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Descriptive Time Series Analysis for Criminal Justice Decision Makers: Local Illinois Robbery and Burglary

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ABSTRACT

This paper gives detailed instructions on how to describe a time series quickly and easily with statistics that can be clearly explained to non-statisticians. For robberies and burglaries from 1972 to 1977 in each county and large city in Illinois, it answers the question, "Did the number of reported crimes show a recent decrease?" In 61 places, there was a significant recent decrease. In 18 of these, a specific month can be found after which the series begins to decrease, and a two segment line increasing before that month and decreasing after it is a significantly better description of the series than a straight line with no change in direction. These 18 time series, with the turning point month in parentheses, are the following:

Alton burglary (August, 1975)
Alton robbery (October, 1975)
Belleville burglary (December, 1975)
Chicago Heights burglary (June, 1975)
DeKalb burglary (April, 1973)
Elgin burglary (October, 1975)
Jersey County burglary (November, 1973)
Lansing burglary (August, 1975)
Livingston County burglary (July, 1976)
Mason County burglary (January, 1973)
Maywood burglary (September, 1975)
North Chicago burglary (October, 1973)
North Chicago robbery (September, 1973)
Peoria County robbery (August, 1975)
Region 17 burglary (November, 1973)
Rock Island burglary (August, 1976)
Rock Island County burglary (July, 1976)
Rockford burglary (July, 1975)

The method of analysis in this paper has three stages of tests. Each succeeding stage describes the series in more detail. Because many series are eliminated by the early screening test, the time and effort required to do the most detailed test is used only on those series which justify it and where the greater detail is required for a particular decision. Even the most detailed test, however, is still quicker to do and more easily understandable than would be a time series analysis using more sophisticated techniques.

These tests are a practical solution for the planner or decision maker who needs a simple description of a time series. Some decisions require complex analysis. Other decisions require a less detailed analysis which is less time consuming to compute and easier to communicate. The advantage of the simple tests in this paper is that they enable an analyst to describe a complex series of data in non-complex terms.

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INTRODUCTION

The analysis of change over time in the number of crimes (time series analysis of crime data) is one of the most useful tools available to criminal justice planners and decision makers. Time series analysis includes the description of patterns of change in the past and the use of past data to forecast into the future. Both description and forecasting are useful, but neither method is generally available to criminal justice decision makers.

First, many administrators are not familiar with statistics appropriate to time series analysis. Second, even if they are familiar with time series analysis methods, they may not have access to the computer packages necessary to perform them with any speed. For example, the Box and Jenkins (1976) statistical time series modelling methods are so commonly used that they may be called classical, but computer packages that can handle these methods are still being developed. Currently there is no single package that is as commonly used and as well documented and supported as SPSS (Nie, et. al., 1975), which can handle time series analysis only with difficulty.

Third, even when the analyst is familiar with statistical modelling techniques, and a computer package is available, such techniques may not always be appropriate to the question at hand. Statistical time series modelling techniques produce a detailed description of the past pattern of a series and often generate good forecasts, but they require a lengthy analysis of each series by a statistician familiar with time series modelling. They produce results in a form that is difficult to communicate to people who are not statisticians.

Although the pattern of a time series may be complex, decisions do not always call for an equally complex descriptive method. A less detailed description of the pattern of a series may be preferable to a more detailed description, if the less detailed description is simple and quick to compute and if its results are easy to present to a general audience. Some decisions require a complex analysis. For example, decisions about the effect of a particular program may require a time series experiment using statistical modelling techniques (see Glass, et. al. 1975.) In other decisions, the level of detail provided by a complex analysis may be sacrificed in favor of a simpler analysis which is less time consuming to compute and easier to communicate.

In the following situations, for example, a simple description of the general pattern of a series is appropriate. If many series, such as the 340 Illinois county and large city Index robbery and burglary series, must be analyzed quickly, complex time series analysis techniques require too much time to use. If the results of a descriptive analysis must be presented in concrete terms to an audience of non-statisticians, complex techniques are too abstract. If the only information needed is an outline of the pattern of the series, complex techniques are not necessary.

A simple, straightforward method of time series analysis is needed, one that is adequate for a general description of a time series, that is quickly and easily done, and that can be easily explained to non-statisticians. The series of tests used in this paper, tests found in the time series analysis literature, each more detailed than the last, constitutes such a method. This method is only appropriate for descriptive analysis. It will neither generate forecasts nor explain any observed changes in the series.[1] It will answer descriptive questions such as, "Has there been a recent decrease in this series of Index robberies?" It will allow an analyst to describe a complex series in non-complex terms.

This report gives detailed instructions on how to describe time series with this method. It uses Illinois Index robberies and burglaries as an example.[2] Nationally, the number of burglary and robbery Index offenses reported to the police and found by the police to actually have occurred in their jurisdiction began to decrease after 1975 (Figure 1a.) In Illinois, reported Index robberies began to decrease after 1974, and burglaries, after 1975 (Figure 1b.) These national-and state-level trends are of little interest to planners and decision makers at the county or municipal level. These analysts want to know which of the local trends exhibit the same decrease as do the state and national trends, and whether the decrease is not a chance fluctuation, but seems likely to represent a real change in the direction of the trend.

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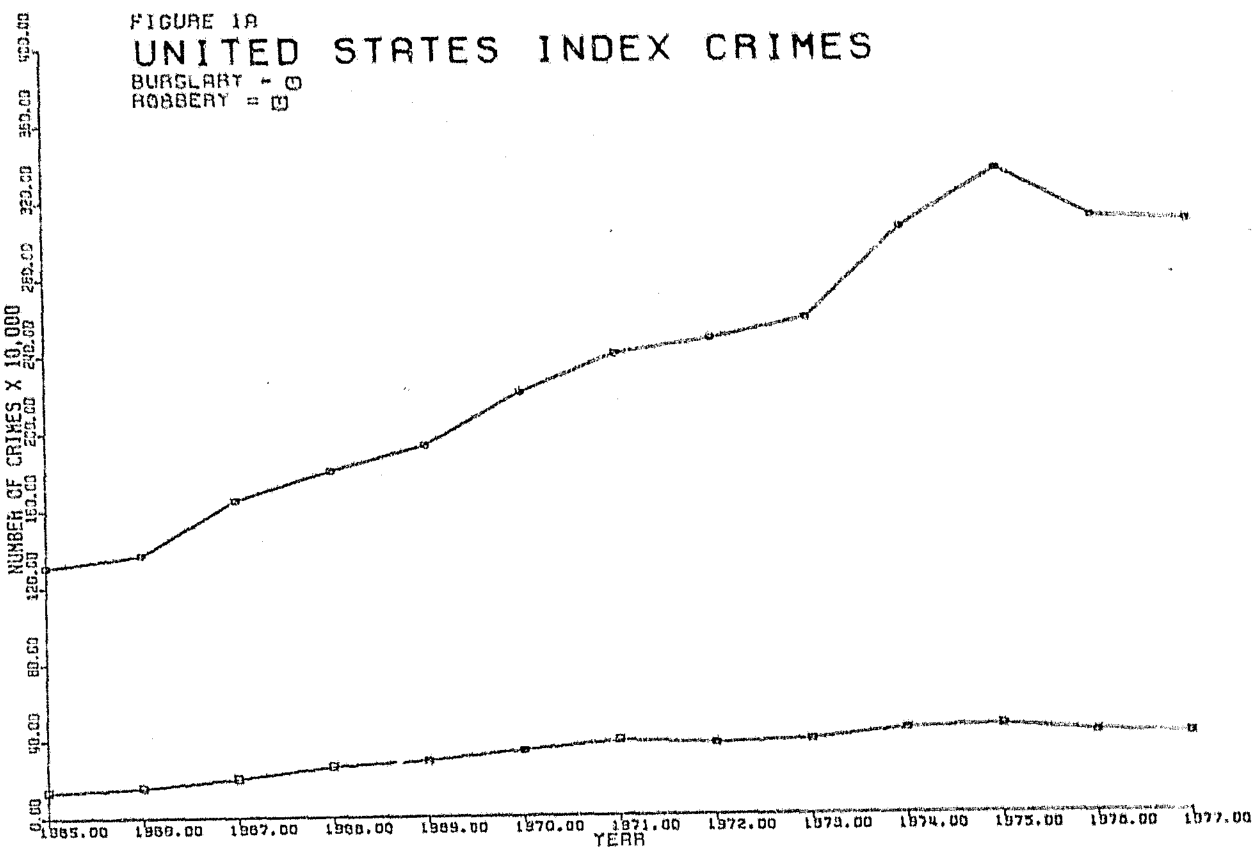
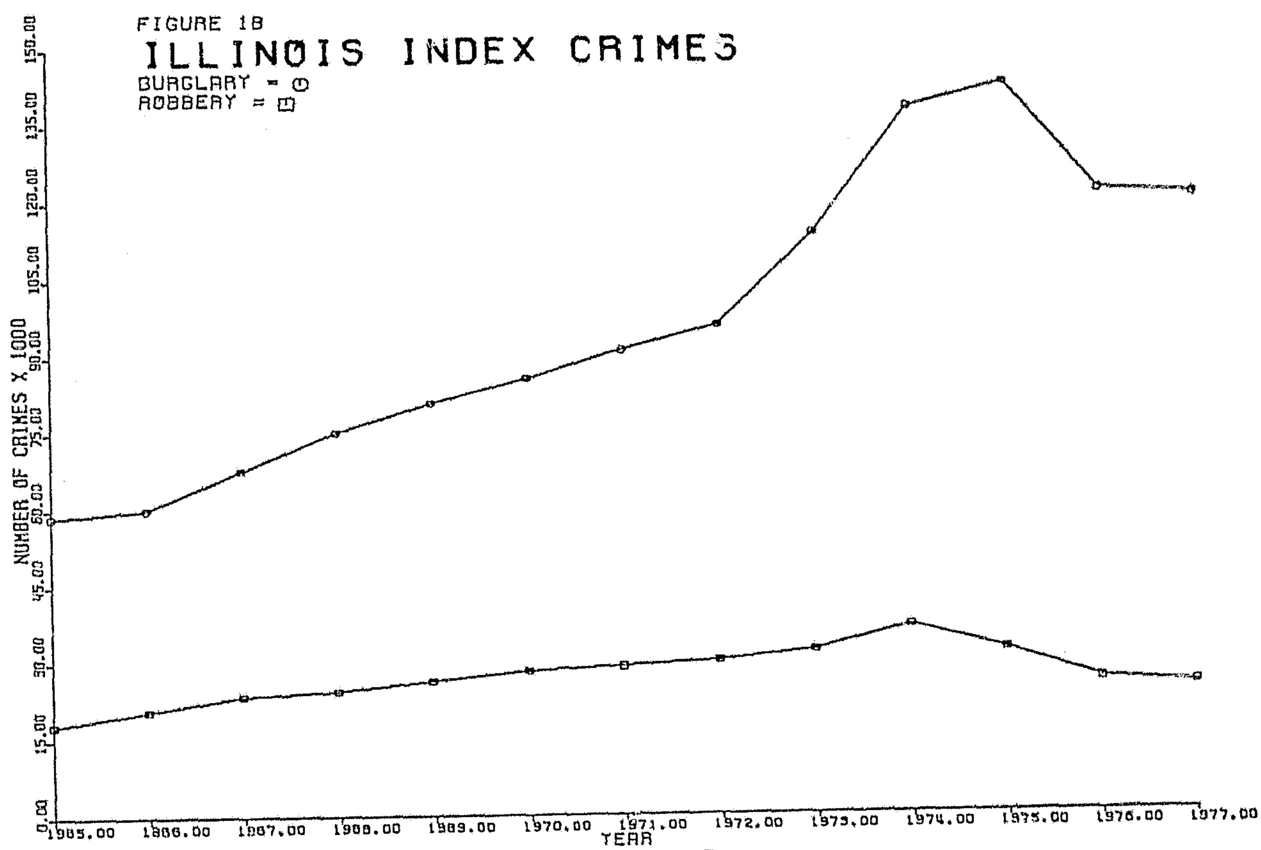
[1]For those who need more than the simple techniques described here, two good introductions to time series analysis are Nelson (1973) and Kendall (1976).) Also see the forthcoming SAC publications, How to Handle Seasonality: It's Detection and Analysis, and Describing and Forecasting Chicago Homicide.

[2]Robbery Index crime includes robbery, armed robbery, and attempted robbery and armed robbery (FBI 1977:16). Burglary Index crime includes forcible entry, unlawful entry with no force, and attempted forcible entry (FBI 1977:23). For official definitions of "offenses reported to the police" and "offenses actually occurred in the jurisdiction" see Perrin (1977) and Kok (1979).



ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH



ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH 3

Before any explanation for a decrease in reported offenses is attempted, and before any administrative changes are made because of the decrease, it is necessary to be sure that a decrease really did occur. It is necessary to describe trends in reported burglaries or robberies before trying to explain them or use them as bases for prediction. This report answers the simple descriptive question, "Which of the 340 city and large county robbery and burglary series in Illinois show a recent decrease?"

Data

Illinois counties and cities with a population over 25,000 were chosen for analysis for three reasons: 1) to determine in which localities the decrease noted at the state level occurred, 2) to provide this information to local level decision makers, and 3) to demonstrate simple time series analysis at the local level. Because some of the smaller counties might have too few reported robberies or burglaries per month to make analysis of monthly series possible, some counties were combined, for the monthly analysis, into Illinois Law Enforcement Commission (ILEC) planning regions. For details of this, see Appendix A.

Reported robbery and burglary Index offenses were chosen instead of the total Index or other individual Index crimes because 1) they are more numerous than some others, and thus more likely to have enough crimes per month for analysis, 2) they represent one property crime and one personal or violent crime[3], 3) their reporting rates are less likely to have changed in recent years than the reporting rates of rape and aggravated assault[4], and 4) they have been chosen by some local Illinois decision makers as important "target crimes" (see Ku and Smith, 1977.) The years 1972 to 1977 were chosen for analysis because the Illinois Department of Law Enforcement (DLE) began to collect and report Uniform Crime Reports (UCR) data for all Illinois jurisdictions in 1972, and 1978 data were not yet available when this paper was written.

The source of the data used in this analysis is the Statistical Analysis Center edition of the Illinois UCR (I-UCR) data files for the years 1972 through 1977 and for each month of those years.[5] In addition, the analysis uses yearly 1971 totals for

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[3]The Violent Crime Rate is defined by the FBI Uniform Crime Reports as the number of reported Index murders, forcible rapes, robberies and aggravated assaults per 100,000 inhabitants. The Property Crime Rate is the number of reported Index burglaries, larceny-thefts and motor vehicle thefts per 100,000 inhabitants (FBI 1977:6).

[4]Both rape and aggravated assault, especially domestic violence, have been targets of recent campaigns to increase the percent of victims who report the crime to the police. See Day (1978.)

[5]There were some problems with missing data. This was not discovered in the yearly series, but the monthly series in some localities were blank for one or more

the same Index crimes and places, data provided by DLE's Bureau of Identification. Although DLE began to formally collect and report I-UCR data only in 1972, yearly Index reported crime figures for 1971, which were reported by the FBI, are comparable with 1972 yearly figures.[6]

Method Overview

The analysis of the 340 series is organized in three stages. Each successive stage gives a more exact answer to the question of whether a series can be described as showing a recent decrease. Those series that survive the first and second stages can be said to show a recent decrease. Those series that also survive the third stage can be said to have decreased after a specific month.

The first stage, described in the following section, is a simple inspection of the yearly series, the yearly screening test. This test was carried out on all yearly robbery and burglary series which had an average of five or more cases per year. Those series that survive the yearly screening test can be said to show a decrease in the yearly data. Because monthly data are necessary for a more exact description, all those series which pass the yearly screening test are analyzed by the second stage, which is an analysis of the monthly series.

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5 (cont.)

months. It was difficult to determine whether the blanks were months with zero reported robberies or burglaries, or months in which some robberies or burglaries were not reported to DLE by the police. Of the monthly county and city series that were run, nine showed no data for at least one month. The last six months of data for 1977 were missing for reported burglary in Lombard, so its monthly series was not analyzed. Two months of burglary data and over half of the months of robbery data were missing for Woodford County. However, the best guess of John Miller, the ILEC regional evaluator of the county, who inquired of the county sheriff's office, is that no robberies or burglaries occurred in those months. A similar determination was made for Bond County and Livingston County burglary. Reported burglary in two cities, Alton and Moline, was blank in months when there probably were some reported burglaries. For these months, May 1972 in Alton and June and August 1972 in Moline, we estimated the missing data by averaging the data for the month before and the month after. The yearly series were then corrected to reflect the monthly changes. Reported robberies in McLean County (one month), were handled the same way. Thus, this study made some attempt to account for the missing data that was discovered. However, since we only ran a monthly series for some of the 340 yearly series, we do not know how many of the rest contain undiscovered missing data. For more information on the quality of I-UCR files, see Kok (1979.)

[6] Conversations with Pat Towner, DLE Criminal Justice Information Service, and Jack Hawley, FBI/UCR Illinois user liaison.

Monthly data raises the posibility that seasonality may affect the analysis. Therefore, each series that survives the yearly screening test and has enough monthly cases to analyze is screened for seasonality. The results are described in the next section, and details of the method are outlined Appendix C.

After the discussion of seasonality, the paper describes the second and third stages of analysis, both of which use monthly data. The second stage is a simple test of whether the decrease apparent in the yearly series is also apparent in the monthly series. For many purposes, no more detailed description is necessary. Where more detail is necessary, the third stage finds the turning point of the series, the month after which the series began to decrease, and plots a two segment line which increases to that point and decreases after it. It then determines whether this two segment line is a better description of the series than a straight line showing no change in direction.

This method does not try to explain the reasons for change over time in the number of reported Index robberies or burglaries.[7] It does not begin with an hypothesis relating a cause to an effect. It does not even hypothesize that a decrease occurred in a particular year or month. Instead, it seeks to describe trends in reported Index robberies and burglaries for the years 1972 through 1977 in each of the 102 Illinois counties and 68 cities of 25,000 or more people. This description determines whether any of these 340 time series showed a decrease after 1973. If such a decrease is found, an explanation of it must await further analysis. Before explaining a phenomenon, it is first necessary to describe it.

[7]Since the study analyzes a series of reported offenses, and not rates of reported offenses, it does not even control for the effect of population changes.

YEARLY SCREENING TEST

The first step in the analysis used yearly data instead of monthly data. The number of reported Index burglaries and the number of reported Index robberies per year were graphed for each locality for the years 1972 through 1977. Each of those series which had an average of at least five cases per year was inspected for a recent decrease. Later, the number of crimes for 1971 was manually added to the graph for each series, and the series was inspected again.[8]

Beginning with an analysis of yearly data eliminates any possible contamination by the effect of seasonality. If certain seasons of the year tend to be high in reported offenses, and others low, this variation will only appear in a series of monthly data.

In addition, beginning the analysis with an inspection of a six-point yearly series rather than a more detailed 72-point monthly series forces the analyst to accept only the series with the most noticeable recent decrease for further analysis. If a recent decrease is not obvious in the yearly series, the series is not analyzed further. This has two results. It makes the entire analysis easier. Some of the 340 time series in this study needed to be analyzed no further than this first yearly screening step. It also makes the entire analysis more conservative. An analyst is more likely to make the mistake of rejecting a series which may actually have declined than the mistake of accepting a series for further analysis which actually did not decline. Since UCR data are not perfectly reliable (see Maltz 1975), a conservative analysis is preferable.

Criteria for deciding that a yearly 1972 to 1977 series shows a recent decrease were the following:

1) There is a decline between 1974 and 1975, 1975 and 1976 or 1976 and 1977 that is at least as great as any previous year-to-year decline.
2) In all years after the decline in #1 above, the series either stays at the same level (within about ten percent) or declines further. It does not increase (more than about ten percent.)[9]

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[8] In another SAC report, Robbery and Burglary Index Offenses: 1971-1977, Ed Day categorizes the 340 early series, as well as ILEC Regional series, into more detailed types of trends. His report also includes a chart of each series.

[9] This guideline of ten percent was not used exactly, because the graphs themselves were not exact. (See Day, 1979.)

3) In all years before the decline in #1 above, the series either stays at the same level or increases. It does not decrease more than the decrease in #1 above.[10]

As an additional criterion, the crime figure for 1971 was appended to each series. If there was a decrease between 1971 and 1972 greater than the decrease in #1 above, the series was screened out. This eliminated those series which showed a pattern of recent decline which may have been part of a four or five year cycle. A considerably longer time series would have been necessary to analyze such a series.

A difficulty in the yearly screening test was that some series, especially robbery series, had so few cases per year that even a general description of the yearly trend was impossible. For example, a city or county might have no reported robberies for any year except 1974, when three were reported. A description of a "trend" is meaningless in such a situation. Therefore, we did not attempt a yearly screening test on those series which had, on the average, fewer than five cases per year for the six years.[11]

According to these criteria, 30 of the 85 counties and 31 of the 68 cities with five or more cases per year showed an apparent decrease in burglary, and 20 of 48 counties and 28 of 65 cities showed an apparent decrease in robbery (see Table 1). Most yearly series were easy to classify using the criteria. The Evanston robbery series, for example, is typical of those yearly series showing a recent decrease (see Figure 2a.) The classification of some yearly series was somewhat ambiguous. Figures 2b and 2c, Oak Park and Peoria robbery, are examples of two of these. The ambiguity in the Oak Park series is that 1977 increases over 1976, but the increase is about ten offenses, which is less than ten percent of the highest years in the series, 1973 and 1974. We decided, therefore, to analyze Oak Park robberies

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[10]A series which decreased from 1972 did not meet the criteria for further analysis, since the analysis is designed to detect a change in the direction of the trend, and such a series does not change. Only five of the 340 series showed this pattern of steady decrease since 1972, and none of the five had enough cases for monthly analysis.

[11]There were also a few series which were not analyzed because they had missing data. See note 5.

TABLE 1

Results of Yearly Screening Test

	Total	Total with Enough Cases per Year for Analysis[a]	Number Showing a Decrease, by Inspection	Number Showing a Decrease, and Having 60 or more Offenses per Year
Burglary				
Counties	102	85	30	23
Cities over 25,000	68	68	31	30
Regions	8[b]	8	3	3
Total	178	161	64	56
Robbery				
Counties	102	48	20	6
Cities over 25,000	68	65	28	12
Regions	8[b]	8	5	3[c]
Total	178	121	53	21
Grand Total	356	282	117	77

[a] An average of at least five cases per year.

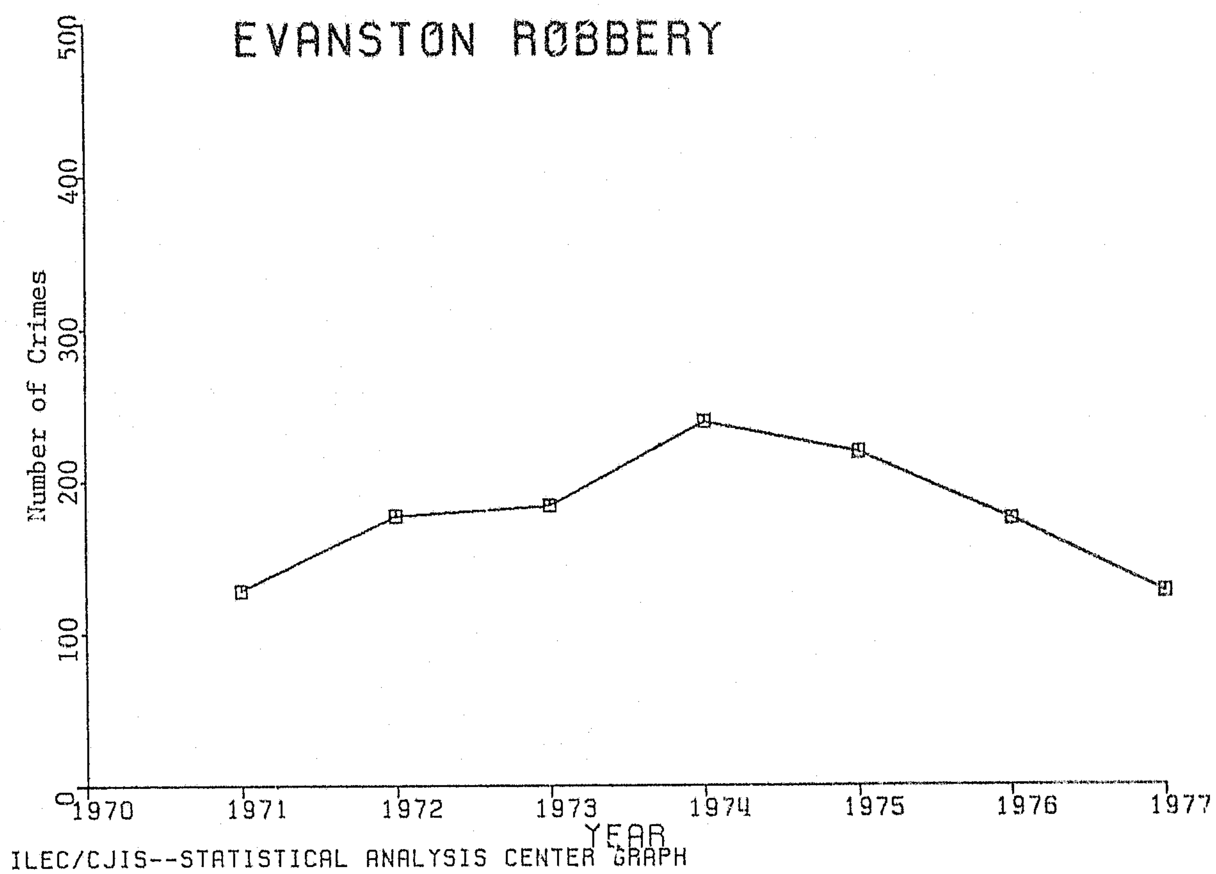
[b] Includes only the eight non-metropolitan regions containing counties that had too few cases for further analysis.

[c] One of these is the combination of Region 10 and Region 13. See Appendix A.

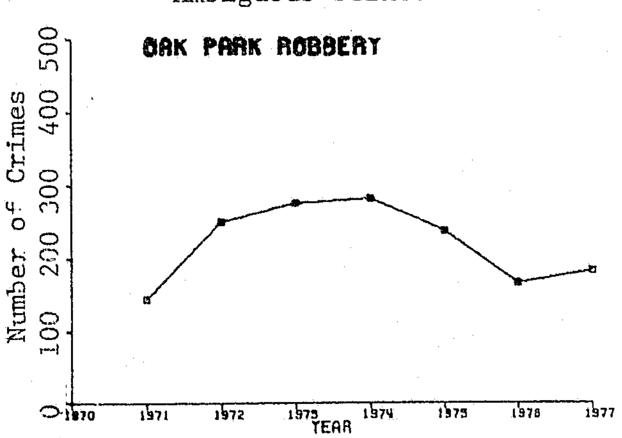
Figure 2

Examples of Yearly Screening Tests

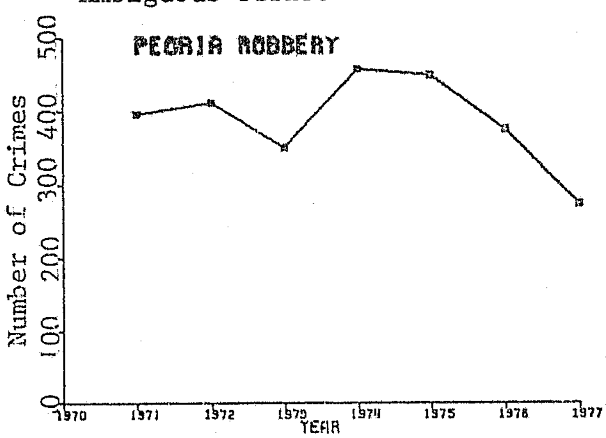
(a)
Typical Series that Passed



(b)
Ambiguous Series



(c)
Ambiguous Series



further, and not to eliminate it from the analysis at this stage.[12] The Peoria series (Figure 2c) is another example of an ambiguous series that was retained. The decrease between 1972 and 1973 was more than ten percent, but the decrease after 1974 was so much greater than the previous decrease that we decided to analyze the series further.

The second stage of analysis of each series requires monthly data. Even though burglary and robbery were chosen for analysis because they are relatively numerous, some of the burglary series and most of the robbery series which passed the yearly screening test did not have enough cases per month to allow a monthly analysis (see Table 1). Our criterion for this was an average of 60 reported offenses per year, a minimum which would allow an average of five per month. Many less populated counties were eliminated from further analysis for this reason.

To provide some analysis of these eliminated county series, we combined them into ILEC regions, and analyzed the regions when they had sufficient monthly cases for analysis. This procedure is described in Appendix A. Of the eight regions analyzed, three burglary yearly series and five robbery yearly series showed apparent decreases (see Table 1.) There were enough cases per month for analysis in five of these. Combining the robbery series for Region 10 with that for Region 13 produced a sixth regional series that showed a recent decline and had enough cases to analyze.

After the yearly screening test, 77 series were retained for further analysis: 23 county burglary series, 30 city burglary series, three regional burglary series, six county robbery series, 12 city robbery series, and three regional robbery series (see Table 1.) These series are listed in Appendix B.

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[12] Other similarly ambiguous series were Waukegan burglary, Peoria County robbery, and Fulton County burglary.

TESTS FOR SEASONALITY

The second stage of analysis requires monthly data. With monthly data, it is possible to have a seasonal effect. According to Nelson (1973:168), "Seasonality means a tendency to repeat a pattern of behavior over a seasonal period, generally one year." (Italics in original.) If a monthly time series is affected by seasonality, then an apparent decrease in the series might really be due, in part, to the seasonal effect. With the yearly screening which cannot be affected by seasonality, we selected a group of places that showed a recent decrease. Still, seasonality, if present, might have affected the statistics used to analyze the monthly series. Therefore, each of the 77 series passing the yearly screen was checked for the presence of seasonality.

Seasonality may seem to be very simple to detect, but in fact it is not. Detecting seasonality is more of an art than a science. The analysis of a seasonal series is a subjective process. There is no objective, generally accepted test that will determine if a series is seasonal, or how to adjust it if it is. Instead, there are numerous tests, ranging from relatively simple to quite complex, that require the user to make subjective choices.

The method used to detect the presence of seasonality in these 77 series was the X-11 computer program of the U.S. Bureau of the Census (Shiskin 1967; Kendall 1976:63-67.) This method is described in detail in Appendix C and in a forthcoming SAC publication (note 1 above.) It was chosen for the following reasons: It is widely used. It has been used by the Census and by the Bureau of Labor Statistics (BLS) since the 1950's, and many governmental decision makers are at least somewhat familiar with its terminology. The basic concept of the X-11 program is easy for non-statisticians to intuitively understand. The X-11 is flexible enough to allow many different kinds of series to be analyzed. It contains a variety of descriptive statistics, and allows the user to manipulate a number of program options.

The X-11 assumes that each series has three components: the trend-cycle, the irregular, and the seasonal. Each observation in the series is the sum of these three.[13] The trend-cycle is the overall pattern of the series, including any upward or downward trend and any periodic cycles such as business cycles. It could be

[13] In a multiplicative model, the three components are multiplied together to equal the original observation.

estimated by a least-squares regression line, or by various sorts of moving average.[14] The seasonal is a periodic cycle in the series that corresponds to the seasons or months of the year. The irregular may be called error, noise or shock. It is what is left after the trend-cycle and the seasonal have been subtracted from the original observation. The X-11 program divides a series into its three components, and then produces statistics which help the user to decide whether the series is significantly seasonal or not.

It is not always necessary to analyze all of the X-11 statistical tests to see if a series is seasonal. Some series are so far from being significantly seasonal that the need for further anslysis can be eliminated by a screening program, the Bell Canada Model Test, which is used by the Bureau of Labor Statistics.[15] This test was used to screen each of the 77 series for seasonality. Each series that showed even questionable seasonality according to the Bell Canada test was then analyzed using the X-11 program.

Appendix C gives details of the results of the Bell Canada and the X-11 statistics for each series. None of the 77 show significant seasonality. Twenty-seven of the 77 series show questionable seasonality, but none show definite seasonality, on the Bell Canada. The X-11 was run for each of these 27. None of the 27 show significant seasonality according to any of the five X-11 tests. Generally, the effect of the irregular component in these series is very high. Some series have a slight seasonal component, but compared to the irregular component, it is small and insignificant. In other words, the seasonal component is so small and the irregular component is so large that it is probable that the small seasonal component could simply be due to chance variations in the data.

Therefore, none of the 77 series which show a recent decrease in the yearly data and have enough monthly cases for further analysis are significantly seasonal. This means that these 77 monthly series may be analyzed without fear that seasonality might bias the analysis.

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[14]This program was developed by John Higginson in 1977. The Bureau of Labor Statistics sent it to SAC.

[15]For a discussion of linear regression and least squares, see, for example, Blalock (1972:362-366.) A moving average is calculated by taking the mean of the first three numbers in a series, then a mean of the second, third and fourth numbers, and so on. These means become a new series. A moving average can be taken by averaging groups of three, four, five, or any number. For a basic introduction to moving averages, see Macaulay (1931) or Kendall (1976.)

The yearly screening test found that 77 series show a recent decrease and have enough cases per month to allow further analysis. The line best describing each of these series is not straight, but turns downward after some point. Although inspection of six yearly points shows a recent decrease, this decrease may not be evident in the more detailed monthly series, with 72 points. The second stage of analysis determines whether the recent decrease noted in inspection of these 77 yearly series is also significantly present in the monthly series. This is done with a runs test for curvilinearity. Those series that pass both the yearly screening test and the runs test can be said to show a recent decrease.

The yearly screening test and the runs test results give enough information for many purposes. If the decision maker needs to know exactly when the series began to decrease, the third stage of analysis will provide this information. The third stage consists of two additional statistical tests.

First, the Hudson analysis determines the turning point of the series, the month after which the series began to decrease. Second, a test for curvilinearity determines whether a two segment line, increasing to the turning point and decreasing after it, describes the series significantly better than a straight line from the beginning of the series to the end.

The Runs Test

A run is "a succession of identical symbols which are followed and preceded by different symbols or by no symbols at all "(Siegel 1956:52.) For example, if 20 tosses of a coin produce 10 heads and then 10 tails, there are two runs. If the 20 tosses produce a head and then a tail at every other toss, there are 20 runs. In the first case there seem to be too few runs, and in the second case, too many, for a fair coin toss to be assumed. A runs test is a nonparametric test that tells us the probability that a certain sequence of events, such as these coin tosses, would have occurred by chance, given that the observations were really random (see Moore, 1970.)[16]

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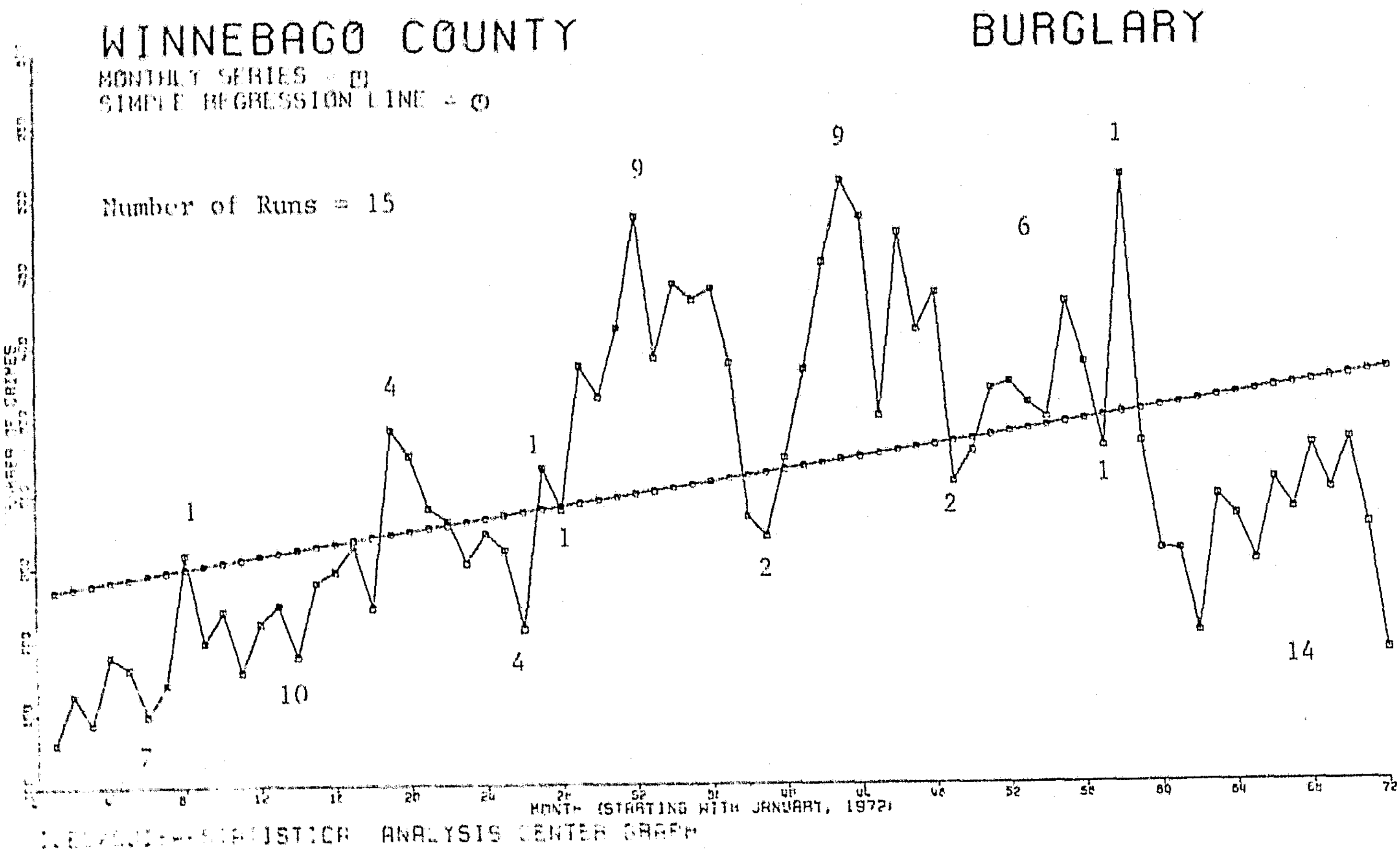
[16] Nonparametric tests do not make as many assumptions about the data as other statistical tests, and do not require such qualified interpretation (see Siegel 1956:3.) A curvilinear series is a series that is better described as a curve than as a straight line. The runs test determines whether a series is curvilinear. Since these series have been screened to eliminate those which do not show a decrease, the curve in those passing the runs test can be said to be a curve showing a recent decrease.

FIGURE 3


WINNEBAGO COUNTY
BURGLARY
MONTHLY SERIES
SIMPLE REGRESSION LINE
Number of Runs = 15
MONTH (STARTING WITH JANUARY, 1972)
ANALYSIS CENTER GRAPH

Diggory (1976) suggests using the runs test to determine whether a curved line or a straight line would best fit a time series. He first fits a straight line to the series, using a least squares regression procedure to find the line that best fits the entire series. He then defines a run as a sequence of points which are all above or all below this line. If the series were best described by a straight line, the points would be randomly scattered above and below the line, and some runs would be expected by chance. If the series were best described by a curve that turns down after some point, then the number of runs would be relatively few. Tables for the probability that a certain number of runs will appear, given a random distribution, are given in Swed and Eisenhart (1943).[17]

The Winnebago County Burglary series (Figure 3) gave the most significant results of those series tested, and therefore is a clear example of this application of the runs test. First, the linear least square line is plotted on the monthly series. In Figure 3, the intercept is 232 and the slope is 2.04. Second, the number of runs above and below this line are counted. The numbers written along the series in Figure 3 are the length of each run. The number of runs is written in the upper left corner. The Winnebago County burglary series begins with a run of seven below the line, then a run of one above, then a run of ten below, and so on. There are fifteen runs in all. According to the Swed and Eisenhart tables, there is less than a five in 1,000 chance that only fifteen runs will occur in a series this long, if the points of the series are really randomly distributed around a straight line. Therefore, we conclude that the Winnebago County monthly burglary series from 1972 to 1977 does not follow a straight line, but probably shows a recent decrease.

Table 2 gives the runs test results for all 77 series. In most of these, the runs test of the monthly series confirmed what was noted in the yearly series, that the series shows a change in direction from a straight line. These series were retained for further analysis.

In 16 series, the decrease apparent by inspection of the yearly series was not significantly apparent in the monthly series.[18] The Springfield burglary series is typical of these. A comparison of the yearly with the monthly series (Figures 4a

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[17]The runs test is also used in other ways in time series analysis. See Wallis and Moore (1941), Kendall (1976:26), and Appendix C.

[18]Diggory has some reservations about using the runs test when the number of cases per month is small (telephone conversation), but he does not specify how many is too small. In this study, the runs test was performed on only those series with an average of five or more cases per month. However, we noticed, in doing

TABLE 2

Runs Test Results
Number of Runs Above and below Regression Line

Burglary

County	Number Runs	City	Number Runs
Cook	17****	Alton	17****
Edgar	39	Arlington Heights	19****
Fulton	31	Belleville	28**
Jersey	27**	Burbank	31
Knox	30	Calumet City	17****
Lake	12****	Chicago	15****
LaSalle	33	Chicago Heights	20****
Livingston	29*	Danville	21****
Macoupin	27**	Decatur	24****
Madison	19****	DeKalb	25****
Mason	29*	Downer's Grove	27**
Monroe	21****	East St. Louis	32
Montgomery	31	Elgin	20****
McDonough	30	Evergreen Park	27**
McHenry	21****	Galesburg	22****
Peoria	17****	Granite City	26***
Piatt	25****	Highland Park	28**
Rock Island	27**	Lansing	28**
St. Clair	24****	Maywood	21****
Sangamon	24****	Moline	30
Stephenson	23****	North Chicago	20****
Tazewell	21****	Oak Park	25****
Winnebago	15****	Pekin	21****
		Peoria	17****
Region[a]		Rock Island	23****
		Rockford	15****
8	37	Schaumburg	25****
10	23****	South Holland	21****
17	28**	Springfield	30
		Villa Park	23****

[a]For definitions of regions, see Appendix A.

*$p \leq .05$ (The probability that this number of runs could have occurred by chance if the series were really a straight line is less than or equal to .05.)

**$p \leq .025$

***$p \leq .01$

****$p \leq .005$

Table 2
(cont.)

Robbery

County	Number Runs	City	Number Runs
Cook	24****	Alton	27**
Kankakee	22****	Calumet City	37
Lake	17****	Chicago	20****
McLean	31	Elgin	39
Peoria	29*	Evanston	27**
Winnebago	21****	Kankakee	22****
		North Chicago	29*
Region[a]		Oak Park	28**
		Peoria	31
1	21****	Quincy	29*
10+13	25****	Rockford	23****
20	34	Waukegan	20****

[a]For definitions of regions, see Appendix A.

*$p \leq .05$ (The probability that this number of runs could have occurred by chance if the series were really a straight line is less than or equal to .05.)

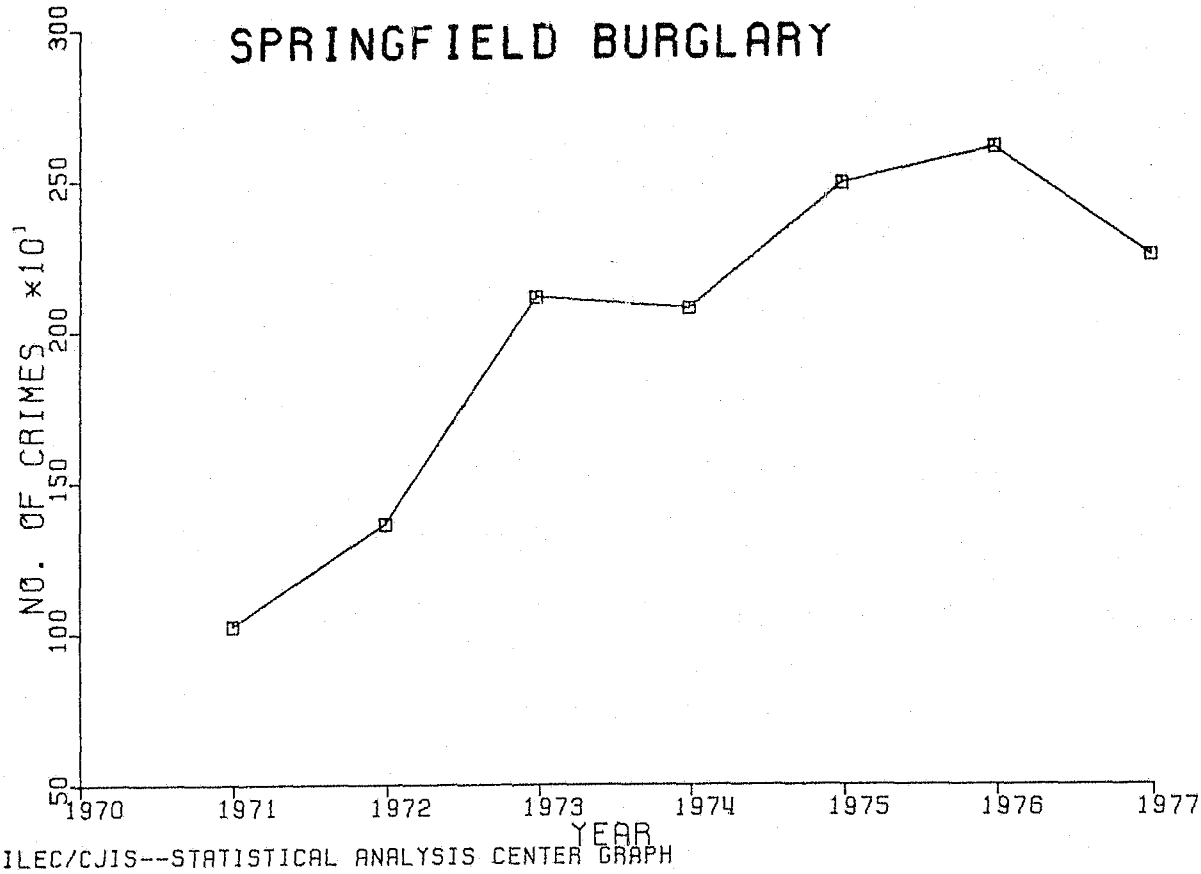
**$p \leq .025$

***$p \leq .01$

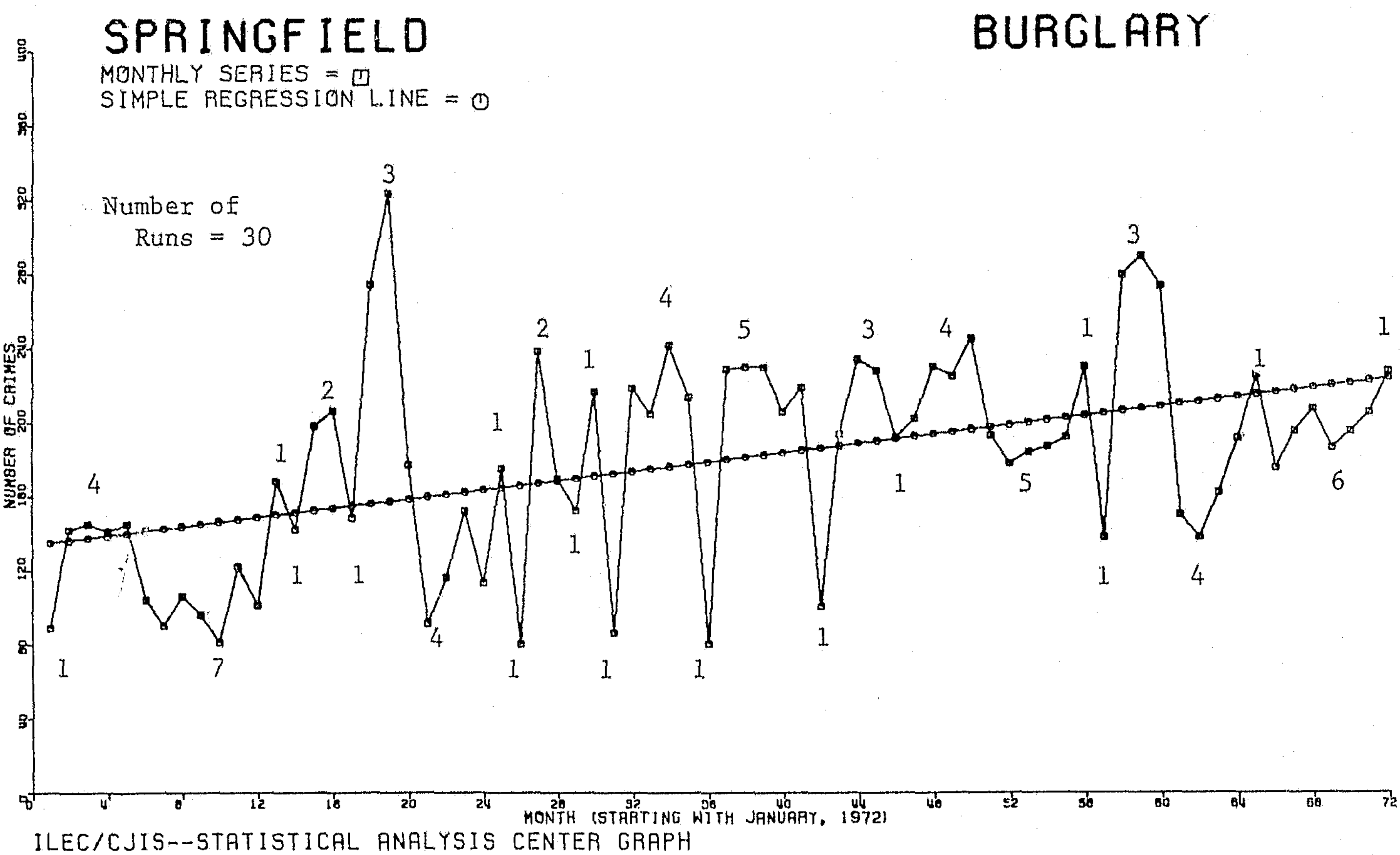
****$p \leq .005$

FIGURE 4

(a)


SPRINGFIELD BURGLARY
NO. OF CRIMES *10^1
50
100
150
200
250
300
1970
1971
1972
1973
1974
1975
1976
1977
YEAR
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

(b)


SPRINGFIELD
BURGLARY
MONTHLY SERIES = □
SIMPLE REGRESSION LINE = ○
Number of
Runs = 30
NUMBER OF CRIMES
MONTH (STARTING WITH JANUARY, 1972)
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

and 4b) is an example of how inspection of a yearly series may lead to conclusions that are not substantiated by analysis of the same series by month. The yearly series showed that Springfield burglaries declined in 1977, but the monthly series showed that the decline was partially an artifact of aggregating the number of offenses over a year. There are 30 runs in Figure 4b, a number that is not significantly different from chance. Since this series could, therefore, be best described by a straight line, it was dropped from further analysis.

Each of the 61 series retained for further analysis shows some deviation from a straight line, according to the runs test. Because each of the 61 was also found to decrease in the yearly screening test, the deviation must be a recent decrease. The combination of the yearly screening test and the runs test of the monthly series, then, showed that 61 of the original 340 series 1) have enough cases for analysis, and 2) show a recent decrease that is probably not due to chance.

Although the yearly screen and the runs test are used here as a test for the presence of a recent decrease, they could also be used as a test for a recent increase. First, an inspection of the yearly series would determine whether there was a recent increase, by some standard criteria. Second, the monthly series would be analyzed by the runs test. If the runs test showed significant curvilinearity and the yearly screen showed an increase, the series could be said to have increased.

These two quick tests will provide conclusions that are detailed enough for many administrative decisions. However, for some purposes it may be necessary to know exactly when the change in the series began. The following section describes a way to discover the most likely point of decrease or increase, the turning point, and to test the probability that a two segment line, changing direction after the turning point describes the series better than a straight line with no change in direction.

---

18 (cont.)

the test, that those series with between five and fifteen cases per month were likely to have more points below the regression line than above it. This affects runs test results where the total number of months is small. Swed and Eisenhart (1943) give special tables for 40 or fewer months. However, in this case, we have 72 months. Whether having between five and fifteen cases per month will affect runs test results in a series of 72 months is uncertain. Based on our observations, it is possible that a series in this study, for example, the Quincy robbery series, passed the runs test when there was really no significant decrease.

Determining the Turning Point

There are two ways to find the turning point of a series.[19] One way is to fit the best possible curved line to the series. The point at which this curve stops increasing and begins to decrease is the turning point. This solution, however, would not be in keeping with the goal of this paper: to use methods which are quick and easy to calculate and easily understood. For example, the equation of a curve may be compared from one series to another, but it would be difficult to explain this comparison to non-statisticians. It would be extremely difficult to compare the equations of 61 curves, those fitting each series that passed the runs test. Such an analysis could be done, but it would be time consuming, and it would be difficult to interpret. A decision maker may not need to know the exact equation of a curve of a series, but might very well need to know if the series changed its general direction and exactly when that change occurred.

The second way in which the turning point of a series can be described is to find the best two (or more) straight line segments which fit the series. The turning point is then the point at which these line segments join each other. This is relatively quick and easy to do and easy to explain to non-statisticians. A group of series can be divided into those which changed direction and those which did not. Those which changed direction can be compared according to the turning point when the change occurred. We suggest using the second technique.

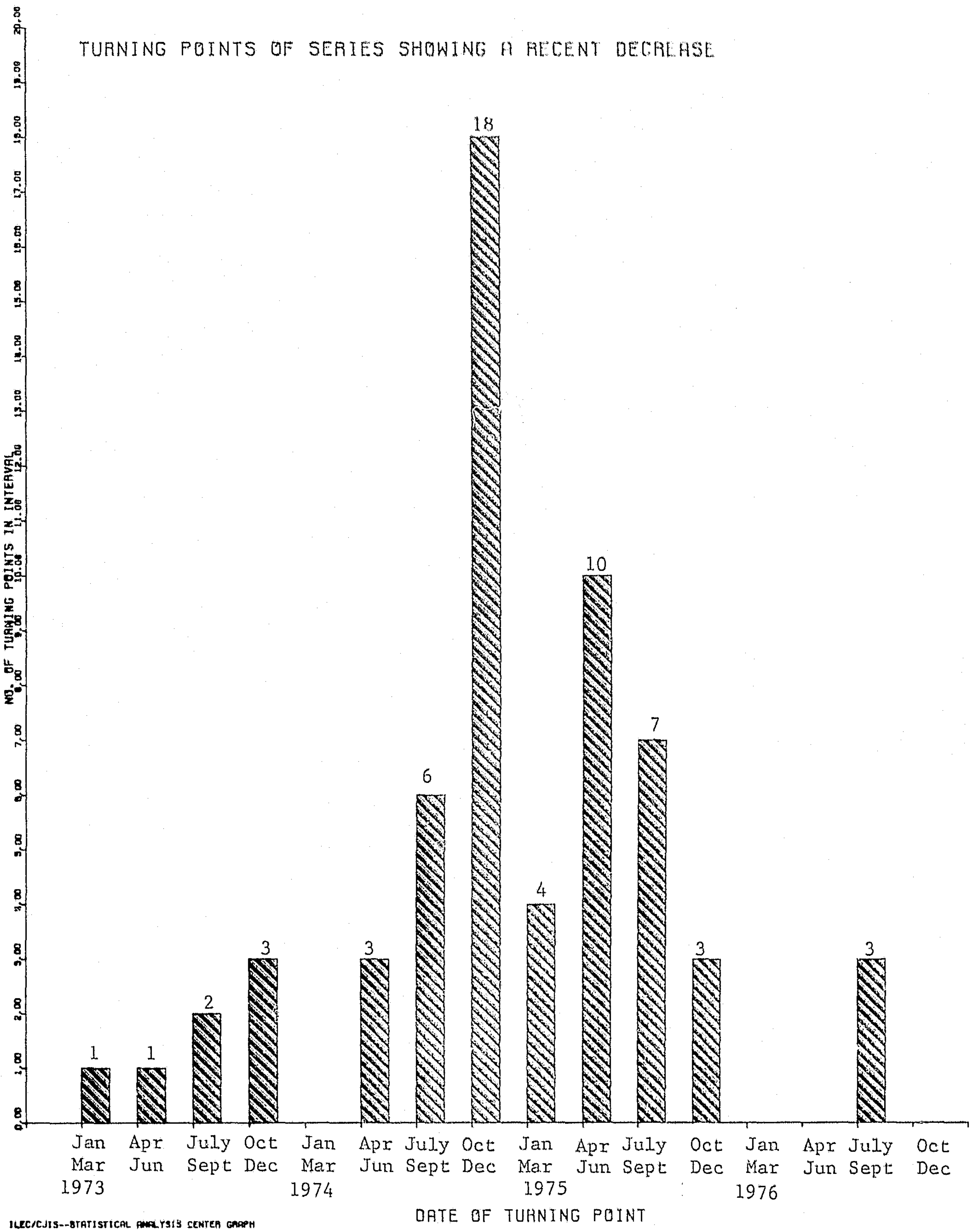
To determine the most likely turning point, we used a method suggested by Hudson (1966), and calculated it using a computer program written by Fox (1978:87-111.)[20] Hudson's method finds the two segment line which best fits the series. Fox's program calculates the least squares error of the regression for every possible combination of line segments, for example, the first three and the fourth through 72nd month, the first four and the fifth through 72nd month, and so on.[21] The two

[19] Traditional time series analysis uses the term "turning point" in a more specialized sense than it is used here. In the analysis of economic cycles, for example, it is important to predict the future point at which the direction of the series will change. An error in such a prediction is a "turning point error" (see Nelson 1973:211.) The analysis in this paper does not attempt to predict future turning points, but only to describe where the series has changed direction in the past.

[20] The program is published in Fox (1978:95-111.) However, SAC has found some mistakes in the program as reproduced in that book. For documentation, contact SAC.

[21] For details of calculating least squares estimates for two or more line segments, see Hudson (1966.)

Figure 5


TURNING POINTS OF SERIES SHOWING A RECENT DECREASE
NO. OF TURNING POINTS IN INTERVAL
DATE OF TURNING POINT
1
1
2
3
3
6
18
4
10
7
3
3
Jan Mar 1973
Apr Jun
July Sept
Oct Dec
Jan Mar 1974
Apr Jun
July Sept
Oct Dec
Jan Mar 1975
Apr Jun
July Sept
Oct Dec
Jan Mar 1976
Apr Jun
July Sept
Oct Dec
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

segment line with the smallest error gives the best fit. The "turning point" in this analysis was defined as the month before the two segments meet.[22]

The turning points of the 61 series which showed a recent decrease ranged from January, 1973 to August, 1976 (Figure 5.) Most of the series began to decrease either in late 1974 (28 series) or mid-1975 (19 series.)

The Hudson/Fox program also provides the user with the slopes and intercepts of the two segments and of the overall straight line. For these 61 series, the overall straight line slope is sometimes increasing and sometimes decreasing, but, in every case, the slope of the first line segment increases and the slope of the second line segment decreases (see Table 3.) This was to be expected, because each of the 61 was chosen by the yearly screen and the runs test as a series that changed direction to a decrease. The Hudson/Fox program simply confirms what these nonparametric tests indicated, and gives the user, in addition, the specific point at which the decrease began. However, the Hudson results do not give us any indication of whether fitting a two segment line to the series describes it better than fitting a straight line. They do not tell us if the segments before and after the turning point really improve our ability to describe the series, or whether a straight line assuming no downward change would describe the series just as well.

A Straight Line or A Two Segment Line?

The Hudson/Fox method will find the best fitting two segment line for a series. However, it will not tell you whether that two segment line is a better description of the series than the best fitting straight line. We have, essentially,

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[22] This paper sets the turning point to an exact month, but the Hudson/Fox program finds exact "join points" that can be between months. The join point may be either somewhere between two months, or it may be exactly at a month. For example, the join point for the Cook County burglary series is 33.81, which is between the thirty-third and the thirty-fourth month (September and October, 1974.) The join point for the McHenry County burglary series is exactly the forty-second month, June 1975. Where the Hudosn join point was between two months, the turning point was defined as the first month, the month before the decrease began (September, 1974 for Cook County burglaries.) Where the Hudson join point was exactly at a month, the test for curvilinearity, described in the next section, determined whether the best fit would be achieved by including that month in the first or in the second line segment. In any case, the month before the decrease began was considered to be the turning point. For McHenry County burglary, for example, the best fit occurred when June, 1975 was the last month in the first line segment rather than the first month in the last line segment. Therefore, June 1975 is the turning point, the month before the decrease began.

two models of a series - the best fitting straight line and the best fitting two segment line. What criterion may be used to decide which of these models yields the best description?

One criterion is a test for curvilinerarity (see Nie 1975:376-377; Blalock 1972:411-413.) The best fitting straight line explains a certain amount of the variance in the number of robberies or burglaries. If the series is divided into two segments, will this additional information explain more of the variance? If so, and if the difference between the two explanations is significant, then the two segment line model is better than the straight line model.

To measure the amount of variance explained by a two segment line model, a dummy variable is created for whether the observation is in the first line segment or not. Then the amount of the variance in the number of Index robberies or burglaries that is explained by the straight line plus the dummy variable is compared to the amount of variance explained by the straight line alone. This produces a statistic which varies as F, and the significance of which can be found in tables of F values.

To calculate the amount of variance explained by a straight line model, we regress the number of crimes on a variable that could be called "Date," which equals from 1 through 72 for the 72 months from 1972 through 1977. In other words, Number of Crimes = a + b (Date). One of the statistics that results from such a regression is the square of the regression coefficient, or R^2. R^2 is the amount of variance explained by a straight line model. In the same way, the amount of variance explained by both the straight line and the two segment line may be calculated, by regressing the number of crimes on both of them at once. In other words, Number of Crimes = a + b (Date) + c (Dummy). This yields another R^2, the amount of variance explained by both Date and the dummy variable for the two segment line.

Given these two R^2 statistics, the following equation may be computed:

$$F = \frac{(R^2 \text{ with Date and dummy variable} - R^2 \text{ with Date only})/k}{(1 - R^2 \text{ with Date and dummy variables})/(N-k-1)}$$

where R^2 is the amount of variance explained

$1 - R^2$ is the amount of variance unexplained
N is the number of cases (here, 72)

k is the number of dummy variables (here, 1)
and k and (N-k-1) are the degrees of freedom.

TABLE 3

Analysis of Series Showing a Recent Decrease

	Date of Turning Point	Overall Slope	First Slope	Second Slope	F of Curvilinearity
Burglary County					
Cook	9/74	7.98	73.48	-44.34	1.02
Jersey	11/73	-.18	.62	-.45	12.44***
Lake	10/74	2.41	6.82	-1.45	.43
Livingston	7/76	.09	.19	-.47	9.87**
Macoupin	4/74	.01	.54	-.27	3.18
Madison	5/75	1.38	6.91	-6.71	3.02
Mason	1/73	-.02	.57	-.08	8.46**
Monroe	2/75	.04	.25	-.19	.18
McHenry	6/75	.32	1.43	-1.46	3.30
Peoria	1/75	.30	4.76	-4.34	.41
Piatt	1/75	.03	.23	-.19	.08
Rock Island	7/76	2.16	3.44	-5.17	16.48***
St. Clair	11/74	-.11	3.61	-3.68	.69
Sangamon	10/74	1.68	4.56	-.86	.43
Stephenson	6/75	.10	.46	-.50	1.41
Tazewell	10/74	-.12	1.38	-1.40	.27
Winnebago	6/75	2.04	6.95	-5.76	1.45
City					
Alton	8/75	.38	1.67	-2.06	5.85*
Arlington Hts	6/75	.33	1.06	-.82	3.57
Belleville	12/75	.03	.29	-.72	4.28*
Calumet City	8/75	.30	1.05	-1.20	2.83
Chicago	8/74	-2.50	44.61	-37.73	2.46
Chicago Hts	6/75	.30	1.34	-1.36	4.50*
Danville	11/74	.20	1.02	-.58	.18
Decatur	12/74	.32	1.55	-.93	.00
DeKalb	4/73	.08	.97	-.06	14.97***
Downers Gr	10/74	-.06	.55	-.60	.43
Elgin	10/75	1.04	1.79	-.67	4.99*
Evergreen Pk	5/74	.09	.34	-.06	1.41
Galesburg	2/75	.22	.76	-.39	.37
Granite City	9/73	-.31	.63	-.56	2.83
Highland Pk	7/75	.08	.26	-.24	1.32
Lansing	8/75	-.03	.28	-.61	8.54**
Maywood	9/75	.01	.75	-1.55	5.83*
No. Chicago	10/73	.22	1.57	-.19	10.01**
Oak Park	5/74	-.37	.33	-.77	1.52
Pekin	9/74	.12	.92	-.46	.99

TABLE 3 Continued

City Con't.	Date of Turning Point	Overall Slope	First Slope	Second Slope	F of Curvilinearity
Peoria	12/74	.52	4.21	-3.33	.24
Rock Island	8/76	1.19	1.89	-3.56	14.21***
Rockford	7/75	1.31	5.08	-5.51	4.62*
Schaumburg	6/75	.54	1.12	-.44	1.59
So. Holland	5/75	.07	.43	-.46	2.35
Villa Park	6/75	.18	.49	-.32	1.78
Region					
10	12/74	.45	1.56	-.71	.53
17	11/73	-.17	1.36	-.68	10.01***
Robbery County					
Cook	9/74	-10.26	8.74	-25.30	.83
Kankakee	10/74	.03	.38	-.29	1.06
Lake	10/74	.24	1.28	-.60	.15
Peoria	8/75	-.10	.22	-.73	5.36*
Winnebago	12/74	.25	.78	-.30	.76
City					
Alton	10/75	-.03	.10	-.31	4.00*
Chicago	9/74	-10.46	6.45	-24.19	.44
Evanston	11/74	-.05	.27	-.36	.39
Kankakee	12/74	.03	.28	-.22	.52
No. Chicago	9/73	.06	.59	-.08	11.32***
Oak Park	10/74	-.13	.04	-.28	.55
Quincy	11/74	.05	.11	-.01	1.04
Rockford	6/75	.21	.61	-.42	2.25
Waukegan	9/74	.10	.73	-.41	2.51
Region					
1	10/74	.02	.13	-.08	.84
10+13	11/74	.07	.24	-.09	1.73

* $p \leq .05$

** $p \leq .01$

*** $p \leq .001$

For example, the turning point of the Highland Park burglary series is July, 1975. This means that the first line segment is from January, 1972 through July, 1975, and the second line segment is from August, 1975 through December, 1977. Therefore, the dummy variable will equal 1 for all months through July, 1975, and 0 otherwise.

The R^2 of the regression of Highland Park burglaries on Date is .06518. The multiple R^2 of the regression of Highland Park burglaries on Date and the dummy variable is .08253. Thus, the additional variance explained by the dummy variable for the two line segments is the difference between .08253 and .06518. The calculation of F is:

$$F = \frac{(.08253 - .06518)/1}{(1 - .08253)/70}$$

$$= \frac{.01753}{.01311}$$

$$= 1.34$$

This 1.34 can be checked against a table of F values, which are given in the back of most statistics textbooks, such as Blalock (1972.) An F of 1.34 with 70 and 1 degrees of freedom is not significant. That means that there is a greater than five per cent chance that this F would be found even if the series were really a straight line. Therefore, we should assume that 1972 to 1977 Highland Park burglaries are better described as a straight line than as a two segment line that began to decrease after July, 1975. The best two segment line model for Highland Park burglaries is not significantly better than the best straight line model.

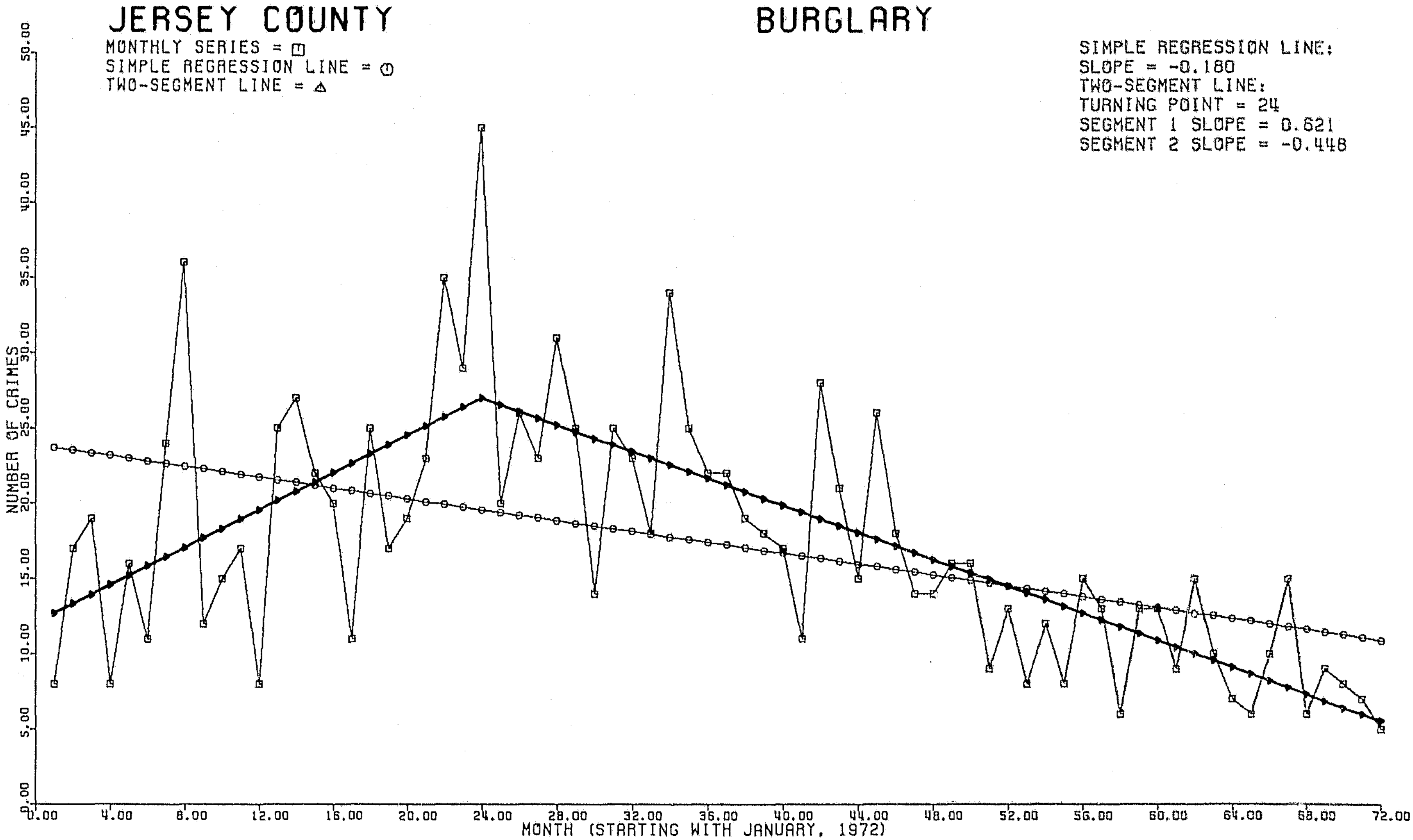
Table 3 shows the results of this test for the 61 series which were found to show a recent decrease by the combination of the yearly screening test and the monthly runs test. In only 18 series could a specific month be found where a downward change in the trend line after this point was a significantly better description than a straight line from beginning to end. Figures 6 through 23 are the graphs of these series, with both the straight line and the two segment line plotted.

A glance at these 18 plots will show that, although they each have different, individual characteristics, they all have one thing in common. They all begin to decrease after some point. That point may be as early as January, 1973 (Mason

County burglary) or as late as August, 1976 (Rock Island City burglary.) The difference in slope between the increasing and the decreasing line segments is sometimes great (Rockford burglary) and sometimes slight (Lansing burglary.) The number of crimes per month is sometimes high (Rockford burglary) and sometimes low (Alton robbery.) However, all of the series turn from increasing to decreasing at some point.

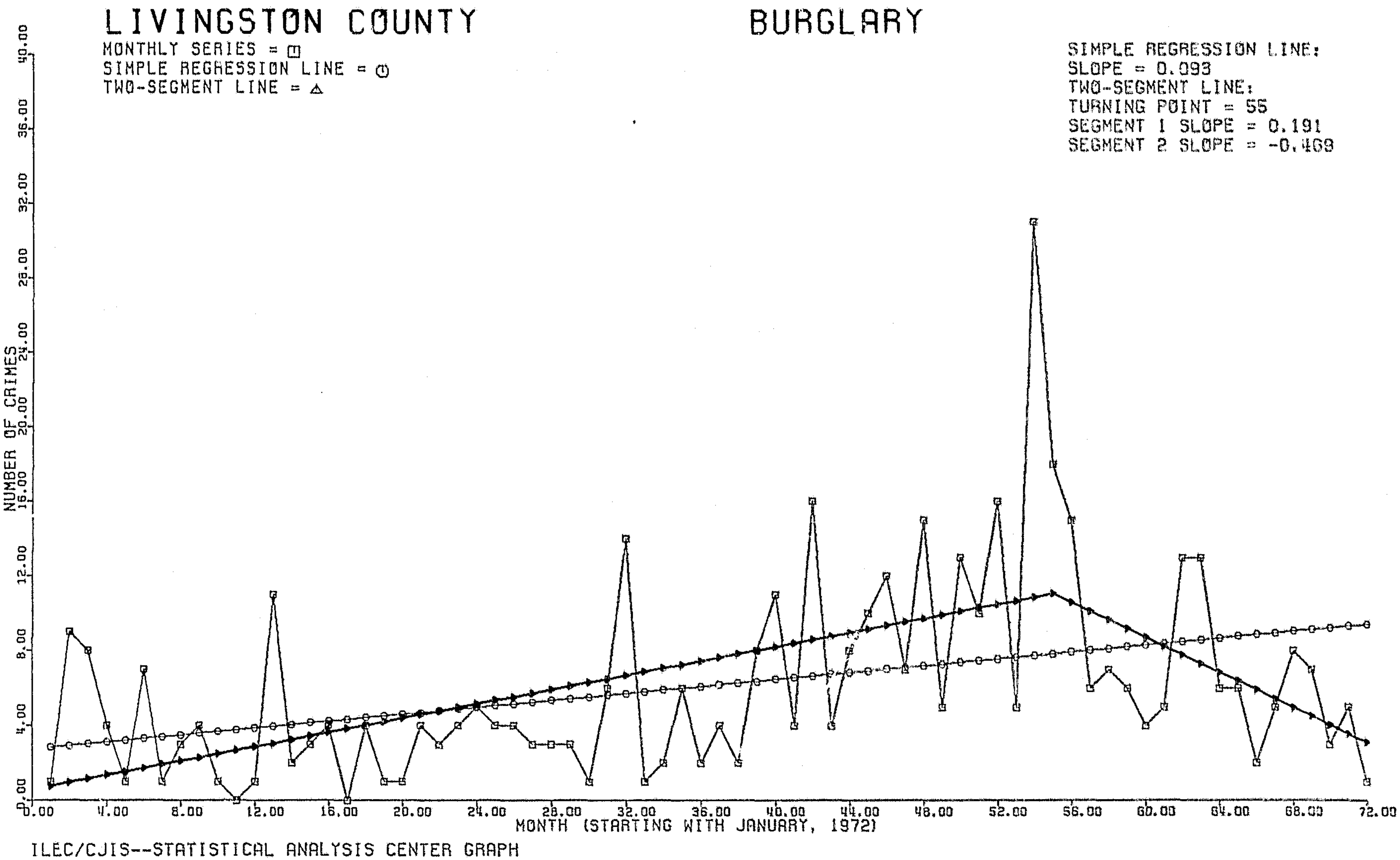
The advantage of the Hudson/Fox two-segment fits and the test of curvilineary is that they enable an analyst to describe a complex series of data in non-complex terms. All of these series, despite their infinite variety, may be described as following a limited number of general patterns. They are either best described as a two segment line about a particular turning point or as a straight line. If they are a two segment line, their turning points and slopes may be compared.

FIGURE 6



ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 7



LIVINGSTON COUNTY
BURGLARY
MONTHLY SERIES = □
SIMPLE REGRESSION LINE = ⊙
TWO-SEGMENT LINE = △
SIMPLE REGRESSION LINE:
SLOPE = 0.093
TWO-SEGMENT LINE:
TURNING POINT = 55
SEGMENT 1 SLOPE = 0.191
SEGMENT 2 SLOPE = -0.469
NUMBER OF CRIMES
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
36.00
40.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
36.00
40.00
44.00
48.00
52.00
56.00
60.00
64.00
68.00
72.00
MONTH (STARTING WITH JANUARY, 1972)
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 8

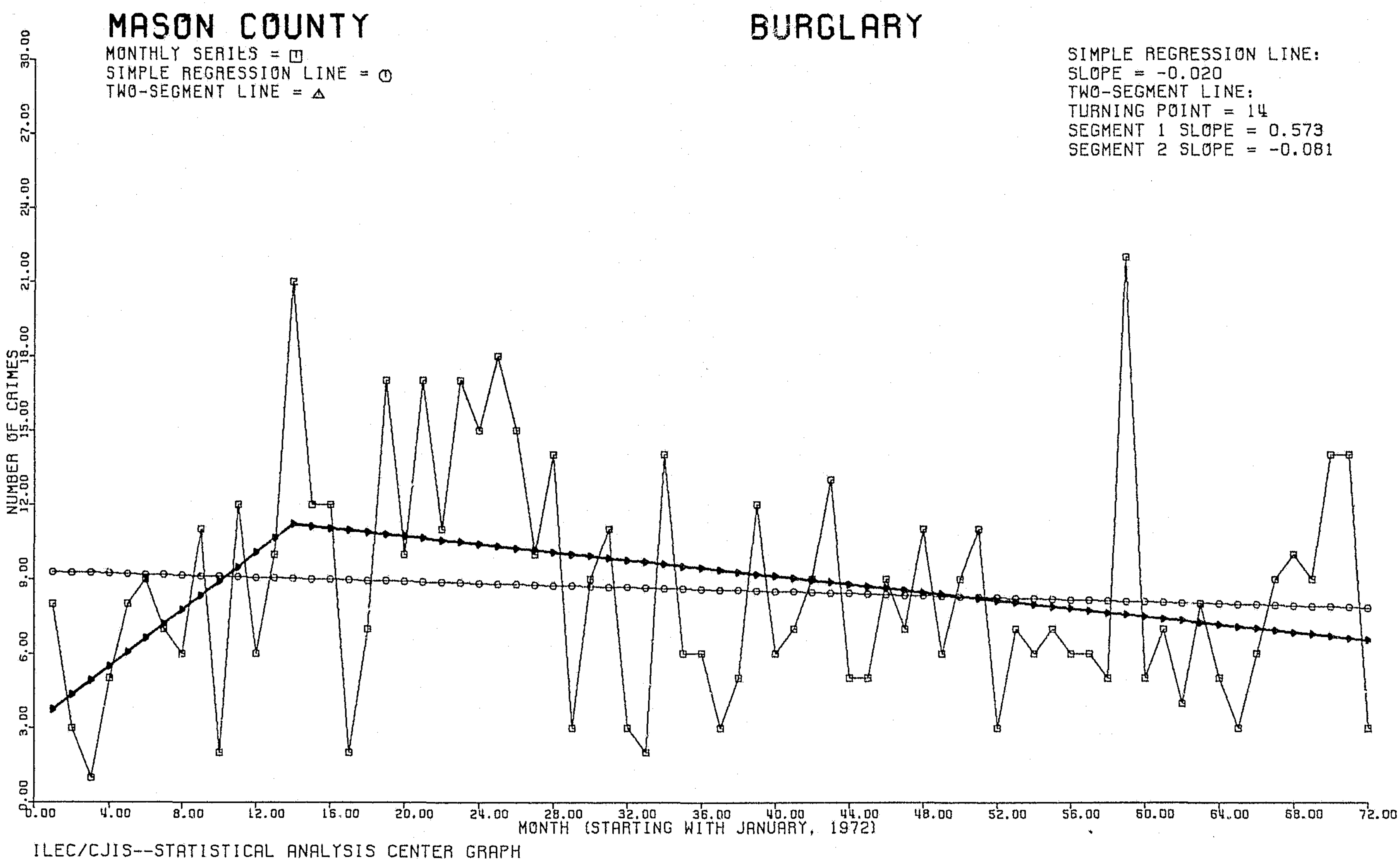
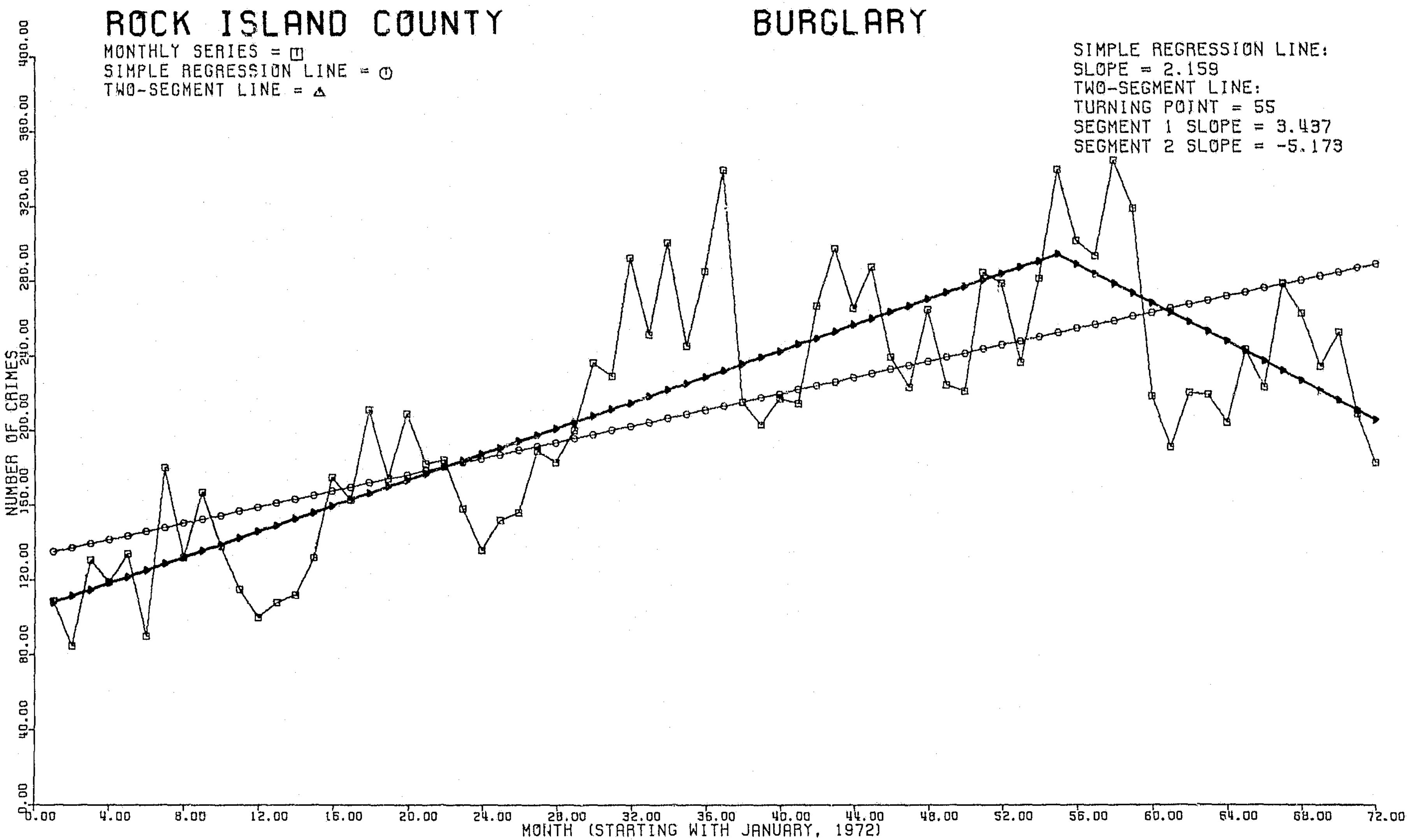
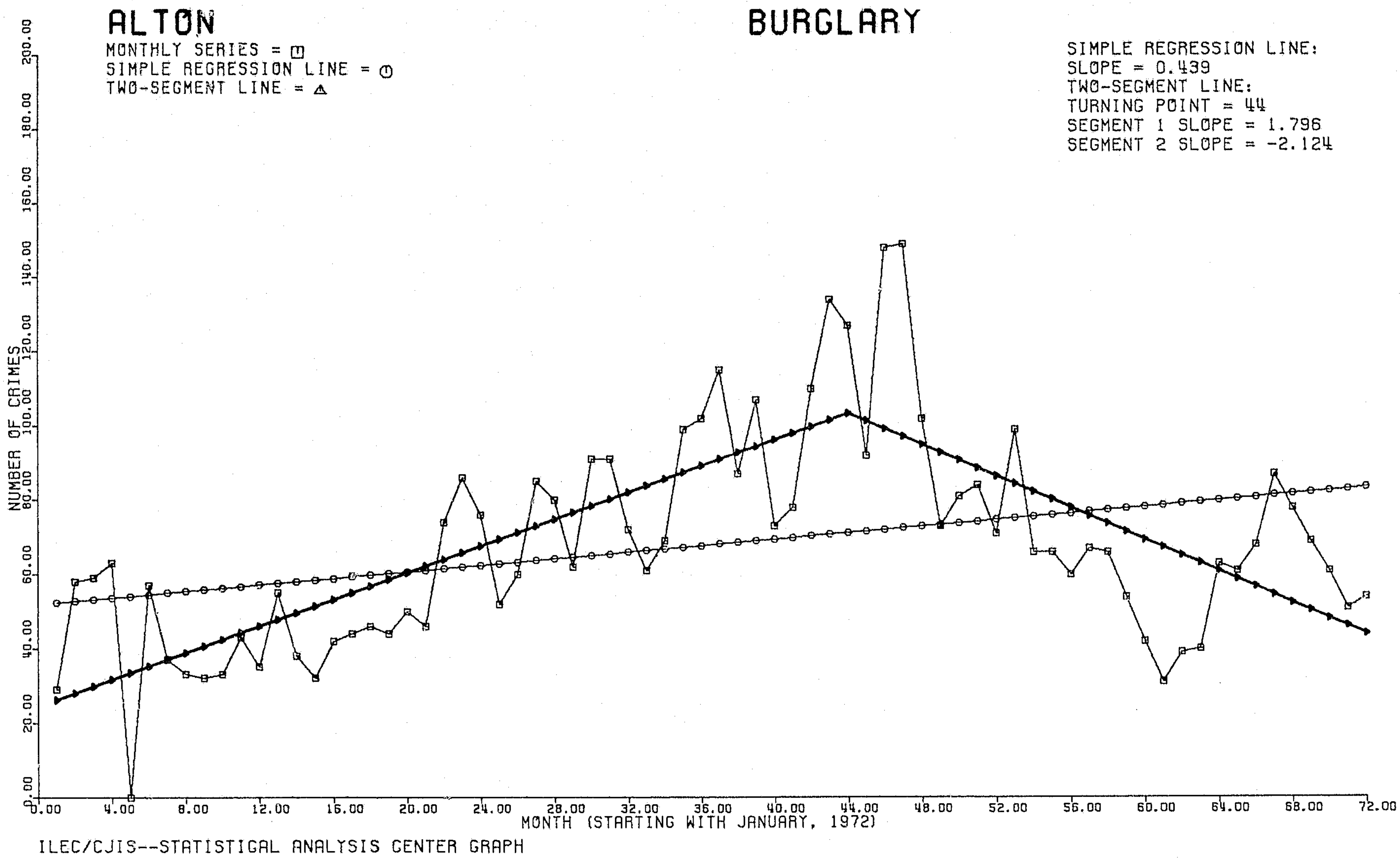

MASON COUNTY
BURGLARY
MONTHLY SERIES = ⊡
SIMPLE REGRESSION LINE = ⊙
TWO-SEGMENT LINE = △
SIMPLE REGRESSION LINE:
SLOPE = -0.020
TWO-SEGMENT LINE:
TURNING POINT = 14
SEGMENT 1 SLOPE = 0.573
SEGMENT 2 SLOPE = -0.081
NUMBER OF CRIMES
0.00
3.00
6.00
9.00
12.00
15.00
18.00
21.00
24.00
27.00
30.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
36.00
40.00
44.00
48.00
52.00
56.00
60.00
64.00
68.00
72.00
MONTH (STARTING WITH JANUARY, 1972)
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 9



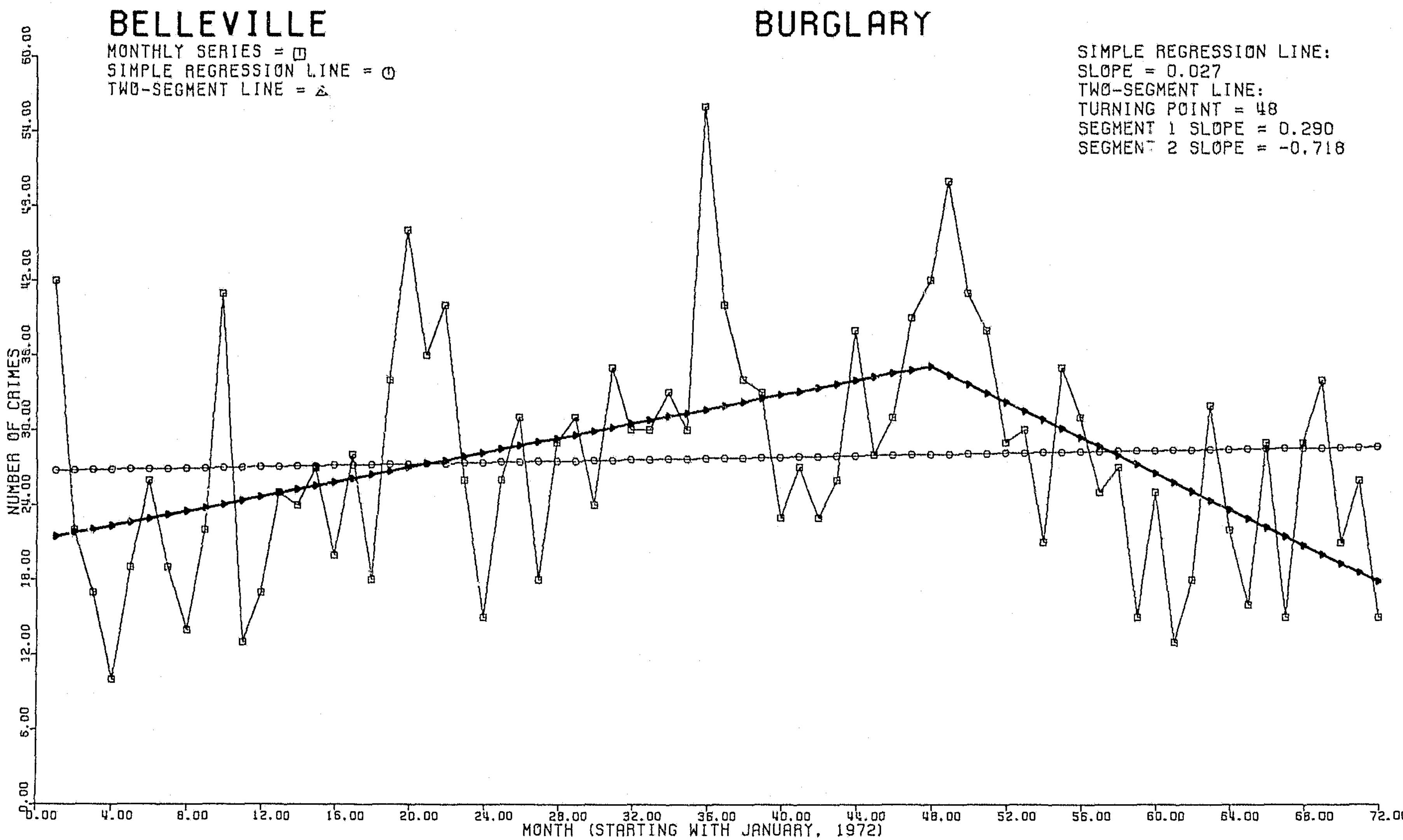
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 10



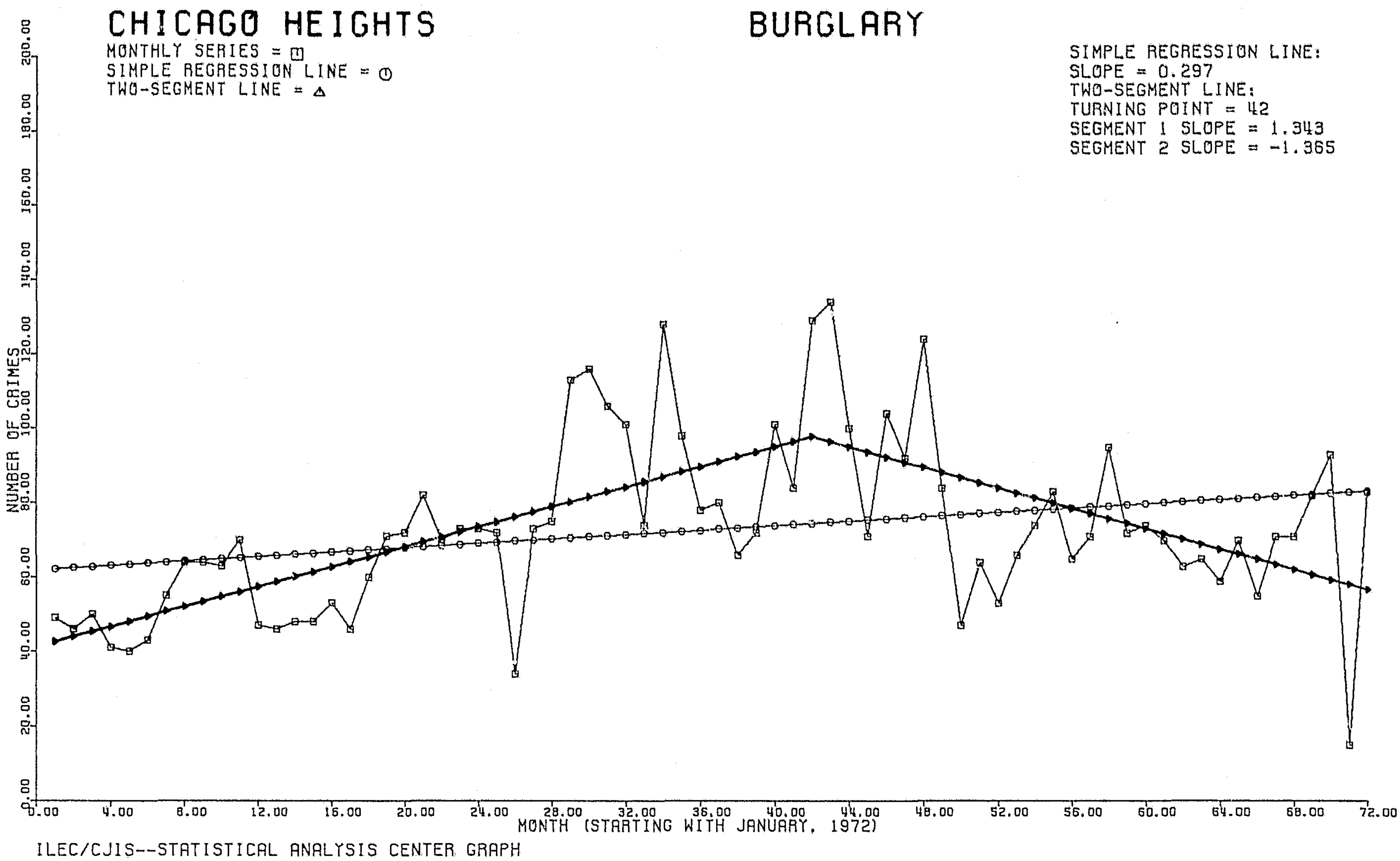
ALTON
BURGLARY
MONTHLY SERIES = ▢
SIMPLE REGRESSION LINE = ○
TWO-SEGMENT LINE = △
SIMPLE REGRESSION LINE:
SLOPE = 0.439
TWO-SEGMENT LINE:
TURNING POINT = 44
SEGMENT 1 SLOPE = 1.796
SEGMENT 2 SLOPE = -2.124
NUMBER OF CRIMES
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
36.00
40.00
44.00
48.00
52.00
56.00
60.00
64.00
68.00
72.00
MONTH (STARTING WITH JANUARY, 1972)
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 11



ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 12



CHICAGO HEIGHTS
BURGLARY
MONTHLY SERIES = ☐
SIMPLE REGRESSION LINE = ○
TWO-SEGMENT LINE = △
SIMPLE REGRESSION LINE:
SLOPE = 0.297
TWO-SEGMENT LINE:
TURNING POINT = 42
SEGMENT 1 SLOPE = 1.343
SEGMENT 2 SLOPE = -1.365
NUMBER OF CRIMES
0.00 20.00 40.00 60.00 80.00 100.00 120.00 140.00 160.00 180.00 200.00
0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00 32.00 36.00 40.00 44.00 48.00 52.00 56.00 60.00 64.00 68.00 72.00
MONTH (STARTING WITH JANUARY, 1972)
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 13

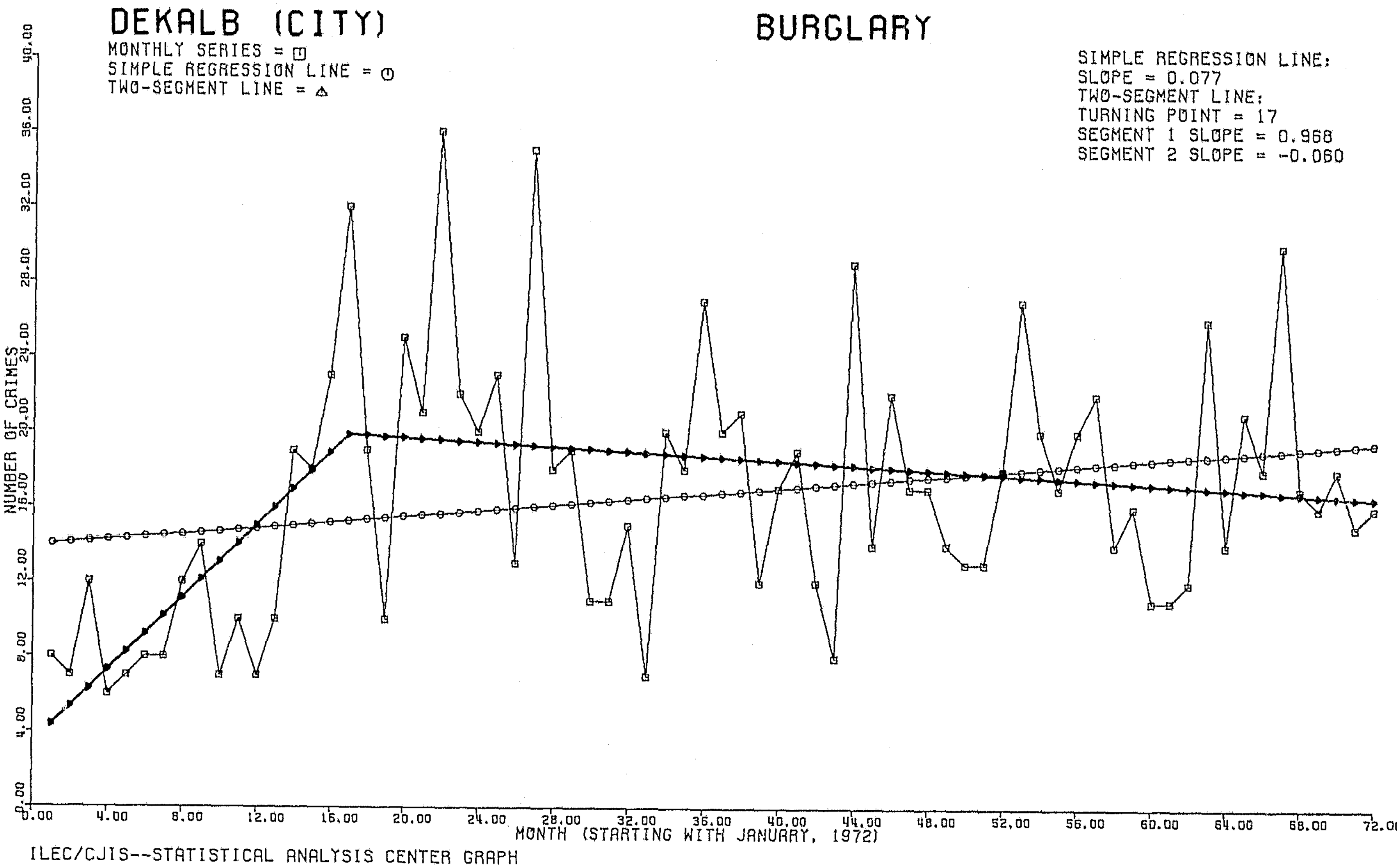
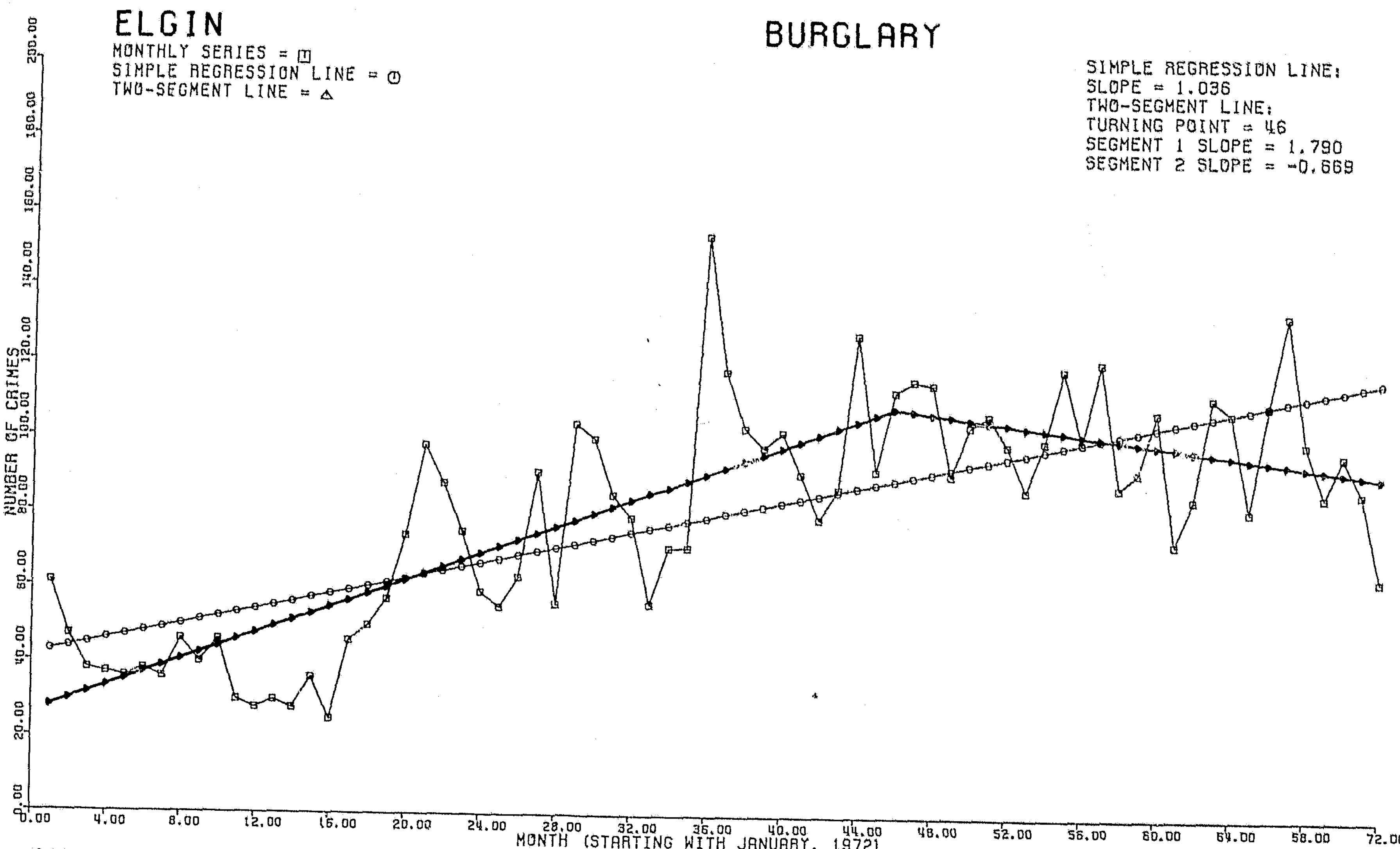
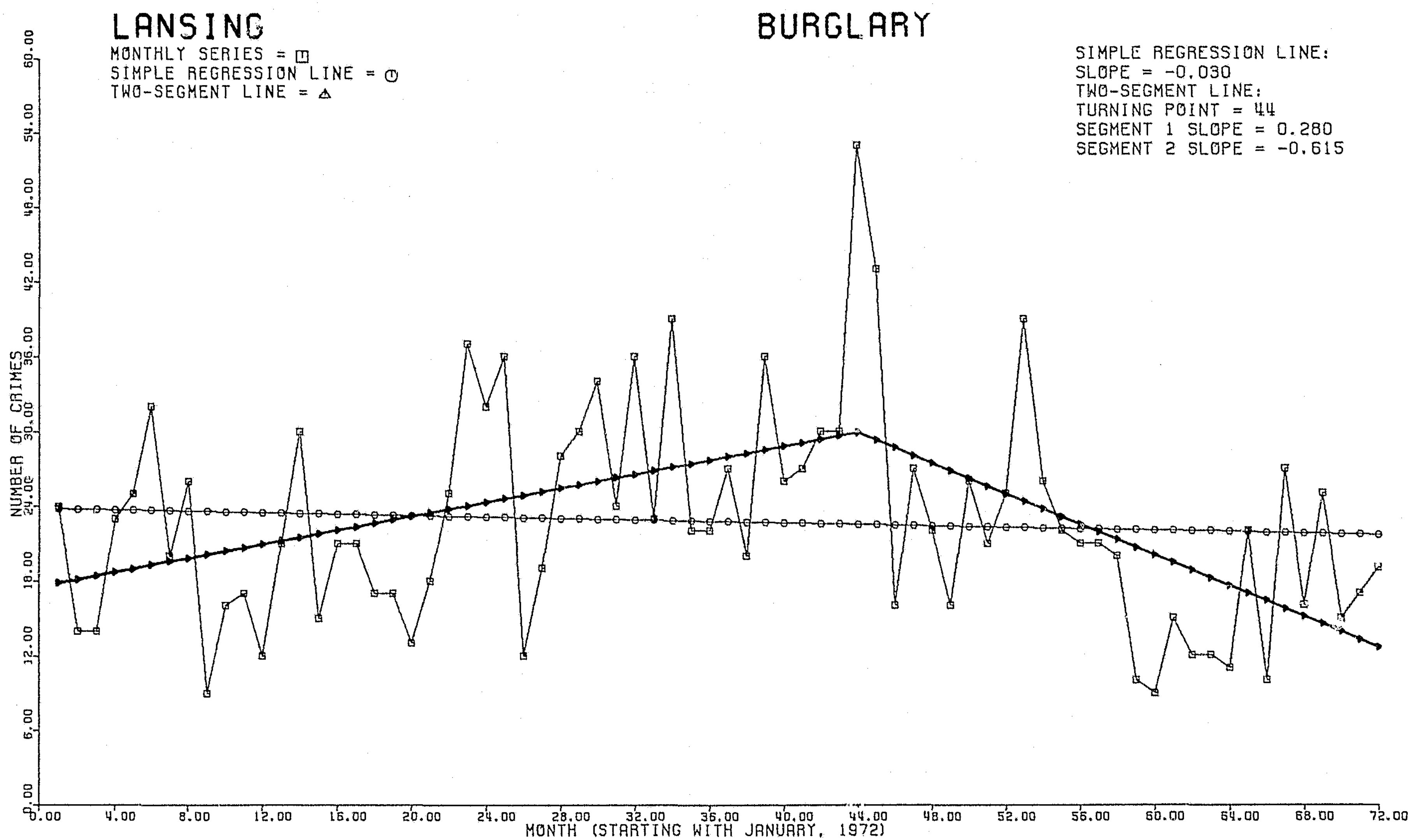

DEKALB (CITY)
MONTHLY SERIES = ⊡
SIMPLE REGRESSION LINE = ⊙
TWO-SEGMENT LINE = △
BURGLARY
SIMPLE REGRESSION LINE:
SLOPE = 0.077
TWO-SEGMENT LINE:
TURNING POINT = 17
SEGMENT 1 SLOPE = 0.968
SEGMENT 2 SLOPE = -0.060
NUMBER OF CRIMES
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
36.00
40.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
36.00
40.00
44.00
48.00
52.00
56.00
60.00
64.00
68.00
72.00
MONTH (STARTING WITH JANUARY, 1972)
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 14



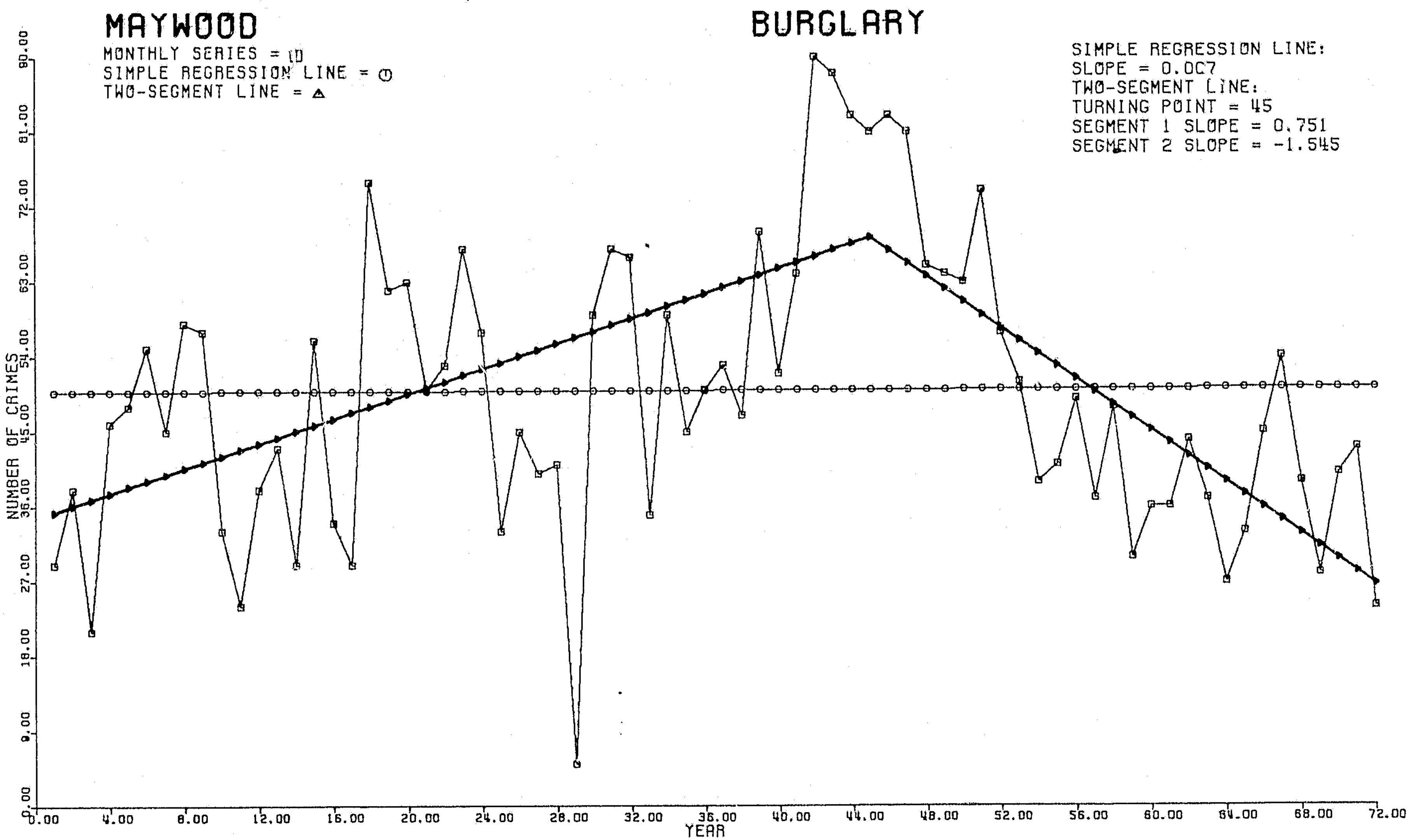
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 15



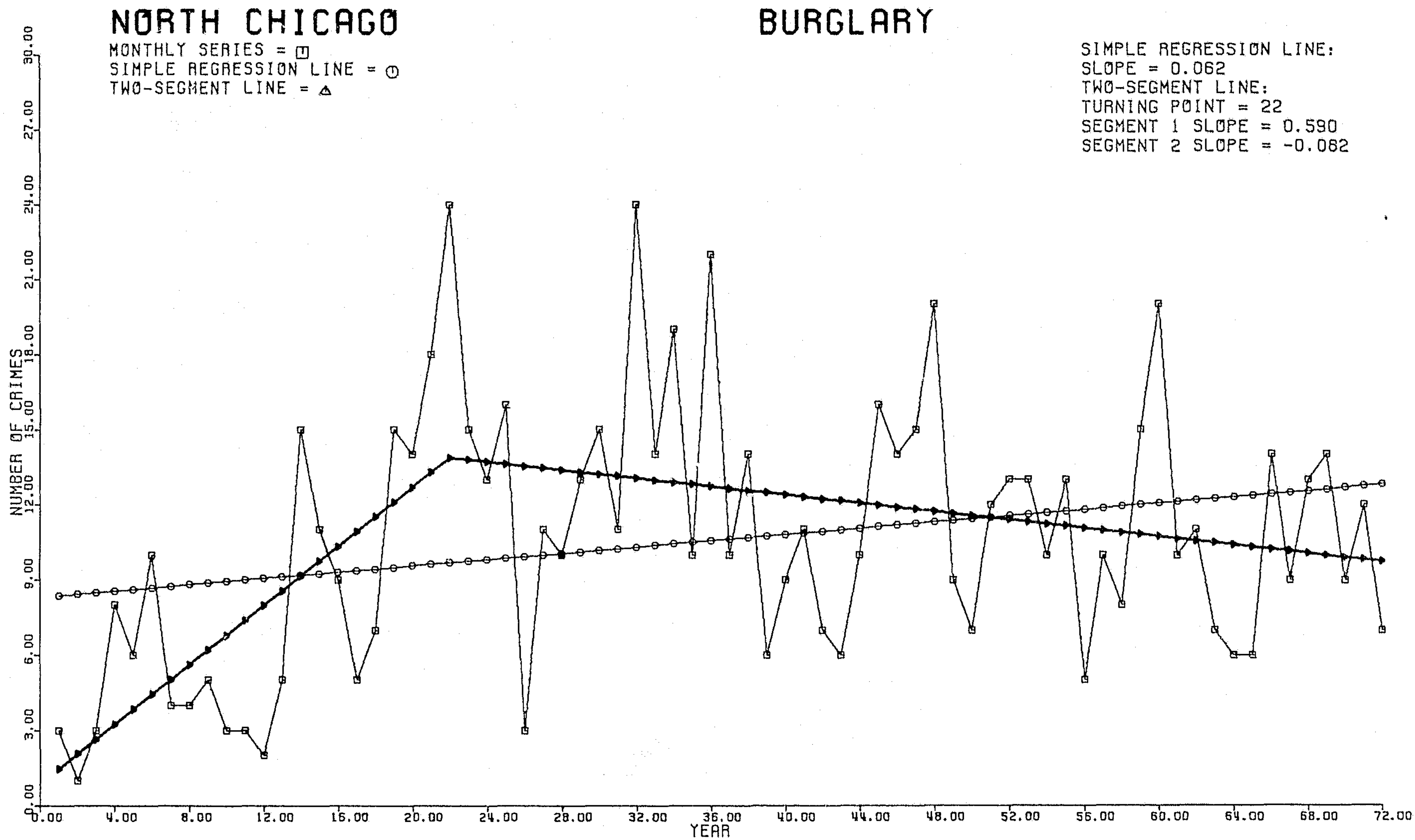
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 16



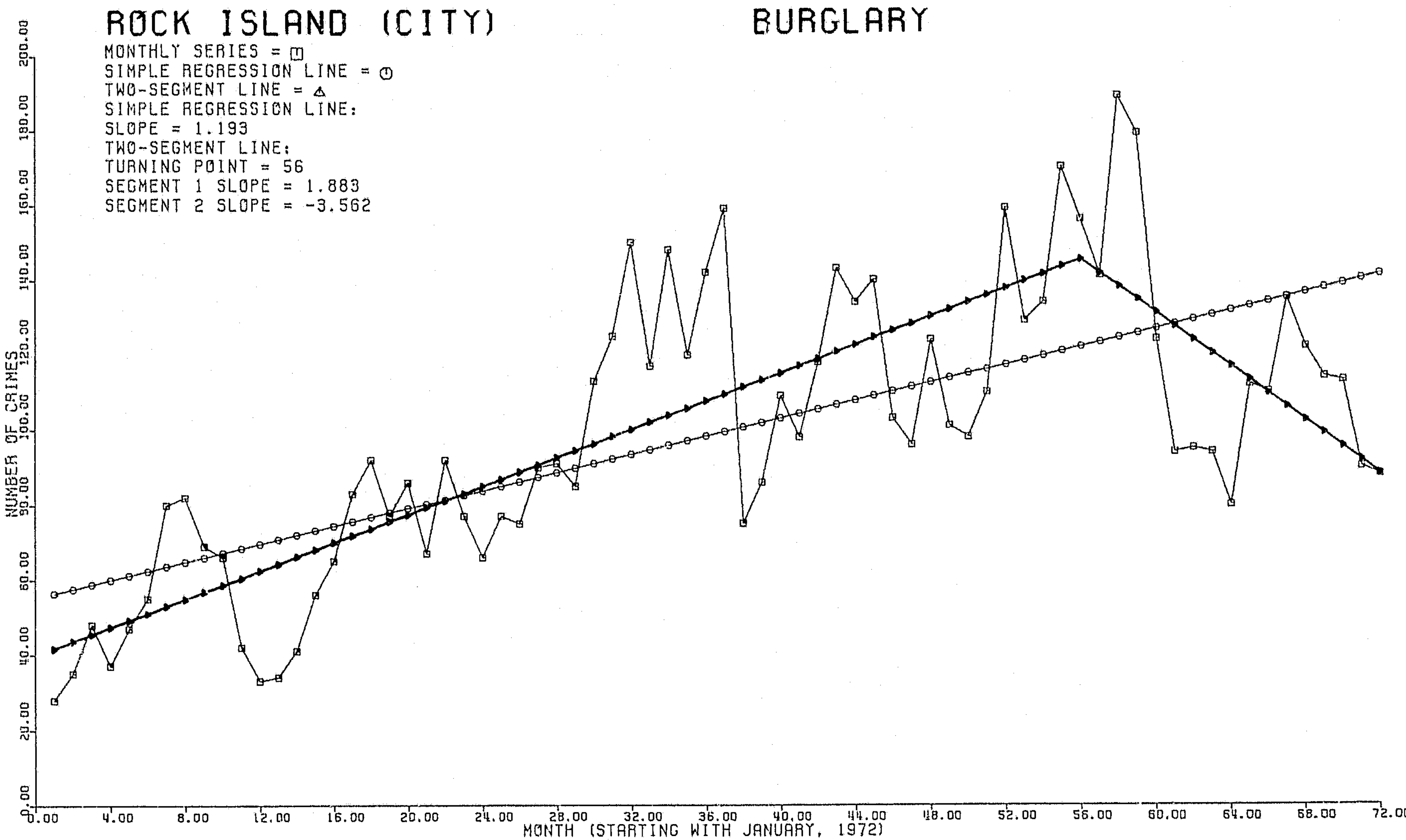
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 17



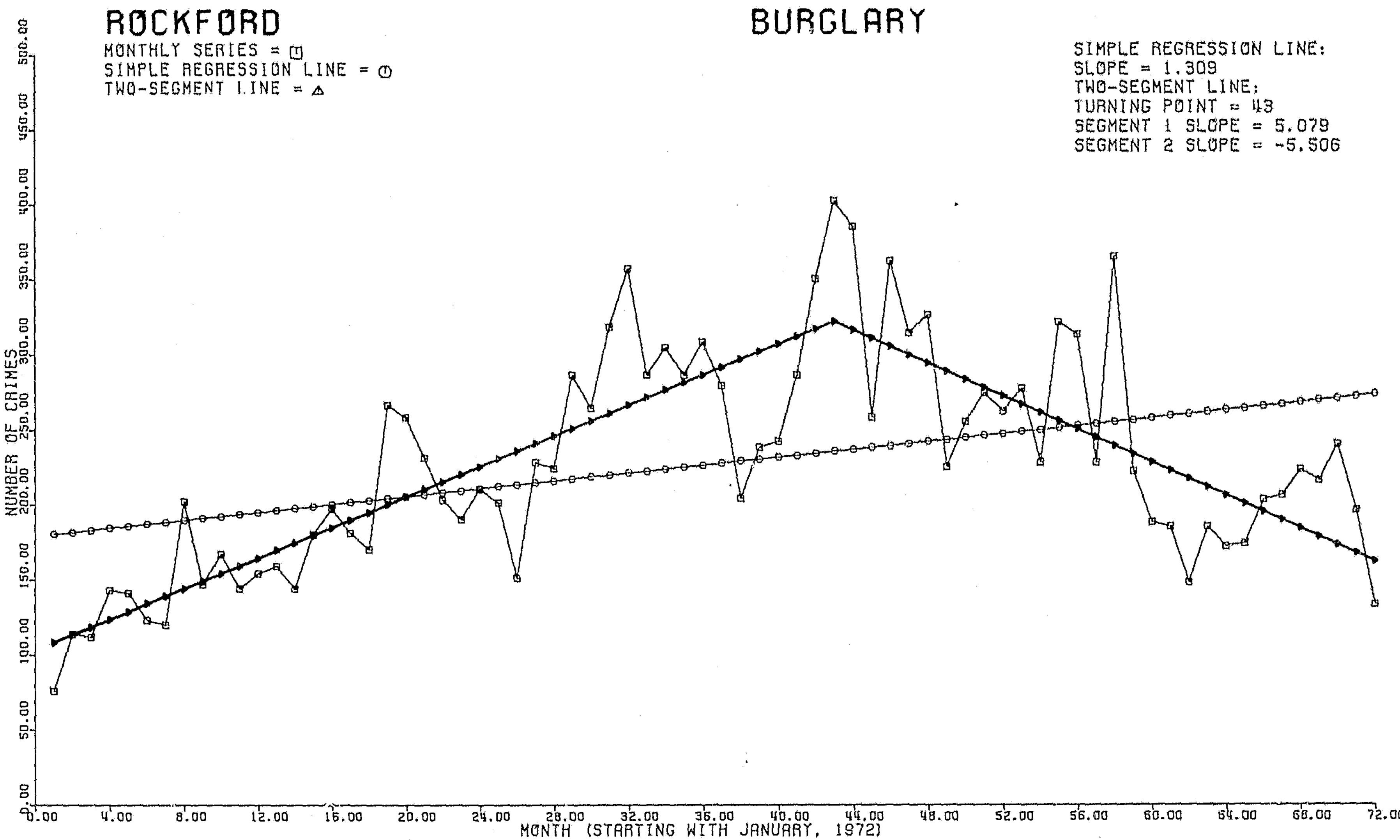
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 18



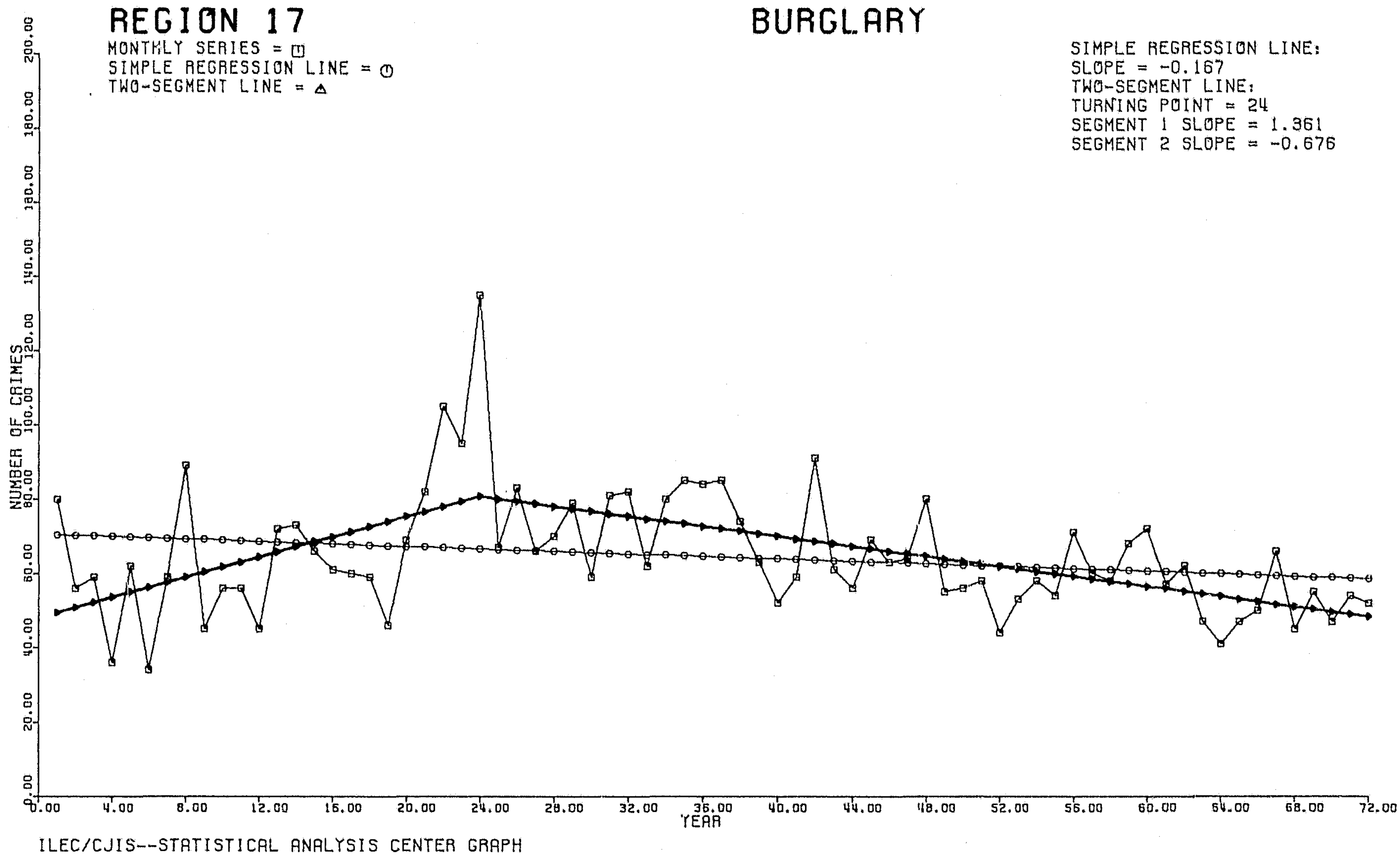
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 19



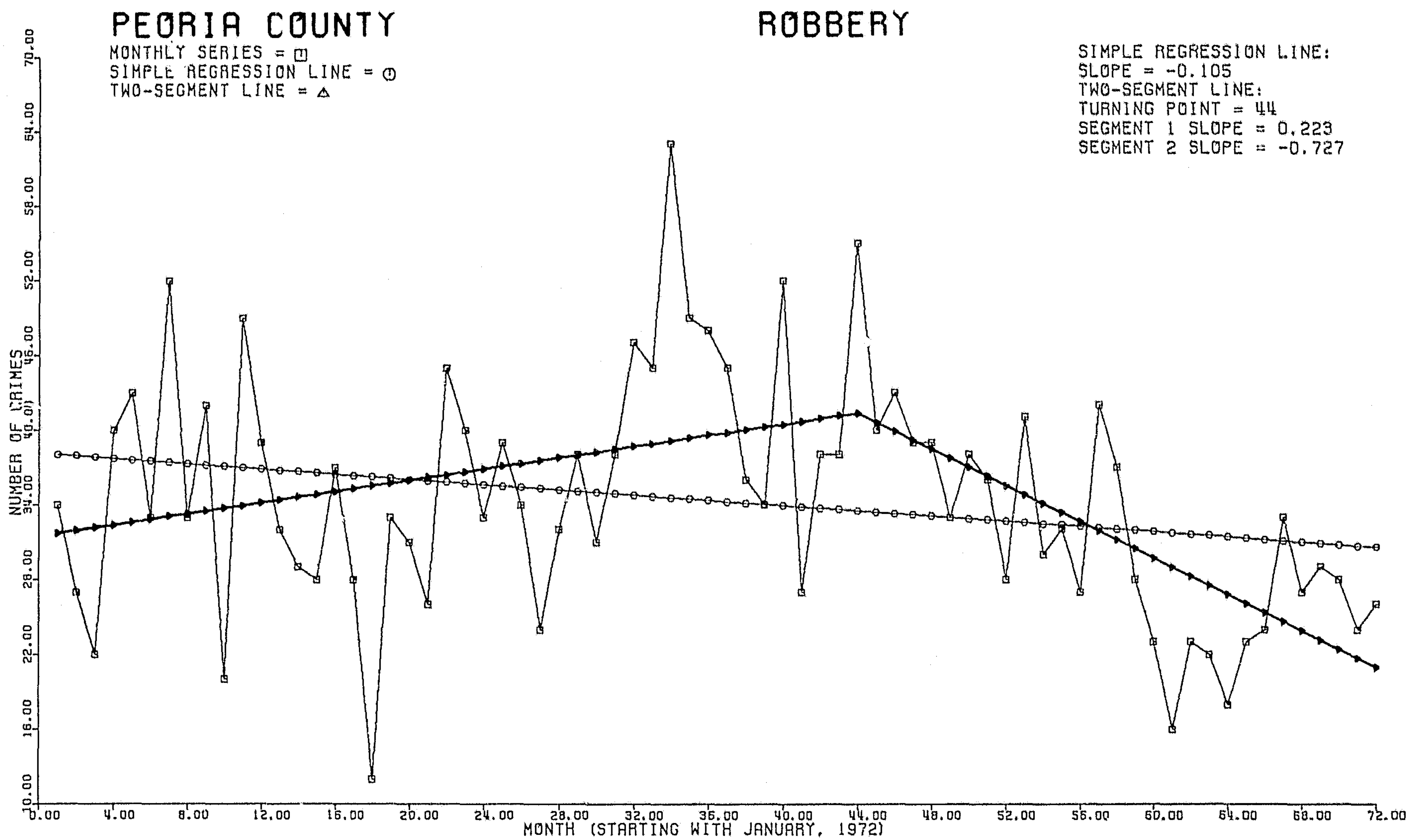
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 20



REGION 17
BURGLARY
MONTHLY SERIES = ▢
SIMPLE REGRESSION LINE = ◯
TWO-SEGMENT LINE = △
SIMPLE REGRESSION LINE:
SLOPE = -0.167
TWO-SEGMENT LINE:
TURNING POINT = 24
SEGMENT 1 SLOPE = 1.361
SEGMENT 2 SLOPE = -0.676
NUMBER OF CRIMES
YEAR
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 21



ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 22

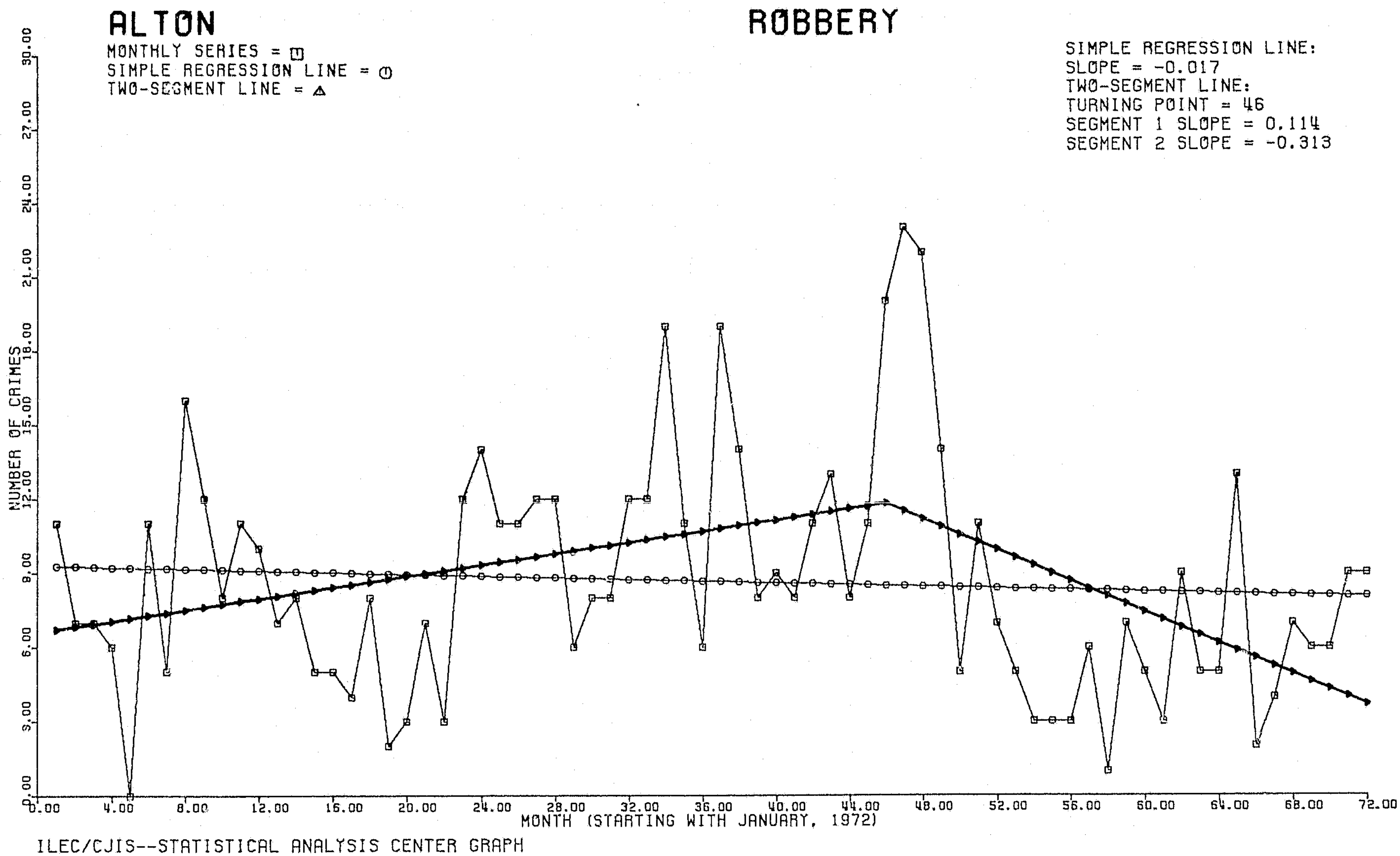
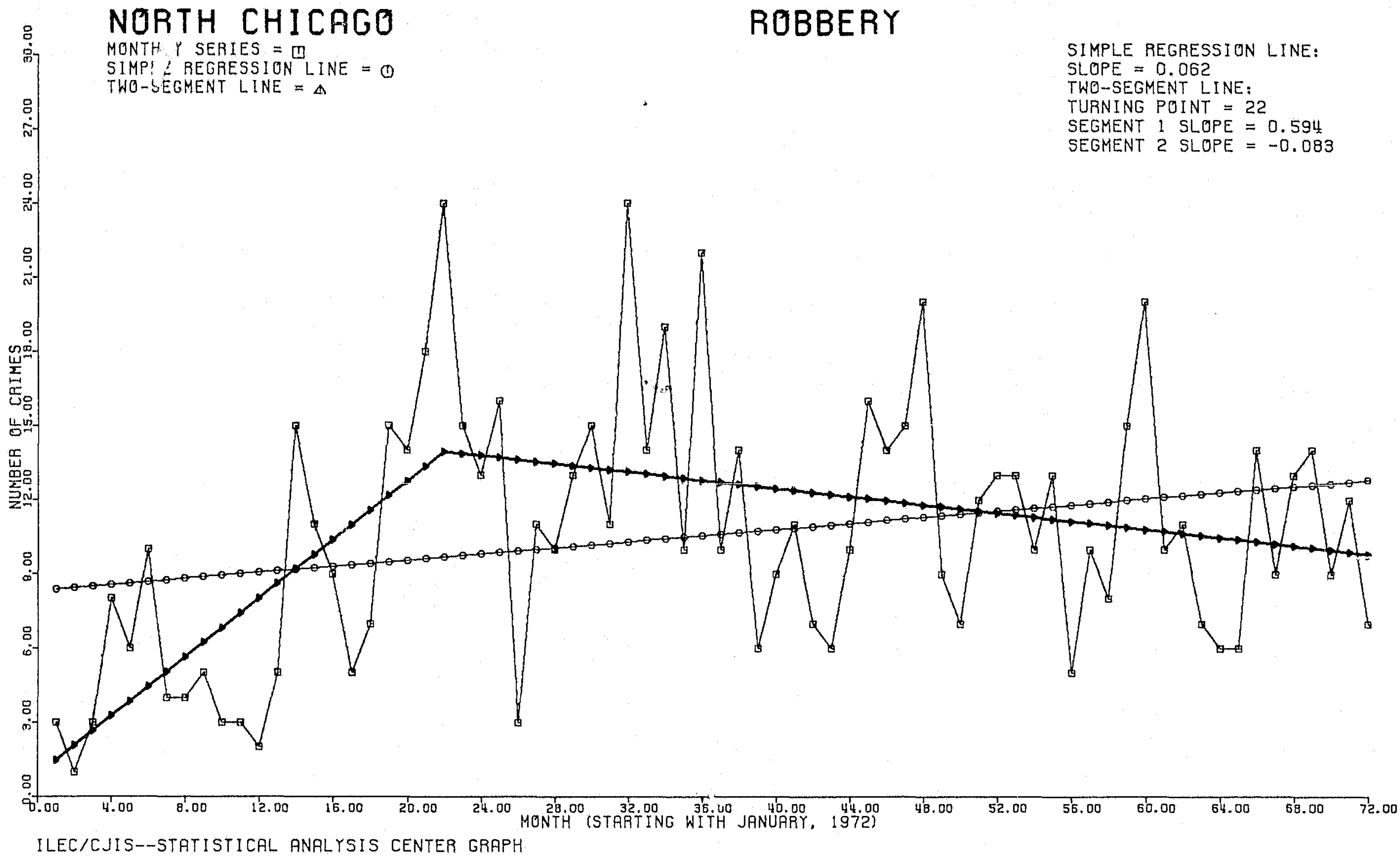

ALTON
ROBBERY
MONTHLY SERIES = ◻
SIMPLE REGRESSION LINE = ○
TWO-SEGMENT LINE = △
SIMPLE REGRESSION LINE:
SLOPE = -0.017
TWO-SEGMENT LINE:
TURNING POINT = 46
SEGMENT 1 SLOPE = 0.114
SEGMENT 2 SLOPE = -0.313
NUMBER OF CRIMES
0.00
3.00
6.00
9.00
12.00
15.00
18.00
21.00
24.00
27.00
30.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
36.00
40.00
44.00
48.00
52.00
56.00
60.00
64.00
68.00
72.00
MONTH (STARTING WITH JANUARY, 1972)
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

FIGURE 23


NORTH CHICAGO
ROBBERY
MONTHLY SERIES = □
SIMPLE REGRESSION LINE = ○
TWO-SEGMENT LINE = △
SIMPLE REGRESSION LINE:
SLOPE = 0.062
TWO-SEGMENT LINE:
TURNING POINT = 22
SEGMENT 1 SLOPE = 0.594
SEGMENT 2 SLOPE = -0.083
NUMBER OF CRIMES
0.00
3.00
6.00
9.00
12.00
15.00
18.00
21.00
24.00
27.00
30.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
36.00
40.00
44.00
48.00
52.00
56.00
60.00
64.00
68.00
72.00
MONTH (STARTING WITH JANUARY, 1972)
ILEC/CJIS--STATISTICAL ANALYSIS CENTER GRAPH

SUMMARY AND CONCLUSIONS

This paper has two purposes: 1) to determine which Illinois counties and cities with population over 25,000 experienced the decline in reported Index robberies and burglaries that was evident in the state as a whole, and 2) to provide an example of such an analysis as a guide for those who want a quickly done and easily understandable method of describing time series.

The method of analysis in this paper has three stages of tests. Each succeeding stage describes the series in more detail. Since many series are eliminated by the early screening test, the time and effort required to do the most detailed test is only used on those series which justify it, and where greater detail is required for a particular decision. Even the most detailed test, however, is still quicker to do and more easily understandable than would be a time series analysis using more sophisticated techniques. Figure 24 summarizes the results of this method for Illinois robbery and burglary.

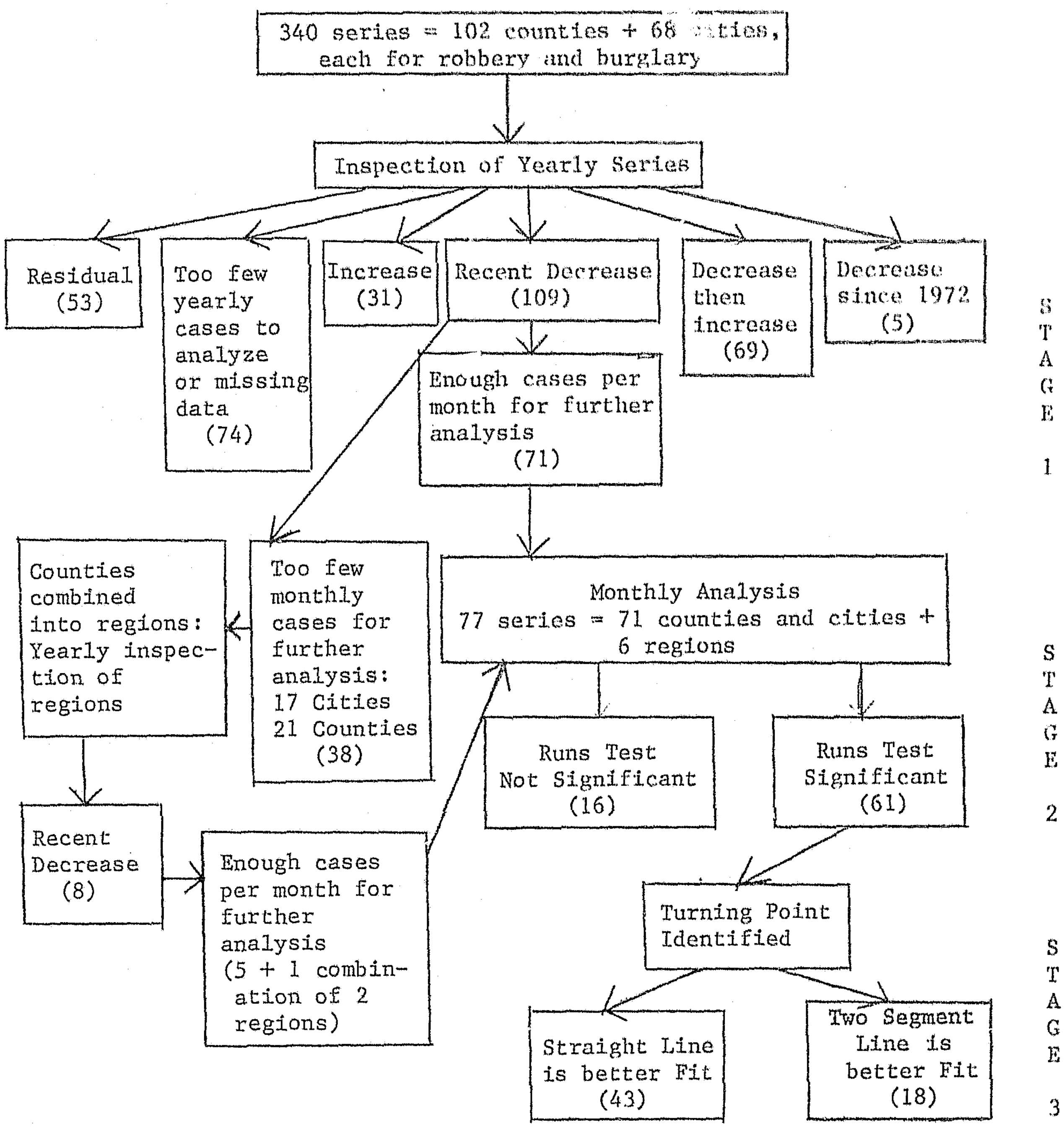
Which of the 340 Illinois reported Index robbery and burglary series for counties and large cities show a recent decrease? The first stage of analysis, an inspection of the yearly series, found 109 series that show a recent decrease. This is 41 percent of the series that had enough cases per year to analyze, and it clearly represents the predominant pattern. Two percent more show a decrease from 1972 rather than a change in the direction of the trend from increasing to decreasing, twelve percent show a steady increase, 26 percent show an increase following a decrease, and 20 percent neither increased nor decreased.

Some of the 109 showing a recent decrease in the yearly screening test were combined with each other and others were eliminated from further analysis, because they had too few cases per month to permit a monthly analysis. Seventy-seven series remained. Each of these was examined to determine if it should be adjusted for seasonality prior to a monthly analysis. None were significantly seasonal (see Appendix C.)

The second stage of analysis, a runs test, was then applied to the 77 series that passed the yearly test screening and had enough cases to analyze. The runs test found 61 monthly series that show a recent decrease. The combination of the yearly screening test and the runs test answers the first question posed by this paper. These 61 series are the local Illinois series that show a recent decrease in Index robbery or burglary. These series are the following:

FIGURE 24

Flow Chart of Method of Analysis



Burglary

County

Cook
Jersey
Lake
Livingston
Macoupin
Madison
Mason
Monroe
McHenry
Peoria
Piatt
Rock Island
St. Clair
Sangamon
Stephenson
Tazewell
Winnebago

City

Alton
Arlington Heights
Belleville
Calumet City
Chicago
Chicago Heights
Danville
Decatur
De Kalb
Downers Grove
Elgin
Evergreen Park
Galesburg
Granite City
Highland Park
Lansing
Maywood
North Chicago
Oak Park
Pekin
Peoria
Rock Island
Rockford
Schaumburg
South Holland
Villa Park

Region

10
17

Robbery

County

Cook
Kankakee
Lake
Peoria
Winnebago

City

Alton
Chicago
Evanston
Kankakee
North Chicago
Oak Park
Quincy
Rockford
Waukegan

Region

1
10+ 13

The final stage of analysis described each of these 61 series in greater detail, finding the month after which the series begins to decrease, the turning point. It then calculated the probability that the series is better described as a two segment line decreasing after this turning point than as a straight line from the beginning to the end of the series. The following 18 series were found to be best described as a two segment line decreasing after the month in parentheses:

Alton burglary (August, 1975)
Alton robbery (October, 1975)
Belleville burglary (December, 1975)
Chicago Heights burglary (June, 1975)
DeKalb burglary (April, 1973)
Elgin burglary (October, 1975)
Jersey County burglary (November, 1973)
Lansing burglary (August, 1975)
Livingston County burglary (July, 1976)
Mason County burglary (January, 1973)
Maywood burglary (September, 1975)
North Chicago burglary (October, 1973)
North Chicago robbery (September, 1973)
Peoria County robbery (August, 1975)
Region 17 burglary (November, 1973)
Rock Island burglary (August, 1976)
Rock Island County burglary (July, 1976)
Rockford burglary (July, 1975)

These results should be interpreted cautiously. First, we cannot say that these 61 series are the only Illinois series that show a recent decrease, because many series show decreases in the yearly analysis but have too few cases to permit a monthly analysis. Second, the methods of analysis used in this report are appropriate for description only. They cannot be used to predict how many reported robberies or burglaries there will be next year or next month. Third, this report makes no attempt to explain why certain Illinois localities showed decreases in reported Index robberies or burglaries and others did not. It simply attempts to accurately describe what occurred, not to explain why it occurred.

The first two stages of analysis, the yearly screening test and the runs test, will give planners and decision makers a quick and easy answer to whether crime has recently declined in an area. With straightforward modifications of the yearly criteria, the same tests will indicate whether crime has increased significantly. The third stage of analysis will provide more detail when necessary. It will determine the exact month a downward (or upward) change occurred, and whether a two segment line describes the series significantly better than a straight line.[23] Only where still more detail or a forecast is required will it be necessary to use more complex time series analysis techniques.

[23] A forthcoming SAC publication, Describing and Forecasting Chicago Homicide, expands this method to three segment line models.

APPENDIX A

METHOD OF COMBINING SMALL COUNTIES

Method of Combining Counties with Few Crimes

When the number of reported robberies or burglaries per month was too few for analysis in some counties, these counties were combined with others that are contiguous to them and that have similar characteristics. This made it possible to analyze a monthly time series for the group of counties, even though an analysis would have been impossible for each county separately.

The choice of groups of counties to combine was made according to the Illinois Law Enforcement Commission's (ILEC) planning regions. Each ILEC region includes a group of counties that are contiguous and somewhat similar to each other geographically and demographically. These counties cooperate with one another to plan for the expenditure of ILEC funds. Although there are, of course, many differences among the counties in a region, they do work together to meet their planning goals.

Regional data were analyzed only where the county's yearly series appeared to show a decrease, and where the county had an average of fewer than 60 robberies or burglaries per year. If one of the counties in a region had enough reported offenses for analysis, but other counties did not, we analyzed both the region and the larger county separately. In one case, two regional robbery series appeared to be decreasing, but there were too few robberies reported in the regions per month for analysis. Since these two regions (10 and 13) were contiguous, we analyzed their combined monthly time series. Even where counties were combined for a monthly analysis, each county and each city was analyzed separately in the yearly analysis.[1]

The following is a list of each region in which a monthly time series was analyzed, and each county in the region. Regions 10 and 13 were analyzed together as well as separately. Figure A is a map showing the location of each region. Table A contains the results of the analysis of the regional yearly series.

---

[1]Yearly analysis was not done if the county or city had an average of five or fewer Index robberies or burglaries per year.

Region 1

Carroll
DeKalb
JoDaviess
Lee
Ogle
Stephenson
Whiteside

Region 8

Bureau
LaSalle
Marshall
Putnam
Stark

Region 10

Fulton
Hancock
Henderson
Knox
McDonough
Warren

Region 13

Adams
Brown
Pike
Schuyler

Region 17

Calhoun
Christian
Greene
Jersey
Macoupin
Montgomery

Region 19

Clay
Crawford
Edwards
Effingham
Fayette
Jasper
Lawrence
Marion
Richland
Wabash
Wayne
White

Region 20

Alexander
Franklin
Gallatin
Hamilton
Hardin
Jackson
Jefferson
Johnson
Massac
Perry
Perry
Pope
Pulaski
Saline
Union
Williamson

Region 22

Clark
Coles
Cumberland
Douglas
Edgar

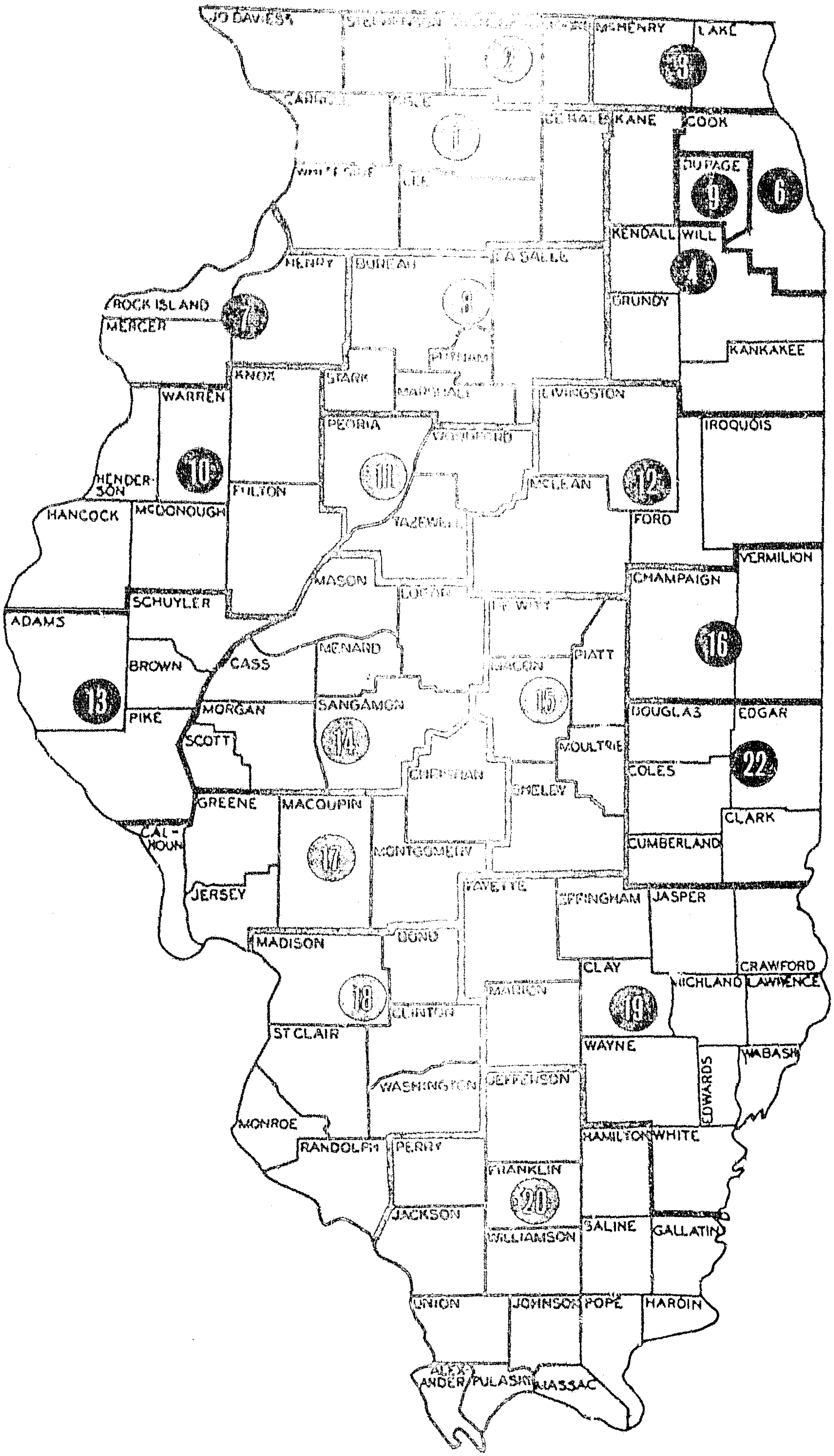

JO DAVIESS
McHENRY
LAKE
3
2
1
KANE
COOK
DU PAGE
9
6
KENDALL
WILL
4
HENRY
BUREAU
LA SALLE
ROCK ISLAND
MERCER
7
8
GRUNDY
KANKAKEE
KNOX
STARK
WARREN
LIVINGSTON
PEORIA
IROQUOIS
10
11
12
HENDER-SON
FULTON
McLEAN
HANCOCK
McDONOUGH
FORD
MASON
VERMILION
CHAMPAIGN
SCHUYLER
ADAMS
16
MENARD
PIATT
BROWN
CASS
13
15
MORGAN
SANGAMON
DOUGLAS
EDGAR
PIKE
SCOTT
14
MOULTRIE
22
COLES
GREENE
MACOUPIN
CAL-HOUN
CLARK
17
CUMBERLAND
JERSEY
JASPER
MADISON
CLAY
CRAWFORD
RICHLAND
LAWRENCE
18
19
ST CLAIR
WAYNE
WABASH
EDWARDS
MONROE
HAMILTON
WHITE
RANDOLPH
PERRY
FRANKLIN
20
JACKSON
SALINE
GALLATIN
WILLIAMSON
UNION
JOHNSON
POPE
HARDIN
ALEX-ANDER
PULASKI
MASSAC

Table A

Results of Yearly Analysis of Regions

Region 1	Robbery	Passed yearly.
	Burglary	Did not pass yearly.
Region 8	Robbery	Did not pass yearly.
	Burglary	Passed yearly.
Region 10	Robbery	Passed yearly; too few monthly cases.
	Burglary	Passed yearly.
Region 13	Robbery	Passed yearly; too few monthly cases.
	Burglary	Did not pass yearly.
Regions 10 + 13	Robbery	Passed yearly.
	Burglary	Not needed.
Region 17	Robbery	Did not pass yearly.
	Burglary	Passed yearly.
Region 19	Robbery	Did not pass yearly.
	Burglary	Did not pass yearly.
Region 20	Robbery	Passed yearly.
	Burglary	Did not pass yearly.
Region 22	Robbery	Passed yearly; too few monthly cases.
	Burglary	Did not pass yearly.

APPENDIX B

ILLINOIS CITIES AND COUNTIES SHOWING A DECREASE IN INDEX ROBBERIES OR BURGLARIES, BY INSPECTION OF YEARLY SERIES 1971-1977.

DECREASE FROM 1972

Niles Burglary[1]
Bureau County Robbery[1]
Clark County Robbery[1]
Marion County Robbery[1]
Washington County Robbery[1]

CHANGE IN DIRECTION FROM INCREASE TO DECREASE

Burglary

Counties

Cook
Douglas[2]
Edgar
Fulton
Jasper[2]
Jersey
Johnson[2]
Knox
Lake
La Salle
Livingston
Macoupin
Madison
Mason
Monroe
Montgomery
McDonough
McHenry
Peoria
Piatt
Pike[2]
Rock Island
Sangamon
St. Clair
Scott[1]
Stephenson
Tazwewll
White[2]
Winnebago
Woodford[1]

Cities

Alton
Arlington Heights
Belleville
Burbank
Calumet City
Chicago
Chicago Heights
Danville
Decatur
De Kalb
Downer's Grove
East St. Louis
Elgin
Evergreen Park
Galesburg
Granite City
Highland Park
Lansing
Lombard[3]
Maywood
Moline
North Chicago
Oak Park
Pekin
Peoria
Rockford
Rock Island
Schaumburg
South Holland
Springfield
Villa Park

Robbery

Counties

Adams[2]
Alexander[2]
Cook
Coles[2]
Franklin[2]
Grundy[1]
Jefferson[2]
Kankakee
Knox[2]
Lake
Lee[2]
Logan[1]
McDonough[2]
McLean
Peoria
Saline[2]
Tazewell[1]
Whiteside[2]
Winnebago
Woodford[1]

Cities

Alton
Arlington Heights[3]
Berwyn[3]
Calumet City
Chicago
De Kalb[3]
Downers Grove[3]
Elgin
Evanston
Evergreen Park[3]
Galesburg[3]
Granite City[3]
Kankakee
Lansing[3]
Lombard[3]
Moline[3]
Niles[3]
North Chicago
Oak Lawn[3]
Oak Park
Park Ridge[3]
Pekin[3]
Peoria
Quincy
Rockford
Schaumburg[3]
Villa Park[3]
Waukegan

---

[1] Too few cases per month to allow a monthly analysis. No regional analysis was done, since the region is metropolitan.

[2] Too few cases per month to allow a monthly analysis, but this county is included in the monthly analysis of a combination of counties (see Appendix B.)

[3] Two few cases in this city for further analysis.

APPENDIX C

METHODS OF DETERMINING THE PRESENCE OF SEASONALITY

Methods of Determining the Presence of Seasonality

This analysis used the Census X-11 program and the Bell Canada Model test to determine whether any of the 77 series that passed the yearly screening test and had enough cases to analyze are significantly seasonal. Neither the X-11, the Bell Canada, or any other method of detecting seasonality gives completely unambiguous results. The results must be interpreted, sometimes subjectively. This appendix describes how the Bell Canada and X-11 results were interpreted for the 77 series. It is also a general guide for those who wish to use these two computer programs. For more detail about detecting and analyzing seasonality, see the references cited below and the forthcoming SAC report on seasonality.

The Bell Canada Test[2]

The Bell Canada Model test uses the same general mathematical logic as the X-11, but is simpler and has fewer options. Both take a moving average to estimate the trend-cycle, and then separate this trend-cycle from the seasonal and the irregular.[3] This produces three component series from the original one: the trend-cycle, the seasonal, and the irregular.

In both the Bell Canada and the X-11, these three components may be related to each other either additively or multiplicatively. If additive, the three components are independent of each other. If multiplicative, they are dependent on each other. In an additive seasonal model, the "extra" number of crimes reported in a high month as opposed to a low month would be about the same, regardless of how high the general trend was. In a multiplicative seasonal model, the seasonal effect in a given month would be high if the trend is high, and low if the trend is low. The Bell Canada calculates the three components twice, once assuming an additive model, and again assuming a multiplicative. It then computes the ratio between the seasonal effect and the irregular effect. This produces a statistic which varies as an F ratio (see pages 27-30.) It thus can be used as a rough

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[2] This program, developed by John Higginson in 1977, was sent to SAC by the Bureau of Labor Statistics.

[3] See pages 15-16 for definitions of the three components.

TABLE B

Results of the Bell-Canada Seasonality Screen

Burglary County	Additive F ratio	Multiplicative F ratio
Cook	4.32*	4.76*
Edgar	2.43*	2.32
Fulton	1.14	1.18
Jersey	.66	.90
Knox	.60	.65
Lake	4.65*	4.90*
LaSalle	.94	.81
Livingston	.91	a
Macoupin	1.78	1.78
Madison	.81	.72
Mason	1.83	1.60
Monroe	1.57	1.65
Montgomery	2.17	2.18
McDonough	.97	1.29
McHenry	2.30	2.11
Peoria	4.32*	4.34*
Piatt	1.21	1.20
Rock Island	3.07*	3.50*
St. Clair	3.22*	3.27*
Sangamon	.51	.53
Stephenson	6.20*	7.21*
Tazewell	1.98	1.82
Winnebago	6.43*	6.96*
City		
Alton	1.22	1.07
Arlington Heights	5.60*	5.75*
Belleville	1.05	1.02
Burbank	.85	.92
Calument City	.90	.80
Chicago	1.74	1.91
Chicago Heights	3.76*	4.05*
Danville	4.09*	4.11*
Decatur	1.16	1.17
DeKalb	1.56	1.43
Downers Grove	.51	.50
East St. Louis	2.97*	a
Elgin	.62	.77
Evergreen Park	1.81	1.50
Galesburg	1.24	1.46
Granite City	.63	.52
Highland Park	2.34	2.38
Lansing	.69	.73
Maywood	2.69*	2.53*
Moline	2.66*	2.86*
North Chicago	.51	.57

TABLE B - Continued

City Con't.		
Oak Park	3.60*	3.28*
Pekin	1.14	1.14
Peoria	4.47*	4.49*
Rock Island	3.39*	3.64*
Rockford	7.78*	8.12*
Schaumburg	.45	.53
South Holland	6.44*	7.72*
Springfield	.38	.46
Villa Park	1.35	1.41
Region		
8	.81	.65
10	.61	.73
17	1.97	2.04
Robbery		
County		
Cook	2.35	2.74*
Kankakee	1.93	1.44
Lake	3.83*	3.70*
McLean	2.45*	a
Peoria	1.61	1.63
Winnebago	3.27*	3.32*
City		
Alton	1.30	1.25
Calumet City	1.13	a
Chicago	2.26	2.63*
Elgin	1.41	1.64
Evanston	1.21	1.05
Kankakee	1.94	1.49
North Chicago	1.01	.62
Oak Park	1.87	1.77
Peoria	1.58	1.60
Quincy	1.18	a
Rockford	3.32*	3.18*
Waukegan	4.54*	4.40*
Region		
1	2.92*	2.37
10+13	2.01	1.59
20	.53	.53

*F ratio 2.41 or over. These series were analyzed further by the Census X-11 program.

[a]A multiplicative adjustment could not be done, since there are zero values in the series.

indicator of whether a series is seasonal, and whether the seasonality is multiplicative or additive.[4]

The X-11 differs from the Bell Canada in a number of ways. 1) It provides options for a variety of moving averages, not just the twelve-by-two term moving average automatically performed by the Bell Canada. 2) It has a standard method, with a number of options available, for handling extreme values. 3) It contains, as an option, a "trading day adjustment," which tests for a pattern according to days of the week as well as seasons of the year.[5] 4) It is able to handle moving seasonality, seasonal effects that change from year to year, in addition to the stable seasonality that the Bell Canada handles. 5) It also provides a number of statistical tests of the series, instead of the Bell Canada's one result: "enough" or "not enough" seasonality. These X-11 tests, used in combination with each other, will provide a clearer indication of whether the series is seasonal, the degree of seasonality, and whether the seasonality is additive or multiplicative than will the Bell Canada.

Table B gives the results of the Bell Canada seasonality screen for all 77 series for which a monthly analysis was done, those series which passed the yearly screening test and had sufficient cases per month for further analysis. Not one of these 77 had a Bell Canada F ratio of 10 or more, either additive or multiplicative. Twenty-seven series had either an additive or a multiplicative F ratio that was between 2.41 and 9. These 27 were analyzed further for seasonality, using the tests available on the X-11 program as suggested by a BLS technical paper (Plewes 1977.)

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[4]The F-test, however, is not entirely appropriate for several reasons, but especially because the oberservations in a time series cannot be assumed to be independent of each other. Perhaps for this reason, the Bell Canada prints out extremely conservative results. Although the one percent significance level for a ten-year monthly series would be 2.41 (given that the assumptions of independence, constant variance, normality, etc. hold), the Bell Canada only prints out that the series shows "enough seasonality" to justify using the X-11 if the F is 20 or over. BLS researcher Kathleen Beale suggests that the following criterion be used (conversation, February, 1979): A Bell Canada F under 2.41 indicates no seasonality; an F between 2.41 and 9 probably indicates no seasonality, but should be studied further; an F of 10 to 19 may be seasonal but should also be studied further; and an F of 20 or more may be considered seasonal. This criterion was used in this study. All series with an F of 2.41 or over on either the additive or multiplicative Bell Canada model were analyzed further with the X-11.

[5]Use of the trading day adjustment requires a longer series than the six-year series examined here.

X-11 Program Results

F test and Relative Contribution of the Irregular (Plewes 1977:4-5,7). The stable seasonality F test on the X-11 is computed like the F test on the Bell Canada, although the results may differ because of differences in the X-11 moving average and treatment of extremes. The relative contribution of the irregular is calculated by comparing the average month-to-month differences without regard to sign (or percent change in a multiplicative adjustment) of the three components, irregular, trend-cycle and seasonal (see Shiskin 1967:18-19.)[6]

Figures B and C are two pages from the X-11 printout for a multiplicative adjustment of the Rockford burglary series.[7] The stable seasonality F ratio is circled in Figure B. It is 8.312. The relative contribution of the irregular over a one month span is circled in Figure C. It is 51 percent, which is quite high. The general rule of thumb suggested by Plewes is to reject the hypothesis of stable seasonality being present if the F is under 2.41, or is 2.41 to 15 and the irregular contribution is over 14 percent, or is between 15 and 50 and the irregular contribution is over 25 percent, or is over 50 and the irregular contribution is over 30 percent. By this rule of thumb, the hypothesis of seasonality would be rejected for the Rockford burglary multiplicative adjustment.

Table C gives the results of these X-11 tests for all 27 series. According to Plewes's rule of thumb, the hypothesis of stable seasonality should be rejected for all 27, since the stable F ratio in each case is between 2.41 and 15 and the relative contribution of the irregular always far exceeds 14 percent.

This X-11 result finds the hypothesis of stable seasonality unlikely. However, the series may have moving seasonality. In moving seasonality, the seasonal effect varies systematically from year to year. There is another X-11 test to detect moving seasonality.

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[6]The relative contribution of each of the three components changes according to the span of months being considered. From month to month, the contribution of the irregular is usually high relative to the contribution of the trend-cycle, since the effect of the trend-cycle gradually builds up over time, while the effect of the irregular does not. As a general rule, the relative contribution of the seasonal should be at least as high as the irregular over a one month span, and should remain relatively high over longer spans, until it drops to near zero at the twelve month span.

[7]We chose the Rockford burglary series as an example, because it seemed to have more seasonality than most of the others we tested.

Figure B

X-11 Stable and Moving Seasonality Results: Rockford Burglaries, Multiplicative Adjustment

D 8. FINAL — ROCKFORD BURGLARIES — UNMODIFIED SI RATIOS — P. 3, SERIES

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
1972	60.1	88.9	85.2	106.5	102.9	88.1	84.3	139.3	99.1	109.0	89.7	91.0	95.3
1973	89.4	77.7	94.6	101.9	92.7	86.3	133.5	127.5	112.8	98.5	92.0	100.8	100.6
1974	93.5	66.8	95.2	88.7	108.7	97.6	115.7	128.2	101.0	105.3	97.8	105.2	100.3
1975	96.7	72.1	84.9	85.9	99.3	117.7	131.1	122.9	81.2	112.8	97.0	100.0	100.1
1976	69.1	79.6	88.3	88.3	98.5	85.5	126.1	127.9	96.9	161.7	102.6	90.7	101.3
1977	92.2	75.0	94.8	89.1	91.1	106.8	108.1	115.6	110.2	121.0	98.2	66.8	97.4
AVGE	83.5	76.7	90.5	93.4	98.9	97.0	116.5	126.9	100.2	118.0	96.2	92.4	

TABLE TOTAL- 7141.4

STABLE SEASONALITY TEST

	SUM OF SQUARES	DGRS.OF FREEDOM	MEAN SQUARE	F
BETWEEN MONTHS	14071.869	11	1279.261	8.312**
RESIDUAL	9234.600	60	153.910	
TOTAL	23306.469	71		

**STABLE SEASONALITY PRESENT AT THE 1 PER CENT LEVEL

MOVING SEASONALITY TEST

	SUM OF SQUARES	DGRS. OF FREEDOM	MEAN SQUARE	F
BETWEEN YEARS	446.062	5	89.212	0.852*
ERROR	5759.424	55	104.717	

*NO EVIDENCE OF MOVING SEASONALITY AT THE ONE PER CENT LEVEL

CONTINUED

1 OF 2

Figure C

X-11 Summary Measures for Rockford Burglaries, Multiplicative Adjustment

F 2. SUMMARY MEASURES

AVERAGE PER CENT CHANGE WITHOUT REGARD TO SIGN OVER INDICATED SPAN

SPAN IN MONTHS	B1 O	D11 CI	D13 I	D12 C	D10 S	A2 P	C18 TD	F1 MCD	E1 MOD.O	E2 MOD.CI	E3 MOD.I
1	16.78	12.80	12.52	2.36	11.98	0.0	0.0	3.13	14.17	6.99	6.66
2	19.40	13.32	11.82	4.75	14.80	0.0	0.0	4.99	17.60	8.86	6.92
3	22.73	14.95	11.76	7.08	16.49	0.0	0.0	7.06	19.92	10.20	6.02
4	25.30	15.25	11.48	9.33	19.29	0.0	0.0	8.91	23.77	11.80	6.51
5	26.29	16.34	10.24	11.50	19.78	0.0	0.0	11.05	25.83	13.57	5.83
6	29.82	16.64	9.21	13.55	21.01	0.0	0.0	13.16	28.49	15.07	5.19
7	30.50	19.57	11.30	15.55	18.82	0.0	0.0	15.48	28.06	16.84	5.81
9	31.58	24.14	11.68	19.81	16.38	0.0	0.0	20.07	28.25	20.96	6.07
11	29.57	26.80	10.16	24.07	11.83	0.0	0.0	24.10	27.83	24.72	5.30
12	29.28	29.20	11.98	26.08	0.91	0.0	0.0	25.87	26.75	26.74	6.91

RELATIVE CONTRIBUTIONS OF COMPONENTS TO VARIANCE IN ORIGINAL SERIES

SPAN IN MONTHS	D13 I	D12 C	D10 S	A2 P	C18 TD	TOTAL	RATIO (X100)
1	51.27	1.82	46.91	0.0	0.0	100.00	108.63
2	36.66	5.91	57.44	0.0	0.0	100.00	101.27
3	30.04	10.88	59.08	0.0	0.0	100.00	89.12
4	22.30	14.74	62.96	0.0	0.0	100.00	92.35
5	16.68	21.04	62.28	0.0	0.0	100.00	90.92
6	11.95	25.86	62.19	0.0	0.0	100.00	79.81
7	17.65	33.41	48.95	0.0	0.0	100.00	77.83
9	17.12	49.21	33.67	0.0	0.0	100.00	79.95
11	12.54	70.44	17.01	0.0	0.0	100.00	94.08
12	17.40	82.50	0.10	0.0	0.0	100.00	96.18

AVERAGE DURATION OF RUN

CI	I	C	MCD
1.69	1.54	11.83	2.39

I/C RATIO FOR MONTHS SPAN

1	2	3	4	5	6	7	8	9	10	11	12
5.30	2.49	1.66	1.23	0.89	0.68	0.73	0.59	0.59	0.51	0.42	0.46

MONTHS FOR CYCLICAL DOMINANCE 5

AVERAGE PER CENT CHANGE WITH REGARD TO SIGN AND STANDARD DEVIATION OVER INDICATED SPAN

SPAN IN MONTHS	B1 O AVGE	B1 O S.D.	D13 I AVGE	D13 I S.D.	D12 C AVGE	D12 C S.D.	D10 S AVGE	D10 S S.D.	D11 CI AVGE	D11 CI S.D.	F1 MCD AVGE	F1 MCD S.D.
1	3.10	22.40	1.64	19.07	0.67	2.78	1.18	15.22	2.33	19.38	0.62	3.80
2	4.40	23.92	1.03	15.81	1.43	5.52	2.06	18.06	2.49	17.00	1.22	5.97
3	6.34	28.02	1.44	17.72	2.22	8.16	2.78	20.02	3.73	20.25	2.07	8.48
4	7.77	30.65	1.16	16.45	3.04	10.66	3.46	22.53	4.21	19.77	2.85	10.78
5	9.03	33.33	0.94	14.87	3.87	13.02	4.48	27.27	4.78	20.22	3.71	13.23
6	11.05	36.50	0.65	13.71	4.70	15.27	5.48	28.82	5.23	20.26	4.61	15.44
7	12.13	37.83	1.87	17.39	5.56	17.43	4.27	23.66	7.44	25.79	5.59	17.71
9	12.22	36.99	1.95	19.44	7.40	21.58	2.63	19.48	9.32	29.55	7.41	22.00
11	11.90	33.78	1.46	14.82	9.33	25.40	1.20	14.73	10.87	30.91	9.29	25.67
12	12.31	34.55	1.80	16.62	10.23	27.14	0.03	1.15	12.25	34.41	10.24	27.22

TABLE C

X-11 Tests for Seasonality[a]

	Additive					Multiplicative				
	Stable F	% Cont. of I.	Moving $F \geq 2.2$?	MCD	1.36-1.75 ADR of I?	Stable F	% Cont. of I.	Moving $F \geq 2.2$?	MCD	1.36-1.75 ADR of I?
Burglary										
County										
Cook	7.96	53.08%	no	5	yes	8.92	52.86%	no	5	yes
Edgar	2.30	60.96	no	6	no 1.34	2.17	56.78	no	6	yes
Lake	8.48	44.38	no	4	yes	7.80	46.19	no	4	yes
Peoria[b]	7.32	56.96	yes 2.59	5	yes	7.04	57.02	yes 2.40	4	yes
Rock Island	4.65	72.17	no	6+	yes	5.65	74.21	no	6	yes
St. Clair[b]	4.70	55.00	yes 3.04	6+	yes	4.41	60.92	yes 3.15	6+	yes
Stephenson	6.63	57.82	no	6+	yes	5.71	59.66	no	6	yes
Winnebago	8.87	47.94	no	5	yes	7.87	46.38	no	5	yes
City										
Arlington Hts[b]	9.31	54.55	yes 3.20	6+	yes	9.27	59.96	yes 2.37	6+	yes
Chicago Hts	4.04	76.84	no	5	yes	3.98	83.60	no	6+	yes
Danville	4.76	61.52	no	6	yes	4.88	60.10	no	6	yes
E. St. Louis[bc]	2.95	64.55	yes 2.90	6	yes					
Maywood	3.20	62.22	no	6+	yes	2.75	72.78	no	6+	yes
Moline	3.32	72.33	no	6	yes	3.60	65.64	no	6	yes
Oak Park	4.54	70.26	no	6	yes	4.33	79.09	no	6	yes
Peoria	6.79	51.22	no	5	yes	6.38	54.78	no	4	yes
Rock Island	6.11	58.06	no	6	yes	7.08	52.25	no	5	yes
Rockford	10.07	46.88	no	5	yes	8.31	51.27	no	5	yes
So. Holland	5.29	59.67	no	6+	yes	5.50	61.20	no	6	yes

TABLE C-Continued

	Additive					Multiplicative				
	Stable F	% Cont. of I.	Moving $F \geq 2.2$?	MCD	1.36-1.75 ADR of I?	Stable F	% Cont. of I.	Moving $F \geq 2.2$?	MCD	1.36-1.75 ADR of I?
Robbery										
County										
Cook	5.22	67.10	no	5	yes	5.67	71.06	no	6	yes
Lake	6.48	64.64	no	5	yes	5.82	61.99	no	6+	yes
McLean[c]	2.12	60.91	no	6+	yes					
Winnebago	5.36	64.54	no	6+	yes	3.92	79.75	no	6+	no 1.82
City										
Chicago	4.68	68.63	no	5	yes	5.19	73.52	no	6	yes
Rockford	5.89	64.97	no	5	yes	4.06	71.87	no	6+	yes
Waukegan	5.65	52.77	no	5	yes	4.70	77.98	no	6	yes
Region										
1	2.76	80.99	no	6+	yes	2.06	88.91	no	6+	yes

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[a]See text for descriptions of these tests.

[b]When these series was re-run with the weights suggested by Plewes (1977:6) for moving seasonality, the results were the following:

Peoria County	7.34	62.83	yes 2.42	5	yes	7.38	63.29	yes 2.29	4	yes
St. Clair Co.	4.82	53.68	yes 2.29	6+	yes	4.49	60.94	yes 2.56	6+	yes
Arlington Hts	10.64	59.36	no	6	yes	9.67	60.47	no	6+	yes
E. St. Louis[c]	3.05	64.38	yes 2.26	6	yes					

[c]Multiplicative adjustment could not be done, since there were zero values in the data.

Moving Seasonality Ratio (MSR). The X-11 program computes an F ratio for moving seasonality, and provides the MSR for each month. The MSR's are guides to adjusting a series with moving seasonality (see Plewes 1977:6; Shiskin 1967:16.)

For the Rockford burglary series example in Figure B, the moving seasonality F ratio is not significant. Plewes's rule of thumb is that an F ratio of 2.20 or greater indicates moving seasonality. Four of the 27 series showed a significant moving seasonality F ratio: the Arlington Heights burglary series, the Peoria County burglary series, the East St. Louis burglary series, and the St. Clair County burglary series (see Table C.) These series were readjusted using the weights for each month according to the MSR for that month, as suggested by Plewes. The results of these adjustments are in a footnote of Table C. The weights produce an insignificant moving seasonality F for for Arlington Heights, and reduce the moving seasonality F in the other three cases. Modified weighting might completely remove the effect of moving seasonality from these three. Even though the problem of moving seasonality was not completely removed, the low stable F ratios and the high percent contributions of the irregular in these three series do not indicate the presence of seasonality.

Months for Cyclical Dominance (MCD). The MCD is a measure of the average number of months required for the trend-cycle to exceed the irregular. From one month to the next, the irregular is the most noticeable movement in a series. Over a longer time span, the relative effect of the trend-cycle gradually increases until it exceeds the relative effect of the irregular. In Figure C, this occurs at a five month span, where the relative contribution of the irregular (I) is 16.68 percent, and the relative contribution of the trend-cycle (C) is 21.04 percent. The MCD is thus 5 for the multiplicative adjustment of the Rockford burglary series. According to Plewes's (1977:9) rule of thumb, a series with a 1, 2 or 3 MCD is usually acceptable, a series with a 4 or 5 MCD is borderline, and a series with a 6 or greater MCD is reflective of problems in the series, and should be studied further.

Of the 52 additive or multiplicative adjustments for the 27 series in Table C, not one meets Plewes's usually acceptable standard of MCD 1, 2 or 3; 19 are borderline at 4 or 5; and 33 are unacceptable at 6 or greater. This indicates, as the results of the F test and relative contribution of the irregular also indicated, that these series show a lot of irregularity.[8]

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[8]Marshall (1977a, 1977b) also found that crime data usually have a strong random or chance character.

Average Duration of Run (ADR). This final X-11 result is a simple test of the smoothness of the irregular component. Although it is a runs test, it is not a test for curvilinearity as is the runs test used for analysis in the body of this paper. The ADR is a runs test of the degree of random variation from one point to the next in the series.

An ADR run is defined as a series of points, each of which is higher (or each of which is lower) than the preceeding point (see Kendall 1976:26.) The higher the ADR, the longer the average run, and therefore, the fewer the total number of runs in the series.

If the irregular has too few runs relative to chance (the ADR is high), it is too smooth, and the seasonal or trend-cycle component of the adjustment may contain some of the irregular. If the irregular has too many runs relative to chance (the ADR is low) the irregular may contain some change that should be considered part of the seasonal or the trend-cycle. Plewes's rule of thumb is that the ADR should fall between 1.36 and 1.75.

In the Rockford burglary series example, Figure C, the average duration of run of the irregular (I) is 1.54, which is within Plewes's acceptable range. Of the 52 adjustments in Table C, two show an unacceptable irregular ADR. The Edgar County burglary additive adjustment is too low and the Winnebago County robbery multiplicative adjustment is too high. However, the multiplicative Edgar County and the additive Winnebago County ADR's are acceptable. This indicates that the adjustment with the acceptable ADR is better than the adjustment, whether additive or multiplicative, without it.

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