure 14. Filter Output of 12-Year Digital Filter Applied to Experimental Data of Figure 12.

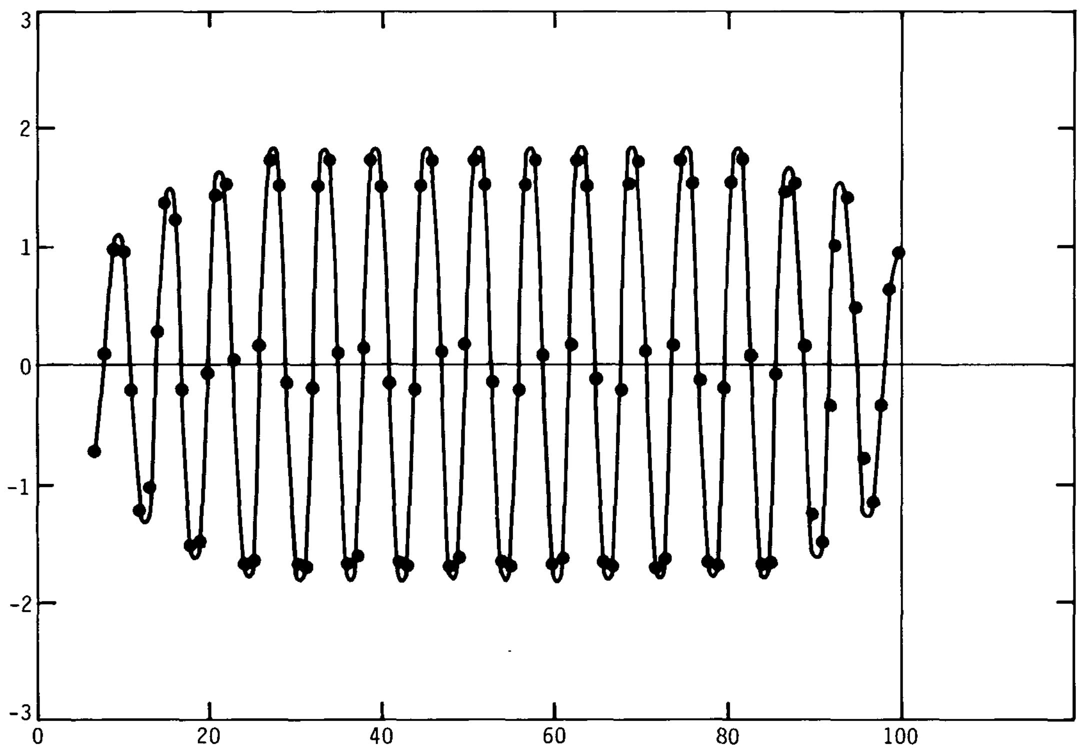


Figure 15. Filter Output of 6-Year Digital Filter Applied to Experimental Data of Figure 12 with Last Two Data Points Removed Before Filtering.

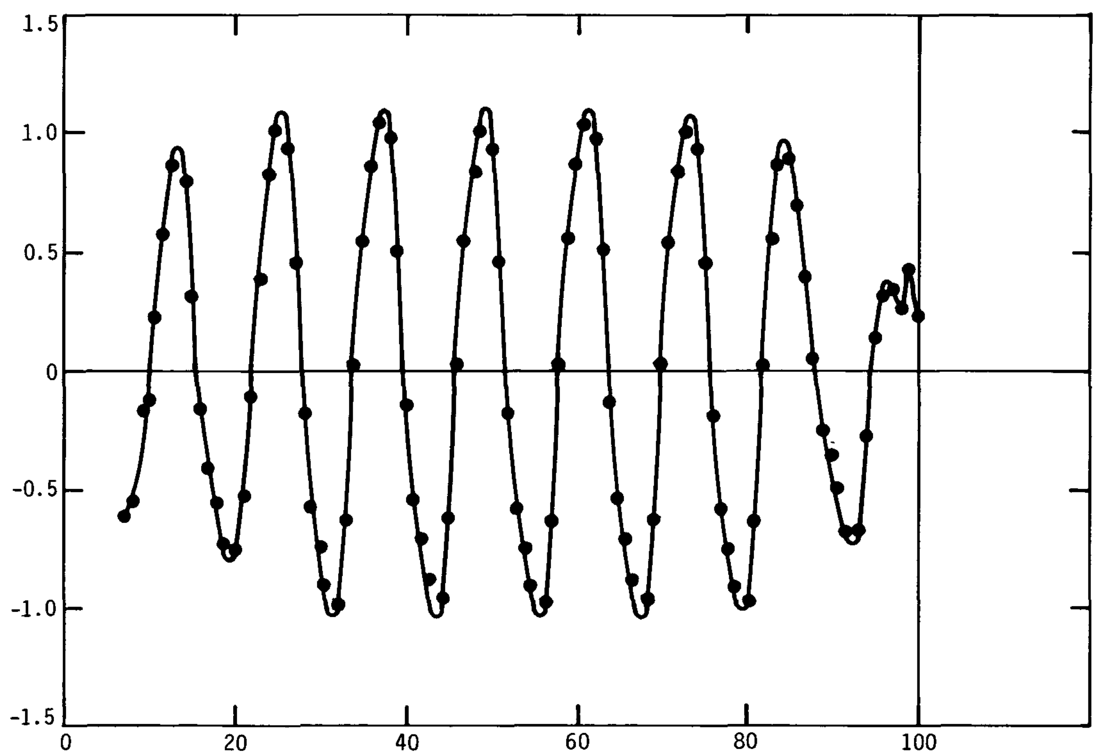


Figure 16. Filter Output of 12-Year Digital Filter Applied to Experimental Data of Figure 12 with Last Two Data Points Removed Before Filtering.

Filtering Correction Constants

As discussed in the previous section, an end effect problem exists in the filtering method. Some way of making a correction is needed. It was, therefore, assumed that the end effect is one of dampening. Correction factors or constant multipliers were determined (see Appendix B) to provide a way of expanding the dampened amplitudes. These multipliers are tabulated in Table 9. The multipliers start with a value of unity (no correction) and increase as each of the 17 right side digital filter points are moved past the last data (year) input value. They are designed to provide an increasing amount of adjustment as the anticipated attenuation increases, as more and more filter points are moved past the data. Therefore, the multipliers are computed values which will produce average adjustments. Some adjustments will be correct, some amplitudes, will be over corrected and still others will not be corrected enough. Over a number of adjusted filter outputs, the average adjustment should be correct. Two examples of the resulting application of these factors are shown in Figures 17 and 18 for the 6-year and the 12-year filter outputs from the experimental data of Figure 12. The adjustment factors of Table 9 were used in the Kansas predictions for comparisons with bandpass results.

Comparison of Methods Based on Annual Trend Prediction Accuracy

Accuracy of the annual trend predictions by the two methods was examined for 1974 through 1978 predictions based on the long Kansas 1924-1973 record see Tables 5 and 7. Both methods predicted "up" correctly for the 1974 state predictions. Both methods produced an incorrect trend prediction for 1975, and then correct predictions for 1976, 1977 and 1978. Thus, for the five Kansas state trend predictions, the accuracy was 80 percent for both methods. Each method failed on the same year.

Average score for the nine district predictions was 51 percent for bandpass and 44 percent for filters. The number of correct trend predictions (7 of 9) by filters for the first year (1974) was higher than the number of correct predictions (6 of 9) by bandpass. The average number of correct predictions for the years in the 1975-1978 period was higher for bandpass (47 percent) as compared to 36 percent for filters.

Accuracy of annual 1974-1978 trend predictions by each method using the shorter (1948-1973) data record was examined from results which were tabulated in Tables 5a and 7a. The overall Kansas state accuracy was the same (80 percent, or 4 of 5 predicted correctly). Both techniques made an incorrect trend prediction for the last year (1978). Filters were again more successful on the first year (1974) of district predictions, with a 100 percent (9 of 9 districts) prediction as compared to an 89 percent (8 of 9) for bandpass. The overall district average of 58 and 60 percent is virtually the same.

Comparison of Methods Based on 3-Year and 5-Year Mean Prediction Accuracy

Predictions for mean loss costs for the next 3 years and next 5 years are more a part of insurance rate revision procedures than the annual trend predictions discussed in the previous section. The ability of bandpass and

Table 9. Multipliers for filter attenuation correction.

Number	Multiplier
1	1.00
2	1.01
3	1-02
4	1.04
5	1.06
6	1.09
7	1.12
8	1.16
9	1.20
10	1.24
11	1.29
12	1.35
13	1.41
14	1.49
15	1.58
16	1.68
17	1.80

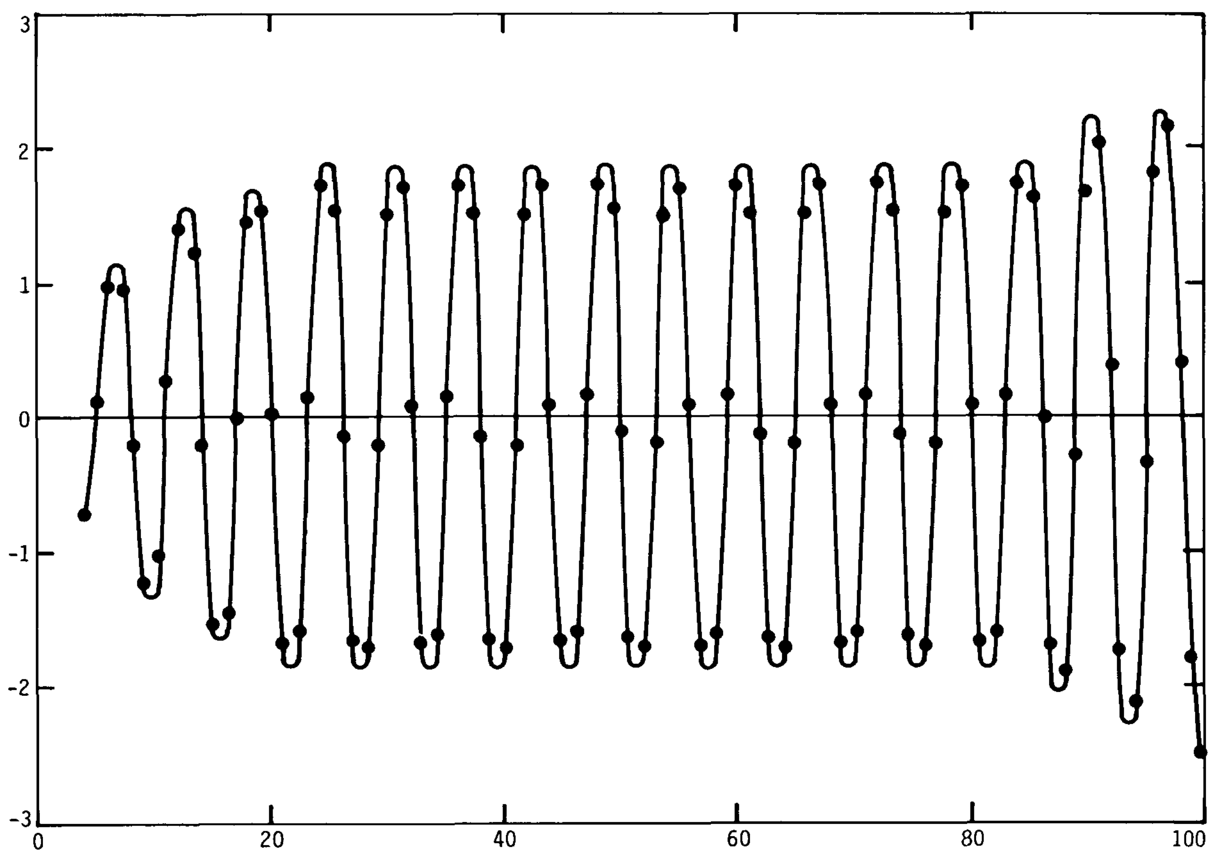


Figure 17. Amplitude Correction Multipliers were Applied to Last 17 Points of Filter Output of Figure 13.

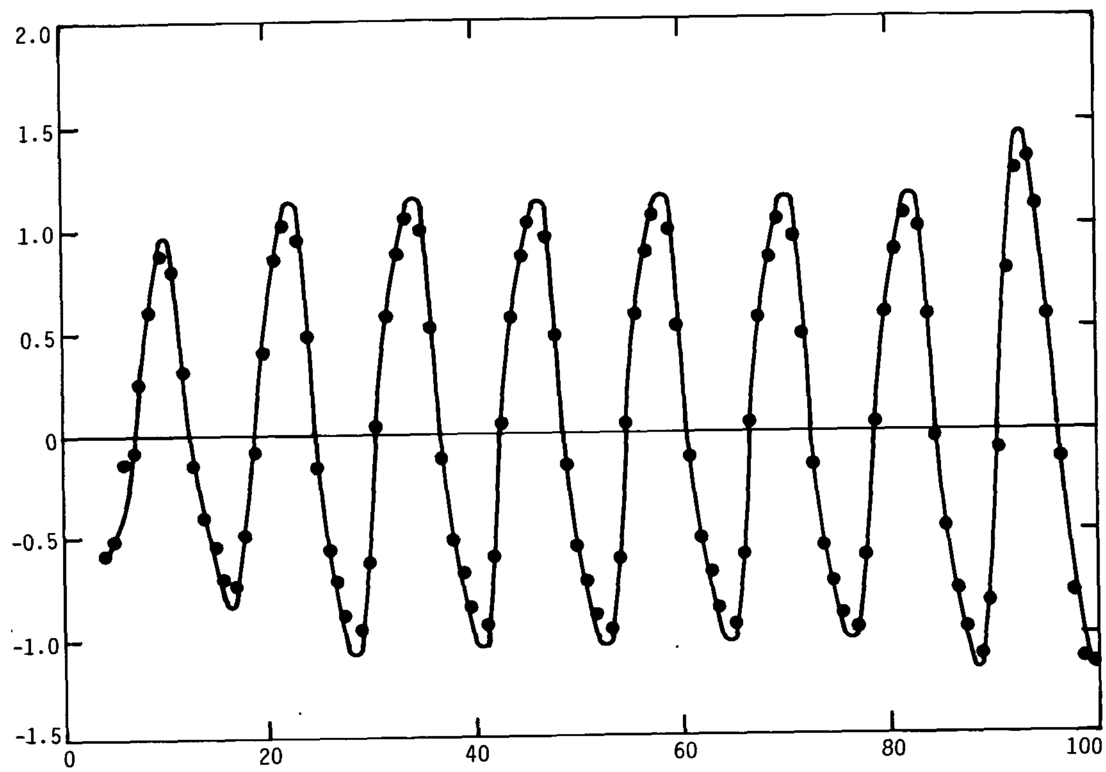


Figure 18. Amplitude Correction Multipliers were Applied to Last 17 Points of Filter Output of Figure 14.

filters to predict these means was compared for the Kansas long and short records. Data for this comparison were tabulated in Tables 6 and 8 when 1924-1973 data were used, and in Tables 6a and 8a when the 1948-1973 record was used.

The state predicted over actual (P/A%) values for 3- and 5-year means are close to 100 percent by both methods for each period of record. However, the 3- and 5-year mean predictions from bandpass were closer to 100 percent in each case. For state average percentages computed from district predictions, bandpass and filter results were very close when the longer 1924-1973 record was used, with bandpass having a slight 1 percent and 3 percent advantage for 3- and 5-year means, respectively. District average errors were greater for both methods when the shorter 1948-1973 data record was used than was recorded with the longer data record. For this comparison, filters had a 4 percent (125-121 and 117-113) smaller error than bandpass for both mean values.

Selection of Method for Further Analyses. Two time series analysis techniques were applied to two Kansas data sets for the purpose of assessing the predictive skill of the two methods. Predictive results (yearly trends and 3- and 5-year means for the 1974 through 1978 period) for each method were summarized and compared in an initial exploratory analysis based on Kansas 1924-1973 and Kansas 1948-1973 loss cost data. Neither method attained a significant advantage over the other.

Since the predictive results of the two methods were very similar, the choice of which method to use with the main 21-state analysis was made in favor of bandpass for the following considerations:

1) the predictive skill for bandpass was equal to that of the filter method,

2) the bandpass method is the simpler, more straight forward, and less subjective method,

3) the 1948-1973 loss cost data record is relatively short (26 years). The filters used in the filtering method are 35 units (years) in length, consequently the loss cost data sample is too short to permit all the filter digital units to be applied to the data at any time during the filtering process. Therefore, the characteristics of underlying periodicities may not be accurately determined.

COMPARISON OF PREDICTION RESULTS WITH BANDPASS FROM 1924-1973 AND 1948-1973 RECORDS

Some light was shed on the importance of data record length for loss cost predictions by comparing results from a short record with those obtained from a longer record. Loss cost data for combination crops and for wheat alone in Kansas and for wheat and barley combined in North Dakota were available for the years 1924-1973 and 1948-1973. These two data sets provided an opportunity for comparative prediction results for the 1974-1978 years. Results of spectral analyses for the long and short records were presented in

Table 1 and la, respectively. Periodicities shown in each line of the tables were used in combination to compute predictions for their respective districts and states. Predictions were for 3 and 5-year means for 1974-1978, and for annual trends (up or down) for the same years.

Predictions for 3- and 5-year mean loss costs for Kansas all crops, Kansas wheat, and North Dakota wheat and barley using periodicities from 1924-1973 data were presented in Table 6. Corresponding P/A% (Predicted/Actual) values from the 1948-1973 record (Table C of appendix A) for district average P/A% and state P/A% are repeated in Table 6a for easy comparison of state and district average percentages. An inspection of corresponding P/A% reveals those percentages from the longer data record are closer to the desired 100% in all but one comparison. The 3-year Kansas all crop case (97% for the longer data set versus 102% for the shorter record) favored the short record prediction by one percentage point. These 12 comparisons favor using the longer data sample for predicting 3- and 5-year mean loss cost.

The annual up and down trend predictions from both long and short records are shown in Table 5. An asterisk is used in the table to indicate a different prediction was obtained from 1948-1973 data periodicities than was obtained from 1924-1973 periodicities. For example, the * in *D/U for district 3 in 1974 indicated periodicities from 1948-1973 data predicted an up trend whereas periodicities from 1924-1973 predicted down. Periodicities from both data records gave the same predictions where asterisks do not appear. For Kansas all crops and North Dakota wheat and barley, 64 percent of the annual trend predictions from the two data sets were in agreement. Districts 3 and 6 for Kansas wheat could not compared due to an absence of significant periodicities for district 6 in the long record (Table 1) and for district 3 in the shorter record (Table la). Among the remaining district and state comparisons, there was an 83 percent agreement for Kansas wheat predictions

Underlined percentages in Table 5 indicate percent correct predictions from 1948-1973 data. Percentages that are not underlined represent prediction accuracy from 1924-1973 data. For first year (1974) predictions, higher average district percentages were achieved with periodicities from the 1948-1973 data set i.e., in all three cases (Kansas all crops, Kansas wheat, North Dakota wheat and barley), the greater accuracy was obtained with periodicities from the shorter data record.

Prediction comparisons from long and short records are rather limited since only three data sets are available for comparative purposes. However, on the basis of the presently available comparisons, a tentative conclusion would be that 1) better 3- and 5-year mean lost cost predictions are expected from a data base of approximately 50 years, and 2) a 25-year record will yield more accurate annual trend predictions.

STUDY OF 1948-1978 LOSS COST DATA

In order to further test the application of time series techniques to loss cost prediction, a much larger areal data coverage was needed than was used in the 1924-1978 initial tests of this report. Data for the longer 1924 through

1978 period were limited, consequently data from a 22-state area (Fig. 1) for a shorter period (1948-1978) were evaluated for quality and areal coverage as described in the "Data and Its Preparation" section of this report. A total of 108 districts for all crops or combination of crops (Fig. 2) were accepted for analysis. Several districts with single crop data for the 1948-1978 period were also accepted for analysis.

Spatial Spectral Variation

The first 26 years (1948-1973) of the data were analyzed with the non-integer spectral analysis program to search for statistically significant periodicities. The 1974-1978 portion of the data was saved for independent prediction evaluation. The 10 percent level of statistical significance was accepted as a guideline for selecting periodicities for use as predictors of loss cost. With a 26-year sample size, a multiple correlation coefficient of 0.40 between a periodicity and loss cost was required for significance.

With a 26-year record, periodicites with a wavelength in the vicinity of 6 years was the upper limit which could be reliably determined. A 2-year periodicity was the lower limit, since a minimum of two points (years) are required to establish a waveform. All significant periodicities from 2.0 through 6.9 were grouped into the same classes used in Table 1.

Periodicities from spectral analysis for the 1948-1973 loss cost observations period are tabulated in Table A of the Appendix A. This table provides a detailed account of the significant periodicities determined for a large geographical area and for a diversity of crops and combinations of crops. It also provides a record of periodicities used as predictors in each bandpass prediction for 1974-1978.

Periodicities tabulated in Table A were examined for spatial coherence. Spatial coherence or homogeneity of periodicities in adjacent districts which form areas as large as a state or larger is evidence of underlying rhythmic pulsations which influence our hail climate. Maps of districts were prepared to show the geographical distribution of each class of periodicity in Table A. Geographical distribution of the periodic classes are represented in Figures 19a through 19e.

A much greater number of districts experienced the short 2.0 - to 2.9-year nonrandom tendency in loss cost. This short term nonrandom tendency is broken into two major regions, a "great northern" and a "southwest to northeast axis." However after comparing these patterns with areas of available data (Fig. 2) and taking difficulty of identifying very short periodicities into account, it is best to defer acceptance of these two regional tendencies until further study is done. The 2.0 - to 2.9-year rhythms are imbedded in the more "noisy" (random) part of the spectrum and are, therefore difficult to establish.

The 3.0- to 3.9-year periodicities occurred primarily in Kansas as was established in the initial Kansas analyses. The 4.0- to 4.9-year periodicities occurred in a number of contiguous districts. The 5.0- to 5.9-year and the 6.0- to 6.9-year periodicities occurred in very few adjacent districts.

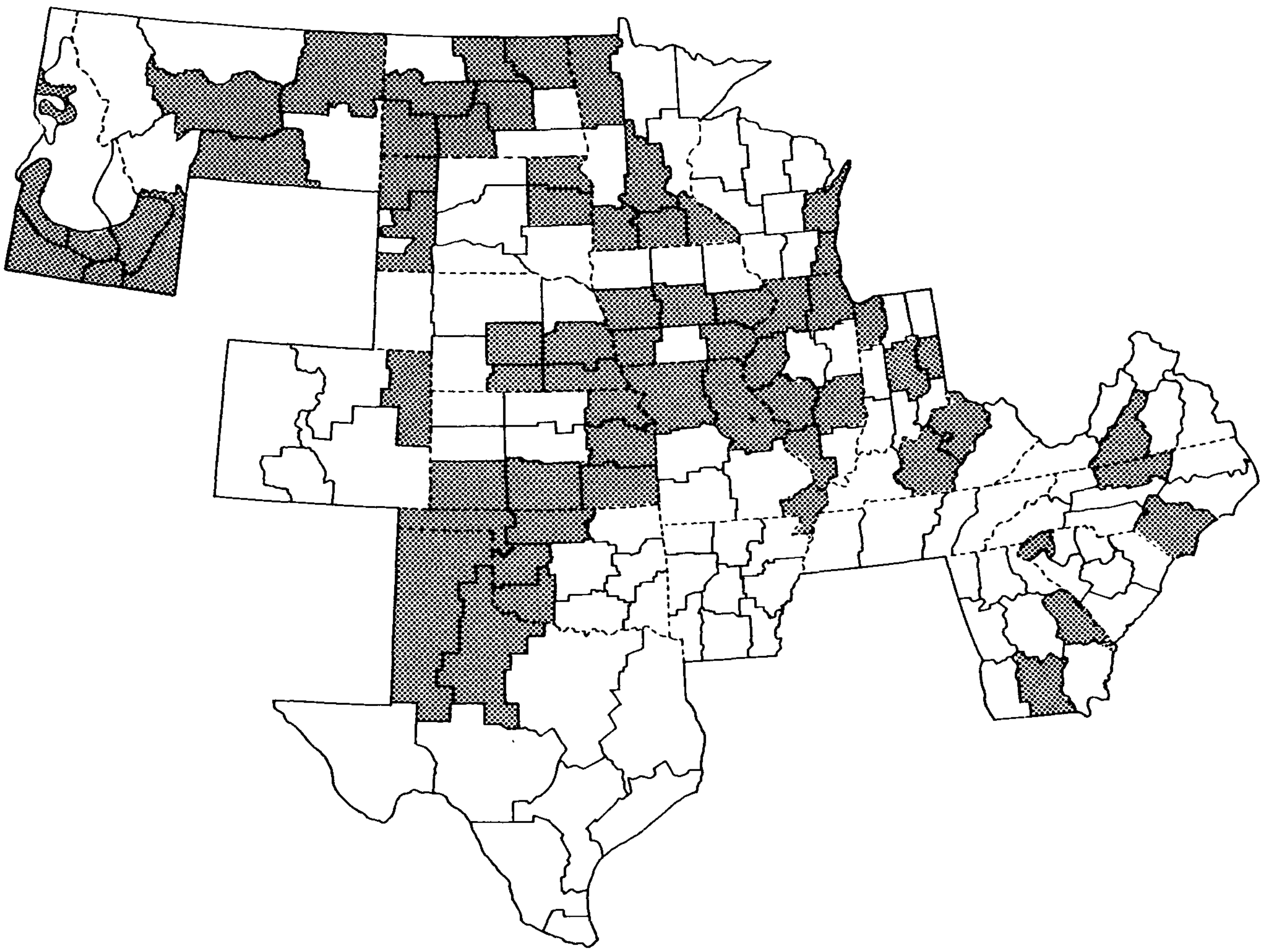
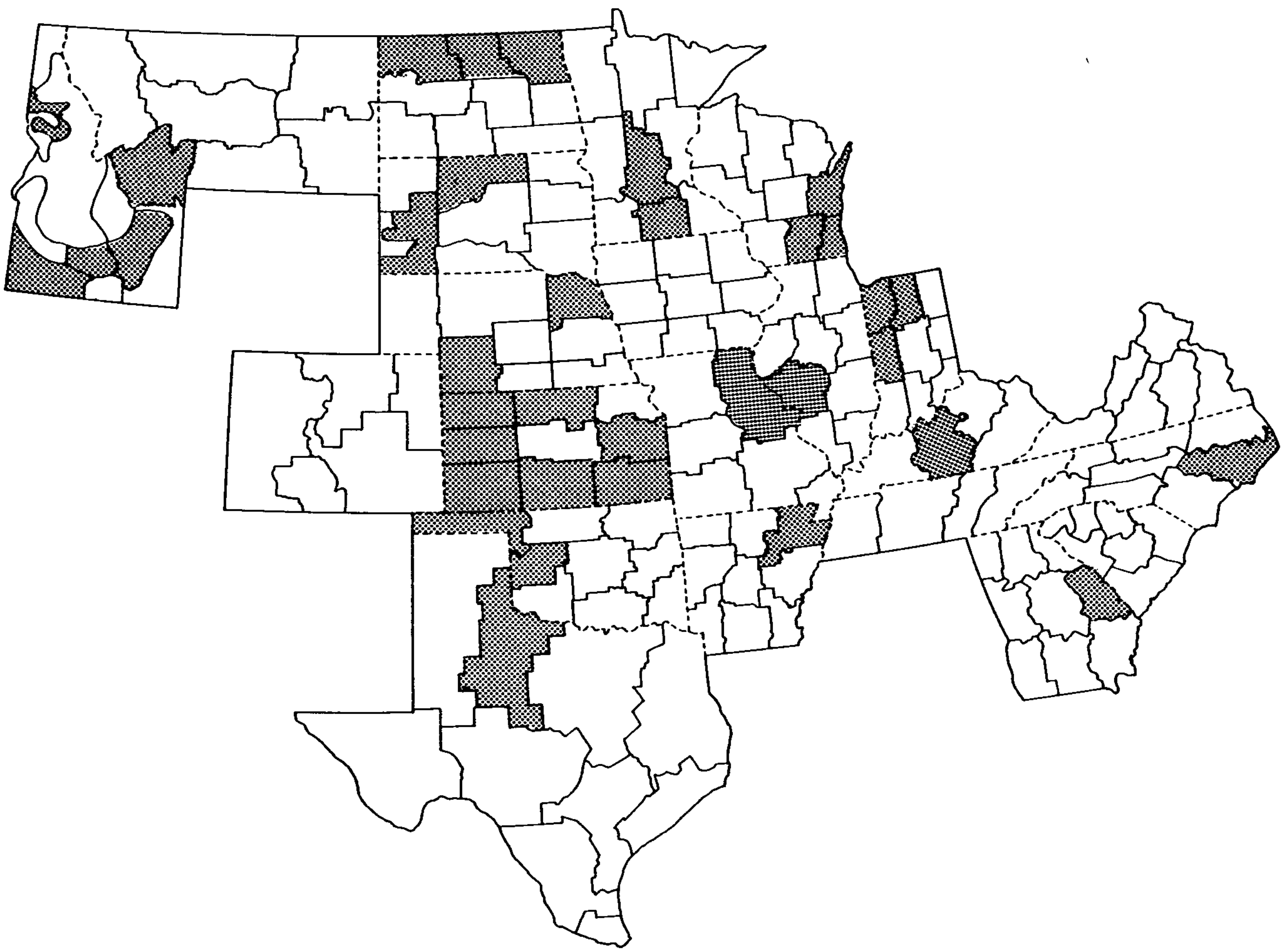
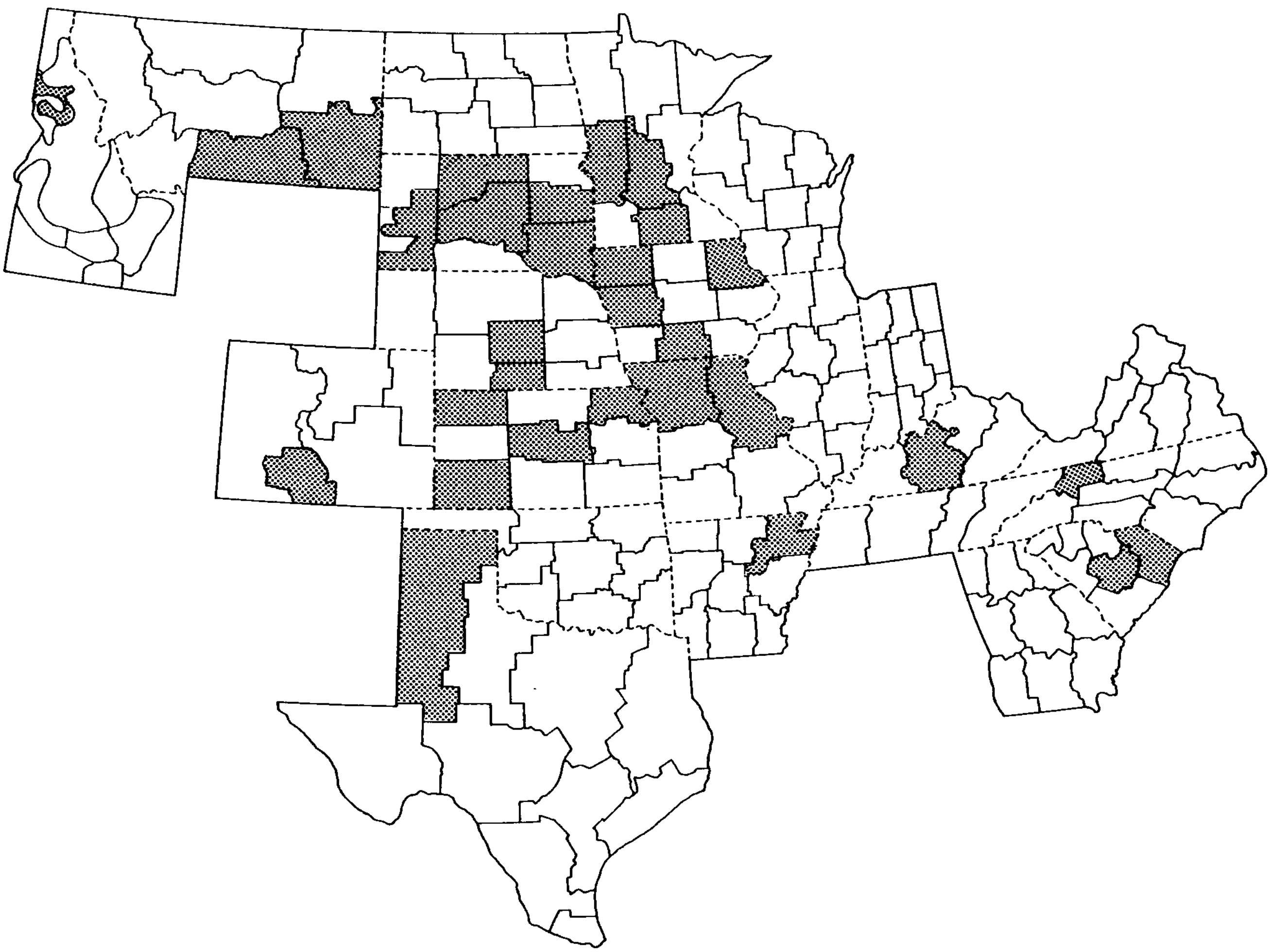


Figure 19. Maps of 21-State Area with Designated Periodicities (Shaded) Based on 1948-1973 Loss Cost Data Analysis.

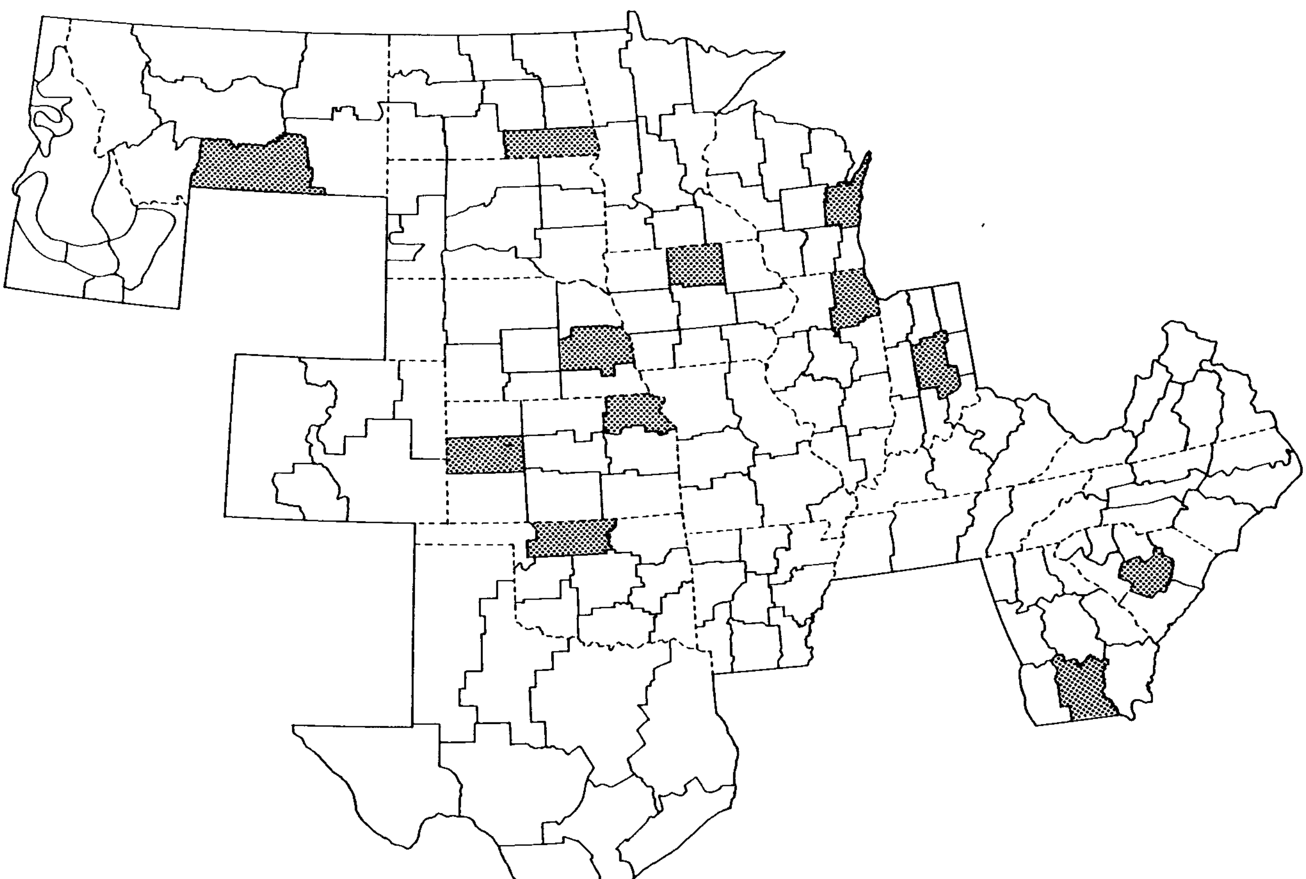
a) 2.0 to 2.9-year periodicities



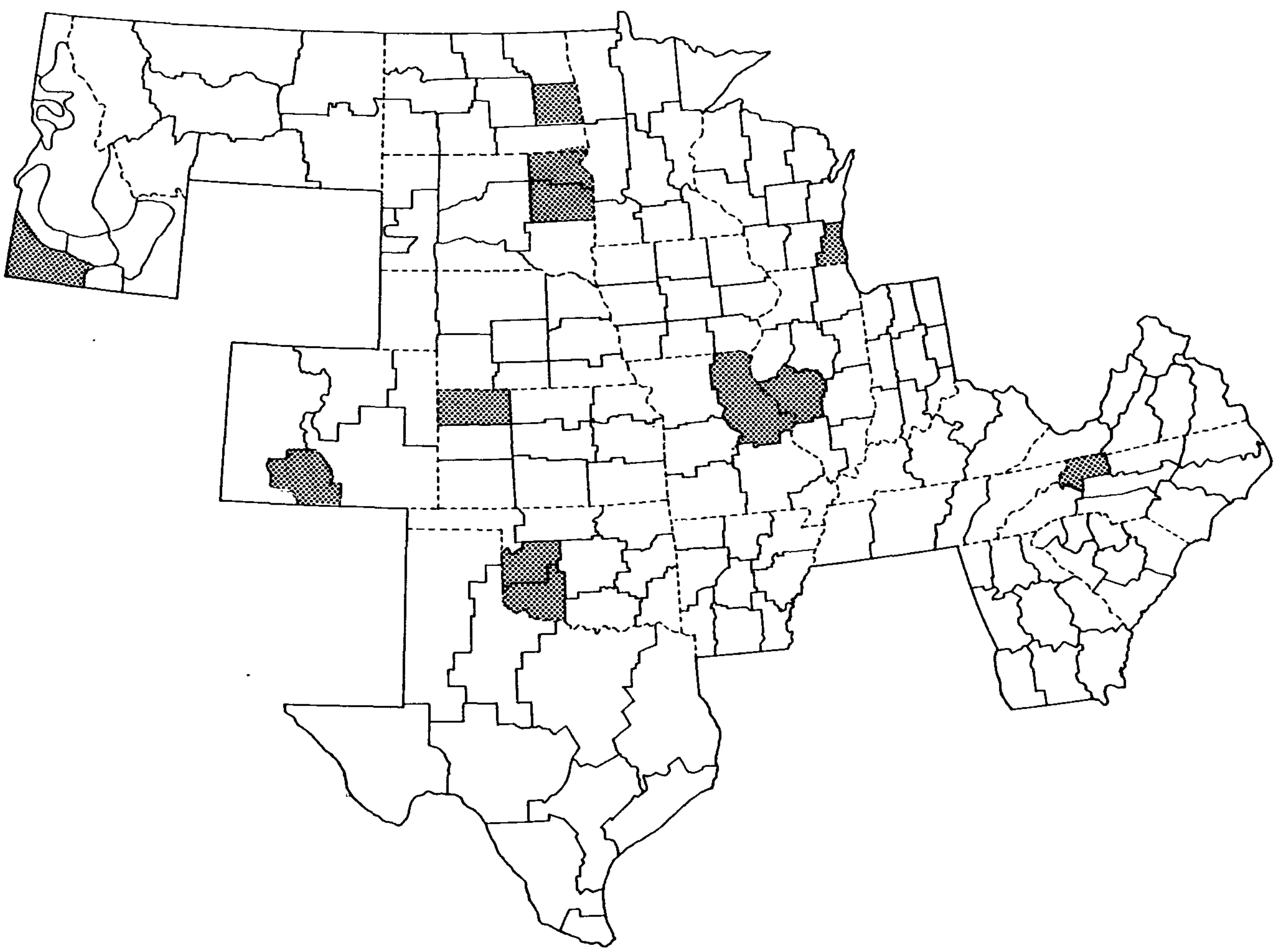
b) 3.0 to 3.9-year periodicities



c) 4.0 to 4.9-year periodicities



d) 5.0 to 5.9-year periodicities



e) 6.0 to 6.9-year periodicities

Predictions for the 21-State Area

Predictions were determined using the bandpass method for each district and each state with periodicities (predictors) which were significant at the 10 percent level (Table A of Appendix A). Tables of predictions are also included in Appendix A. Trend predictions of loss costs for each year for 1974 through 1978 are tabulated along with actual yearly trends in Table B, Appendix A. Comparison of the 3- and 5-year predicted loss cost means and the corresponding 3-year and 5-year actual mean loss costs are presented in Table C, Appendix A. Annual loss cost predictions for the years 1974 through 1978 are compared with actual yearly loss costs in Table D of Appendix A.

Evaluation of Loss Cost Predictions

Three types of evaluations of the predicted loss cost values were made to fulfill various potential applications of the predictions to the hail insurance industry. First, the yearly trends for each of the five years in the future test period (1974-78) were compared with the actual trends (up or down). Second, the mean loss costs of the 3-year (1974-76) and 5-year (1974-78) predictions were compared with the actual mean loss costs. Here both the direction of trend and the magnitude of trend were compared and evaluated. Finally, years with unusually high or low costs in the 1974-78 period were identified and the predictions of these extreme events were assessed as to the accuracy of detection. All three types of evaluations included consideration of 94 crop district values and the 21 state values. Often the data were grouped in three regions: 1) the Great Plains - Mountain states, 2) the Midwest, and 3) the Southeast.

Yearly Trend Predictions. The state and district yearly trend predictions appear in Table B of the Appendix. The number of correct district yearly trend predictions were counted for each state and each year. The percentage of accurate predictions for each state was determined and are presented in Table 10. A regional summary is shown on the bottom line for each region. The last line of Table 10 is an overall summary for the 21-state area. It is apparent that only nominal skill was demonstrated for anuual trend predictions with the bandpass method. The regional percentages of correct predictions were 51 and 52 for the High Plains and Midwest, respectively. The percent correct predictions for the Southeast (tobacco and cotton) region was higher at 63. A number of very good percentages were obtained for individual states in some years (see Kansas 1974; Minnesota, 1977; Illinois, 1975; and North Carolina, 1974). However, there was no evidence that the method predicted the trends in the first year (1974) more accurately than later years as would be anticipated.

If one examines the individual state results in Table 10, certain interesting findings emerge. On a temporal basis predictions of trends were best (higher regional percentages) for the first (1974), second (1975), and fifth years (1978). Greater skill in the first two years is expected. However, the greater skill in the fifth year, as opposed to the fourth year, is inexplicable.

Figure 20 depicts the correctness of the district the first year predictions (as extracted from Table B of Appendix A). As noted in the bottom line of Table 10, 53 of the 94 districts (56%) were predicted correctly. The

Table 10. Annual loss cost trend prediction evaluation from bandpass method for 1974 through 1978 based on an analysis of 1948-1973 data.

State	1974 C[1]	1974 D[2]	1974 %[3]	1975 C	1975 D	1975 %	1976 C	1976 D	1976 %	1977 C	1977 D	1977 %	1978 C	1978 D	1978 %	Average Percent
High Plains-Mountain Region																
Kansas	8	9	89	6	9	67	4	9	44	4	9	44	5	9	56	60
Nebraska	2	6	33	2	6	33	2	6	33	1	6	17	4	6	67	37
South Dakota	4	7	57	5	7	71	2	7	29	4	7	57	4	7	57	54
North Dakota	4	9	44	5	9	56	6	9	67	6	9	67	5	9	56	58
Montana	4	5	80	2	5	40	1	5	20	2	5	40	2	5	40	44
Colorado	0	2	0	0	2	0	1	2	50	0	2	0	1	2	50	20
Idaho	0	6	0	2	6	53	3	6	50	3	6	50	3	6	50	37
Oklahoma	2	4	50	3	4	75	1	4	25	2	4	50	2	4	50	50
Texas	1	1	100	0	1	0	0	1	0	0	1	0	0	1	0	20
Regional Summary	25	49	51	25	49	51	20	49	41	22	49	45	26	49	53	48

[1]C = Number of district trends correctly predicted, based on algebraic agreement (up with up or down with down)

[2]D = Number of districts

[3]% = Percent of total districts correct

Table 10. CONTINUED

State	1974 C	1974 D	1974 %	1975 C	1975 D	1975 %	1976 C	1976 D	1976 %	1977 C	1977 D	1977 %	1978 C	1978 D	1978 %	Avg. %
Midwest Region																
Minnesota	3	6	50	1	6	17	4	6	67	5	6	83	4	6	67	57
Iowa	4	9	44	6	9	67	5	9	56	2	9	22	5	9	56	49
Missouri	2	3	67	1	3	33	1	3	33	2	3	67	2	3	67	53
Illinois	3	6	50	5	6	83	2	6	33	1	6	17	2	6	33	43
Wisconsin	1	3'	33	3	3	100	2	3	67	2	3	67	2	3	67	67
Indiana	2	5	40	2	5	40	3	5	60	2	5	40	3	5	60	48
Arkansas	1	1	100	1	1	100	1	1	100	1	1	100	0	1	0	80
Regional Summary	16	33	48	19	33	58	18	33	55	15	33	45	18	33	55	52
Southeast																
Kentucky-	2	2	100	1	2	50	2	2	100	1	2	50	2	2	100	80
Virginia	1	1	100	1	1	100	1	1	100	0	1	0	1	1	100	80
North Carolina	4	4	100	2	4	50	1	4	25	1	4	25	2	4	50	50
South Carolina	3	3	100	2	3	67	0	3	0	1	3	33	3	3	100	60
Georgia	2	2	100	1	2	50	1	2	50	1	2	50	2	2	100	70
Regional Summary	12	12	100	7	12	58	5	12	42	4	12	33	10	12	83	63
Overall 21-state Summary	53	94	56	51	94	54	43	94	46	41	94	44	54	94	57	51

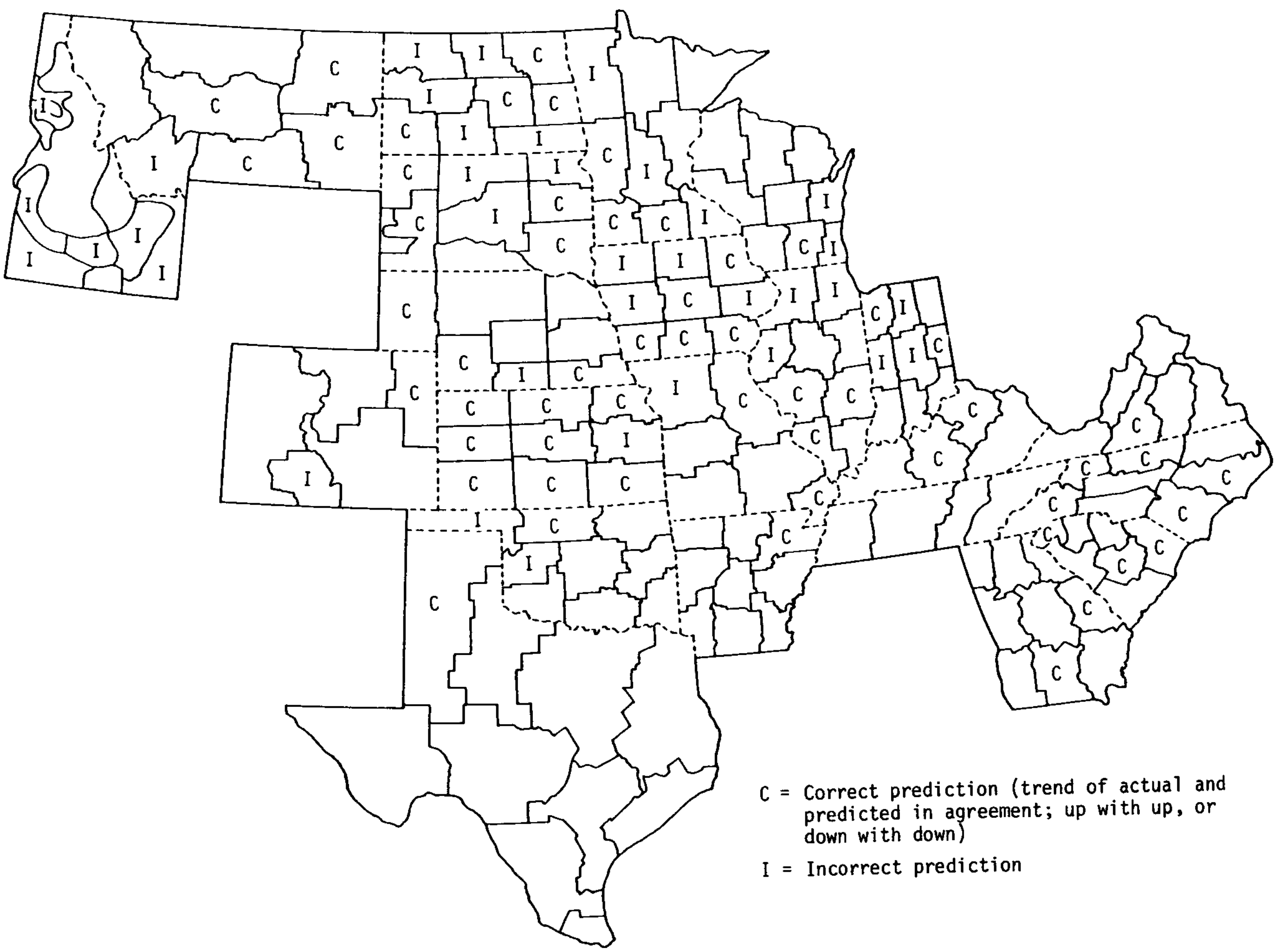


Figure 20. Accuracy of Trends Predicted for Loss Cost Values in the First Year (1974) of the 5-Year (1974-1978) Sequence.

pattern displayed in Figure 20 reveals that there were marked geographic differences in the accuracy. Trends of all the districts in the Southeast were correct, and in fact, trends for most of the districts south of 40° N latitude (Nebraska - Kansas border) were correctly predicted. Most incorrect first year trend predictions, therefore, were in the upper Midwest including northern Illinois, Indiana, Wisconsin, Iowa, and Minnesota; in the two Dakotas, and in all of Idaho. It is also noteworthy that trends for the districts in the lee of the Rockies (eastern Montana, western Dakota, and eastern Colorado) were correctly predicted.

Inspection of the state values, both the yearly and the resulting average percentages in Table 10, reveals there are two groups of states where the frequency of correct trends were better. A "northern area" (composed of North Dakota, South Dakota, Minnesota and Wisconsin) had 4 out of 5 years with percentages higher than chance (50%). The other region where state predictions exceeded chance in at least 3 of the 5 years was a "southern area," embracing Kansas, Oklahoma, Missouri, Arkansas, and the five Southeast states in the cotton and tobacco growing region. Generally poor predictive skill for annual trends existed in the major mountainous states (Montana, Idaho, Colorado), and in an west-east belt including Nebraska, Iowa, Illinois and Indiana.

This skill in the trends of the five annual predictions for each district is displayed in Fig. 21. The pattern is similar to that of Fig. 20. Districts with better than chance (> 60% correct) trend predictions are most common in the "southern half" of the 21-state area. Many districts in Illinois, Iowa, Indiana, and Nebraska frequently did not have correctly predicted trends (40% or less). An area of frequently accurately predicted yearly trends exists in the eastern Dakotas and southwestern Minnesota. Predictions for districts in the mountain states (Colorado, Montana, and Idaho) were largely incorrect.

The areas of greater predictive accuracy tend to be where CHIAA records are considered "best"; that is, where the liability has been extensive over a long period of years, and where crop typing (and expansion) has not changed substantially since 1948. This suggests that the degree of success in the yearly trend predictions may be seriously influenced by the quality of the historical (1948-73) loss cost data. Possibly more restrictive criteria than used in this study need to be applied to define districts "suitable" for prediction analysis. Conversely, there does not seem to be any known climatological reason for the areas of success, although the fact that yearly loss cost trends are correctly predicted most frequently on the lee of the Rockies and in the more southern (below 40° N latitude) states suggests some atmospheric influences. Such regional homogenity also suggests there are differences in predictive skills such that predictions could be used with more confidence in some states and with less in others.

Evaluation of 3-Year and 5-Year Mean Loss Cost Predictions. A primary goal of the research was to investigate the skill of predictions of mean loss cost values for the next 3 years and the next 5 years, the values for potential use in state rating decisions. The predicted mean loss costs and actual means loss costs for 1) the 3-year (1974-1976), and 2) the 5-year (1974-1978) periods are shown for all states and their districts in Table C of

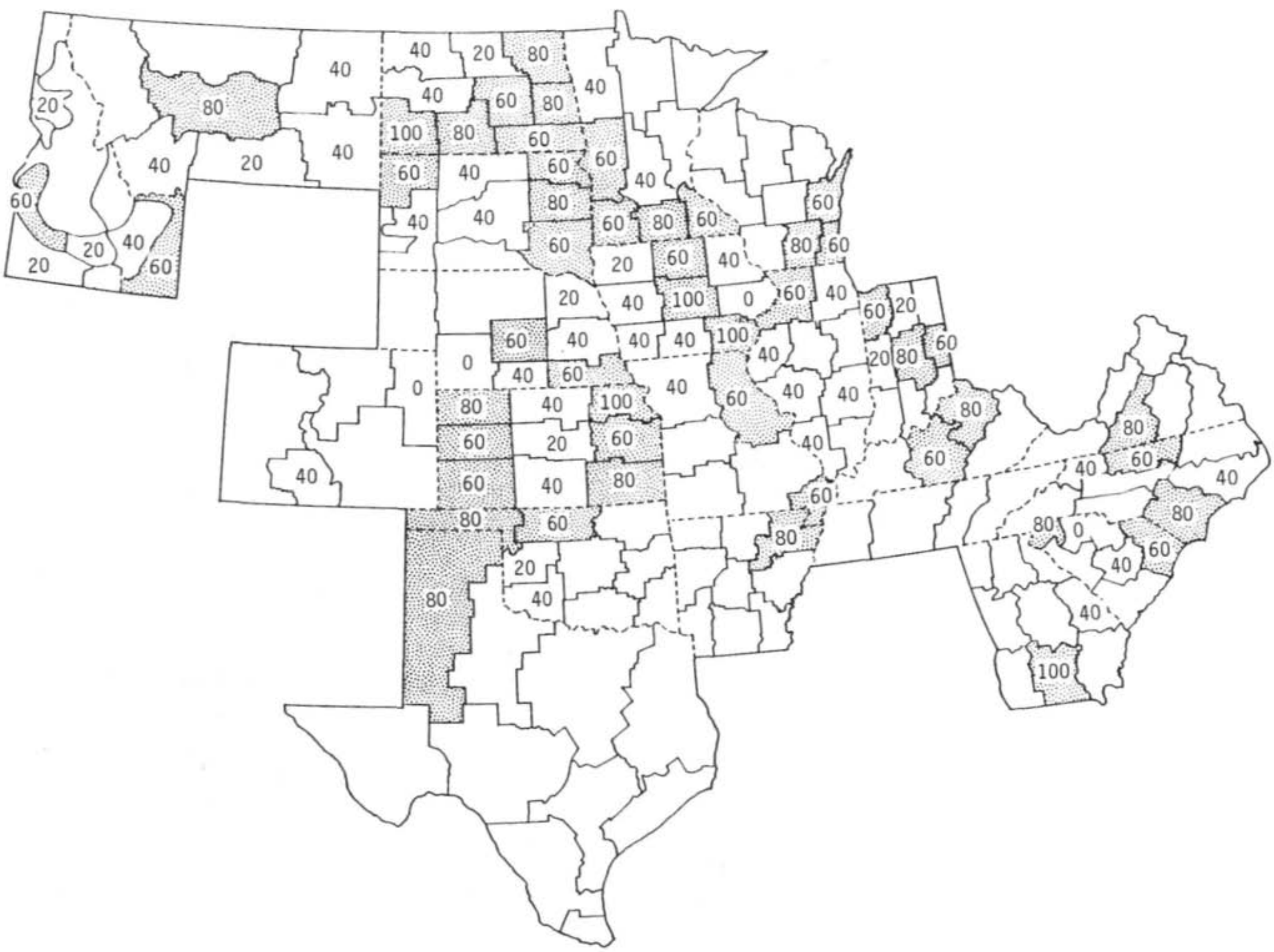


Figure 21. The Percent Frequency of Correctly Predicted Yearly Trends of Loss Cost Values for the 5-Years in the 1974-1978 Period.

Appendix A. These values were analyzed to investigate 1) the accuracy of the trends predicted (up or down), and 2) the accuracy of the magnitude of the predicted mean loss costs.

First, let us consider the accuracy of the trend predictions for the mean 3-year and mean 5-year loss costs. The trends of the predictions and of the acutal loss cost values of the 1974-76 and 1974-78 periods were defined as being up or down by their algebraic sign, or departure from the loss cost mean for preceeding years. For example, in Table C of Appendix A for the Kansas "State" line, one sees an "A-M" value (actual mean of 1974-76 minus the mean for 1971-73) of -$0.46; that is, the actual value of $4.33 was $0.46 less than the 3-year mean of $4. 79 - the state's mean value when the prediction was made. A recent 3-year mean was used for the 3-year future reference since it is considered the historical value most relevant to the future 3 years (a 5-year mean was used for the 5-year predictions). In an identical procedure, the predicted 3-year mean loss cost was compared with the pre-prediction mean (1971-73) to get a "P-M" value. One notes this value for the Kansas "State" value is -$0.36. Thus, both the Actual trend and Predicted trend were minus, or downward, and this was defined as a correct trend prediction.

Table 11 presents an evaluation of the number of correct trend predictions for each state and its districts, and the results are grouped by regions. Inspection of the 3-year mean trends for the districts show 65% accuracy in the Great Plains - Mountain states, 60% in the Midwest, and 70% in the Southeast. Figure 22 shows the geographic distribution of the 60 correct districts and 34 incorrect districts 3-year mean loss cost predictions. Areas of bad values are found in eastern Nebraska - western Iowa, North Dakota, and Illinois - Indiana. The state loss cost predictions of trend for the 3-year means are much better, having 75% or better accuracy in the three regions. The overall values for the 94 districts is 64% (60 of 94 correct), and 17 of 21 state trends (81%) were correctly predicted.

Inspection of the 5-year mean loss cost trend results in Table 11 reveal better three regional percentages (65% in the Great Plains, 69% in Midwest, and 80% in Southeast). These values and those for the districts reveal, as with the 3-year percentages, improvement in predictive accuracy as one moves from west to east. Figure 23 shows that most of the 29 incorrect district trend predictions were in the northern Great Plains (Dakotas and Minnesota). These 5-year results are similar to those for the 3-year values (Fig. 22), but differ dramatically from the annual trend predictions in the Dakotas which were often correct.

The number of correct trend predictions for the 5-year mean loss costs is greater than obtained for the 3-year predictions. Note that the correct district frequency of the 5-year values is 69% (64% for the 3-year), and is 90% for the 21 states as compared to 81% for the 3-year state values.

These results indicate a highly accurate capability to predict the future trends in state average (mean) loss cost values for 3 years and 5 years in advance. Figure 24 reflects this accuracy with only Minnesota having incorrectly predicted 3-year and 5-year values. As shown in Figure 21 (yearly district skill), predictions in the Southeast and in the southern Great Plains are the hest .

Table 11. Evaluation of Trend Direction in 3-year and 5-year Mean Loss Cost Predictions (all crops unless noted otherwise). Trend agreement based on similar algebraic signs for the Prediction and Actual Value, based on departure from historical mean.

	3-year trends		5-year trends	
	Districts*	State	Districts*	State
		Great Plains-Mountains		
Kansas	7/9*	yes**	6/9*	yes
Nebraska	3/6	yes	6/6	yes
South Dakota	4/7	no	4/7	yes
North Dakota	5/9	no	5/9	yes
Montana	5/5	yes	3/5	yes
Colorado	1/2	yes	1/2	yes
Idaho	4/6	yes	3/6	yes
Oklahoma	2/4	yes	3/4	yes
Texas	1/1	yes	1/1	yes
Regional Summary	32/49(65%)	7/9(78%)	32/49(65%)	9/9(100%)
		Midwest		
Minnesota	4/6	no	2/6	no
Iowa	6/9	yes	7/9	yes
Missouri	1/3	yes	2/3	yes
Illinois	2/6	yes	6/6	yes
Wisconsin	2/3	yes	2/3	yes
Kentucky	2/2	yes	0/2	no
Arkansas	1/1	yes	1/1	yes
Indiana	3/5	no	4/5	yes
Regional Summary	21/35(60%)	6/8(75%)	24/35(59%)	6/8(75%)
		Southeast-South		
North Carolina (tobacco)	3/4	yes	3/4	yes
South Carolina	2/3	yes	3/3	yes
Georgia	1/2	yes	1/2	yes
Virginia	1/1	yes	1/1	yes
Regional Summary	7/10(70%)	4/4(100%)	8/10(80%)	4/4(100%)
National Total	60/94	17/21	64/94	19/21
Percent Corrent	64%	81%	69%	90%

*First number is correct, and the second is the number of districts; hence,
*First number is correct, and the second is the number of districts; hence,
7/9 means that 7 of 9 districts had predictions of trend which agreed with actual trend.

**Yes means agreement of predicted and actual state trends.

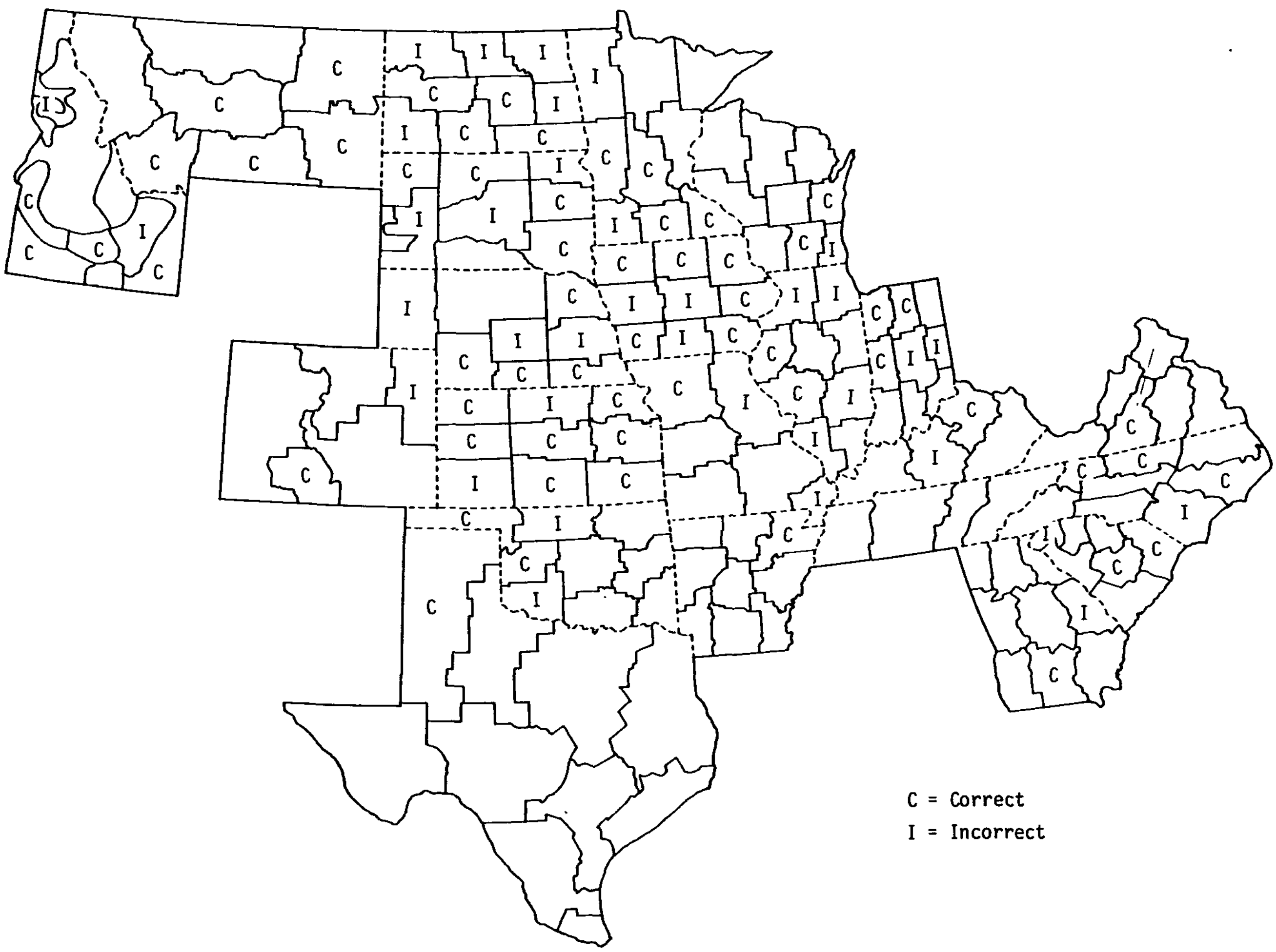


Figure 22. Prediction Correctness of Trends for the Next 3-Year Mean Loss Cost (direction of trend being either up or down).

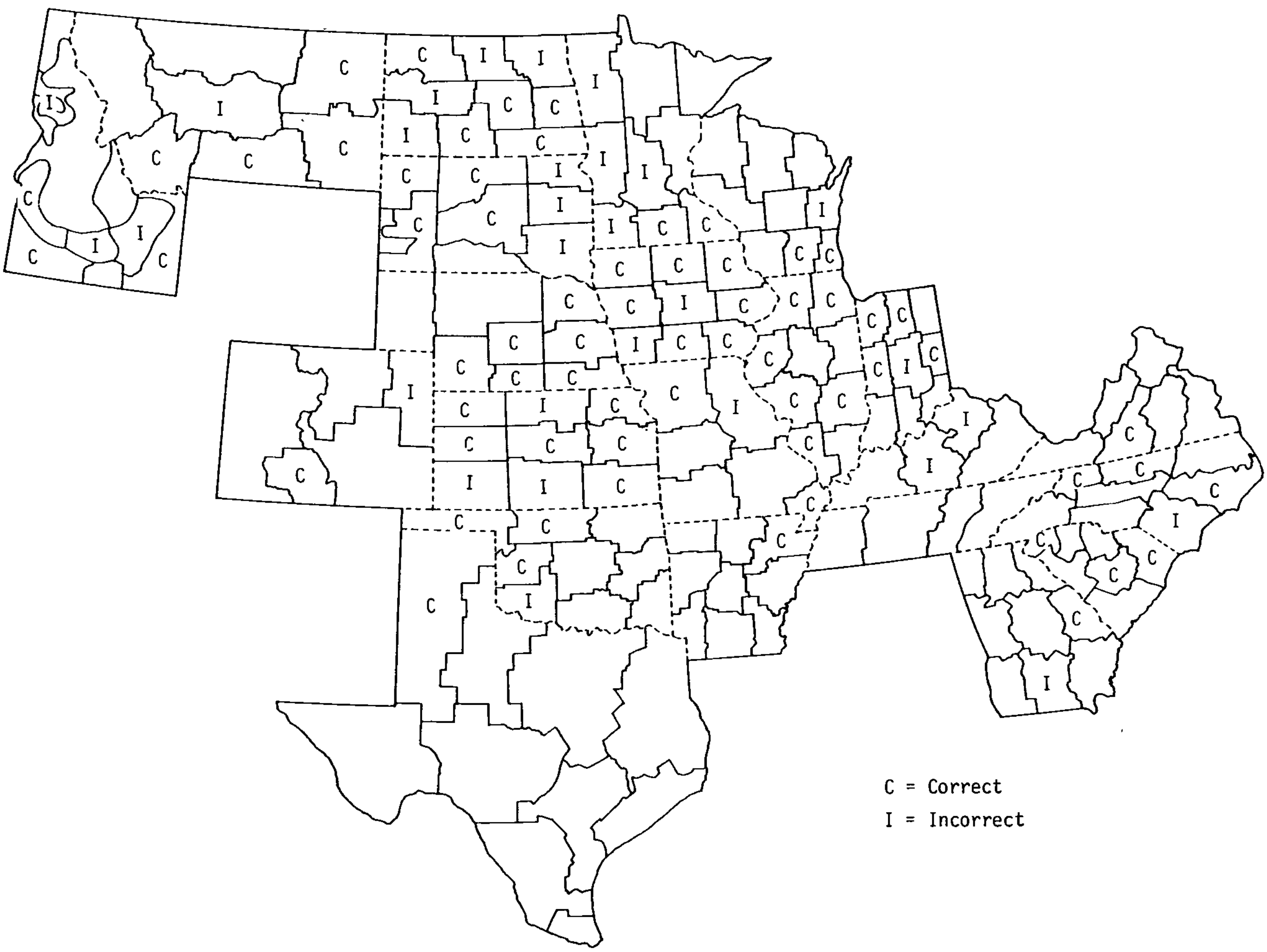
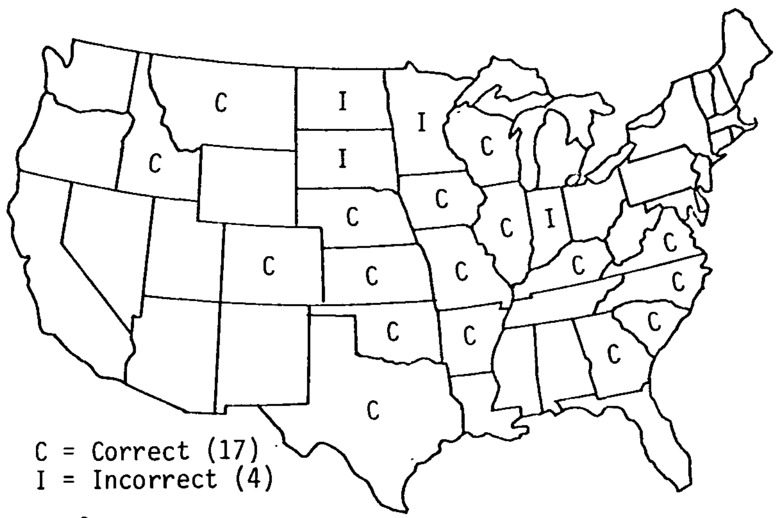
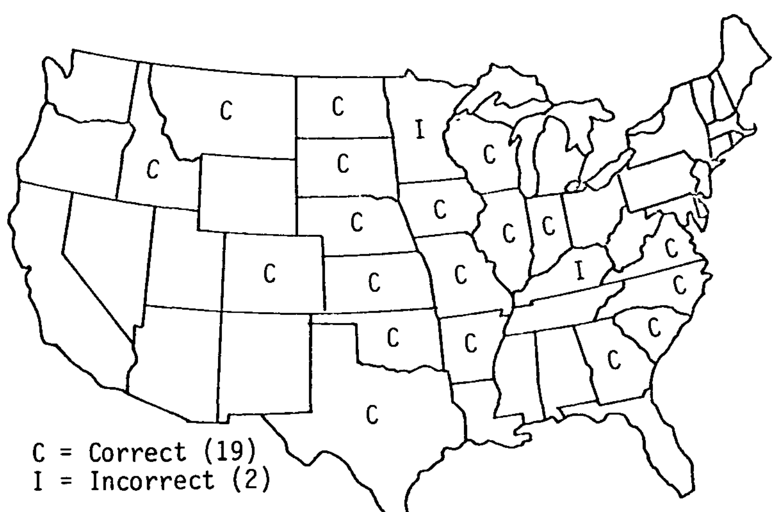


Figure 23. Prediction Correctness of Trends for the Next 5-Year Mean Loss Cost (direction of trend being either up or down).



a. 3-year



b. 5-year

Figure 24. Correction of Mean Loss Cost Trends for State Values for the Next 3 Years and Next 5 Years.

The other major assessment of the 3-year and 5-year mean loss cost predictions (Table C of Appendix A) was based not on the trend directions, but on the magnitude of the difference between the actual and predicted mean values. Table 12 presents the state values showing the differences between the actual and predicted mean loss costs. The values of the 21 states shows there were more overestimates (13 to 8 for the 3-year and for 5-year) than underestimates. The tendency was for overestimates to occur in the western states, as shown in Figures 25 and 26 which are based on district P-A differences. The areas of underestimates in both the 3-year and 5-year patterns are 1) in the northwest mountains (Idaho-Montana); 2) in a broad area that begin in Iowa and extends southeast to include the Coastal States; and 3) in central Kansas and Oklahoma. These last two. areas are ones where the trend predictions are also good (Figs. 22 and 23).

Comparison of the 3-year and 5-year values in Table 12 shows there is generally greater accuracy in the 5-year predictions than in the 3-year (as with trends, see Table 11). The algebraic average of the difference percentages is +21% for the 3-year values but only +9% for the 5-year values. Nineteen of the 21 state 5-year predictions were within 40% of the actual, and 9 predictions (Texas, Oklahoma, Kansas, Nebraska, Iowa, Missouri, Arkansas, North Carolina, and Virginia) were within 10% of the actual 5-year values. Closer predictions (small differences) were found in the more eastern states. For example, the three regional medians for the 3-year prediction differences were +28% for the Great Plains - Mountains, +23% for the Midwest, and -13% for the Southeast group. These regional differences are reflected in Figures 25 and 26 with most excessive district differences (> +100% and > -50%) found in the Idaho - Montana area and in the Midwest.

The results presented in Table 12 indicate usefully accurate state predictions were produced for both the 3-year average loss costs and 5-year average loss costs. This is clearly reflected in the 21-state medians of +4%. Furthermore, most of the district predicted values were usefully close to the actual ones. Table 13 presents the frequency distribution of the 94 district predictions (Predicted vs Actual differences) for the 5-year mean loss costs. Note that 19 are + 10%, 40 are + 20% and 54 are + 30%. The average of the negative (underestimates) was 23% and the average of the positive percentages was 47%.

Another analysis was based on the P/A values of Table C. These were grouped into classes, as indicated in Tables 14 and 15. The frequency (numbers of district percentages) are tabulated in these tables by states within regions. The 90-109% class embraces the desired, 100% value for the predicted/actual comparisons.

According to the distributions shown, the predicting process had a tendency to predict a greater number of means that are larger than the actual means (over prediction), as also shown in Table 13. The magnitude of the district differences (predicted/actual) in the means for the 3 years ahead (1974-1976) shown in Table 14 was analyzed on a state by state basis. As a measure of state quality, the number of district values in the three classes from 70 to 129% (+30% accuracy) was counted. This analysis showed reasonably good skill in most states aligned north-south in the Great Plains (North Dakota, Nebraska, Oklahoma, Kansas, and Texas), and poor skill in the more mountainous areas (Idaho, Montana, Colorado). In the Midwest, only Iowa,

Table 12. Differences in predicted and actual state mean loss costs for 3-year and 5-year periods.

	3 year (1974-76) period			5 year (1975-78) period		
	Actual[1]	Difference[2]	Difference as % of Actual	Actual	Difference	Difference as % of Actual
				Great Plains-Mountains		
Kansas (all crops)	$4.33	$+0.10	+ 2%	$4.48	$+0.28	+ 6%
Nebraska (wheat)	4.99	+3.38	+68	5.49	+1.76	+32
Nebraska (all crops)	3.54	+0.99	+28	4.50	+0.05	+ 1
Nebraska (corn)	2.49	+0.02	+ 1	3.58	-0.61	-17
South Dakota (all crops)	2.84	+2.09	+74	3.73	+0.91	+24
North Dakota (all crops)	3.70	+1.27	+34	4.29	+0.92	+21
Montana (all crops)	5.88	+0.06	+ 1	7.25	-1.13	-15
Colorado (all crops)	5.33	+5.05	+94	5.80	+4.25	+73
Idaho (all crops)	0.89	+1.05	+118	1.06	+1.02	+96
Oklahoma (all crops)	5.04	-0.59	-12	4.35	+0.36	+ 8
Texas (all crops)	5.71	+1.05	+18	5.47	+0.48	+ 9
Regional Algebraic Average (1)			+39%			+25%
Regional Median(1)			+28%			+ 9%
				Midwest		
Minnesota (all crops)	$1.53	+1,,05	+69%	$1.75	+0.61	+35%
Iowa (all crops)	1.61	-0..06	- 4	1.55	+0.10	+ 6
Missouri (all crops)	0.79	+0..44	+56	1.01	+0.10	+10
Illinois (all crops)	0.79	-0..19	-24	0.65	-0.09	-14
Wisconsin(all crops)	0.40	+0..30	+75	0.55	+0.18	+33
Indiana (all crops)	0.73	-0,.26	-36	0.59	-0.15	-25
Arkansas (all crops	1.00	+0..27	+27	0.95	+0.05	+ 5
Regional Average			+27%			+ 7%
Regional Median			+23%			+ 6%

(1) Actual is mean loss cost value in the predicted period of prior years.

(2) Difference is $ value between actual and predicted loss costs.

Table 12. CONTINUED

	3 year (1974-76) period			5 year (1975-78) period		
	Actual	Difference	Difference as % of Actual	Actual	Difference	Difference as % of Actual
Southeast-South						
North Carolina (tobacco)	$3.27	$-0.27	- 8%	$3.17	$-0.28	9%
South Carolina (all crops)	4.45	-0.58	-13	4.08	-0.45	-11
Georgia (all crops)	3.38	-0.77	-23	3.58	-0.70	-20
Virginia (all crops)	3.53	+0.15	+ 4	4.06	-0.36	- 9
Kentucky (all crops)	4.48	-1.85	-41	4.75	-1.90	-40
Regional Average			-16			-18
Regional Median			-13			-11
All-State Values[1]						
Algebraic Average			+21%			+ 9%
Median			+ 4%			+ 4%
Number over Estimated			13			13
Number under Estimated			8			8
Number with Estimate ±10%			5			9
±40%			14			19

[1] Nebraska based on its all crop value.

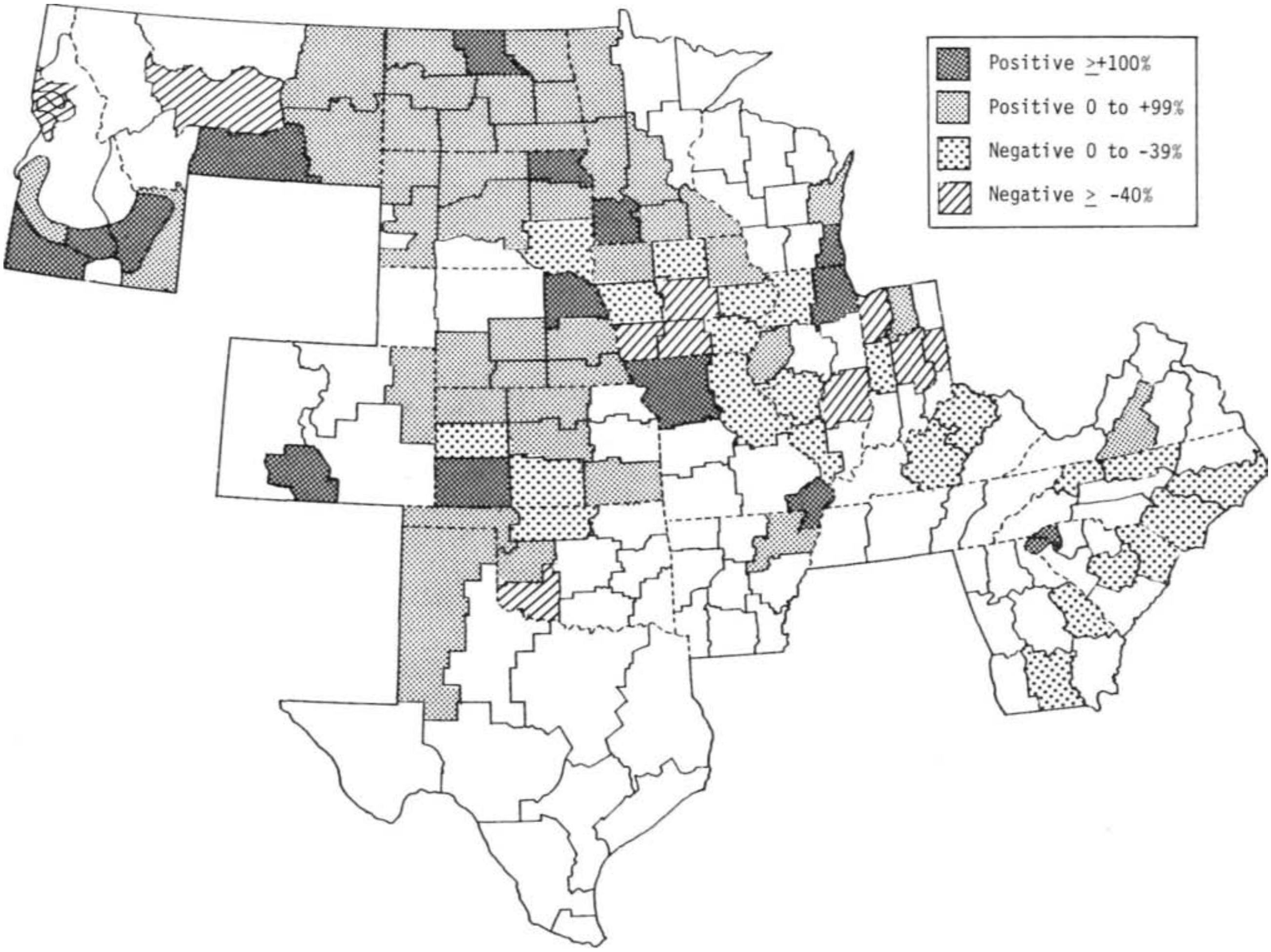


Figure 25. Difference Between Predicted and Actual Average 3-Year (1974-1976) Values, Expressed as a Percent of the Actual Average.

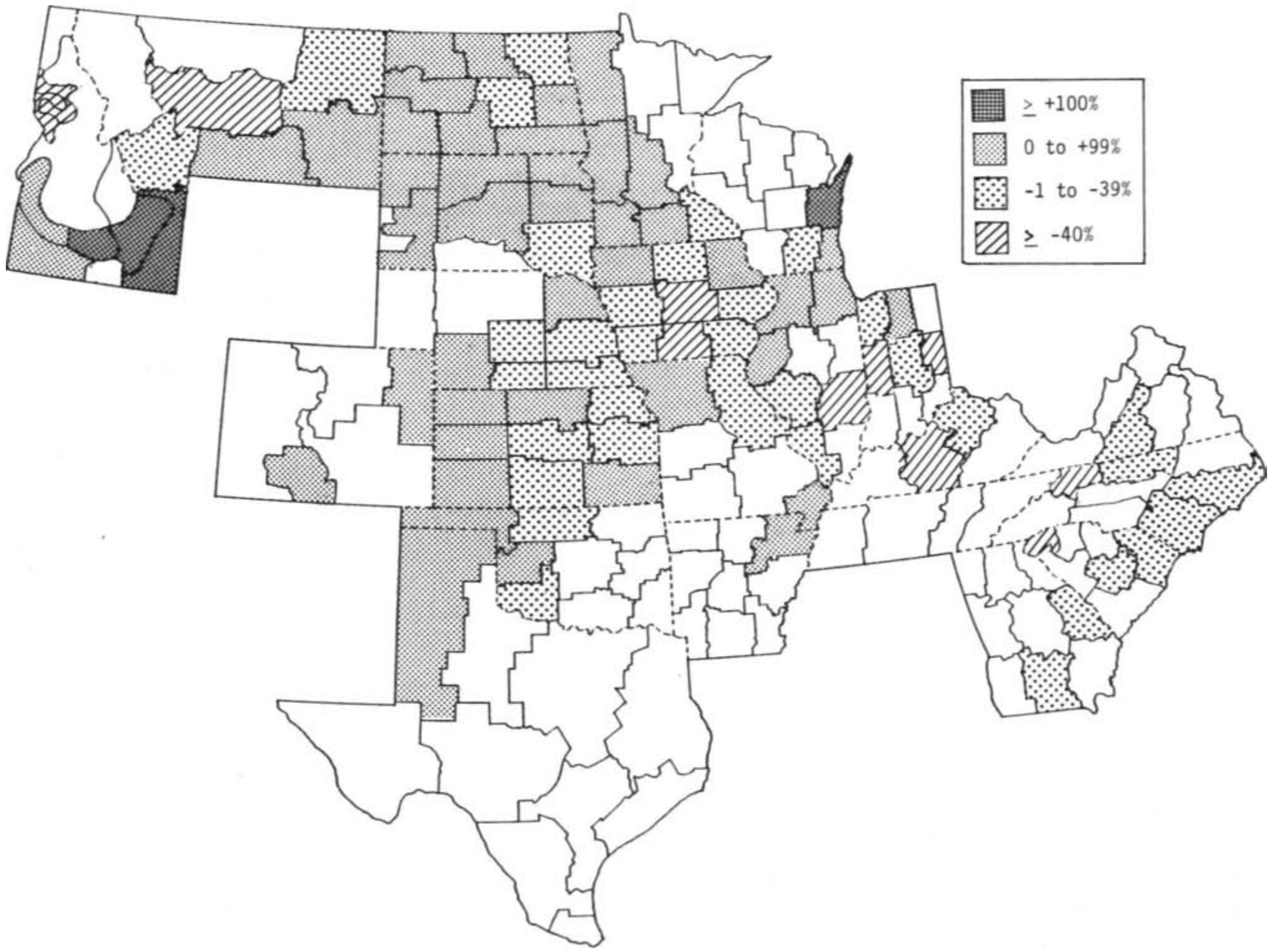


Figure 26. Difference Between Predicted and Actual Average 5-Year (1974-1978) Values, Expressed as a Percent of the Actual Average.

Table 13. Frequency Distribution of District Differences in Predicted and Actual 5-year Mean Loss Costs Expressed as Percent of the Actual Values.

Range of Difference in Percent		Number of District Values in Each Class
- 1% to -10%		13
-11% to -20%		12
-21% to -30%		9
-31% to -40%		4
-41% to -50%		2
-51% to -60%		6
	TOTAL =	46

Average = 23%

Median = 19%

+ 1% to + 10%		6
+11% to + 20%		9
+21% to + 30%		5
+31% to + 40%		5
+41% to + 50%		4
+51% to + 60%		2
+61% to + 70%		4
+71% to + 80%		2
+81% to + 90%		2
+91% to L00% ≥101%		4
	TOTAL =	48

Average = 47%

Median = 37%

Table 14. Frequency tabulation of 3-year district loss cost values/3-year actual for 1974-1976.

State	Predicted/Actual Classes in Percent												
	10-29	30-49	50-69	70-89	90-109	110-129	130-149	150-169	170-189	190-209	210-229	230-249	250--
High Plains Region													
Kansas				4	*	2		2			1		
Nebraska					2	1		1	1		1		
S. Dakota				1			1	1	1*	2			1
N. Dakota				1	1	2	2	1	1		1		
Montana		1			2		1				1		
Colorado									1	1			
Idaho	1								1	2	1		1
Oklahoma			1	1	2								
Texas						1							
Region Totals	1	1	1	7	7	6	4		5	5	5	0	2
Midwest Region													
Minnesota						1		3	1				
Wisconsin				1		1							1
Iowa	1		2	4	*			1			1		
Missouri				1						1		1	
Arkansas						1							
Illinois		1	1	2*		1							1
Indiana	1	1	1*	1	1								
Region Totals	2	2	4	9	1	4	0	4	1	1	1	1	3
Southeast Cotton-Tobacco Region													
Kentucky			2*										
Virginia					1								
N. Carolina			1	2	1*								
S. Carolina				1*	1								1
Georgia				2*									
Region Totals	0	0	3	5	3	0	0	0	0	0	0	0	1
Grand Totals	3	3	8	21	11	10	4	9	6	6	6	1	6

*represents the class with the state value where available.

Table 15. Frequency tabulation of 5-year district loss cost values/5-year actual for 1974-1978.

State	10-29	30-49	50-69	70-89	90-109	110-129	130-149	150-169	170-189	190-209	210-229	230-249	250--
						Predicted/Actual Classes in Percent							
						High Plains Region							
Kansas			1	3	*	2	1		1	1			
Nebraska				2	2	1	1						
S. Dakota			1		1	1*	2		1	1			
N. Dakota				2	1	2*	2	1	1				
Montana		1		1	1	2							
Colorado								1	1				
Idaho		1					1	1		*	1	1	1
Oklahoma					2	2							
Texas					1								
Region Totals	0	2	2	8	8	10	7	3	4	2	1	1	1
						Midwest Region							
Minnesota				1			2	2	1				
Wisconsin					2						1		
Iowa		1	1	2	4*			1					
Missouri				1		1*	1						
Arkansas					1								
Illinois		1		2*	1	1				1			
Indiana		2		2*			1						
Region Totals	0	4	1	8	8	2	4	3	1	1	1	0	0
						Southeast Cotton-Tobacco Region							
Kentucky			2*										
Virginia					1								
N. Carolina			1	2*	1								
S. Carolina		1		1*	1								
Georgia				2									
Region Totals	0	1	3	5	3	0	0	0	0	0	0	0	0
Grand Totals	0	7	6	21	19	12	11	6	5	3	2	1	1

Illinois, and Wisconsin had relatively good predictions in several districts. Predictions in the +30% range were common for most districts in the southeast states.

If one were to chose arbitrarily certain states as having greater predictive skill, based on the results in Tables 10-14 one would conclude good skills exist in 1) all the tobacco-cotton region states, 2) in Kansas, 3) Oklahoma, 4) Arkansas, and 5) in North Dakota. Other states with slightly lesser skill include Texas, Illinois, Iowa and Nebraska. States where little predictive skill (in trends or percentage of means) is shown include Montana, Idaho, Colorado, South Dakota, Minnesota, Indiana, Missouri, and Kentucky. Whether these states with poorer predictions reflect some geographical climatic differences, or differences in the past crop hail records (due to rapidly changing liability, changing crop types, etc.) could not be assessed.

Evaluation of Extreme Annual Loss Costs. Another interest of the hail insurance industry is in extreme, very high or very low, annual loss cost values in crop reporting districts and particularly within states. These events affect many aspects of the business activity including excessive profits or losses on a given year, public impetus to purchase insurance, etc.

Therefore, an investigation was made of these extreme events, both on a district and on a state scale. It should be recognized that with a prediction method such as developed in this project, that predictions of extreme events are not apt to be highly accurate. This is because the prediction technique tends to be based on smoothing. Hence, one should expect the predictive values, either for high or low annual values to be "underestimates." That is, to under predict the high value of the high year or that of the low years. Results verified this expectation. The question remains whether the prediction accuracies obtained in these extreme years are of use to the hail insurance industry.

A definition of extremely high and low loss cost years had to be developed to perform this investigation. To this end, it was decided to express departures from the median historical loss cost values. Median values were used since the historical averages (or means) of loss cost are based on a rather skewed distribution (many low and a few high) and it was desired to have rather even distribution of high and low values around the central tendency. Once the median loss cost values had been determined, say for the state of Kansas and from its 50 years of its historical values, then the "high" and "low" values in the predicted study period, 1974-78, were determined, both for the five actual annual values and for the five predicted values. An annual loss cost value was classed as an extremely high annual value if it fell within the upper quartile (upper 25% of the values), as defined from the distribution of the historical values. Similarly, a value was declared as an extremely low if fell in the lower quartile.

Once the extreme annual events in the predicted period, 1974-78, were so defined, two investigations were made. The first of these addressed the magnitude of the differences between the predicted and the annual values classed by whether the actual values were extremely high or low. That is, given an extremely high or low value occurred, how close did the predicted value come? The other investigations was based simply on the frequency of high and low years and essentially addressed the double error question: when the actual was high (or low) was the predicted value high (or low), and what happened when the predicted value was a high or low (did the actual value correspond)?

The evaluation of magnitude of the differences between the actual and the predicted values dealt separately with the high actual values and the low actual values.

Table 16 presents the results from many of the district and state analysis, as condensed into regional values. This was a valid summarization since the state values in a given region, or the district values, did not vary much between states. Within the analysis of the extremely high loss cost years, the predicted values were classed as either the "number above" the actual, "or the number below" the actual values. Basically the differences between the predicted and annual (P-A) were expressed as a percent of the actual extreme value to measure the degree of error. For example, let us examine the district values (Table 16) for the Great Plains-Mountains area and for the extremely high values. One finds that there were 7 predicted values above the actual extremely high values and the average of their overestimate was +47%. The number of predictions below the actual (since these are high values, they represent underestimates) was 47 with an average of -53%. The extremes show that one district had an underestimate that was 88% below the actual and another had an overestimate that was more than double, +207%.

Inspection of the frequency of values above and below for the districts (Table 16) shows there was a great tendency, as expected, for the predictive technique to yield underestimates of the actual value. There were 133 high year district values (out of 470 possible), and 117 were below the actual and only 16 values were above the actual.

The differences in average percentages also show (for the districts) regional variations. The average predicted district highs were -53% in the Great Plains, -59% in the Midwest and -42% in the Southeast of the actual. For example, if a high loss cost value in the district was $5.00, the difference was often more than half (> $2.50) of the actual value, a considerable underestimate. The few overestimates also were much above the actual. As shown in Table 16, the average of the 7 overestimates in the Great Plains was +47%.

The predictions of high values in the state loss costs are also exhibited in Table 16. There were 21 actual high values out of a possible 105 years (21 states x 5 years), and in all but 1 of these 21 the predictions were underestimates. The 20 state underestimates produced averages of -33% in the Great Plains, -38% in the Midwest, and -31% in the Southeast. Comparison of the state average differences with the district average differences in Table 16 shows that the state predictions were consistently less different, or closer to the actual, than the typical district predictions.

A similar analysis of differences (magnitude) for extremely low years between the predicted annual loss costs and the actual loss costs was also pursued. Tabulation of these results on a regional basis appears in Table 16. On a district basis there is a great tendency to underestimate the low values; that is, the predicted values often were "above" the actual and seldom

Table 16. Differences Between Predicted Annual Loss Costs and Actual Loss Costs for Years with Extremely High and Low Values[1].

	District Values		State Values	
	Extremely High Years	Extremely Low Years	Extremely High Years	Extremely Low Years
Great Plains - Mountains				
Number above	7	50	0	7
Average	+47%	+ 240%	-	149%
Number below	47	8	5	0
Average	-53%	- 42%	-33%	-
Extremes	-88 to +207%	-200 to +934%	-16 to -50%	+ 30 to +550%
Midwest				
Number above	8	24	1	3
Average	+57%	+278%	+ 7%	+ 126%
Number below	42	0	7	9
Average	-59%	-	-38%	-
Extremes	-100 to +163%	+ 40 to +720%	+ 7 to -71%	+ 69 to +175%
Southeast				
Number above	1	11	0	2
Average	+ 3%	+ 107%	-	+ 85%
Number below	28	0	8	0
Average	-42%	-	-31%	-
Extremes	+ 3 to - 93%	+ 19 to +257%	- 6 to -57%	+ 16 to 153%

[1]High and low chosen, based on occurrence in the upper or lower quartiles, as derived from the 1948-1973 values.

were as low as the actual values. That is, 85 of the 93 very low actual district loss cost values during the 1974-78 period were "above" the actual values, and 8 predicted values were more extreme, or "below" the actual lows.

The differences in Table 16 show the average for the many district values above the actual in the Great Plains-Mountains was +240%, in the Midwest +278%, and in the Southeast only +107%. This means, for example, that a typical district extremely low loss cost value in the Great Plain, say $1.00 in a year, has an average difference in its predicted value of 240%. In this example, the difference would be $2.40 meaning the predicted value would, have been $3.40. Larger percentages exist with the extreme lows than the extreme highs only because underestimates (typical of the extreme high values) are limited to a range of percentages of 0 to 99% of the actual, whereas the underestimates of the low values (which are expressed as the percentage of above) can range from +1% to positive infinity. The low value district extremes were great with one district having a predicted value that was +934% of the actual which occurred in a case of a very low actual value of $0.01.

Consideration of the extremely low years on a state basis, as revealed in Table 16, indicates there were 12 low year values within the 105 possible sampled years in the predicted period. All of the predictions associated with these 12 lows were -above the actual, or were underestimates of the actual. The Southeast Area average state value was +85%, that in the Midwest was +126%, and +149% in the Great Plains-Mountain Area. Again, the state predictions, on the average, were better than the district values.

In conclusion, most of the predicted values of either high or low extreme annual loss costs tended to be underestimates, or moderated. The state predictions, as would be expected, had lesser average percentage differences than did the district values. The best estimates of the extremes occurred in the Southeast states followed by lesser accuracy in the Great Plains and even less accuracy in the Midwest. These results tend to follow the other results relating to the predicton of annual trends and the results of the trends and magnitudes of future 3-year and 5-year average loss costs. The greatest skill is in the Southeast. The question for the hail insurance user is whether the magnitudes of the differences between the predicted and actual values shown in Table 16 are of use to the hail insurance industry.

Another analysis of the predictive capability of the technique to address the extreme annual loss cost values (high or low) in the 1974-1978 study period was investigated. This investigation was based on comparing whether actual extreme values (high or low) were correctly predicted. Two views are needed to test the predictive capability. First, given an actual extreme value occurred, how many were correctly predicted. The other aspect is given a predicted extreme, how many of these matched actual extremes were correct. The analysis was based on the district values an on the state values. Some state values were not obtained because the state values did not have statistically significant periodicities.

Table 17 presents the frequency of the district extreme loss cost values, both for the actual extremes and the predicted extremes during the 1974-1978 period. The table shows, for example, that in Montana (with 6 districts and 5 years of predictions, or 30 possible events) there were 13 actual extreme values (a high or a low) that occurred. The table also shows that only 1 of these was correctly predicted, or 8% of the actual. Further examination of the Montana district values in Table 17 shows that there were 4 predicted extremes and one of these was correct, or 25% of the predicted were correct. Inspection of the district values for all the states in Table 17 reveals very poor skill given an actual extreme occurred. For example, the area totals for the Great Plains-Mountains states show only 14% of the actual values were correctly predicted, with 21% correctly predicted in the Midwestern districts and 20% in the Southeast state districts. It is interesting that the percentages accuracy shows very little change between the three major regions. There are state-to-state variations ranging from 0% correct up to no higher than 60% in Georgia. The situation wherein an extreme has been predicted shows slightly higher accuracy but not much. It is interesting to note that in both the Great Plains-Mountains and the Midwest, the number of correct predictions was 30% on an area basis, and in the Southeast, 40% of the predictions were correct.

Correct means a match between a high with a high and a low with a low. The national totals shown in Table 18 reveal that predictions catch only 23% of the actual events correcly, and given that a prediction is made by the system (there were 169 predictions) roughly one-third of these were correct. Clearly, the accuracy of the system to detect correctly each extreme high and low loss costs is not good.

Table 18 presents the results obtained for state loss cost values that were extremely high or low, and addresses both the actual extremes and the predicted extremes. Comparison of the actual with the correctly predicted frequencies shows an extremely poor performance of the 12 annual state extremes in the Great Plains-Mountains states, none were correctly predicted; of the 11 in the Midwest only 1 was correctly predicted and only 2 of the 12 actual extremes in the Southeast states were correct. Thus, national totals show that there were 35 annual extremes (high or low) during the 1974-1978 study period and only 3 of these or 9%, were correctly predicted. Also shown in Table 18 is the frequency of predicted highs and lows which are generally less than the actual number. The fewer number of predicted extremes is expected because of the technique employed tends to "moderate" the amplitude of the annual values. There were 14 annual predictions of extreme highs and lows, and the 3 correct ones yield a 21% national correct value. The state predictive capabilities are lower than the district values as shown in Table 17. There is a suggestion the state extremes in the Southeast were predicted with much greater accuracy than in the other 2 areas. However, accuracies are very poor and are not expected to be useful.

SUMMARY AND RECOMMENDATIONS

Research performed for this project was designed to develop and test methods of predicting future hail loss cost values for various crops grown in the principal hail loss districts across the United States. The Crop Hail Insurance Actuarial Association provided the Water Survey with loss cost and liability data at the county level for 22 states. After a data evaluation, all states except Tennessee had one or more districts with qualifying data. The insurance industry is interested in the prediction of mean (average) loss costs for future 3-year and 5-year periods. These values would be helpful in

Table 17. Frequency of District Extreme (High and Low) Loss Cost Values, both Actual and Predicted, during 1974-78 and Based on All-Crops Data Unless Noted

	Number of Actual Extremes	Number of Correct Predictions of Actual Extremes	% C/A	Number of Predicted Extremes	% C/P
Great Plains - Mountains					
Montana	13	1	8	4	25
Idaho	13	5	38	21	24
North Dakota	21	4	20	15	27
South Dakota	17	4	24	14	29
Nebraska	19	2	10	4	50
Kansas	21	9	43	21	43
Colorado	4	0	0	5	0
Oklahoma	6	3	50	10	30
Texas	2	0	0	1	0
Area Totals	116	28	24%	95	30%
Midwest					
Minnesota	11	2	18	11	18
Iowa	17	6	35	15	40
Wisconsin	7	3	43	9	33
Missouri	6	0	0	2	0
Arkansas	5	0	0	3	0
Illinois	13	3	23	7	43
Indiana	15	2	13	7	29
Area Totals	74	16	21%	54	30%
Southeast					
Kentucky (tobacco)	7	2	29	3	67
Virginia (tobacco)	3	0	0	0	0
North Carolina	13	1	8	6	17
South Carolina	12	2	16	5	40
Georgia	5	3	60	6	50
Area Totals	40	8	20	20	40
National Totals	230	52	23	169	37

Table 18. Frequency of State Extreme (High or Low) Loss Costs, both Actual and Predicted, During 1974-78, Based on All Crops and for States with Significant Periodicities.

	Number of Actual Extremes	Number of Correct Predictions of Actual Extremes	% C/A	Number of Predicted Extremes	% C/P
Great Plains - Mountains					
Kansas	1	0	0	1	0
Nebraska	3	0	0	0	0
South Dakota	2	0	0	2	0
Idaho	3	0	0	2	0
Oklahoma	3	0	0	1	0
Area Totals	12	0	0	6	0
Midwest					
Iowa	5	1	20	1	100
Missouri	1	0	0	2	0
Illinois	1	0	0	0	0
Indiana	4	0	0	0	0
Area Totals	11	1	9	3	33
Southeast					
Kentucky (tobacco)	4	1	25	1	100
North Carolina (tobacco)	3	1	33	3	33
South Carolina	5	0	0	1	0
Area Totals	12	2	17	5	40
National Totals	35	3	9%	14	21%

rate setting which is done for most states every 3 to 5 years. Consequently, research was directed toward testing and developing methods for predicting mean loss cost values for the next 3 years and for the next 5 years, following a data analysis period.

Time series analysis procedures were employed for the prediction study. The first step involved a search of the historical loss cost data for significant periodicities (nonrandom fluctuations). Significant periodicities were expressed mathematically as harmonics (sine-cosine waves) and used as predictor variables. Two variations (a bandpass method and a filtering method) were tested initially for their utility in the use of these predictors.

The initial exploratory analysis was completed on loss cost data for the state of Kansas and its 9 crop reporting districts. This analysis was done for the purpose of testing and refining the two prediction techniques and for obtaining a basis for selecting one of the two for use in a much larger and more comprehensive 21-state analysis project.

The predictions and comparisons for the exploratory analyses were presented in Tables 5 through 8a of the section on "Comparison of Two Prediction Methods." The predictive ability for both methods was good for annual trends and for the prediction of 3- and 5-year means. Neither prediction process (bandpass and filters) demonstrated a real advantage over the other in their ability to predict either annual trends or 3 and 5-year means. The same was true of the two methods when compared for their ability to indicate district trends for 3 and 5-year means. Bandpass predicted 3 and 5-year Kansas state trends correctly for both sample records. Filters predicted the 3-year mean trends correctly.

Analysis for the primary data sample (21 states for the 1948-1978 record) was done with the bandpass method. This method is easier to use than the filter method and as accurate. Intuitively, it is also better adapted to the short (26-year) analysis record than filters.

The bandpass method was also used in a comparative study of predictive results from 50-year (1924-1973) and 26-year (1948-1973) data samples in Kansas and North Dakota where the longer records were available. From this limited analysis (two states), it was generally concluded that prediction of annual trends was more accurate when the shorter record was used as a prediction basis. The reverse was true when 3 and 5-year mean predictions were compared, i.e., the longer record provided a basis for more accurate prediction of means.

Summaries of the prediction results from bandpass for the 21-state analysis using 1948-1973 were presented in Tables 10 through 18 of this report. Evaluations of three predicted loss cost values (annual trends, 3 and 5-year means, and extreme events) were made to test prediction reliability. Most of the evaluations were made on a regional basis (Great Plains, Midwest, and Southeast). Annual trend predictions of five years (1974-1978) were compared with actual trends. Yearly trend (Table 10) predictions were about the same as expected by chance expect in the Southeast cotton and tobacco region, where an overall trend skill of 63 percent was realized. On a 21-state basis there was evidence that the method predicted the first two years (1974 and 1975) more accurately than the 3rd and 4th years as would be expected. However, predictive skill was greater again for the 5th year. A results which was unexplainable.

A primary interest of the insurance industry is in the 3 and 5-year mean loss cost predictions for potential use in state insurance rate adjustments. Both trend predictions and actual loss cost value predictions were made and evaluated. Evaluation of trend direction (up or down) was summarized in Table 11. Trend predictions for 3 and 5-year mean loss costs were better for the Southeast region as was also the case with annual trend predictions. Overall 3 and 5-year trend predictions were good (81% and 90% for 3 and 5-year means, respectively). Trends of the 5-year values were correctly predicted in 19 of the 21 states, and the average error was 10%. Nine of the states had predicted 5-year loss costs within 10% of the actual value, and 19 were within 40%.

The other assessment of 3 and 5-year mean predictions was based on the magnitude of the differences between actual and predicted mean values. Comparison of the 3 and 5-year values (Table 12) shows there was generally a greater predictive skill associated with the 5-year predictions than with those for 3 years. For state values, the algebraic average of difference percentages was +21% for 3-year means and +9% for prediction of 5-year means.

Another predictive interest of the insurance industry is in the prediction of very high and very low annual loss costs in crop district and states. Extreme annual loss cost experiences (either up or down) can produce either excessive profits or losses in a given year. Consequently, an investigation was made for the capability of predicting extreme loss cost events. Results of this evaluation are shown in Tables 16, 17, and 18. It was generally concluded that the accuracy of predictions for extreme loss cost experiences was poor and of doubtful use in insurance applications.

Development of successful techniques for use in predicting weather and its accumulative and average features which we think of as climate has been one of man's ambitions for generations. Many techniques have been tried. For the research described in this report, time series statistical techniques involving spectral analysis, bandpass, and filtering of historical data series were used. These techniques are current statistical tools in use. However, it is a fact that neither bandpass or filtering techniques and other statistical procedures can succeed without, 1) proper identification of underlying periodicities (nonrandom fluctuations) in historical data of variables people want to predict, and 2) the underlying periodicities repeat their influence in the future.

Spectral analyses performed for this project have pointed out either a difficulty in identification of periodicities and their characteristics or that periodicities may not exist to the degree envisioned. Periodicities found in crop-hail loss cost data were generally not very consistent (coherent) in either time or space. Unless a periodicity can be identified in adjacent districts, its presence in the data of a single district must be considered a random event. Spatial variation was evident in Table 10 and temporal variation was demonstrated in Tables 2, 3, and 4. However, the question of what constitutes the same and or a different periodicity from district to district needs clarification. Likewise, what temporal variation in computed wavelength and amplitudes is really significant in the statistical sense and of practical importance in predicting.

A partial demonstration of how small differences in wavelength of a periodicity can change a prediction was inspired by Table 2 of this report. The wavelength or period of the Kansas 3.3-year periodicity varied slowly within a range of 3.1 to to 3.6 years as spectra were computed for 20-year samples along the 55-year loss cost record (1924-1978). Do period changes from 0.1 to 0.5 year represent changes of practical imporatance in predictions? Six computed sine-cosine curves are shown in Figure 27. Each curve had the same amplitude and phase but the period was varied from 3.1 to 3.6 years. These curves all drawn for yearly computed values are all very similar from their beginning to the sixth year. All up and down trends are in the same direction during the first 5 years. Between the 6th and 7th years, it is clear that the 3.1—and 3.2-year periodicities have changed to an upward trend, the 3.3-year is leveling off and the 3.4—to 3.6-year periodicities are still definitely downward. Thus, periodicities with wavelength differences as small as 0.1 and 0.2 year soon become out of phase and produce very different contributions at a specified time to a prediction process. In case, of the bandpass method, the phase angle or computed starting point is near the first of a data record. By the time any of these curves passed along or through the data bases (analysis) period, say 20 years in this example, their projections into the predictions period would be quite different. For example, the 3.6-year periodicity would contribute about -1.4 loss cost units to be subtracted from a mean value while the 3.2-year periodicity would contribute about +1.4 loss cost units to be added to a mean.

The point being stressed with the Figure 27 illustration is that sample wavelength variation of as much as 0.5 year may be tolerated for up to 5 years after the phase angle (first maximum amplitude following the beginning of data record). Therefore, it may be important that phase points be fixed (determined) just prior to the prediction period, i.e., end of the data record rather than at the beginning. It is apparent from Tables 2, 3, and 4 that sample periodicities determined from historical data are not constant in wavelength and amplitude but instead, they are almost constantly varying, perhaps due to random variations in the data sample and other unknown causes.

A Suggestion for future study is as follows:

1) Perform an extremely thorough spatial and temporal spectral analysis on the best data records available to gain a thorough understanding of periodic tendencies in the data sample.

2) Devise a method of determining a phase point at the end of the historical data record or sample. (The filtering approach the authors experimented with in this report attempts to accomplish this but it has amplitude "end effect" difficulties). Intuitively, it seems important to have the periodicity accepted as a predictor variable in synchronization with the very recent part of the data sample.

3) If more than one predictor periodicity variable is being used, each should be as much as possible, tied in with recent oscillations in the data analysis sample.

Any statistical prediction procedure will only succeed when the proper underlying periodicities, if any, or identified and when the future follows these same periodic tendencies. The better predictive success (80 percent) for the case of Kansas state as a whole data may have been due to a better identification of periodicities or better loss data. This may have been due to proper areal (spatial) averaging, better quality data, and a locality where underlying periodicities are more consistent. Table 1 and Table A do suggest a relatively high amount of activity for periodicities in Kansas. Table 2 is evidence of one rather consistent (coherent) periodicity (3.3-year) in the temporal sense. According to Figure 11, the synthesis (reconstruction) of the analysis data was in synchronization with the data just before the prediction period started. In this research case there is also evidence in Tables 2 and 3 that the 3.3 and 4.8-year periodicities used in predictions were probably active during the subsequent 5-year prediction period. At least, periodicities with wavelengths in the vicinity of 3.3 and 4.8 years were evident in the last five 20-year moving sample spectral analyses (Tables 2 and 3).

In summary, it is possible to reconstruct the past with only a few periodicities identified in the data. These periodicities generally are documented by rather low correlation coefficients. Those used in predictions had correlations in the range of 0.30 to 0.40. This represents and explanation, in the variance sense, of 9 to 16 percent of the historical sample. The periodicities are, therefore, not strong and their amplitudes are not large. Consequently, the predictive power of each is nominal.

The research results are sufficiently encouraging to recommend continued studies over the years of the accumulated loss cost data.

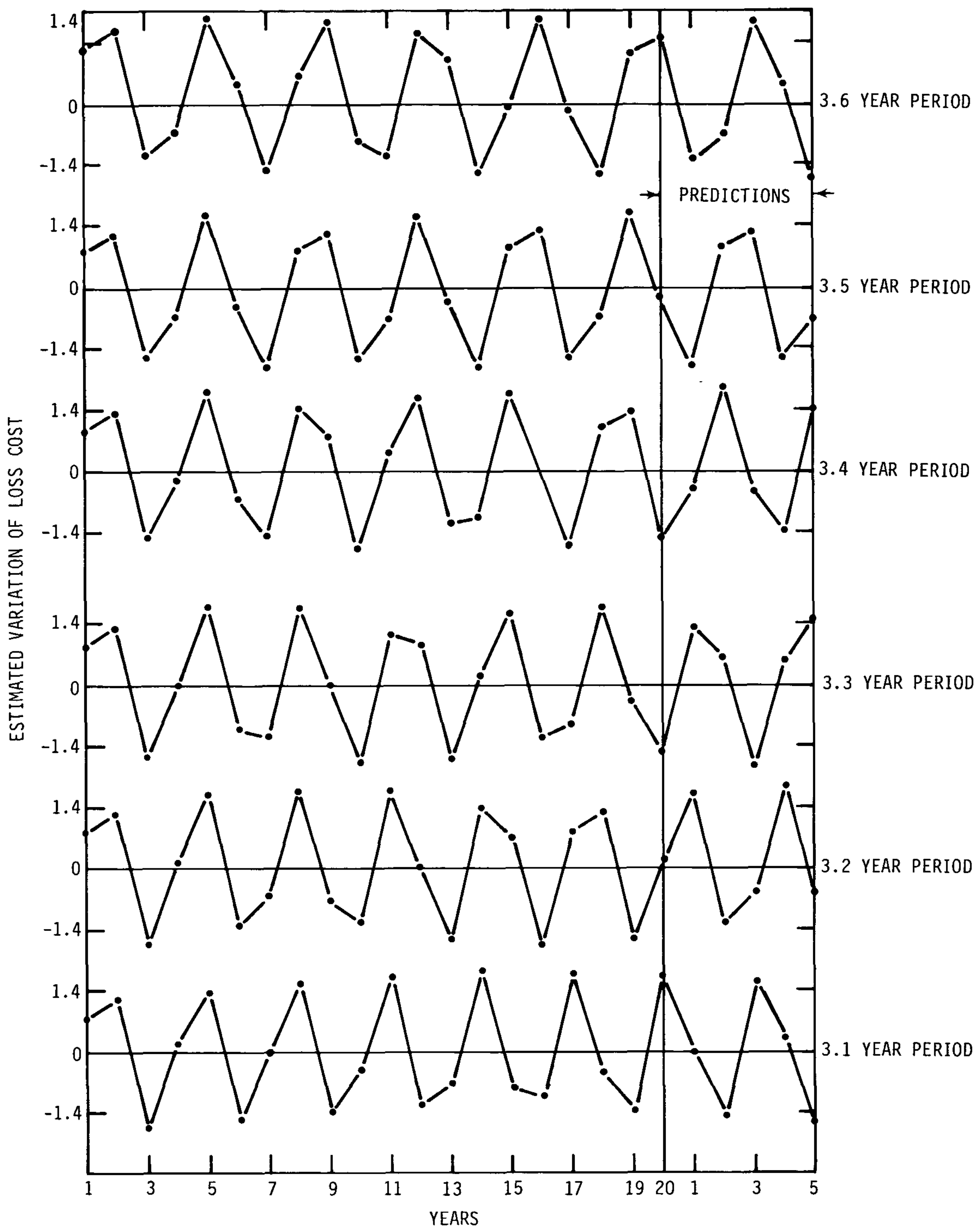


Figure 27. Six Sine-Cosine Waveforms with the Same Amplitude and Phase Point and with Different Periods.

APPENDIX A

Table A. Loss cost periodicities for a,21-state area based on 1948-1973 data.[1]

Districts	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9
		Kansas (all crops)			
1		3.2	4.5		6.8
2		3.5			
3	2.3		4.2	5.7	
4		3.3		5.4	
5			4.8		
6	2.2,2.5	3.7			
7	2.3	3.3	4.2		
8	2.3	3.2,3.9			
9	2.0,2.4	3.2,3.9			
State[1]		3.3			
		Nebraska (wheat)			
1	2.3				
6	2.5			5.9	
7	2.4	3.0			
8					6.5
State	2.4			5.8	
		Nebraska (all crops)			
3		3.9			
4	2.9		4.4		
5	2.9			5.3	
6		3.5			

[1]Obtained from an analysis after combining county data.

Table A. CONTINUED

Districts	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9
		Nebraska (all crops) continued			
7	2.2		4.9		
8	2.1				
State			4.1	5.5	
		Nebraska (corn)			
3		3.9			
4	2.9		4.4		
5	2.9			5.4	
6		3.5			
7	2.2		4.9		6.9
8	2.1				
State			4.1	5.5	
		South Dakota (all crops)			
1	2.7				
2		3.4	4.6		
3	2.8				6.2
5	2.6	3.1	4.1		
6			4.1		
7	2.3		4.7		6.4
9			4.4		
State					6.8

Table A. CONTINUED

Districts	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9
		North Dakota (all crops)			
1		3.5			
2	2.4	3.1.3.9			
3	2.7	3.4			
4	2.9				
5	2.4,2.9				
6					6.4
7	2.1				
8	2.9				
9				5.6	
State	No significant periodicities				
		Montana (all crops)			
2		3.1,3.7			6.5
4	2.0				
5	2.3		4.0	5.4	
6	2.9				
7			4.0		
State	No significant periodicities				
		Colorado (all crops)			
3	2.3,2.6				
5			4.9		6.4
		Idaho (all crops)			
2	2.0	3.2	4.9		
5	2.3,2.9				
6	2.4	3.2,3.8			6.3
7	2.3	3.1			

Table A. CONTINUED

Districts	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9
		Idaho (all crops) continued			
9	2.4,2.7	3.2			
10	2.4				
State	2.4				
		Oklahoma (all crops)			
1	2.3	3.6			
2	2.0,2.7			5.0	
4	2.0	3.0			6.1
7	2.2				6.4
State		3.3			
		Texas (grain)			
1	2.7		4.2		
		Texas (cotton)			
2	2.9	3.8			
		Minnesota (all crops)			
1	2.4				
4			4.8		
5	2.4	3.0	4.9		
7	2.4				
8	2.2	3.2,3.9	4.8		
9	2.5,2.9				
State	No significant periodicities				

Table A. CONTINUED

Districts	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9
		Iowa (all crops)			
1			4.0		
2				5.3	
3			4.9		
4	2.2,2.7		4.3		
5	2.3,2.6				
6	2.0,2.8				
7	2.7				
8			4.3		
9	2.2				
State	2.7,2.2				
		Missouri -(all crops)			
1	2.3		4.6		
2	2.2	3.1	4.4		6.7
6	2.5				
State	2.3		4.6		
		Illinois (all crops)			
1	2.0,2.7				
2	2.7			5.5	
3	2.8				
6	2.2	3.3			6.7
7	2.3				
8	2.8				
State	2.8				
		Wisconsin (all crops)			
6	2.1	3.0,3.5		5.3	
8		3.7			

Distrlcts	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9
		Wisconsin (all crops) continued			
9	2.0	3.2			6.8
State	No significant periodicities				
		Indiana (all crops)			
1	2.3	3.6			
2		3.0			
4		3.8			
5	2.2,2.7			5.0	
6	2.7				
State	2.3				
		Arkansas (all crops)			
3		3.1	4.9		
		Kentucky (Tobacco)			
2	2.0	3.8	4.7		
3	2.1,2.4, 2.9				
State	2.1,2.4, 2.9				
		Virginia (Tobacco.)			
3	2.7				
		North Carolina (all crops)			
2			4.6		6.1
3	2.2				
6	2.8				

Table A. CONTINUED

Districts	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9
	North Carolina (all crops) continued				
7		3.0			
State	2.2				
	South Carolina (all crops)				
1	2.0,2.9				
4			4.8		
6			4.0	5.0	
State			4.9		
	Georgia (all crops)				
6	2.5	3.2,3.8			
8	2.0			5.6	

Table B. Comparison of yearly predicted trends from bandpass method using 1948-1973 data with actual trends for 1974-1978.

Trends, up(U) or down(D) with predicted on left and actual on right for each year

Districts	1974	1975	1976	1977	1978	%correct
			Kansas (all crops)			
1(NW)	U/U	U/U	D/D	D/U	D/D	80
2(NC)	U/U	D/U	D/U	U/U	U/D	40
3(NE)	U/U	D/D	U/U	D/D	D/D	100
4 (WC)	U/U	D/D	D/U	U/D	D/D	60
5(C)	U/U	U/D	U/D	D/U	D/U	20
6 (EC)	D/D	U/U	U/D	U/U	D/D	60
7(SW)	U/U	D/D	D/D	D/U	U/D	60
8(SC)	U/U	D/D	U/D	D/U	U/D	40
9(SE)	U/D	D/D	D/D	U/U	D/D	80
Percent Correct	89	67	44	44	56	60
State Value CD	U/U	D/D	D/D	U/U	U/D	80
			Nebraska (wheat)			
1(NW)	U/U	D/D	U/D	D/U	U/D	40
6(SW)	U/U	D/D	D/U	U/D	D/U	40
7(SC)	D/U	U/U	U/D	D/U	D/U	20
8(SE)	U/U	U/U	D/U	D/U	D/U	40
Percent Correct	75	100	0	0	0	35
State Value(1)	U/U	D/D	U/U	D/D	D/U	80

(1)Obtained by an analysis based on combining of county data.

Table B. CONTINUED

Districts	1974	1975	1976	1977	1978	%correct
Nebraska (all crops)						
3(NE)	U/U	U/D	D/U	D/U	U/D	20
4(C)	U/D	D/D	U/U	D/U	D/D	60
5 (EC)	D/U	D/D	U/D	D/U	U/U	40
6(SW)	U/D	U/D	D/U	U/D	U/D	0
7(SC)	D/D	D/U	U/D	D/U	U/U	40
8(SE)	D/U	U/D	D/D	U/U	D/D	60
Percent Correct	33	33	33	17	67	37
State Value[1]	D/U	D/D	U/U	D/U	U/D	40
Nebraska (corn)						
3(NE)	U/U	U/D	D/U	D/U	U/D	20
4(C)	D/D	D/D	U/D	D/U	D/D	60
5 (EC)	D/U	D/D	U/D	D/U	U/U	40
6(SW)	U/D	U/D	D/U	U/D	U/D	0
7(SC)	D/D	D/U	U/D	D/U	U/U	40
8(SE)	D/U	U/D	D/U	U/U	D/D	40
Percent Correct	50	33	0	17	67	33
State Value[1]	D/U	D/D	U/U	U/U	U/U	80
South Dakota (all crops)						
1 (NW)	D/D	U/U	U/U	D/U	U/D	60
2(NC)	U/D	D/D	D/U	U/U	U/D	40
3(NE)	U/D	U/U	D/U	D/D	U/U	60
5 (SW)	U/U	D/U	D/U	U/U	D/U	40
6(C)	D/U	U/D	U/U	D/U	D/D	40
7 (EC)	U/U	U/U	D/U	U/U	D/D	80
9(SE)	U/U	D/D	D/U	U/D	U/U	60
Percent Correct	57	71	29	57	57	54
State Value[1]	U/U	U/D	U/U	D/U	D/U	40

Table B. CONTINUED

Districts	1974	1975	1976	1977	1978	%correct
			North Dakota (all crops)			
1 (NW)	D/U	U/U	U/D	D/D	D/U	40
2 (NC)	U/D	U/D	D/U	U/U	U/D	20
3(NE)	D/D	D/D	U/U	D/D	D/U	80
4 (WC)	D/U	D/U	U/U	U/D	D/D	40
5(C)	U/U	D/D	U/U	D/U	U/D	60
6(EC)	U/U	U/D	U/U	U/U	D/D	80
7(SW)	D/D	U/U	D/D	U/U	D/D	100
8(SC)	D/U	D/D	U/U	U/U	D/D	80
9(SE)	U/D	U/D	U/D	D/U	D/D	20
Percent Correct	44	56	67	67	56	58
State Value	No significant periodicities					
			Montana (all crops)			
2 (SW)	D/U	U/U	U/D	D/D	D/U	40
4(C)	U/U	D/D	U/D	D/D	U/U	80
5(SC)	U/U	D/U	D/U	U/D	D/U	20
6(NE)	U/U	D/U	D/D	U/D	D/U	40
7(SE)	U/U	D/U	D/U	U/D	U/U	40
Percent Correct	80	40	20	40	40	44
State Value	No significant periodicities					
			Colorado (all crops)			
3(NE)	U/D	D/U	U/D	D/U	U/D	0
5(SC)	U/D	U/D	U/U	D/U	D/D	40
Percent Correct	0	0	50	0	50	20
State Value	No data					

Table B. CONTINUED

Districts	1974	1975	1976	1977	1978	%correct
			Idaho (all crops)			
2 (EC)	D/U	U/U	D/U	U/D	D/U	20
5(SW)	U/D	D/0*	U/U	D/D	U/U	60
6(SSW)	U/D	U/U	D/U	U/D	U/D	20
7(SC)	D/U	U/D	D/U	U/D	D/D	20
9(SEC)	U/D	D/U	D/D	U/U	U/D	40
10(SE)	U/D	D/U	D/D	U/U	D/D	60
Percent Correct	0	33	50	50	50	37
State Value	U/D	U/U	D/D	U/U	D/D	80
			Oklahoma (all crops)			
1(NW)	D/U	D/D	U/U	U/U	D/D	80
2(NC)	U/U	D/D	U/D	D/U	D/D	60
4(WC)	D/U	D/U	U/D	D/D	U/D	20
7(SW)	D/D	U/U	D/U	U/D	U/D	40
Percent Correct	50	75	25	50	50	50
State Value	U/U	U/D	D/D	U/U	U/D	60
			Texas (all crops)			
1(NW)	U/U	U/D	U/D	D/U	U/D	20
Percent Correct	100	0	0	0	0	20
			Texas (cotton)			
2(WWC)	D/D	D/D	U/U	D/D	D/U	80
Percent Correct	100	100	100	100	0	80

*No Change

Districts	1974	1975	1976	1977	1978	%correct
			Minnesota (all crops)			
1(WW)	U/D	D/U	U/D	D/D	U/U	40
4(WC)	U/U	U/D	U/U	D/D	D/U	60
5(C)	U/D	U/D	U/U	D/D	D/U	40
7(SW)	D/D	U/D	D/U	U/U	U/U	60
8(SC)	U/U	U/D	U/U	D/D	U/U	80
9(SE)	D/U	D/D	U/U	D/U	U/U	60
Percent Correct	50	17	67	83	67	57
State Value	No significant periodicities					
			Iowa (all crops)			
1(NW)	D/U	U/D	U/U	D/U	D/U	20
2(NC)	D/U	D/D	U/U	U/n	U/U	60
3(NE)	U/U	U/D	U/D	D/U	D/D	40
4(WC)	D/U	D/D	D/U	U/D	U/U	40
5(C)	U/U	D/D	U/U	U/U	D/D	100
6(EC)	D/U	U/D	U/0	D/U	U/D	0
7(SW)	U/U	U/U	D/U	U/D	U/D	40
8(SC)	D/U	D/D	U/U	U/D	U/D	40
9(SE)	U/U	D/D	U/U	D/D	U/U	100
Percent Correct	44	67	56	22	56	49
State Value	U/U	U/D	D/U	D/D	U/U	60
			Missouri (all crops)			
1(NW)	U/D	D/U	D/D	D/U	U/U	40
2(NE)	D/D	U/D	U/D	D/D	U/U	60
6(SE)	U/U	D/D	D/U	U/U	D/U	60
Percent Correct	67	33	33	67	67	53
State Value	U/D	D/U	U/D	D/U	U/U	20

Table B. CONTINUED

Districts	1974	1975	1976	1977	1978	%correct
			Illinois (all crops)			
1(NW)	D/U	U/U	D/D	U/U	U/D	60
2(NE)	U/D	U/U	D/D	U/D	D/U	40
3(WC)	D/U	D/D	U/D	D/U	U/U	40
6(SW)	U/U	D/D	U/D	D/U	U/D	40
7(SE)	U/U	D/D	U/D	D/U	U/D	40
8(SSW)	U/U	U/D	D/U	U/D	U/U	40
Percent Correct	50	83	33	17	33	43
State Value	D/U	U/U	U/D	D/D	U/U	60
			Wisconsin (all crops)			
6 (EC)	U/D	D/D	D/U	U/U	D/D	60
8(SC)	U/U	U/U	D/D	U/U	U/D	80
9(SE)	U/D	D/D	U/U	D/U	D/D	60
Percent Correct	33	100	67	67	67	67
State Value	No significant periodicities					
			Indiana (all crops)			
1(NW)	U/U	D/U	D/D	D/D	U/D	60
2(NC)	U/D	D/U	U/D	U/D	D/D	20
4(WC)	D/U	U/D	D/D	D/U	U/D	20
5(C)	U/D	U/U	U/U	D/D	U/U	80
6 (EC)	U/U	D/D	D/U	U/D	D/D	60
Percent Correct	40	40	60	40	60	48
State Value	U/U	D/U	U/D	D/D	U/D	40
			Arkansas (all crops)			
3(NE)	U/U	D/D	U/U	D/D	D/U	80
Percent Correct	100	100	100	100	0	80

Table B. CONTINUED

Districts	1974	1975	1976	1977	1978	%correct
			Kentucky (Tobacco)			
2(C)	U/U	U/D	D/D	D/U	U/U	60
3(NC)	D/D	U/U	D/D	U/U	D/D	100
Percent Correct	100	50	100	50	100	80
State Value	D/U	U/U	D/D	U/U	D/U	60
			Virginia (Tobacco)			
3(SC)	D/D	U/U	D/D	D/U	U/U	80
Percent Correct	100	100	100	0	100	80
			North Carolina (tobacco)			
2(NWC)	U/U	D/U	D/U	U/D	U/D	20
3(NEC)	U/U	D/D	U/D	D/U	U/U	60
6(SE)	U/U	U/D	D/D	U/U	D/D	80
7 (EC)	D/D	U/U	D/U	D/U	U/D	40
Percent Correct	100	50	25	25	50	50
State Value	U/U	D/D	U/D	D/U	U/D	40
			South Carolina (all crops)			
1(NW)	U/U	D/D	U/0	U/U	D/D	80
4(NE)	U/U	U/D	U/D	D/U	D/D	40
6(C)	U/U	U/U	U/D	D/U	D/D	60
Percent Correct	100	67	0	33	100	60
State Value	D/U	U/D	U/D	D/U	D/D	20
			Georgia (all crops)			
6 (EC)	U/U	D/U	D/U	U/D	U/U	40
8(SC)	D/D	D/D	D/D	U/U	U/U	100
Percent Correct	100	50	50	50	100	70
State Value	No data					

Table C. Comparison of actual loss cost, predicted loss cost from bandpass method, with 1948-1973 data, and 3-year and 5-year mean values.

District	3-year						5-year					
	Mean 1971-73	Actual 1974-76	Predicted 1974-76	A-M	P-M	P/A%	Mean 1969-73	Actual 1974-78	Predicted 1974-78	A-M	P-M	P/A%
Kansas (all rops) 1948-73												
1 (NW)	6.98	7.66	12.06	0.68	5.08	157	6.73	8.04	10.25	1.31	3.52	127
2 (NC)	3.84	2.59	4.15	-1.25	0.31	160	3.95	3.84	4.36	-0.11	0.41	114
3 (NE)	0.83	2.44	2.08	1.61	1.25	85	1.15	1.87	1.52	0.72	0.37	81
4 (WC)	8.80	7.97	6.94	-0.83	-1.86	87	7.75	7.66	10.81	-0.09	3.06	141
5 (C)	7.78	4.60	5.14	-3.18	-2.64	112	7.08	5.43	3.92	-1.65	-3.16	72
6 (EC)	3.10	1.39	1.37	-1.71	-1.73	99	2.78	2.18	1.44	-0.60	-1.34	66
7 (SW)	5.12	4.27	1.24	-0.85	4.12	216	5.05	4.15	7.89	-0.90	2.84	190
8 (SC)	4.01	5.37	4.19	1.36	0.18	78	4.78	4.97	4.24	0.19	-0.54	85
9 (SE)	2.34	1.45	1.86	-0.89	-0.48	128	2.72	1.40	2.44	-1.32	-0.28	174
Average	4.76	4.19	5.23	-0.56	0.47	125	4.67	4.39	5.21	0.27	0.53	117
State[1]	4.79	4.33	4.43	-0.46	-0.36	102	4.78	4.48	4.76	-0.30	-0.02	106

[1] Obtained by an analysis based on combining county data.

Table C. Continued

District	3-year Mean (71-73)	3-year Actual (74-76)	3-year Predicted (74-76)	3-year A-M	3-year P-M	3-year P/A%	5-year Mean (69-73)	5-year Actual (74-78)	5-year Predicted (74-78)	5-year A-M	5-year P-M	5-year P/A%
KanSas (wheat) (1948-1973)												
1 (NW)	5.67	5.73	10.09	0.06	4.42	176	5.57	6.64	9.08	1.07	3.51	137
2 (NC)	3.69	2.30	4.04	-1.39	0.35	176	3.71	3.76	4.26	0.05	0.55	113
3 (NE)	No significant periodicities											
4 (WC)	6.86	6.49	8.69	-0.37	1.83	134	6.09	6.32	10.86	0.23	4.77	172
5 (C)	8.38	4.62	5.32	-3.76	-3.06	115	7.50	5.57	4.02	-1.93	-3.48	72
6 (EC)	4.09	0.97	1.54	-3.12	-2.55	159	3.62	2.14	1.70	-1.48	-0.44	79
7 (SW)	3.57	4.64	9.14	1.07	5.57	197	5.09	5.18	8.51	0.09	3.42	164
8 (SC)	4.03	5.42	4.20	1.39	0.17	77	4.80	4.79	4.25	-0.01	-0.55	89
9 (SE)	2.83	1.45	1.69	-1.38	-1.14	117	3.00	1.48	2.48	-1.52	-0.52	168
Average	4.35	3.51	4.97	-0.84	0.62	142	4.38	3.99	5.02	-0.39	0.64	126
Stated[1]	4.78	4.21	4.83	-0.57	0.05	115	4.94	4.55	5.05	-0.39	0.11	111
North Dakota (wheat & barley) (1948-1973)												
1 (NW)	4.01	3.70	6.72	-0.31	2.71	182	3.24	3.38	5.98	0.14	2.74	177
2 (NC)	3.34	1.80	3.34	-1.54	0	186	4.03	4.29	3.32	0.26	-0.71	77
3 (NE)	3.37	3.48	2.82	0.11	-0.55	81	3.36	3.37	2.70	0.01	-0.66	80
4 (NC)	1.74	3.42	5.05	1.68	3.31	148	3.05	2.88	5.79	-0.17	2.74	201
5 (C)	3.57	3.76	5.00	0.19	1.43	133	3.07	5.43	5.21	2.36	2.14	96
6 (EC)	3.17	2.64	1.92	-0.53	1.24	73	2.62	3.09	2.77	0.47	0.15	90
7 (SW)	7.38	5.65	9.13	-1.73	1.75	162	7.44	6.10	9.18	1.34	1.74	150
8 (SC)	5.57	6.62	7.27	1.05	1.70	110	5.97	6.83	8.05	0.86	2.08	118
9 (SE)	4.67	2.47	2.68	-2.20	-1.99	109	3.07	3.33	4.24	0.26	1.17	127
Average	4.09	3.73	4.88	-0.36	0.79	131	3.98	4.30	5.25	0.32	1.27	122
State[1]	3.60	3.16	4115	-0.44	0.55	131	3.35	3.59	4.46	-0.24	1.11	124

[1] Obtained from an analysis after combining county data.

Table C. CONTINUED

District	3-year Mean 1971-73	3-year Actual 1974-76	3-year Predicted 1974-76	3-year A-M	3-year P-M	3-year P/A%	5-year Mean 1969-73	5-year Actual 1974-78	5-year Predicted 1976-78	5-year A-M	5-year P-M	5-year P/A%
Nebraska (Wheat) 1948-73												
1 (NW)	8.83	5.41	13.06	-3.42	4.23	241	8.80	7.53	12.27	-1.27	3.47	163
6 (SW)	6.11	8.55	9.41	2.44	3.30	110	8.96	7.42	8.03	-1.54	-0.93	108
7 (SC)	3.20	4.01	6.02	0.81	2.82	150	3.81	4.53	4.80	0.72	0.99	106
8 (SE)	1.52	1.98	4.98	0.46	3.46	252	1.54	2.47	3.89	0.93	2.35	157
Average	4.91	4.99	8.37	0.07	3.45	188	5.78	5.49	7.25	-0.29	1.47	133
State	4.03	4.30	6.87	0.27	2.84	160	4.48	4.51	5.73	0.03	1.25	127
Nebraska (all crops) 1948-73												
3 (NE)	1.49	1.52	3.11	0.03	1.62	205	1.65	1.90	2.73	0.25	1.08	144
4 (C)	6.08	4.11	6.28	-1.97	0.20	153	4.35.	6.18	5.35	1.83	1.00	87
5 (EC)	2.01	1.72	2.12	-0.29	0.11	123	1.83	2.66	2.42	0.83	0.59	91
6 (SW)	9.67	9.51	9.48	-0.16	-0.19	100	7.89	8.10	9.66	0.21	1.77	119
7 (SC)	3.51	2.16	3.88	-1.35	0.37	180	3.32	4.87	4.74	1.55	1.42	97
8 (SE)	1.16	2.22	2.32	1.06	1.16	105	0.97	3.28	2.42	2.31	1.45	74
Average	3.99	3.54	4.53	-0.45	0.54	144	3.33	4.50	4.55	1.16	1.22	102
State	2.46	2.51	2.88	0.55	0.42	1.15	2.16	3.52	2.86	1.36	0.7	81

Table C. CONTINUED

District	3-year						5-year					
	Mean 1971-73	Actual 1974-76	Predicted 1974-76	A-M	P-M	P/A%	Mean 1969-73	Actual 1974-78	Predicted 1974-78	A-M	P-M	P/A%
Nebraska (corn) 1948-73												
3 (NE)	1.49	1.53	3.11	0.04	1.62	203	1.65	1.99	2.73	0.34	1.08	137
4 (C)	7.01	3.92	5.13	-3.09	-1.88	131	4.92	6.30	5.20	1.38	0.28	83
5 (EC)	2.00	1.74	2.21	-0.26	0.21	127	1.82	2.74	2.36	0.92	0.54	86
6 (SW)	9.67	9.84	9.48	0.17	-0.19	96	7.89	8.30	9.66	0.41	1.77	116
7 (SC)	3.67	2.34	4.97	-1.33	1.30	212	3.42	4.97	4.68	1.55	1.26	94
8 (SE)	1.05	2.01	2.31	0.96	1.26	115	0.90	3.17	2.41	2.27	1.51	76
Average	4.15	3.56	4.53	-0.58	0.39	147	3.43	4.58	4.51	1.14	1.07	99
State	2.56	2.49	2.51	-0.07	-0.05	101	2.22	3.58	2.97	1.36	0.75	83
South Dakota (all crops) 1948-73												
1 (NW)	12.92	5.42	8.66	-7.50	-4.26	160	11.09	6.68	7.76	-4.41	-3.33	116
2 (NC)	10.85	3.91	5.37	-6.94	-5.48	137	12.19	3.73	7.40	-8.46	-4.79	198
3 (NE)	2.14	1.37	3.58	-0.77	1.44	261	2.54	1.70	3.05	-0.84	0.51	179
5 (SW)	6.22	3.84	7.48	-2.38	1.26	195	6.78	7.24	7.48	0.46	0.70	103
6 (C)	4.81	2.97	5.13	-1.84	0.32	173	5.77	3.69	4.81	-2.08	-0.96	130
7 (EC)	1.38	2.42	4.71	1.04	3.33	195	2.87	2.52	3.57	-0.35	0.70	142
9 (SE)	1.73	5.06	3.64	3.33	1.91	72	4.79	5.71	3.88	0.92	-0.91	68
Average	5.72	3.57	5.51	-2.15	-0.21	170	6.58	4.47	5.42	-2.11	-1.15	134
State	3.12	2.84	4.93	-0.28	1.81	174	4.84	3.73	4.64	-1.11	-0.20	124

Table C. CONTINUED

District	3-year Mean 1971-73	3-year Actual 1974-76	3-year Predicted 1974-76	3-year A-M	3-year P-M	3-year P/A%	5-year Mean 1969-73	5-year Actual 1974-78	5-year Predicted 1974-78	5-year A-M	5-year P-M	5-year P/A%
North Dakota (all crops) 1948-73												
1 (NW)	4.15	3.60	5.07	-0.55	0.92	141	3.26	3.32	4.63	0.06	1.37	139
2 (NC)	3.54	1.79	3.71	-1.75	0.17	207	4.06	4.00	4.71	-0.06	0.65	118
3 (NE)	3.20	3.42	2.60	0.22	-0.60	76	3.21	3.34	2.54	0.13	-0.67	76
4 (WC)	1.86	3.35	4.79	1.49	2.93	143	3.18	2.88	5.10	-0.30	1.92	177
5 (C)	3.52	3.86	4.70	0.34	1.18	122	3.06	5.69	4.89	2.63	1.83	86
6 (EC)	2.93	2.64	3.26	-0.29	0.33	123	2.66	3.08	3.62	0.42	0.96	118
7 (SW)	7.26	5.74	9.67	-1.52	2.41	168	7.88	6.21	9.74	-1.67	1.86	157
8 (SC)	5.59	6.53	6.55	0.94	0.96	100	5.75	6.74	7.07	0.99	1.32	105
9 (SE)	4.64	2.35	4.41	-2.29	-0.23	188	3.08	3.34	4.58	0.26	1.50	137
Average	4.08	3.70	4.97	-0.38	0.89	134	4.02	4.29	5.21	0.27	1.19	121
State	No significant periodicities											
Montana (all crops) 1948-73												
2 (SW)	1.44	3.44	3.61	2.00	2.17	105	5.34	4.83	3.67	-0.51	-1.67	76
4 (C)	3.26	11.69	5.50	8.43	2.24	47	6.84	12.06	5.49	5.22	-1.35	46
5 (SC)	1.80	3.54	7.13	1.74	5.33	201	5.07	5.73	6.48	0.66	1.41	113
6 (NE)	4.26	4.77	4.92	0.51	0.66	103	4.08	5.22	5.18	1.14	1.10	99
7 (SE)	4.68	5.97	8.52	1.29	3.84	143	9.97	8.39	9.78	-1.58	-0.19	117
Average	3.09	5.88	5.94	2.79	2.85	120	6.26	7.25	6.12	0.99	-0.14	90
State	No significant periodicities											

Table C. CONTINUED

District	3-year Mean 1971-73	3-year Actual 1974-76	3-year Predicted 1974-76	A-M	P-M	P/A%	5-year Mean 1969-73	5-year Actual 1974-78	5-year Predicted 1974-78	A-M	P-M	P/A%
Colorado (all crops) 1948-73												
3 (NE)	8.95	6.95	13.04	-2.00	4.09	188	11.30	7.50	12.61	-3.80	1.31	168
5 (SC)	17.19	3.71	7.72	-13.48	-9.47	208	11.61	4.10	7.49	-7.51	-4.12	183
Average	13.07	5.33	10.38	-7.74	-2.69	198	11.45	5.8	10.05	-5.65	-1.40	175
State	No data available											
Idaho (all crops) 1948-73												
2 (EC)	1.45	2.96	0.86	1.51	-0.59	29	1.49	2.70	1.22	1.21	-0.27	45
5 (SW)	0.90	0.35	0.61	-0.55	-0.29	174	1.02	0.31	0.47	-0.71	-0.55	152
6 (SSW)	0.93	1.75	3.94	0.82	3.01	225	2.93	2.05	2.75	-0.88	-0.18	134
7 (SC)	0.08	0.40	0.83	0.32	0.75	207	0.40	0.35	0.71	-0.05	0.36	203
9 (SEC)	1.17	0.41	1.89	-0.76	0.72	461	1.78	0.83	2.21	-0.95	0.43	266
10 (SE)	2.85	1.29	2.48	-1.56	-0.37	192	4.70	1.13	2.76	-3.57	-1.94	244
Average	1.23	1.19	1.77	-0.04	0.54	215	2.05	1.23	1.69	-0.82	-0.36	174
State	1.99	0.89	1.94	-1.10	-0.05	218	3.25	1.06	2.08	-2.19	-1.17	196

Table C. CONTINUED

District	3-year Mean 1971-73	3-year Actual 1974-76	3-year Predicted 1974-76	A-M	P-M	P/A%	5-year Mean 1969-73	5-year Actual 1974-78	5-year Predicted 1974-78	A-M	P-M	P/A%
Oklahoma (all crops) 1948-73												
1 (NW)	11.10	6.02	6.44	-5.08	-4.66	107	11.66	6.20	7.80	-5.46	-3.86	126
2 (NC)	6.53	6.54	5.19	0.01	-1.34	79	6.09	4.39	4.05	-1.70	-2.04	92
4 (WC)	3.09	3.85	4.09	0.76	1.00	106	3.83	2.72	3.26	-1.11	-0.57	120
7 (SW)	3.54	3.77	2.09	0.23	-1.45	55	3.81	4.09	3.74	0.28	-0.07	91
Average	6.06	5.04	4.45	-1.02	-1.61	87	6.35	4.35	4.71	-2.00	-1.63	107
State	7.51	5.79	5.49	-1.72	-2.02	95	7.16	4.58	5.77	-2.58	-1.39	126
Texas (all crops) 1948-73												
1 (NW)	4.75	5.71	6.76	0.96	1.05	118	4.21	5.47	5.95	1.26	1.74	109
Average	4.75	5.71	6.76	0.96	1.05	118	4.21	5.47	5.95	1.26	1.74	109
State	No data available											
Texas (cotton) 1948-73												
2 (NWC)	4.23	3.17	3.10	-1.06	-1.13	98	3.29	2.85	2.75	-0.44	-0.54	96
Average	4.23	3.17	3.10	-1.06	-1.13	98	3.29	2.85	2.75	-0.44	-.54	96
State	No data available											

Table C. CONTINUED

District	Mean 1971-73	Actual 1974-76	Predicted 1974-76	A-M	P-M	P/A%	Mean 1969-73	Actual 1974-78	Predicted 1974-78	A-M	P-M	P/A%
Minnesota (all crops) 1948-73												
1 (NW)	2.36	1.72	2.88	-0.64	0.52	167	2.05	2.00	2.65	-0.05	0.60	132
4 (WC)	1.75	2.01	3.33	0.26	1.58	166	1.67	1.57	2.72	-0.10	1.05	173
5 (C)	2.56	1.39	2.17	-1.17	-0.39	156	1.91	1.29	1.99	-0.62	0.08	154
7 (SW)	1.90	0.99	2.48	-0.91	0.58	251	1.98	1.67	2.82	-0.31	0.84	169
8 (SC)	2.87	1.37	2.58	-1.50	-0.29	188	2.22	1.65	2.17	-0.57	-0.05	132
9 (SE)	1.56	1.68	2.04	0.12	0.48	121	1.27	2.31	1.83	1.04	0.56	79
Average	2.17	1.53	2.58	-0.64	0.41	175	1.85	1.75	2.36	-0.10	0.59	140
State	No significant periodicities											
Iowa (all crops) 1948-73												
1 (NW)	2.68	1.53	2.54	-1.15	-0.14	166	3.35	2.42	2.44	-0.93	-0.91	101
2 (NC)	2.52	1.37	1.15	-1.15	-1.37	84	1.87	1.91	1.90	0.04	0.03	99
3 (NE)	1.88	0.72	1.46	-1.16	-0.42	203	1.26	0.78	1.19	-0.48	-0.07	153
4 (WC)	1.78	2.00	1.44	0.22	-0.34	72	2.51	2.07	1.94	-0.44	-0.57	94
5 (C)	1.12	2.05	1.08	0.93	-0.04	53	1.24	2.04	1.00	0.80	-0.24	49
6 (EC)	0.52	0.96	0.76	0.44	0.24	79	0.50	0.82	0.73	0.32	0.23	89
7 (SW)	0.74	2.42	1.35	1.68	0.61	56	1.57	1.85	1.56	0.28	-0.01	84

Table C. CONTINUED

District	3-year Mean 1971-73	Actual 1974-76	Predicted 1974-76	A-M	P-M	P/A%	5-year Mean 1969-73	Actual 1974-78	Predicted 1974-78	A-M	P-M	P/A%
8 (SC)	1.96	3.43	0.82	1.47	-1.14	24	3.16	2.30	1.25	-0.86	-1.91	54
9 (SE)	0.61	1.18	0.94	0.57	0.33	80	0.99	0.94	0.90	-0.05	-0.09	96
Average	1.53	1.74	1.28	0.21	-0.25	91	1.83	1.68	1.43	-0.15	-0.39	91
State	1.54	1.61	1.55	0.07	0.01	96	1.76	1.55	1.65	-0.21	-0.11	106
Missouri (all crops) 1948-73												
1 (NW)	0.67	0.67	1.57	0.00	0.90	234	0.98	1.00	1.29	0.02	0.31	129
2 (NE)	0.87	1.09	0.84	0.22	-0.03	77	0.95	1.04	0.77	0.09	-0.08	74
6 (SE)	1.65	0.82	1.69	-0.83	0.04	206	2.20	1.20	1.71	-1.00	-0.49	142
Average	1.06	0.86	1.37	-0.20	0.30	172	1.38	1.08	1.26	-0.30	-0.12	115
State	0.73	0.79	1.23	0.06	0.50	156	0.97	1.01	1.11	0.04	0.14	110
Illinois (all crops) 1948--73												
1 (NW)	0.77	0.95	0.74	0.18	-0.03	78	0.59	0.78	0.87	0.19	0.28	112
2 (NE)	0.69	0.62	1.59	-0.07	0.90	256	0.59	0.67	1.29	0.08	0.80	193
3 (WC)	0.43	0.63	0.73	0.20	0.30	116	0.44	0.51	0.62	0.07	0.18	122
6 (SW)	0.45	0.62	0.54	0.17	0.09	87	0.39	0.54	0.44	0.15	0.05	81
7 (SE)	0.45	0.83	0.32	0.38	-0.13	39	0.30	0.63	0.30	0.33	0.00	48
8 (SSW)	0.39	0.45	0.29	0.06	-0.10	64	0.41	0.36	0.32	-0.05	-0.09	89

Table C. CONTINUED

District	3-year Mean 1971-73	3-year Actual 1974-76	3-year Predicted 1974-76	3-year A-M	3-year P-M	3-year P/A%	5-year Mean 1969-73	5-year Actual 1974-78	5-year Predicted 1974-78	5-year A-M	5-year P-M	5-year P/A%
Average	0.53	0.68	0.70	0.15	0.17	107	0.45	0,58	0.64	0.13	0.19	107
State	0.52	0.79	0.60	0.27	0.08	76	0.44	0.65	0.56	0.21	0.12	86
Wisconsin (all crops) 1948-73												
6 (EC)	0.94	0.38	0.45	-0.56	-0.49	118	0.63	0.45	0.96	-0.18	0.33	213
8 (SC)	0.51	0.71	0.60	0.20	0.09	85	0.37	0.63	0.60	0.26	0.23	95
9 (SE)	0.30	0.12	1.04	-0.18	0.74	867	0.27	0.58	0.62	0.31	0.35	107
Average	0.58	0.40	0.70	-0.18	0.11	357	0.42	0.55	0.73	0.13	0.30	138
State	No significant periodicities											
Indiana (all crops) 1948-73												
1 (NW)	0.42	0.85	0.50	0.43	0.08	59	0.42	0.56	0.45	0.14	0.03	80
2 (NC)	0.33	0.36	0.39	0.03	0.06	108	0.24	0.24	0.38	0.00	0.14	158
4 (WC)	0.59	0.91	0.65	0.32	0.06	71	0.43	1.11	0.53	0.68	0.10	48
5 (C)	0.66	0.78	0.33	0.12	-0.33	42	0.49	0.60	0.43	0.11	-0.06	72
6 (SC)	0.25	0.64	0.21	0.39	-0.04	33	0.22	0.45	0.22	0.23	0.00	49
Average	0.45	0.71	0.42	0.26	- .03	63	0.36	0.59	0.40	0.23	0.04	81
State	0.49	0.73	0.47	0.24	-0.02	64	0.40	0.59	0.44	0.19	0.04	75

Table C. CONTINUED

District	3-year Mean 1971-73	3-year Actual 1974-76	3-year Predicted 1974-76	3-year A-M	3-year P-M	3-year P/A%	5-year Mean 1969-78	5-year Actual 1974-78	5-year Predicted 1974-78	5-year A-M	5-year P-M	5-year P/A%
North Carolina (tobacco) 1948-73												
2 (NWC)	1.50	5.78	3.23	4.28	1.73	56	3.07	5.68	3.42	2.61	0.35	60
3 .(NEC)	1.34	3.55	3.04	2.21	1.70	86	1.75	3.34	2.86	1.59	1.11	86
6 (SE)	3.03	3.73	2.88	0.70	-0.15	77	3.54	3.61	3.00	0.07	-0.54	83
7 (EC)	2.29	2.52	2.46	0.23	0.17	98	2.86	2.54	2.51	-0.32	-0.35	99
Average	2.04	3.89	2.90	1.85	0.86	79	2.80	3.79	2.95	0.99	0.14	82
State	2.16	3.27	3.00	1.11	0.84	92	2.72	3.17	2.89	0.45	0.17	91
South Carolina (all crops) 1948i-73												
1 (NW)	0.69	0.29	0.92	-0.40	0.23	317	0.65	3.06	0.94	2.41	0.29	31
4 (NE)	7.02	4.60	4.37	-2.42	-2.65	95	6.53	4.19	3.90	-2.34	-2.63	93
6 (C)	6.56	3.94	2.96	-2.62	-0.98	75	5.24	3.59	2.66	-1.65	-2.58	74
Average	4.76	2.94	2.75	-1.81	-1.13	162	4.14	3.61	2.50	-0.53	-1.64	66
State	6.95	4.45	3.87	-2.50	-3.08	87	6.28	4.08	3.63	-2.20	-2.65	89
Georgia (all crops) 1948-73												
6 (EC)	2.61	3.30	2.48	0.69	-0.13	75	2.50	3.10	2.38	0.60	-0.12	77
8 (SC)	5.41	3.46	2.94	-1.95	-2.47	85	4.64	4.07	3.38	-0.57	-1.26	83
Average	4.01	3.38	2.71	-0.63	-1.30	80	3.57	3.58	2.88	0.01	-0.69	80
State	No data available											

Table C. CONTINUED

District	3-year Mean 1971-73	3-year Actual 1974-76	3-year Predicted 1974-76	3-year A-M	3-year P-M	3-year P/A%	5-year Mean 1974-78	5-year Actual 1974-78	5-year Predicted 1974-78	5-year A-M	5-year P-M	5-year P/A%
Arkansas (all crops) 1948-73												
3 (NE)	1.39	1.00	1.27	-0.39	-0.12	127	1.61	0.95	1.00	-0.66	-0.61	105
Average	1.39	1.00	1.27	-0.39	-0.12	127	1.61	0.95	1.00	-0.66	-0.61	105
State	No data available											
Kentucky (Tobacco) 1948-73												
2 (C)	2.51	4.41	2.94	1.90	0.43	67	2.56	5.12	2.55	2.56	-0.01	50
3 (NC)	6.01	4.51	2.81	-1.50	-3.20	62	4.21	4.53	3.09	0.32	-1.12	68
Average	2.76	4.46	2.87	0.20	-1.38	64	3.38	4.82	2.82	1.44	-0.56	59
State	4.79	4.48	2.63	-0.31	-2.16	59	2.63	4.75	2.85	1.12	-0.78	60
Virginia (Tobacco) 1948-73												
3 (SC)	2.06	3.53	3.68	1.47	1.62	104	2.79	4.06	3.70	1.27	0.91	91
Average	2.06	3.53	3.68	1.47	1.62	104	2.79	4.06	3.70	1.27	0.91	91
State	No data available											

Table D. Comparison of annual actual loss cost and predicted loss cost from bandpass method based on 1948-1973 data.

Districts	1974 Pre-dicted	1974 Actual	1974 P/A%	1975 Pre-dicted	1975 Actual	1975 P/A%	1976 Pre-dieted	1976 Actual	1976 P/A%	1977 Pre-dieted	1977 Actual	1977 P/A%	1978 Pre-dicted	1978 Actual	1978 P/A%
Kansas (All Crops)															
1(NW)	11.85	9.51	125	13.42	9.85	136	10.90	3.63	300	10.44	12.92	81	4.65	4.29	108
2(NC)	5.07	2.10	241	4.70	2.45	192	2.66	3.23	82	3.94	6.99	56	5.41	4.45	121
3(NE)	2.44	3.67	66	1.73	1.79	97	2.07	1.85	112	1.47	1.57	94	-0.11	0.45	-24
4(WC)	13.50	9.40	144	4.67	6.51	72	2.65	8.00	33	16.70	7.58	220	16.55	6.83	242
5(C)	2.70	5.72	47	6.21	5.22	119	6.49	2.85	228	3.11	6.58	47	1.10	6.80	16
6 (EC)	1.29	1.74	74	0.68	2.01	34	2.14	0.42	509	2.35	6.01	39	0.72	0.70	103
7(SW)	13.38	5.63	238	7.24	5.17	140	7.11	2.02	352	5.60	6.20	90	6.13	1.73	354
8(SC)	6.92	6.75	102	2.24	6.16	36	3.42	3.21	106	2.28	6.17	37	6.34	2.55	249
9(SE)	3.56	2.50	142	2.30	1.39	165	-0.29	0.47	-62	4.28	1.69	253	2.35	0.94	250
State	5.72	5.42	105	4.64	4.76	97	2.92	2.80	104	5.13	6.13	84	5.40	3.30	164
Nebraska (Wheat)															
1(NW)	16.13	6.81	237	7.72	5.71	135	15.34	3.71	413	9.77	11.36	86	12.37	10.08	123
6(SW)	13.60	10.06	135	7.87	5.74	137	6.76	9.85	69	7.82	4.88	160	4.11	6.55	63
7 (SC)	3.53	4.07	87	4.24	5.26	81	10.30	2.70	381	3.60	3.08	117	2.31	7.53	31
8(SE)	5.04	0.88	573	5.40	2.22	243	4.49	2.84	158	2.91	3.08	94	1.62	3.31	49
State	7.42	4.42	168	6.46	3.82	169	6.73	4.67	144	5.07	3.83	132	2.97	5.80	51

Table D. (Continued)

Districts	1974 Pre-dicted	1974 Actual	1974 P/A%	1975 Pre-dicted	1975 Actual	1975 P/A%	1976 Pre-dicted	1976 Actual	1976 P/A%	1977 Pre-dicted	1977 Actual	1977 P/A%	1978 Pre-dicted	1978 Actual	1978 P/A%
Kansas (wheat)															
1 (NW)	11.27	4.12	274	10.75	11.20	96	8.25	1.87	441	9.49	7.62	125	5.62	8.40	67
2 (NC)	6.21	1.38	450	3.45	2.85	121	2.48	2.67	93	4.93	6.22	79	4.23	5.70	74
4 (WC)	11.27	8.06	140	7.56	9.15	83	7.24	2.26	320	17.88	4.95	361	10.37	7.19	144
5 (C)	2.70	5.72	47	6.47	5.27	123	6.77	2.86	237	3.15	6.73	47	0.98	7.25	14
6 (EC)	0.83	0.65	128	2.66	1.88	141	1.12	0.39	287	2.24	6.68	34	1.63	1.10	148
7 (SW)	16.08	3.43	469	6.63	7.90	84	4.72	2.60	182	6.94	6.34	109	8.19	5.63	145
8 (SC)	7.00	7.28	96	2.25	6.29	36	3.34	2.69	124	2.32	5.02	46	6.36	2.68	237
9 (SE)	3.49	2.40	145	1.58	1.50	105	-0.02	0.44	-5	5.23	1.85	282	2.10	1.23	171
State	6.94	4.92	141	5.72	5.38	106	1.82	2.33	78	4.28	5.34	80	6.50	4.80	135
North Dakota (wheat and barley)															
1 (NW)	5.50	1.96	280	9.30	5.70	163	5.34	3.44	155	2.55	2.09	122	7.22	3.72	194
2 (NC)	4.14	3.43	121	2.22	0.49	453	3.66	1.47	249	3.44	13.85	25	3.15	2.22	142
3 (NE)	2.40	3.66	66	2.06	0.54	381	4.02	6.24	64	3.28	2.13	154	1.72	4.27	40
4 (WC)	6.49	2.04	318	7.28	3.74	195	1.38	4.50	31	7.22	3.28	220	6.56	0.87	754
5 (C)	6.24	3.19	196	4.25	1.81	235	4.51	6.28	72	3.83	14.52	26	7.22	1.34	505
6 (EC)	2.54	6.14	41	1.43	0.49	292	1.80	1.28	141	3.34	6.76	49	4.71	0.77	612
7 (SW)	8.96	0.82	1093	10.65	9.23	115	7.76	6.89	113	11.78	9.01	131	6.72	4.53	148
8 (SC)	7.94	6.98	114	10.29	5.68	181	3.57	7.21	50	8.77	11.33	77	9.65	2.93	329
9 (SE)	2.94	2.87	102	3.25	2.51	129	1.85	2.04	91	8.16	8.02	102	5.01	1.22	411
State	5.29	3.94	134	3.37	1.50	225	3.80	4.05	94	5.53	5.93	93	4.32	2.52	171

Table D. (Continued)

Districts	1974 Pre-dicted	1974 Actual	1974 P/A%	1975 Pre-dicted	1975 Actual	1975 P/A%	1976 Pre-dicted	1976 Actual	1976 P/A%	1977 Pre-dicted	1977 Actual	1977 P/A%	1978 Pre-dicted	1978 Actual	1978 P/A%
Nebraska (All Crops)															
3(NE)	2.15	2.74	78	3.66	2.74	572	3.52	1.18	298	2.02	2,72	74	2.29	2.24	102
4(C)	7.70	4.81	160	5.00	3.53	142	6.15	3.98	155	4.22	9.87	43	3.70	8.73	42
5(EC)	2.42	2.78	87	1.16	1.63	71	2.78	0.75	371	2.77	3.74	74	2.97	4.42	67
6(SW)	10.45	3.60	290	11.27	3.48	324	6.71	21.44	31	7.92	7.55	105	11.94	4.45	263
7(SC)	4.37	2.12	206	1.51	2.96	51	5.75	1.40	411	4.47	5.56	80	7.57	12.29	62
8(SE)	1.88	5.09	37	3.54	0.84	421	1.54	0.73	211	3.84	7.34	52	1.29	2.39	54
State	2.83	3.22	88	2.78	1.73	161	3.02	2.59	117	2.72	5.43	50	2.94	4.65	63
Nebraska (Corn)															
3(NE)	2.15	2.74	78	3.66	0,64	572	3.52	1.21	291	2.03	3.10	65	2.28	2.24	102
4(C)	4.74	4.31	110	2.29	3.95	58	8.36	3.51	238	7.80	9.87	79	2.80	9.85	28
5(EC)	2.78	2.78	100	1.34	1.63	82	2.49	0.80	311	2.38	3.49	68	2.80	4.99	56
6(SW)	10.45	3.60	290	11.27	3.46	326	6.71	22.46	30	7.92	7.55	105	11.94	4.45	268
7(SC)	6.09	2.04	298	2.74	2.83	97	5.61	2.14	262	3.03	5.56	54	5.94	12.29	48
8(SE)	1.88	4.73	40	3.52	0.63	559	1.54	0.68	226	3.81	7.44	51	1.29	2.39	54
State	3.31	3.19	104	1.83	1.72	106	2.38	2.56	93	3.63	5.19	70	3.72	5.25	71

Table D. (Continued)

Districts	1974 Pre-dicted	1974 Actual	1974 P/A%	1975 Pre-dicted	1975 Actual	1975 P/A%	1976 Pre-dicted	1976 Actual	1976 P/A%	1977 Pre-dieted	1977 Actual	1977 P/A%	1978 Pre-dicted	1978 Actual	1978 P/A%
							South Dakota (All Crops)								
1(NW)	4.55	0.44	1034	9.36	5.86	160	12.06	9.95	121	5.24	12.46	42	7.61	4.69	162
2 (NC)	11.82	5.79	204	4.03	1.04	387	0.24	4.89	5	7.30	5.22	140	13.59	1.71	795
3(NE)	3.57	0.75	476	4.85	1.63	297	2.33	1.73	135	1.47	1.70	86	3.04	2.69	113
5(SW)	8.48	2.32	365	7.38	3.85	192	6.57	5.36	122	9.78	10.54	93	5.19	14.12	37
6(C)	3.27	5.08	64	5.09	1.19	428	7.03	2.65	265	5.35	5.14	104	3.29	4.39	75
7 (EC)	5.20	1.62	321	5.89	2.47	238	3.05	3.17	96	3.17	3.82	83	0.57	1.50	38
9(SE)	5.34	3.69	145	3.60	2.33	154	1.96	9.17	21	3.23	4.12	78	5.24	9.24	57
State	4.03	3.29	122	5.20	2.17	240	5.55	3.06	181	4.82	4.28	113	3.57	5.86	61
							North Dakota (All Crops)								
1(NW)	2.83	1.93	147	5.18	5.40	96	7.19	3.48	207	5.10	2.08	245	2.83	3.70	76
2(NC)	4.42	3.35	132	5.31	0.53	1001	1.38	1.49	93	1.47	12.42	12	5.58	2.23	250
3(NE)	1.23	3.67	33	2.57	0.50	514	4.01	6.09	66	2.17	2.18	99	2.70	4.24	64
4(WC)	5.96	2.14	278	2.05	3.56	57	6.35	4.35	146	8.16	3.45	236	2.97	0.89	334
5(C)	5.87	3.15	186	4.02	1.86	216	4.22	6.57	64	3.67	15.46	24	6.68	1.40	477
6 (EC)	2.12	6.19	34	3.32	0.52	638	4.34	1.21	359	4.54	6.70	68	3.78	0.77	491
7(SW)	9.39	0.77	1219	11.63	9.17	127	7.98	7.29	109	12.96	9.37	138	6.75	4.44	152
8 (SC)	8.56	7.08	121	3.80	5.65	67	7.30	6.85	106	10.35	11.19	92	5.36	2.93	183
9(SE)	2.67	2.78	96	4.58	2.61	175	5.97	1.67	357	5.70	8.40	68	3.99	1.25	319
State	No significant periodicities														

Table D. (Continued)

Districts	1974 Pre-dicted	1974 Actual	1974 P/A%	1975 Pre-dicted	1975 Actual	1975 P/A%	1976 Pre-dicted	1976 Actual	1976 P/A%	1977 Pre-dicted	1977 Actual	1977 P/A%	1978 Pre-dicted	1978 Actual	1978 P/A%
							Montana (All Crops)								
2(SW)	0.88	2.35	37	2.43	4.53	54	7.51	3.43	219	5.45	3.04	179	2.10	10.78	19
4(C)	5.56'	13.85	40	5.37	11.19	48	5.57	10.03	56	5.37	3.31	162	5.57	21.90	25
5(SC)	12.12	2.14	566	5.22	2.67	196	4.06	5.80	70	5.89	5.15	114	5.10	12.91	40
6(NE)	6.63	2.21	300	4.77	6.18	77	3.35	5.91	57	6.80	2.49	273	4.34	9.31	47
7(SE)	13.15	2.72	483	7.67	4.11	187	4.73	11.07	43	10.22	6.62	154	13.15	17.41	76
State	No significant periodicities														
							Colorado (All Ci:ops)								
3(NE)	17.03	1.33	1280	8.59	14.58	59	13.48	4.93	273	11.77	11.65	101	12.18	5.03	242
5(SC)	0.62	4.02	15	8.87	3.14	282	13.68	3.98	344	10.92	4.92	222	3.37	4.46	76
State	No data														
							Idaho (All Crops)								
2 (EC)	0.15	0.27	56	1.61	2.80	58	0.82	5.82	14	2.58	0.42	61	0.94	4.19	22
5(SW)	0.40	0.10	400	0.26	0.10	260	1.16	0.86	135	-0.33	0.21	-157	0.83	0.27	307
6(SSW)	6.06	0.27	2244	7.29	0.28	2604	-1.52	4.70	-32	-0.64	4.03	-16	2.58	0.95	272
7(SC)	-0.00	0.25	0	1.55	0.06	2583	0.95	0.89	107	1.17	0.48	244	-0.13	0.06	-217
9(SEC)	3.42	0.08	4275	2.69	0.65	414	-0.44	0.50	-88	2.29	2.49	92	3.10	0.45	689
10(SE)	3.38	0.74	457	3.12	2.09	149	0.92	1.04	88	3.75	1.10	341	2.64	0.67	394
State	1.85	0.44	420	2.95	1.49	198	1.03	0.75	137	3.25	2.17	150	1.32	0.45	293

Table D. (Continued)

Districts	1974 Pre-dicted	1974 Actual	1974 P/A%	1975 Pre-dicted	1975 Actual	1975 P/A%	1976 Pre-dicted	1976 Actual	1976 P/A%	1977 Pre-dicted	1977 Actual	1977 P/A%	1978 Pre-dicted	1978 Actual	1978 P/A%
Oklahoma (All Crops)															
1(NW)	9.63	10.08	96	-0.46	3.27	-14	10.14	4.72	215	12.34	7.03	156	7.38	5.88	126
2(NC)	5.36	9.71	55	3.75	9.50	39	6.45	0.40	1613	5.48	1.66	330	-.77	0.66	-117
4(WC)	4.86	3.66	133	3.08	4.48	69	4.34	3.41	127	1.08	1.66	65	2.93	0.37	792
7(SW)	1.40	1.86	75	3.92	4.25	92	0.95	5.21	18	2.44	5.16	47	10.01	3.95	253
State	6.21	8.04	77	6.75	6.63	102	3.53	2.71	130	5.10	3.50	146	7.29	2.05	356
Texas (All Crops)															
9(NW)	6.35	6.83	93	6.83	6.64	103	7.10	3.67	193	2.75	6.28	44	6.70	3.94	170
Texas (Cotton)															
2(NWC)	1.81	4.89	37	0.70	1.55	45	6.79	3.06	222	3.73	2.05	182	0.71	2.70	26
Minnesota (All Crops)															
1(NW)	3.35	0.93	360	1.34	2.21	61	3.95	2.02	195	1.44	1.81	79	3.18	3.04	105
4(WC)	2.23	1.91	117	3.88	1.42	273	3.88	2.70	144	2.23	0.87	256	1.38	0.97	142
5(C)	1.63	1.59	102	1.78	0.77	231	3.10	1.80	172	2.32	1.08	215	1.13	1.20	94
7(SW)	1.15	1.44	80	4.54	0.29	1565	1.74	1.24	140	3.20	2.56	125	3.46	2.81	123
8 (SC)	2.04	1.65	124	2.44	0.75	325	3.25	1.70	191	1.14	0.91	125	2.00	3.25	61

Table D. (Continued)

Districts	1974 Pre-dicted	1974 Actual	1974 P/A%	1975 Pre-dicted	1975 Actual	1975 P/A%	1976 Pre-dicted	1976 Actual	1976 P/A%	1977 Pre-dicted	1977 Actual	1977 P/A%	1978 Pre-dicted	1978 Actual	1978 P/A%
9(SE)	1.85	2.84	65	0.91	1.04	87	3.34	1.15	290	1.15	2.44	47	1.86	4.09	45
State	No significant periodicities														
							Iowa (All Crops)								
1(NW)	1.55	2.59	60	2.30	0.72	319	3.77	1.29	292	3.02	1.66	182	1.55	5.86	26
2(NC)	1.22	1.86	66	0.60	0.22	273	1.63	2.04	80	3.02	0.97	311	3.03	4.44	68
3(NE)	0.40	0.92	43	1.70	0.71	239	2.30	0.54	426	1.34	1.16	116	0.20	0.55	36
4(WC)	1.61	1.74	93	1.49	1.21	123	1.22	3.05	40	1.99	1.88	105	3.37	2.46	137
5(C)	1.90	3.48	55	0.44	0.70	63	0.91	1.97	46	1.42	2.15	66	0.32	1.91	17
6(EC)	0.44	2.11	21	0.83	0.39	213	1.02	0.39	262	0.40	0.80	50	0.97	0.39	249
7(SW)	1.09	0.81	135	2.45	1.29	190	0.51	5.16	10	1.81	1.28	141	1.96	0.69	284
8(SC)	1.61	2.75	59	0.33	2.00	17	0.53	5.54	10	1.84	0.62	297	1.94	0.58	334
9(SE)	1.05	1.93	54	0.43	0.53	81	1.34	1.08	124	0.21	0.45	47	1.46	0.73	200
State	1.49	2.16	69	1.78	0.74	241	1.38	1.94	71	1.27	0.75	169	2.31	2.16	107
							Missouri (All Crops)								
1(NW)	2.55	0.39	654	1.20	0.89	135	0.95	0.73	130	0.57	1.45	39	1.19	1.54	77
2(NE)	0.66	1.27	52	0.71	1.17	61	1.14	0.84	136	0.43	0.79	54	0.91	1.15	79
6(SE)	1.98	1.52	130	1.79	0.38	471	1.30	0.55	236	2.28	1.77	129	1.19	1.78	67
State	1.98	0.63	314	0.84	0.98	86	0.88	0.77	114	0.62	1.27	49	1.24	1.42	87

Table D. (Continued)

Districts	1974 Pre-dicted	1974 Actual	1974 P/A%	1975 Pre-dicted	1975 Actual	1975 P/A%	1976 Pre-dicted	1976 Actual	1976 P/A%	1977 Pre-dicted	1977 Actual	1977 P/A%	1978 Pre-dicted	1978 Actual	1978 P/A%
							Illinois (All Crops)								
1(NW)	0.25	0.80	31	1.54	1.80	86	0.43	0.24	179	0.68	0.56	121	1.44	0.49	294
2(NE)	1.00	0.26	385	3.13	1.19	263	0.63	0.40	158	0.99	0.37	268	0.69	1.13	61
3(WC)	0.58	1.08	54	0.32	0.75	43	1.29	0.06	2150	0.34	0.33	103	0.56	0.35	160
6(SW)	0.84	1.07	79	0.21	0.62	34	0.55	0.16	344	0.22	0.61	36	0.35	0.22	159
7(SE)	0.40	1.70	24	0.13	0.46	28	0.43	0.34	126	0.15	0.48	31	0.37	0.16	231
8(SSW)	0.28	0.90	31	0.46	0.16	288	0.12	0.28	43	0.36	0.20	180	0.40	0.26	154
State	0.33	0.75	44	0.60	1.16	52	0.86	0.46	187	0.27	0.41	66	0.75	0.47	160
							Wisconsin (All Crops)								
6(EC)	1.05	0.23	456	0.78	0.19	410	-0.49	0.71	-69	3.02	1.06	285	0.41	0.05	820
8(SC)	0.75	0.75	100	0.82	0.77	106	0.23	0.61	38	0.31	0.81	38	0.88	0.19	463
9(SE)	1.26	0.19	663	0.69	0.08	862	1.16	0.10	1160	0.58	2.33	25	-0.57	0.18	-317
State	No significant periodicities														
							Indiana (All Crops)								
1(NW)	0.58	0.19	305	0.46	1.67	27	0.45	0.69	65	0.30	0.20	150	0.45	0.06	750
2 (NC)	0.56	0.21	267	0.15	0.48	31	0.45	0.40	112	0.56	0.11	509	0.15	0.01	1500
4(WC)	0.32	1.21	26	0.84	0.76	110	0.80	0.75	107	0.28	2.63	11	0.41	0.19	216

Table D. (Continued)

Districts	1974 Predicted	1974 Actual	1974 P/A%	1975 Predicted	1975 Actual	1975 P/A%	1976 Predicted	1976 Actual	1976 P/A%	1977 Predicted	1977 Actual	1977 P/A%	1978 Predicted	1978 Actual	1978 P/A%
5(C)	0.24	0.18	133	0.28	0.72	39	0.47	1.45	32	0.46	0.24	192	0.70	0.42	167
6(EC)	0.29	1.06	27	0.19	0.34	56	0.15	0.52	29	0.30	0.24	125	0.14	0.07	200
State	0.58	0.43	135	0.28	0.97	29	0.55	0.78	70	0.36	0.63	57	0.44	0.16	275
Arkansas (All Crops)															
3(NE)	1.05	2.24	47	0.98	0.37	265	1.77	0.39	454	1.34	0.38	353	-0.14	1.39	-10
Kentucky (Tobacco)															
2(C)	2.72	5.72	48	3.68	4.03	91	2.41	3.48	69	1.53	4.76	32	2.43	7.63	32
3 (NC)	2.29	4.28	54	3.99	5.62	71	2.15	3.63	59	4.71	4.86	97	2.32	4.28	54
State	2.22	4.73	47	3.63	5.13	71	2.04	3.57	57	4.31	4.83	89	2.04	5.50	37
Virginia (Tobacco)															
3(SC)	1.83	2.09	88	4.62	7.21	64	4.57	1.28	357	1.85	3.94	47	5.64	5.76	98

Table D. (Continued)

Districts	1974 Predicted	1974 Actual	1974 P/A%	1975 Pre-dicted	1975 Actual	1975 P/A%	1976 Pre-dicted	1976 Actual	1976 P/A%	1977 Pre-dicted	1977 Actual	1977 P/A%	1978 Pre-dicted	1978 Actual	1978 P/A%
North Carolina (Tobacco)															
2(NWC)	3.76	3.43	110	3.69	6.05	61	2.25	7.86	29	2.46	6.02	41	4.95	5.04	98
3(NEC)	3.77	5.02	75	1.60	3.84	42	3.73	1.78	210	1.81	2.18	83	3.37	3.87	87
6(SE)	3.11	4.55	68	3.29	3.74	88	2.24	2.91	77	3.37	5.39	63	3.01	1.45	208
7(EC)	1.95	1.95	100	3.22	2.17	148	2.22	3.45	64	1.95	4.21	46	3.22	0.92	350
State	3.46	3.67	94	2.06	3.26	63	3.48	2.89	120	2.15	3.96	54	3.29	2.09	157
South Carolina (All Crops)															
1(NW)	1.62	0.87	186	0.47	0.00	00	0.66	0.00	00	1.60	14.42	11	0.34	0.00	00
4(NE)	3.03	6.04	50	4.77	5.46	37	5.30	2.30	230	3.85	5.01	77	2.56	2.15	119
6(C)	1.40	4.86	29	3.69	6.03	61	3.79	0.94	403	2.32	4.52	51	2.10	1.60	131
State	2.51	5.83	43	4.07	5.53	74	5.04	1.99	253	4.04	4.89	83	2.49	2.15	116
Georgia (All Crops)															
6(EC)	3.13	2.36	133	3.08	3.00	103	1.22	4.55	27	1.57	1.17	134	2.92	4.42	66
8(SC)	4.08	4.52	90	2.59	3.60	72	2.15	2.27	95	3.35	4.50	74	4.74	5.45	87

APPENDIX B

APPENDIX B

Calculation of "End Effect" Correction Constants for Standard Symmetrical Filters

1. Select a filter, for example the one for 12 units (years).

2. Construct a test series of unit amplitude which is a pure sine series with a wavelength of 12 years. The sine series should be 5 or 6 cycles long or longer. The series used for the current discussion was 8 cycles in length plus one year.

3. Add 17 zero values (the mean of the series) to the series to allow the filtering process to proceed to completion, that is, the filter is moved along the data until the central value of the filter is on the last point of the sine series. A filter output value is produced for each data point of the sine series. Figure Bl shows the original sine series and the 17 zero values extended on the right.

4. Figure B2 is a plot of-the filter output. The test series was reproduced exactly through the center wavelengths (between point A, 17 points from the left and point B, 17 from the end on the right, Figure Bl and B2) when the filter is entirely within the original series. An increasing amount of dampening (reduction in amplitude) is evident throughout the last 17 points of the filter output as an increasing number of filter values were applied to the zeros.

5. The amplitude corrections required to bring the dampened amplitudes back up to that of the original series are the ratios of the original amplitude (unity) to each of 17 points (years) on an "attenuation line" (Fig. B2). The ratios increase from 1.0 (no correction) to about 1.8 on the extreme right.

6. The attenuation line will vary with each filter. Consequently, the process was repeated with several different filters. Averages of the ratios were computed to obtain the multipliers shown in Table 9 of this report.

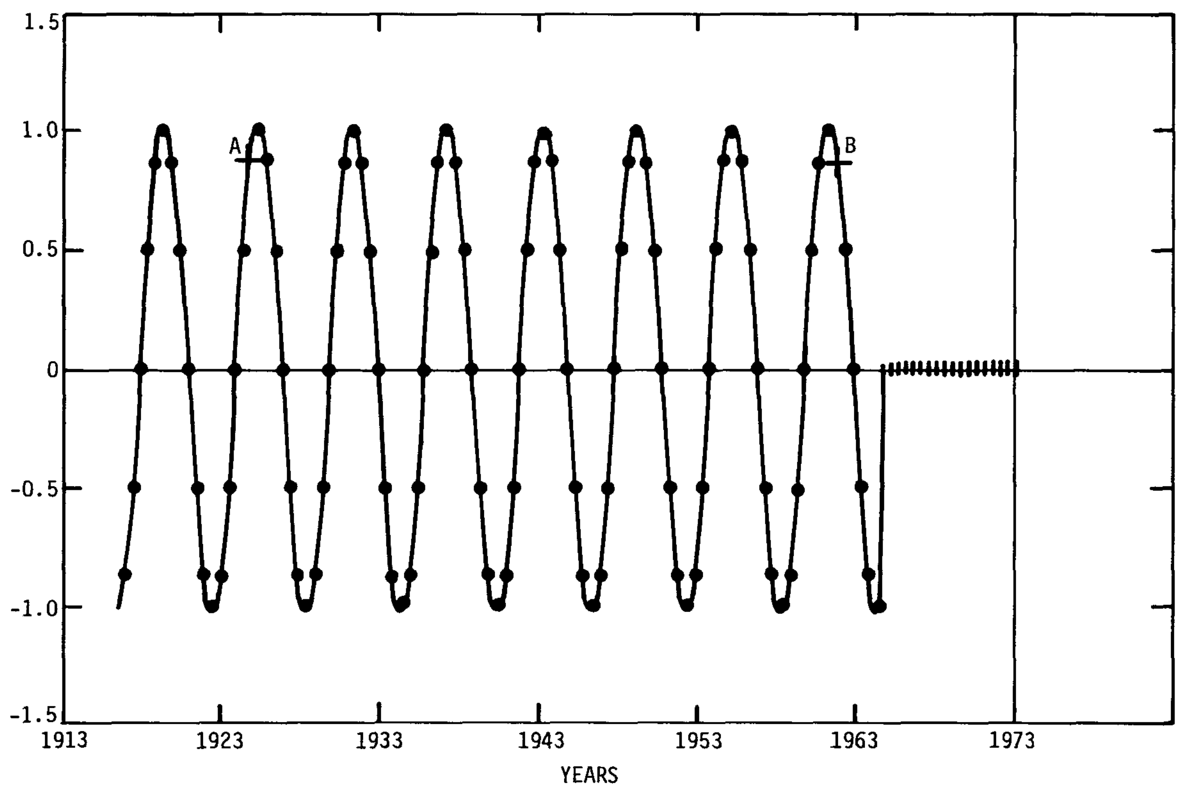


Figure Bl. A sine series generated with unit amplitude and 12-period and 17 zeros on the right.

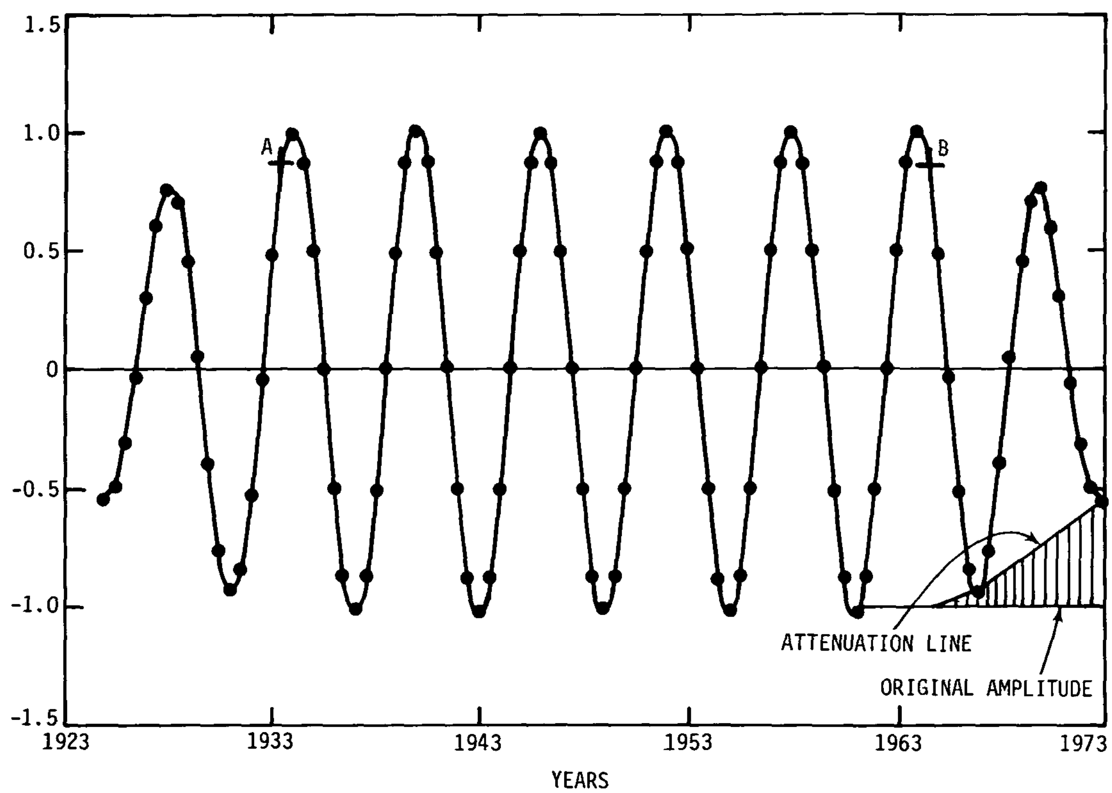


Figure B2. Filter output of Figure Bl using a 12-year digital filter.