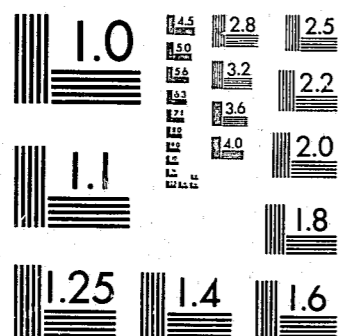


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STATE OF WASHINGTON

John Spellman, Governor

HISTORY OF CRIMES AND ARRESTS:
STATE OF WASHINGTON 1971 TO 1982

Prepared by
OFFICE OF FINANCIAL MANAGEMENT
FORECASTING AND ESTIMATION DIVISION
JOE TALLER - DIRECTOR



STATE OF WASHINGTON

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STATE OF WASHINGTON, 1971 TO 1982**

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Olympia, Washington
August 1983

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U.S. Department of Justice
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INTRODUCTION

This report presents a comparison of crime and arrest data for the State of Washington from 1971 to 1982. The report is the result of an extensive update of historical crime and arrest data for the state. Its purpose is to present a complete and accurate history of recent crime and arrest patterns and to provide an historical context for evaluating many of the changes now effecting Washington's criminal justice system. With this goal in mind the report has been designed as an historical summary with a scope broad enough to be useful to many of the agencies that comprise the state's criminal justice system.

The bulk of the work represented by the report involved the estimation of non-reported arrest data. Section 1 is the methods section of the report, where these estimation procedures are outlined. Also included in this section are definitions of the terms and concepts used throughout the report.

In section 2, results are shown as a comparison of crime and arrest volumes from 1971 to 1982, using a series of graphs. Following is a discussion of some of the implications of those results.

Section 3 consists of the appendices. Procedures outlined in the methods section of the text are documented here.

SECTION I

METHODS

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Data Sources

The source of both crime and arrest data has been the Uniform Crime Reporting (UCR) program. This is a system of reporting crimes and arrests according to a uniform set of definitions, outlined in the Uniform Crime Reporting Handbook, published by the FBI. The UCR program is organized both at the state and the national level. Nationally the program is run by the FBI. They collect monthly data from each reporting police jurisdiction in the U.S. (reporting to the UCR program is voluntary), to be analyzed and compiled in annual publications of Crime in the United States. The Washington UCR program is managed by the Washington Association of Sheriffs and Police Chiefs. Their data are also published annually, in Crime in Washington State. Data from national and state publications are compatible and both have been used as source documents for this study.

Population data are from Washington State Office of Financial Management intercensal estimates and from federal census counts.

Data Limitations

Crime reporting is more complete than arrest reporting. On the average jurisdictions serving only 80% of the state's population reported arrest data, while 95% of the population was represented in crime reports. Consequently the FBI estimates totals for reported crime. This is done by establishing a crime rate from the reporting population for each type of crime and applying it to the total population.* However total arrests are not estimated by the FBI, so it was necessary to establish methods for estimating missing arrest data.

This estimation effort was limited to seven of the eight part I crimes. Arson was not used because it has only recently been included as a Part I crime. Part I crimes are *violent crimes* and serious property crimes. They are:

*1982 FBI data had not been published at the time of this writing and data used from Crime in Washington State 1982 was not published with 100% estimates. Consequently 1982 crime totals have been estimated from that publication using this method.

1. Murder
2. Rape
3. Robbery
4. Aggravated Assault
5. Burglary
6. Larceny
7. Auto Theft
8. Arson

Part I crimes constitute the FBI's crime index. They were selected for their seriousness, frequency of occurrence and the probability of their being reported to police agencies. They are a good indicator of the trend in total crime, as well as the crimes for which people are most frequently incarcerated. Since Part I crimes involve not only expenditures in loss of property and safety, but also the high cost of processing and detaining criminals, they may be considered the crimes that represent the greatest costs to society.

Estimates of Missing Data

There were two types of missing arrest data. The first was partially reported data, where a jurisdiction failed to report for part of a year. In these cases the available data were multiplied by a factor to bring them up to a twelve month total. For example, if a jurisdiction reported for only six months their arrest totals were multiplied by 2. This method was not used if there were less than 5 months of reporting. In those cases the jurisdictions were considered to have no reporting.

The second type of missing data was nonreported data, where jurisdictions did not report any data during a given year. This was by far the most serious problem with the arrest data. The gaps left in arrest data by nonreporting jurisdictions had limited previous efforts to analyze historical arrest patterns. One of the main purposes of this report is to fill these gaps and provide a reliable series of historical arrest data for the state.

Due mainly to the efforts of the Washington UCR program nonreporting has recently become far less of a problem. Arrest reporting for 1981 and 1982 was nearly as good as the crime reporting for those years. Consequently it was possible to use the same method of estimation for these two years as the FBI uses to estimate missing crime data (see appendix 3). However estimates of nonreported data for the 1971 to 1980 period required a more technically complex method.

Estimates of Missing Data: 1971 to 1980

Table 1 is a summary of the arrest reporting history of all jurisdictions in the state from 1971 to 1980. It shows three types of nonreporting jurisdictions:

1. Those that have police protection contracts with the county sheriff's department. All arrests occurring in these jurisdictions are recorded in the county reports. No estimates were made for these unless a county with contract jurisdictions failed to report. In that case an estimate was made for the county inclusive of its contract jurisdictions.
2. Those failing to report for the entire 10 year period under study. These were almost exclusively very small jurisdictions.
3. Those reporting for at least one year. This was the case for all the larger jurisdictions except one.

The pattern of reporting suggested a different method of estimation for each of the two population categories of jurisdictions (over and under 5000). For jurisdictions serving populations greater than 5000 there was an average of 6.7 years of reporting each (over the ten year period). This was adequate to serve as a base for making individual estimates for each of these jurisdictions. The available data from each jurisdiction was used to establish a mean annual arrest rate for each crime type. Rates were applied to the jurisdiction's population during nonreported years to estimate a mean number of arrests for each such year. Estimated mean arrests were then weighted to correspond with the yearly variation found in that jurisdiction's crime reports. In no case were estimated values used in lieu of actual data.

Jurisdictions serving a population under 5000 had poor reporting as a rule. 44% of these never reported and 31% failed to report for at least one year; thus 75% of jurisdictions under 5000 population required estimates. However, jurisdictions in this category were far more similar in population size than those serving larger populations. Most of the smaller jurisdictions served a population around 1500. Because of this similarity it was decided to develop a pooled estimate for smaller jurisdictions.

A preliminary study of 18 small jurisdictions with good reporting over the period 1971 to 1979 was used to establish a set of mean arrest rates. These were applied to the total population over the ten year period of nonreporting jurisdictions in the under 5000 category. The product was an estimate of total arrests for each nonreporting year. These annual totals were then weighted to correspond to the crime trend in rural areas of Washington.

Several factors limited the possibility of making individual estimates for small jurisdictions. In many cases the data were simply not there. Even if data were available and individual estimates made, the gain would have been insignificant. Less than 6% of the state's total arrests are from this category. By comparison, estimates made for jurisdictions in the over 5000 category accounted for 12% of the state's total arrests and nearly 70% of all estimated arrests.

Table 1 summarizes the arrest reporting history for Washington state by size of jurisdiction and by the extent of reporting. Table 2 shows the total number of estimated arrests (known + estimated) for Washington state by crime type for the period 1971 to 1982. The various technical methods for estimating arrests are discussed in detail in Appendix 3 and 4.

TABLE 1
SUMMARY OF ARREST REPORTING HISTORY
ALL JURISDICTIONS
STATE OF WASHINGTON: 1971-1980

	Jurisdictions With 1971 Pop Less than 5000		Jurisdictions With 1971 Pop Greater than 5000		Total
	#	Row %	#	Row%	
Report to County	40	1.00	0	.00	40
Col %	.18		.00		.13
No Reporting 71-80	98	.99	1	.01	99
Col %	.44		.01		.33
1 to 9 years Reporting	69	.68	33	.32	102
Col %	.31		.41		.34
Full reporting 71-80	17	.27	46	.73	63
Col %	.07		.58		.20
Total	224	.74	80	.26	304

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TABLE 2
 REPORTED AND ESTIMATED ARRESTS
 STATE OF WASHINGTON: 1971 to 1982

		<u>Murder</u>	<u>Rape</u>	<u>Robbery</u>	<u>Assault</u>	<u>Burglary</u>	<u>Larceny</u>	<u>Auto</u>	<u>Total</u>	<u>% Est.</u>
1971	Reported	128	108	888	1094	5017	17210	2237	26682	
	Est.	22	37	54	311	1583	2720	414	5141	
	Total	150	145	942	1405	6600	19930	2651	31823	16.2
1972	Reported	106	142	750	1096	3947	15025	1691	22757	
	Est.	34	65	172	436	2796	4559	859	8921	
	Total	140	207	922	1532	6743	19584	2550	31678	28.2
1973	Reported	106	160	899	1061	4479	14668	2139	23512	
	Est.	26	78	150	571	2785	5810	967	10387	
	Total	132	238	1049	1632	7264	20478	3106	33899	30.6
1974	Reported	143	185	1013	1465	6587	19598	2351	31342	
	Est.	18	48	146	409	2282	4271	721	7895	
	Total	161	233	1159	1874	8869	23869	3072	39237	20.1
1975	Reported	188	302	1124	1784	7778	20005	2438	33619	
	Est.	19	40	111	470	1622	4842	712	7816	
	Total	207	342	1235	2254	9400	24847	3150	41435	18.9
1976	Reported	175	389	997	1907	7383	23979	2385	37215	
	Est.	6	26	70	313	1462	3896	507	6280	
	Total	181	415	1067	2220	8845	27875	2892	43495	14.4
1977	Reported	189	359	940	1688	6622	22910	2293	35001	
	Est.	48	91	115	744	2345	5188	784	9315	
	Total	237	450	1055	2432	8967	28098	3077	44316	21.0
1978	Reported	180	377	1046	1840	7327	25026	2592	38388	
	Est.	26	108	120	756	2423	4751	866	9050	
	Total	206	485	1166	2596	9750	29777	3458	47438	19.1
1979	Reported	189	486	1207	2264	7768	28259	2685	42858	
	Est.	19	56	98	472	1560	4635	687	7527	
	Total	208	542	1305	2736	9328	32894	3372	50385	14.9
1980	Reported	265	632	1262	2880	8455	32601	2503	48598	
	Est.	19	67	108	568	1468	4196	630	7056	
	Total	284	699	1370	3448	9923	36797	3133	55654	12.7
1981	Reported	228	586	1329	3325	8767	34899	2033	51167	
	Est.	35	72	179	458	947	3162	150	5003	
	Total	263	658	1508	3783	9714	38061	2183	56170	8.9
1982	Reported	255	672	1381	3271	9506	39173	2079	56337	
	Est.	24	72	139	405	770	2626	166	4202	
	Total	279	744	1520	3676	10276	41799	2245	60539	6.9

SECTION 2

RESULTS

Comparing Crime and Arrest Data

Presentation of results begins with a series of seven graphs, each comparing the history of crime and arrest volumes for a single crime type. One goal in preparing these graphs was to visualize how closely arrest volumes vary with crime volumes. The proportion of arrests to crimes, called percent arrests, was used to measure this relationship. This is the percentage of total crime volumes represented by total arrest volumes*. Percent arrest are calculated for each year for each crime type. The following table shows the calculation of percent arrests for total crime volumes in Washington state from 1971 to 1982.

TABLE 3
TOTAL PERCENT ARRESTS
STATE OF WASHINGTON: 1971 to 1982

	<u>Reported Arrests</u>	÷	<u>Reported Crime</u>	x 100 =	<u>Percent Arrests</u>
1971	31823		160526		19.8
1972	31678		163565		19.4
1973	33899		174588		19.4
1979	39237		208939		18.8
1975	41435		217731		19.0
1976	43495		209353		20.8
1977	44316		209714		21.1
1978	47438		230919		20.5
1979	50385		256474		19.6
1980	55654		284566		19.6
1981	56170		284131		19.8
1982	60539		273129		22.1

There is an insert for percent arrests on each graph. Table 4 at the end of the graph series shows the crime and arrest data used to calculate percent arrest values and to construct the graphs.

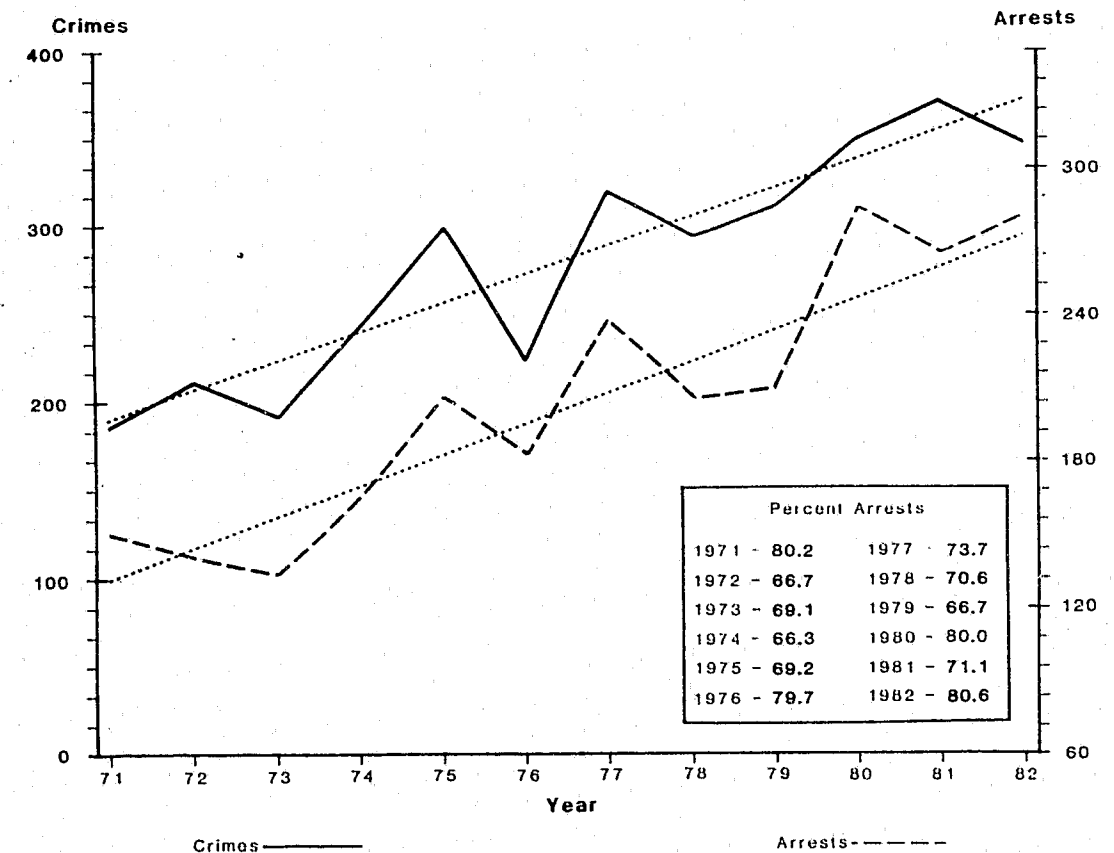
*Percent arrests for a given crime for one year is defined by $\frac{\text{Arrests}}{\text{Crimes}} \times 100$. Although it is tempting to think of percent arrests as the percentage of crimes ending in an arrest, this is not strictly true. One person can commit many crimes yet only be arrested once and, conversely, more than one person may be arrested for a single crime.

Each graph has two vertical scales. The left scale is for volumes of reported crimes and the right scale is for estimated arrests. Volumes of crimes and arrests have been plotted against their respective scales for each year. These annual plot points have been connected with straight lines to form crime and arrest "curves". Since different scales are being used for the crime and arrest curve on each graph, the distance between them is not representative of the actual difference between volumes of crimes and arrests. The techniques for construction of the graphs are discussed in appendix I.

The graphs have been designed to accurately compare trends between crime and arrest volumes. To aid in this comparison a trend line has been superimposed on each crime and arrest curve. This is an ordinary least squares regression line, plotted through the center of the curve. It represents the long term trend in crimes and arrests by plotting their average annual increases over the entire eleven year period - i.e. if crime and arrest volumes had increased the same amount since 1971, but at a constant rate, their curves would assume the shape of their trend lines.

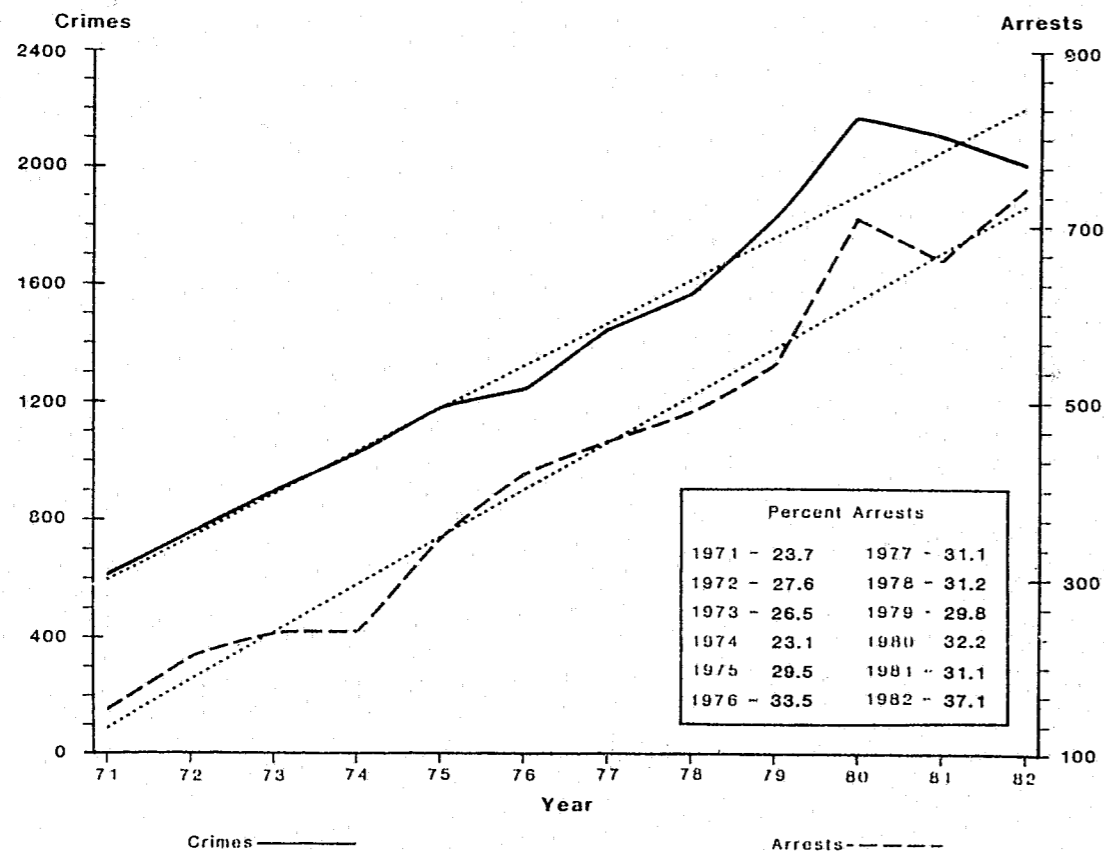
Converging curves indicate an increasing trend in percent arrests and diverging curves indicate decreasing percent arrests. To statistically test for divergence of the curves a Chow difference of slopes F test is calculated for each type of crime. The F statistic is given with each graph; in every case the critical value is 3.49, which the F statistic must fall below. These tests indicate that statistically the curves are parallel. What little divergence or convergence there is, is not significant. See appendix 5 for a detailed description of the difference of slopes tests.

Graph 1
MURDER
 Reported Crime and Estimated Arrest Volumes
 State of Washington: 1971 to 1982



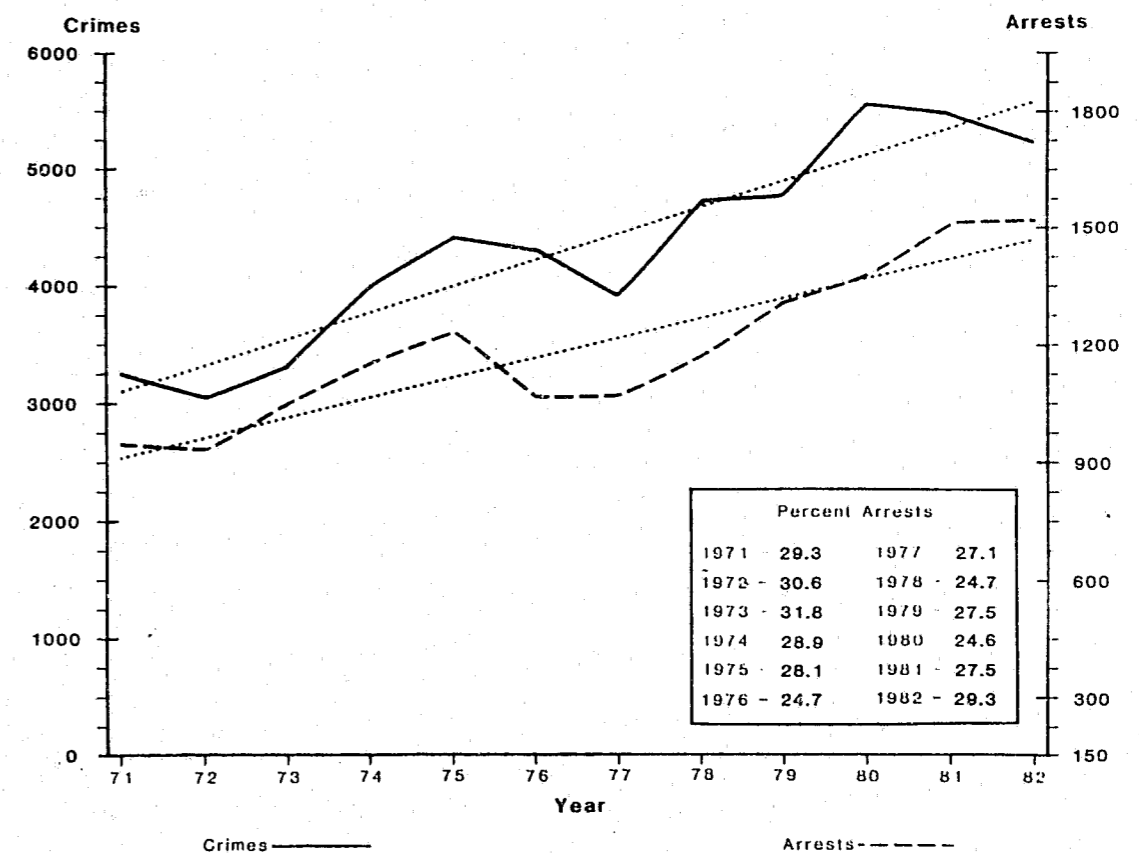
- o The volume of murders is the lowest among part I crimes, while values of percent arrests for murder are the highest.
- o Because of the low volume of this crime a small number of arrests can cause relatively large changes in percent arrests.
- o The peak in murder volumes during 1975 is typical of other crimes. The dramatic peak in 1977 is unique to this crime. Also, most other crimes peaked again in 1980, rather than 1981.
- o $F_{2, 20} = .00256, p < .05$

Graph 2
RAPE
 Reported Crime and Estimated Arrest Volumes
 State of Washington: 1971 to 1982



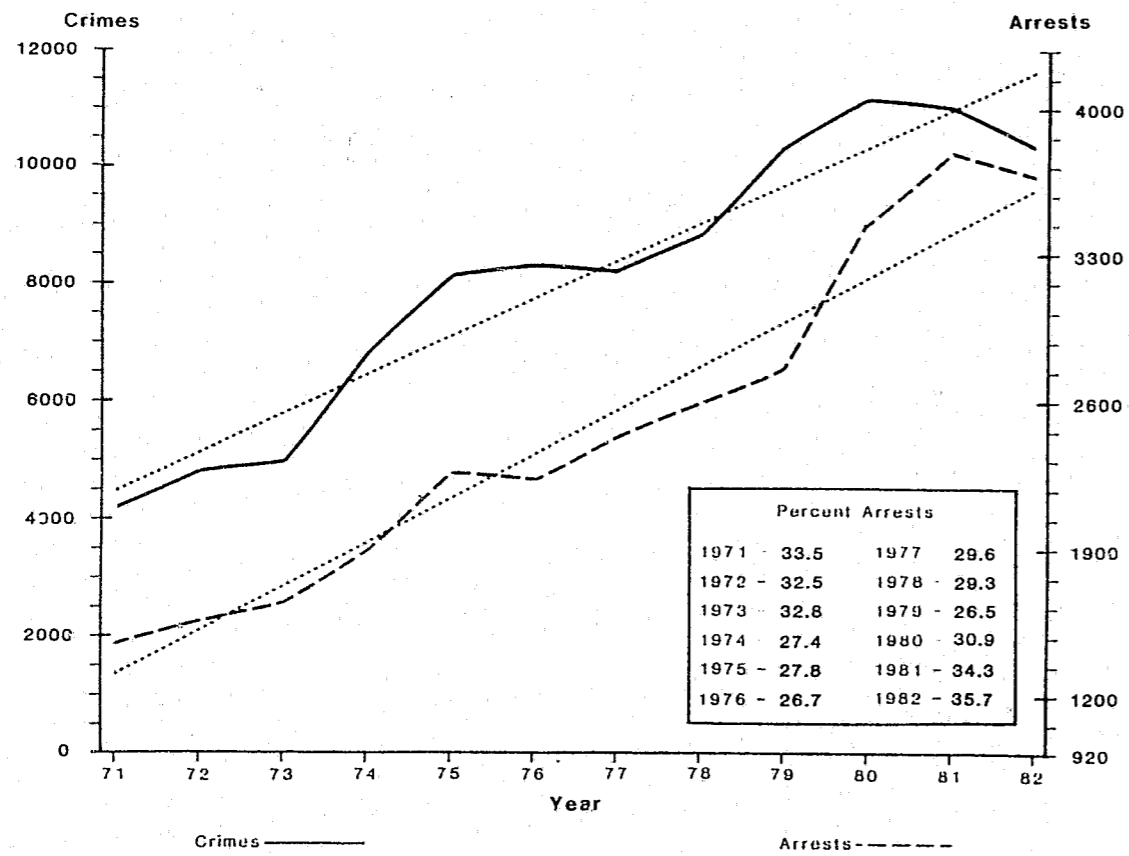
- o Reported rapes and subsequent arrests have increased more rapidly than any other crime.
- o Reported rapes more than tripled between 1971 and 1980, while arrests for rape increased by a factor of four. This makes rape the crime with the most rapidly increasing values for percent arrests. The increase in percent arrests for rape was so dramatic that it was not possible to plot it as the other crimes have been plotted, without the crime and arrest curves crossing one another. See appendix I for an explanation of this difference.
- o The increase in percent arrests is probably indicative of an increasingly positive response to this crime on the part of law enforcement.
- o It is suspected that an increased tendency on the part of victims to report being raped has had an effect upon the increases in reported rape volumes.
- o $F_{2, 20} = .01526, p < .05$

Graph 3
ROBBERY
 Reported Crime and Estimated Arrest Volumes
 State of Washington: 1971 to 1982



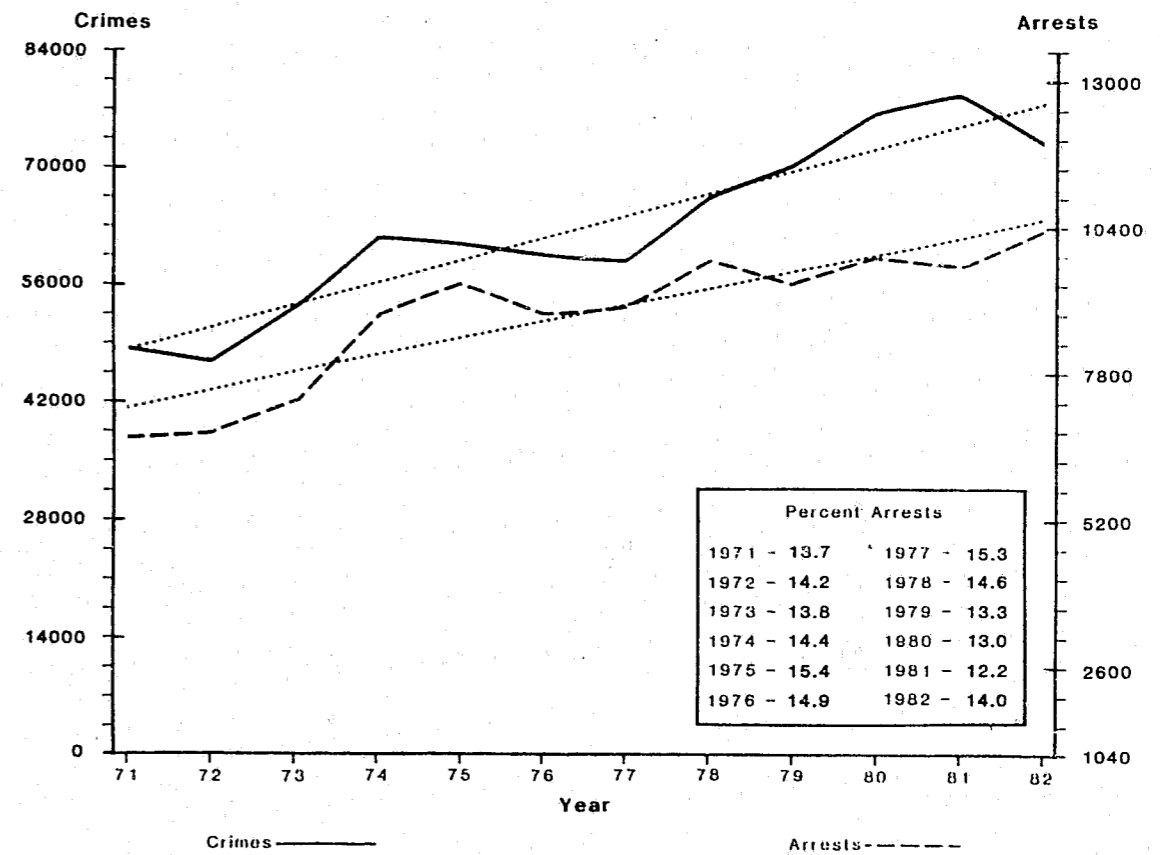
- o The shape of the crime curve for robbery more closely resembles the property crime of burglary than it does any of the other violent crimes.
- o The tendency for percent arrests to decrease while crime volumes are high is typical of other crimes.
- o $F_{2, 20} = .01254, p < .05$

Graph 4
AGGRAVATED ASSAULT
 Reported Crime and Estimated Arrest Volumes
 State of Washington: 1971 to 1982



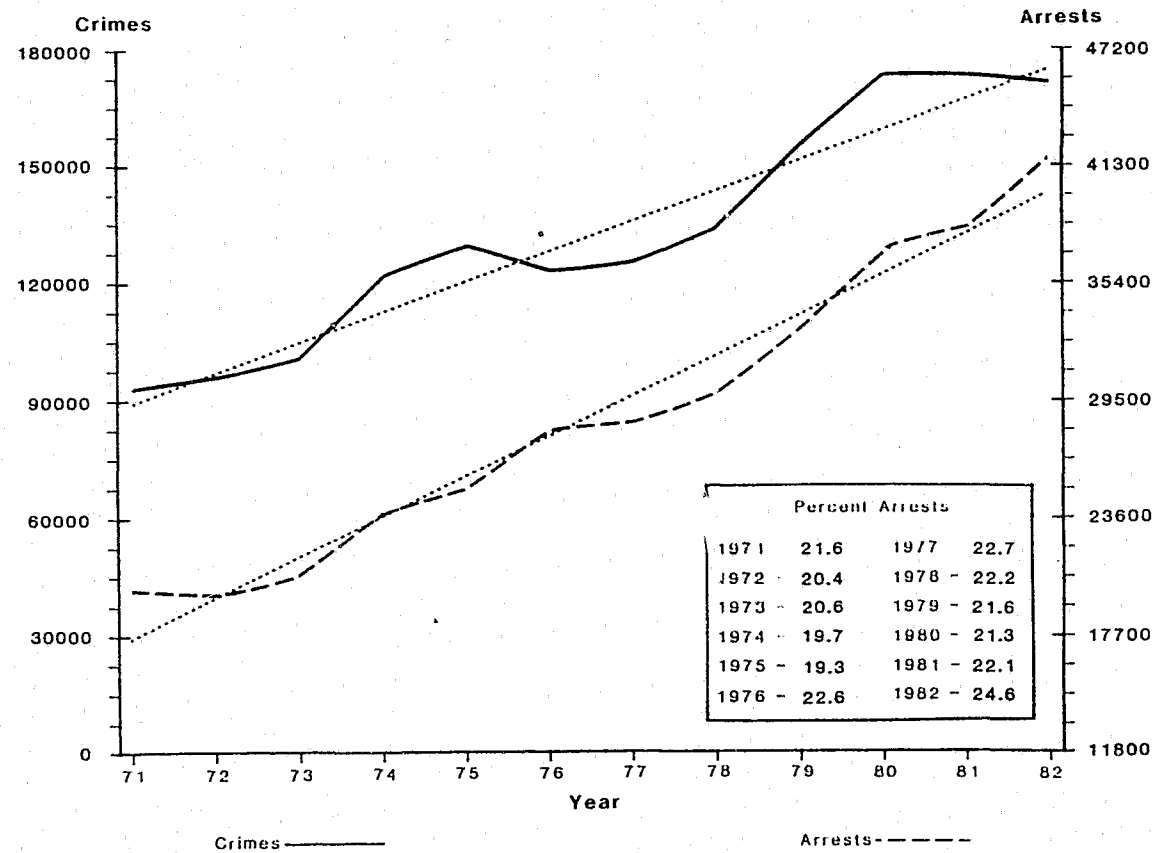
- o Reported aggravated assaults have increased almost as rapidly as reported rapes; from 4194 in 1971 to a peak 11,146 in 1980.
- o Percent arrests have shown a mild average increase for this crime.
- o The increase in percent arrests here during the peak crime year of 1980 is unique, however during other high crime years the tendency of percent arrests to fall is again seen.
- o $F_{2, 20} = .01428, p < .05$

Graph 5
BURGLARY
 Reported Crime and Estimated Arrest Volumes
 State of Washington: 1971 to 1982



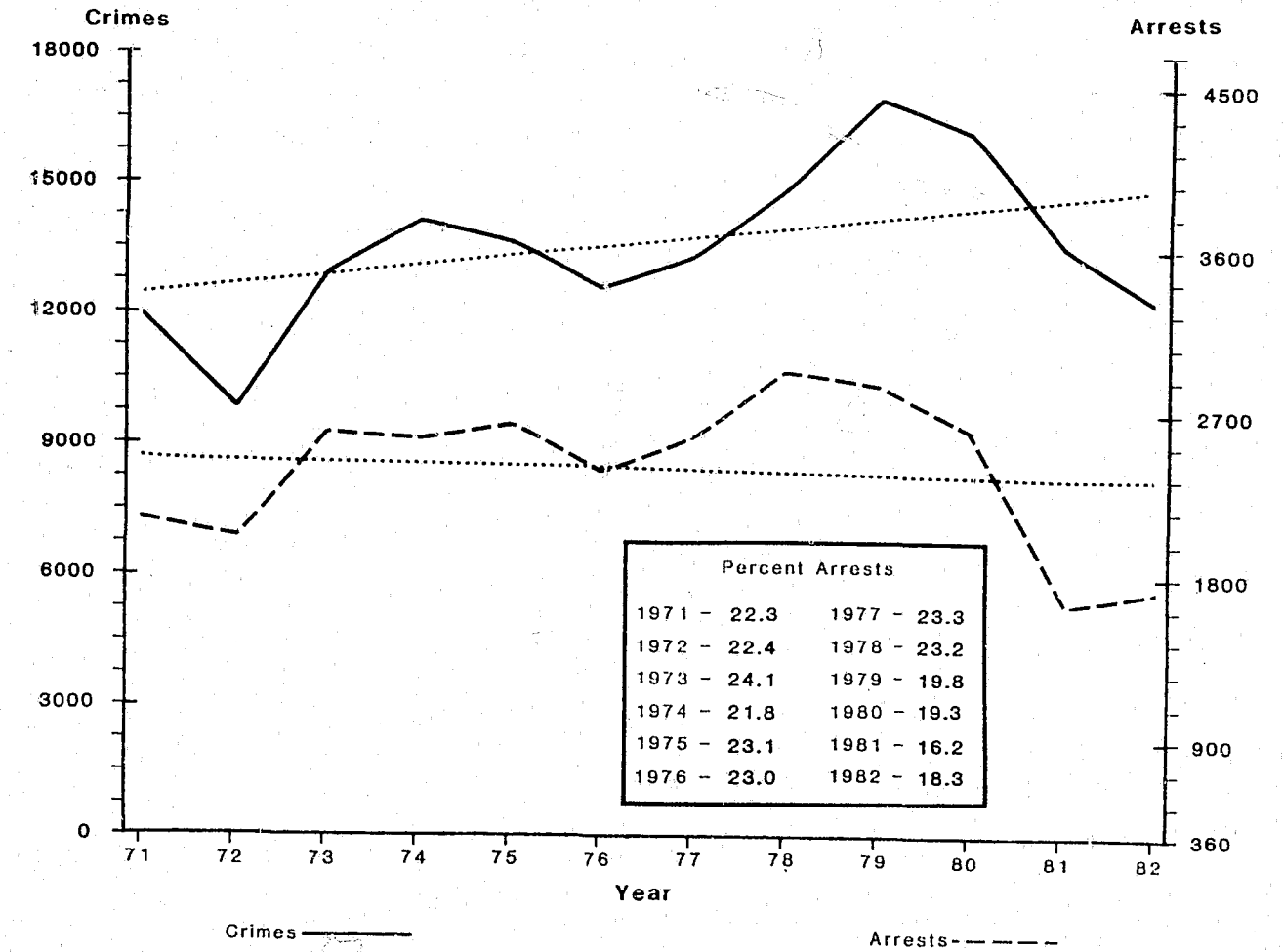
- o The curve for reported burglaries is most similar in shape to that for reported robberies. However it peaks a year earlier in 1974 and a year later in 1981 than does robbery. Only auto theft exhibits a similar peak in 1974 and the only other crime peaking in 1981 is murder.
- o The lowest values for percent arrests occur as with other crimes during years of increasing or high crime volumes.
- o $F_{2, 20} = .04872, p < .05$

Graph 6
LARCENY
Reported Crime and Estimated Arrest Volumes
State of Washington: 1971 to 1982



- o Larceny is by far the highest volume crime among part I crimes. Since there is a preponderance of larcenies relative to other crimes, it has a strong influence on total part I crime values.
- o Percent arrests are lowest during increasing and high crime volume years.
- o $F_{2, 20} = .19418, p < .05$

Graph 7
AUTO THEFT
Reported Crime and Estimated Arrest Volumes
State of Washington: 1971 to 1982



- o Auto theft is the third highest volume crime among part I crimes being studied here.
- o Auto theft, like burglary, shows an early peak during 1974 instead of 1975. Unique to this crime is the peak in reported crimes during 1979.
- o Although the tendency for percent arrests to fall during peak periods of crime is evident here, the extremely low values for percent arrests during the low crime years 1981 and 1982 are unique to auto theft.
- o $F_{2, 20} = .92951, p < .05$

Table 4 is a summary table of reported crime and arrest volumes. The data used to construct most of the graphs and tables in this report are from Table 4. The values recorded here for arrests are the final arrest estimate results. Details and methods of estimation may be found in appendices 3 and 4. Values for reported crime shown in Table 4 are from UCR Reports for Washington state 1971 to 1982, excepting reported murder totals and reported larceny totals in 1971 and 1972. Details of these changes are in Appendix 2.

TABLE 4
 REPORTED CRIME & ESTIMATED ARREST VOLUMES
 STATE OF WASHINGTON: 1971 to 1982

YEAR	MURDER		RAPE		ROBBERY		ASSAULT		BURGLARY		LARCENY		AUTO THEFT		TOTAL	
	Arr	Crime	Arr	Crime	Arr	Crime	Arr	Crime	Arr	Crime	Arr	Crime	Arr	Crime	Arr	Crime
71	150	187	145	612	942	3219	1405	4194	6600	48038	19930	92402	2651	11874	31823	160526
72	140	210	207	749	922	3016	1532	4716	6743	47563	19584	95905	2550	11406	31678	163565
% Chg	-6.7	12.3	42.8	22.4	-2.1	-6.3	9.0	12.4	2.2	-1.0	-1.7	3.8	-3.8	-3.9	-0.5	1.9
73	132	191	238	897	1049	3302	1632	4973	7264	52819	20478	99522	3106	12884	33899	174588
% Chg	-5.7	-9.0	15.0	19.8	13.8	9.5	6.5	5.4	7.7	11.1	4.6	3.8	21.8	13.0	7.0	6.7
74	161	243	233	1008	1159	4015	1874	6834	8869	61611	23869	121132	3072	14096	39237	208939
% Chg	22.0	27.2	-2.1	12.4	10.5	21.6	14.8	37.4	22.1	16.6	16.6	21.7	-1.1	9.4	15.7	19.7
75	207	299	342	1160	1235	4395	2254	8094	9400	61065	24847	129060	3150	13658	41435	217731
% Chg	28.6	23.0	46.8	15.1	6.6	9.5	20.3	18.4	6.0	-0.9	4.1	6.5	2.5	-3.1	5.6	4.2
76	181	227	415	1238	1067	4317	2220	8327	8845	59324	27875	123324	2892	12596	43495	209353
% Chg	-12.6	-24.1	21.3	6.7	-13.6	-1.8	-1.5	2.9	-5.9	-2.9	12.2	-4.4	-8.2	-7.8	5.0	-3.8
77	237	322	450	1447	1055	3886	2432	8222	8967	58732	28098	123894	3077	13181	44316	209714
% Chg	30.9	41.9	8.4	16.8	-1.1	-10.0	9.5	-1.3	1.4	-1.0	1.0	0.5	6.4	4.6	1.9	0.2
78	206	292	485	1556	1166	4719	2596	8846	9750	66672	29777	133931	3458	14903	47438	230919
% Chg	-13.1	-9.3	7.8	7.5	10.5	21.4	6.7	7.6	8.7	13.5	6.0	8.1	12.4	13.1	7.0	10.1
79	208	312	542	1821	1305	4739	2736	10317	9328	70024	32894	152204	3372	17057	50385	256474
% Chg	1.0	6.8	11.8	17.0	11.9	0.4	5.4	16.6	-4.3	5.0	10.5	13.6	-2.5	14.5	6.2	11.1
80	284	355	699	2169	1370	5558	3448	11146	9923	76598	36797	172468	3133	16272	55654	284566
% Chg	36.5	13.8	29.0	19.1	5.0	17.3	26.0	8.0	6.4	9.4	11.9	13.3	-7.1	-4.6	5.1	11.0
81	263	370	658	2115	1508	5475	3783	11036	9714	79696	38061	171994	2183	13445	56170	284131
% Chg	-7.4	4.2	-5.7	-2.5	10.1	-1.5	9.7	-1.0	-2.1	4.0	3.4	-0.3	-30.0	-17.4	0.9	-0.2
82	279	346	744	2006	1520	5193	3676	10287	10276	73166	41799	169894	2245	12237	60539	273129
% Chg	6.1	-6.5	13.1	-5.2	0.8	-5.2	-2.9	-6.8	5.8	-8.2	9.8	-1.2	2.8	-9.0	7.8	-3.9

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Stability of The Relationship Between Reported Crime and Arrests

One goal of this report is to assess the stability of the relationship between volumes of reported crimes and arrests, earlier labeled "Percent Arrests". Table 5 is an historical summary of percent arrests. It can be seen from this table and the inserts on the preceeding graphs that the relationship between numbers of crimes and arrests is nearly constant. Between 1971 and 1982 total volumes of arrests represent an average of 20.0 percent of total reported crime volumes. From year to year this figure usually varies around the mean by not more than one percentage point. At the extremes this variance is about 2 percentage points - in 1982 percent arrests for total crime peaked at 22.1 and was at a low of 18.8 in 1974.

At the bottom of Table 5 is a measure of the variation in percent arrests. This is labeled the standard deviation. This indicates that most of the time any given crime's value for percent arrests will fall within the range of that crime's mean for percent arrests, plus or minus the standard deviation*. For example the mean percent arrests for total crime is 20.0% and the standard deviation is 1.0%. Therefore most of the yearly values of percent arrests are 20.0%, plus or minus 1.0%. Most of the future values for percent arrests may also be expected to fall in this range.

The standard deviations listed for each type of crime reveals that percent arrests vary within quite a small interval for most crimes. The higher volume property crimes vary the least, ranging from 1.0 percentage points for burglarly to 2.4 percentage points for auto theft. Among the violent crimes of rape, robbery and assault, those that increased fastest show the largest variation. Murder is a special case because it is such a low volume crime; a difference of very few arrests can make a large difference in percent arrests for this crime. The fact that all violent crimes are relatively low volume means that, although they exhibit larger variation than property crimes, the number of arrests represented by that variation is smaller.

*The mean, plus or minus one standard deviation creates a range in to which 67% of cases may be expected to fall. The mean, plus or minus two standard deviations includes 95% of all cases.

TABLE 5
 PERCENT ARRESTS
 STATE OF WASHINGTON: 1971 to 1982

	<u>Murder</u>	<u>Rape</u>	<u>Robbery</u>	<u>Assault</u>	<u>Burglary</u>	<u>Larceny</u>	<u>Auto</u>	<u>Total</u>
1971	80.21	23.7	29.3	33.5	13.7	21.6	22.3	19.8
1972	66.7	27.6	30.6	32.5	14.2	20.4	22.4	19.4
1973	69.1	26.5	31.8	32.8	13.8	20.6	24.1	19.4
1974	66.3	23.1	28.9	27.4	14.4	19.7	21.8	18.8
1975	69.2	29.5	28.1	27.8	15.4	19.3	23.1	19.0
1976	79.7	33.5	24.7	26.7	14.9	22.6	23.0	20.8
1977	73.7	31.1	27.1	29.6	15.3	22.7	23.3	21.1
1978	70.6	31.2	24.7	29.3	14.6	22.2	23.2	20.5
1979	66.7	29.8	27.5	26.5	13.3	21.6	19.8	19.6
1980	80.0	32.2	24.6	30.9	13.0	21.3	19.3	19.6
1981	71.1	31.1	27.5	34.3	12.2	22.1	16.2	19.8
1982	80.6	37.1	29.3	35.7	14.0	24.6	18.3	22.1
Mean	72.8	29.7	27.8	30.6	14.1	21.6	21.4	20.0
Standard Deviation	5.7	4.0	2.3	3.2	0.9	1.5	2.4	1.0

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Specific Variations in the Relationship Between Reported Crime and Arrests

As noted in the previous section, the relationship between reported crime and arrests is not perfectly stable. This section deals with two situations where this relationship does not remain stable. First is the situation of rape, where percent arrests has increased rapidly. Clearly this trend cannot continue infinitely, so it is expected that this relationship will stabilize in the future. The mean for percent arrests for rape must be conditionally applied as a forecasting tool until it is known what the peak of percent arrests is for this crime.

A second type of variation is more widespread and predictable. This is the observed tendency for percent arrests to decrease as reported crime shows rapid increases. For the purposes of forecasting this is a useful finding. Keeping this in mind, it is possible for the forecaster to adjust percent arrests downward during times of rapidly increasing crime, turning forecasts to the crime trend from year to year. More generally, it is important to know that percent arrest values vary predictably with the crime trend in most cases. (This is in contrast to a random variation that would make the measure of percent arrests a far less useful forecasting tool.)

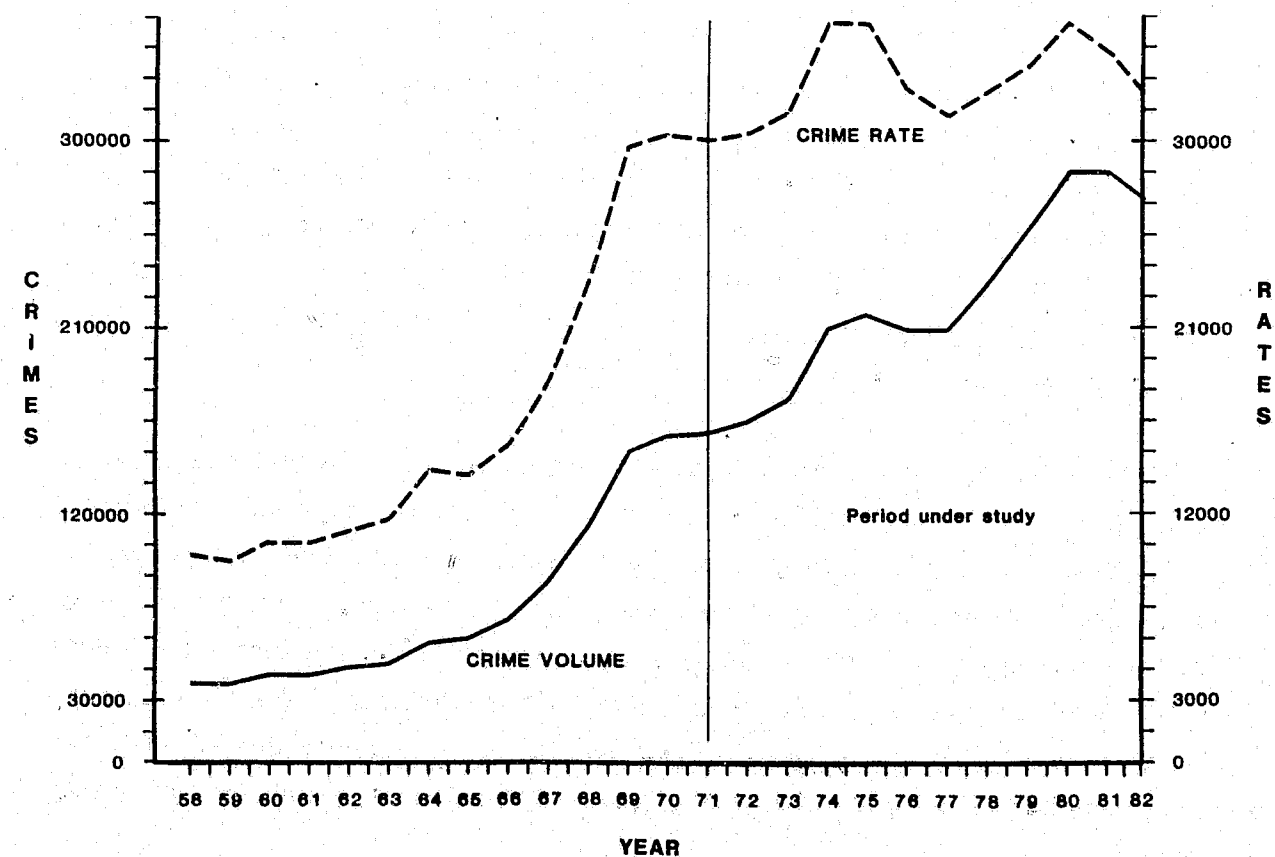
A speculation about the cause of the variation in percent arrests is that the extra resources required to cope with the situation of a rapid and continual increase in crime are finite. That is, the money, manpower and time needed to apprehend more and more criminals is limited, at least during budget cycles. Consequently, practical realities may impose a limit upon the proportion of criminals that can be arrested.

Crime Trends

From graphs 1 through 7 is it clear that the trend in crime volumes is an increasing one. Graph 8, below, shows that increases in crime volumes are not confined to the period under study. An earlier OFM study, Report On The Incidence Of Major Crime In Washington State 1958-1979, shows that between 1961 and 1971 total part 1 crime volumes increased 285%, from 41,666 to 160,526. Over the same amount of time, from 1971 to the peak in 1981 this increase was only 74%; from 160,526 to 279,559.

The measure of volume increases in crime is important because it corresponds to real increases in victims of crime and demands for police, court, prison and other supervision services. However volume measures do not take into account population growth, a major driver of crime volumes. Therefore the crime rate has also been plotted on graph 8. Shown is the rate per 100,000 males 18 to 39 years of age. This is the "at risk" population for part 1 crimes. This group is conventionally considered to be responsible for most part one crimes, especially violent crimes. It is this group that is most likely to commit crimes, be arrested, be convicted and be imprisoned. Nationally, in 1981 FBI arrest data show that 71 percent of violent crime arrests and 55 percent of property crime arrests are from persons in this group.

Graph 8
REPORTED CRIME RATES AND VOLUME
State of Washington: 1958 to 1982



The method for controlling for changes in the size of the at risk group is to use rates. Crime rates compare the number of crimes with the population of the at risk group. This is usually expressed as the number of crimes per 1,000 or per 100,000 persons in the at risk group. If the rate remains constant, the amount of crime per unit of population is constant. For example, if the volume of crimes increased in one year while the crime rate remained constant, the increase could be explained by an expanding population, not by reference to increased activity among criminals or by an increasing percentage of persons becoming criminal. On the other hand, if the crime rate increased while the population remained constant the increase in crime volumes would be due to an increasingly criminal society and not a change in the population.

The plot of crime rates against crime volumes in graph 8 reveals that during the period under study people are not becoming more criminal. This has occurred in the past, but increases in many crimes occurring now are due to population increases.

Table 6 shows the crime rate for each type of crime, detailing the effect seen in graph 8. While the crime volume has risen steadily for all crimes except auto theft, the crime rates have behaved in a variety of ways. For instance, it can be seen that the crime rate for burglary was on a long increase peaking in 1974 at 10,531 reported crimes per 100,000 18-39 year old males. The rate has since then declined slightly yet the volume of reported burglaries has continued to increase. This signifies that the increases in the actual number of reported burglaries in the late 1970's was due to an increase in the number of persons in the at risk group and not an increase in the criminal nature of society.

However, the opposite is true for assault. The volume of reported aggravated assaults has increased drastically since 1971. This becomes more alarming when it is realized that unlike burglary rates, assault rates have also been increasing. In this case there are two factors operating. Not only has the at risk group grown but the probability of someone committing a serious assault has increased. Using 18-39 year old males as a base it was about 1.6 times more probable that someone would commit a serious assault in 1982 than in 1971. However this situation has been improving since 1980 when the aggravated assault rate was nearly double that for 1971.

TABLE 6
 CRIME AND ARREST RATES
 PER 100,000 MALES AGES 18 to 39
 STATE OF WASHINGTON: 1971 to 1982

Yr	Population Males 18-39	MURDER		RAPE		ROBBERY		ASSAULT		BURGLARY		LARCENY		AUTO THEFT		TOTAL	
		Arr Rate	Crime Rate	Arr Rate	Crime Rate	Arr Rate	Crime Rate	Arr Rate	Crime Rate	Arr Rate	Crime Rate	Arr Rate	Crime Rate	Arr Rate	Crime Rate	Arr Rate	Crime Rate
1971	536317	28	35	27	114	176	600	262	782	1231	8957	3716	17229	494	2214	5934	29954
1972	542151	26	39	38	138	170	556	283	870	1244	8773	3612	17690	470	2104	5843	30158
1973	557097	24	34	43	161	188	593	293	893	1304	9481	3676	17864	558	2313	6085	31329
1974	584326	28	42	40	173	198	687	321	1170	1518	10544	4085	20730	526	2412	6715	35746
1975	610660	34	49	56	190	202	720	369	1325	1539	10000	4069	21135	516	2237	6785	35639
1976	639018	28	36	65	194	167	676	347	1303	1384	9284	4362	19299	453	1971	6807	32750
1977	669326	35	48	67	216	158	581	363	1228	1340	8775	4198	18510	460	1969	6621	31303
1978	710304	29	41	68	219	164	664	365	1245	1373	9386	4192	18855	487	2098	6679	32493
1979	755517	28	41	72	241	173	627	362	1366	1235	9268	4354	20146	446	2258	6669	33930
1980	800043	31	44	78	271	177	695	391	1393	1283	9574	4682	21557	428	2034	7071	35553
1981	827642	32	45	80	256	181	662	457	1333	1138	9629	4551	20781	259	1624	6697	34311
1982	838004	33	41	89	239	181	620	431	1228	1226	8731	4988	20274	268	1460	7224	32593

The increasing trend in crime rates is most significant for rape. The rape crime rate increased steadily until 1981, and even after 2 years of decline it was double the 1971 rate. It can be argued that improved police procedures, rape relief projects and more publicity about the severity of this crime have all combined to have the effect of improved reporting for rape. However it is probably a mistake to contribute all of the increasing trend solely to an increase in reporting.

SECTION 3
APPENDICES

APPENDIX I
GRAPH SCALING

For graphs 1 through 7 it was not possible to show volumes of crime and arrest together on the same scale, and still provide a meaningful presentation in the context of the report. This is due to the large differences in volume between crimes and arrests for most crimes. Since arrest volumes are so much lower than crime volumes, arrests curves plotted on the crime scale would look almost flat and count not be visually compared to crime curves.

Since the relationship of crime and arrest volumes from year to year is the focus of this report, graphs have been scaled in such a way that highs and lows for both crime and arrest curves are visually of the same magnitude, and so that the overall trend in percent arrests may be seen.

These two features were accomplished with the use of a floating right hand axis. After appropriate values were determined for reported crime scales (left hand axis) a ratio of the 1971 regression line estimates for crimes and arrests was made, such that:

$$\text{RATIO} = \frac{\hat{A}_c^{1971}}{\hat{C}_c^{1971}} \quad (1)$$

Where \hat{A}_c^{1971} is estimated arrests for crime c during 1971 and \hat{C}_c^{1971} is estimated crimes during 1971 for crime c . This is essentially the percent arrests measurement applied to the 1971 values for crime and arrest volumes as they are estimated by the trend line. Scaling was based on the starting point of the period as a convention. Also, if there was a trend of divergence or convergence in percent arrests for a crime, it is best seen by "attaching" the curves to each other at the beginning of the period.

The ratio was applied to reported crime scale values to determine arrest scale values, such that:

$$\text{Arrest Scale Values} = (\text{Ratio})(\text{Crime Scale Values})$$

The entire right hand scale was then moved downward so that the curves would not lie on top of one another. The amount each right hand scale was shifted downward is equal to the bottom value on each arrest scale, corresponding to zero on the left hand scale.

Special Case: Rape

Percent arrests for rape had increased enough since 1971 that it was not possible to show the convergence of crime and arrest curves on the same graph without having them cross one another. Instead of using 1971 as a starting point from which the curves converge, it was necessary to show them as diverging "backwards" in time from 1982.

To make this change equation (1) becomes

$$\text{RATIO} = \frac{\hat{A}_C^{1982}}{\hat{C}_C^{1982}}$$

This change has the effect of increasing the value of the ratio, because the numerator (arrest volumes) is increased relative to the denominator (crime volumes). Consequently, increments on the arrest scale represent larger volumes and the scale becomes compressed, compared to its appearance using 1971 as a base.

The total effect of this change is to dampen the apparent convergence of the crime and arrests curves on the graph depicting rape.

APPENDIX 2 ESTIMATION OF REPORTED LARCENIES & ESTIMATION OF REPORTED MURDERS

ESTIMATING THE NUMBER OF REPORTED LARCENIES
IN WASHINGTON STATE 1958-1972

To calculate the historical crime rates for Washington State it was necessary that the different methods of reporting larceny be reconciled. Until 1973, the UCR code specified that only larcenies of over \$50 be counted. No count was made of larcenies under \$50. Beginning in 1973, the UCR code allowed for the recording of all larcenies. This difference in reporting caused a large gap in the number of larcenies reported between 1972 and 1973. In order that a single estimate of the total volume of reported crime be used in the calculations of crime statistics, an estimate was made of all reported larcenies between 1958 and 1972. Equation (1) shows this method

$$\frac{L_{\text{Tot}}^{73-76}}{\hat{L}_{>50}^{73-76}} (L_{>50}^{58-72}) = \hat{L}_{\text{Tot}}^{58-72} \quad (1)$$

This estimate was based on a ratio between the number of larcenies greater than \$50 and total larcenies. The numbers of larcenies greater than \$50 for 1958-1972 were multiplied by this ratio which yields estimates for total larcenies for 1958-1972.

The steps in this procedure are as follows:

First, the linear fit for the number of reported larcenies was obtained for 1973 to 1978. Second, based upon 1958-1972 data, the linear trend of reported larcenies was obtained for the years 1973-1976 for larcenies greater than \$50. Third, the percentage of difference between the reported number of larcenies from the linear fit and the linear trend was calculated. Fourth, these percentage difference figures were multiplied by the linear trend expected values for larcenies greater than \$50. These values then served as the estimated number of reported larcenies over \$50 for 1973 - 1976. Fifth, the ratio for the difference between the actual number of all larcenies for 1973-1976 and the estimated larcenies greater than \$50 for 1973-1976 was determined.

These ratios were then averaged, and the average ratio was multiplied by the number of reported larcenies greater than \$50 for the years 1958-1972, yielding estimates for total larceny for those years.

TABLE 7
 PROCEDURES FOR ESTIMATING THE NUMBER OF REPORTED
 LARCENIES IN WASHINGTON STATE 1958-1972

	(1) Number of Reported Larceny	(2) Expected Linear Trend Values (Based 1973-1978 Actual Data)	(3) Expected Linear Trend Values For Larceny Greater Than \$50 1973-1976 (Based On 1961-1972 Actual Data)	(4) Estimated Values For Larceny Greater Than \$50 Based on Percentage Difference Between the Actual & The Expected Values 1973-1978	(5) Difference Ratio Between (4) & Actual No. of Larcenies 1973-1976 (1)	(6) Estimated All Larceny 1961-1972 Based on Difference Ratio & Actual Larceny \$50 and Greater
1958		7,941				18,471
1959		8,267				19,229
1960		9,459				22,001
1961		9,215				21,434
1962		10,197				23,718
1963		10,513				24,453
1964		13,510				31,424
1965		13,689				31,840
1966		16,263				37,827
1967		20,076				46,696
1968		27,640				64,290
1969		36,207				84,217
1970		38,488				89,523
1971		39,726				92,402
1972		41,232				95,905
***CHANGE IN REPORTING PROCEDURE						
1973		99,522	110,516	45,114	40,656	2.447
1974		121,132	114,642	48,547	51,297	2.361
1975		129,060	118,768	51,918	56,448	2.286
1976		123,324	122,894	55,310	55,380	2.226
1977		123,894	127,020			Average Difference
1978		127,954	131,146			ratio equals 2.33 (2.32597725)

Estimated increases in reported larcenies from 1958 to 1972 were then added to corresponding reported crime totals. Table 8 shows the resulting estimated reported crime totals, used to construct Graph 8 in the body of the report.

TABLE 8
TOTAL REPORTED CRIME 1958 to 1972

<u>Year</u>	<u>Total Reported Crimes</u>
1958	37,887
1959	38,017
1960	42,022
1961	41,666
1962	45,561
1963	47,938
1964	57,641
1965	58,917
1966	68,621
1967	86,684
1968	114,122
1969	149,517
1970	158,648
1971	160,526
1972	163,565
1973	174,588
1974	208,939
1975	217,731
1976	209,353
1977	209,714
1978	230,919
1979	256,474
1980	284,566
1981	284,131
1982	273,129

ESTIMATION OF REPORTED MURDERS

STATE OF WASHINGTON 1977-1982

In 1977 the FBI discontinued counting negligent manslaughter under the part I crime category of murder. Total commitments to prison or probation for this crime were added to FBI figures, reasoning that most persons guilty of manslaughter are apprehended and are not released without some sentence. These values are as follows:

<u>Year</u>	<u>Commitments</u>
1977	95
1978	96
1979	102
1980	130
1981	157
1982	155

It should also be noted that values for reported murders are also somewhat higher than those published by the FBI from 1971 to 1976. Discrepancies were found in these data; specifically reported arrests exceeded reported crimes for murder during some years. For the purposes of this study all reported murders were recounted using the most recent and complete data available. Updated totals revealed higher reported murder totals.

Results of both these changes are shown in Table 9.

TABLE 9
RECOUNT OF REPORTED MURDERS

<u>Year</u>	<u>UCR Total</u>	+	<u>Recount Additions</u>	+	<u>1977-1981 Commitments</u>	=	<u>Total Reported Murders</u>
1971	130		57		0		187
1972	146		64		0		210
1973	137		54		0		191
1974	179		64		0		243
1975	202		97		0		299
1976	154		73		0		227
1977	159		68		95		322
1978	175		21		96		292
1979	187		23		102		312
1980	221		0		130		351
1981	205		0		157		362
1982	191		0		155		346

APPENDIX 3
ARREST ESTIMATION METHODS

ARREST ESTIMATION METHOD
JURISDICTIONS UNDER 5000 POPULATION
1971 to 1980

There were 304 jurisdictions in Washington state that were examined for completeness of their arrest data. This total includes all of the state's counties and all of its incorporated cities and towns. It does not include state patrol, Native American tribal reservation, state park or national historic site jurisdictions. Data from these jurisdictions were never disincluded from arrest totals; rather no attempt was made to assess if any of these jurisdictions failed to report. Consequently no estimate was made if one of these failed to report. The primary reason for this was when arrests occurring in these jurisdictions were reported it was through local county or municipal jurisdiction reports and it was impossible to separate their data from those local reports.

Table 1 has been duplicated on page 49 as table 10. It shows that out of 304 jurisdictions 224 served 1971 populations of less than 5000. Each of these were included in the under 5000 category throughout the period 1971 to 1980, even if their population exceeded 5000 during that time. 40 of these 224 jurisdictions had contracts for police protection with their respective counties and 17 reported for all ten years; neither of these groups required arrest estimates. The remaining 167 jurisdictions required an estimate for at least one year of arrest data.

The set of 167 jurisdictions requiring estimates may be seen on table 10 to fall into two categories. Those with no reporting (98 jurisdictions) and those with 1 to 9 years of reporting (69 jurisdictions). Of those cases with 1 to 9 years of reporting 30 had quite good reporting and for them it was possible to make individual estimates. This technique is discussed later in this section.

The remaining 137 jurisdictions (224 total minus 40 reporting to county, 17 with full reporting and 30 with good reporting) were estimated as a group. These included all 98 jurisdictions with no reporting and 39 jurisdictions with reporting that was considered too poor for an individual estimate base. The decision to estimate these jurisdictions together was based on the almost total lack of individual data about them. There was little or no arrest or crime data for any of these jurisdictions. The only data available for these jurisdictions were census population data and intercensal population estimates. Therefore, the decision was made to establish arrest rates from jurisdictions with similar populations and good reporting and apply these rates to the population of the estimate group.

This procedure was also problematic because jurisdictions with good reporting tended to have a higher mean population than that of the estimate group. The mean population between 1971 and 1980 of the 137 nonreporting jurisdictions being estimated as a group was 1478. Over the same period the mean population of the 17 jurisdictions with full reporting (See table 10) was 3532.

By choosing jurisdictions from the full reporting group that had smaller populations and jurisdictions in the 1 to 9 years of reporting group that had relatively good reporting, it was possible to obtain a set of 18 jurisdictions with a mean population of 2750. Arrest rates were established from this set by dividing total arrests 1971 to 1979 by the total reporting population 1971 to 1979. 1980 data were not included here because only state totals for arrests were available for that year, and there was no way to obtain arrest volumes by jurisdiction. These results are shown in table 11.

TABLE 10
SUMMARY OF ARREST REPORTING HISTORY
ALL JURISDICTIONS
STATE OF WASHINGTON: 1971-1980

	Jurisdictions With 1971 Pop Less than 5000		Jurisdictions With 1971 Pop Greater than 5000		Total
	#	Row %	#	Row %	
Report to County	40	1.00	0	.00	40
Col %	.18		.00		.13
No Reporting 71-80	98	.99	1	.01	99
Col %	.44		.01		.33
1 to 9 years Reporting	69	.68	33	.32	102
Col %	.31		.41		.34
Full reporting 71-80	17	.27	46	.73	63
Col %	.07		.58		.20
Total	224	.74	80	.26	304

TABLE 11
TOTAL MEAN ARREST RATES
18 JURISDICTIONS UNDER 5000 POPULATION

Total # of Jurisdiction Years of Reporting = 120
Mean Years Reported Per Jurisdiction = 6.67
Total Reporting Population 1971 to 1979 = 329933
Mean Reporting Population 1971 to 1979 = 2750

	Total # Arrests 1971-1979	Total Estimated Reporting Population 1971-79	=	Arrest Rate 1971 to 1980	x 100000	=	Arrest Rate Per 100,000
Murder	6	329933		.000018555			1.82
Rape	20	329933		.0000606184			6.06
Robbery	37	329933		.000112144			11.21
Assault	278	329933		.0008425953			84.26
Burglary	1252	329933		.0037947098			379.47
Larceny	2321	329933		.0070347616			703.48
Auto Theft	396	329933		.0012002437			120.02

The total nonreporting population of the 137 jurisdiction estimate group was then calculated for each year. This was done by subtracting the number of reporting jurisdictions in the group from the total of 137 and multiplying the remainder by the total mean population of the estimate group (1478). Table 12 shows these results.

TABLE 12
TOTAL NONREPORTING POPULATION
137 JURISDICTIONS UNDER 5000 POPULATION
1971-1980

	# of Jurisdictions	# Reporting Jurisdictions	=	# Nonreporting Jurisdictions	x	Estimated Total Mean Pop	=	Estimated Annual Non- reporting Pop
1971	137	0		137		1478		202468
1972	137	0		137		1478		202468
1973	137	0		137		1478		202468
1974	137	0		137		1478		202468
1975	137	0		137		1478		202468
1976	137	0		137		1478		202468
1977	137	0		137		1478		202468
1978	137	2		135		1478		199530
1979	137	8		128		1478		190662
1980	137	44		93		1478		137454
				Total Nonreporting Pop =				1945048

The resulting total nonreporting population is the sum of nonreporting populations over the ten year period. This value (1,945,048) was then multiplied by the arrest rates shown in table 11, to give a total number of arrests for each type of crime to be distributed over the 10 year period. These results are shown below in table 13.

TABLE 13
TOTAL ESTIMATED ARRESTS
137 JURISDICTIONS UNDER 5000 POPULATION
1971-1980

	Estimated Nonreporting Population	x	Arrest Rate	=	Total Estimated Arrests 1971-80
Murder	1945048		.0000182		35
Rape	1945048		.0000606		118
Robbery	1945048		.0001121		218
Assault	1945048		.0008426		1639
Burglary	1945048		.0037947		7381
Larceny	1945048		.0070348		13683
Auto Theft	1945048		.0012004		2335
					25409

Total estimated arrests were then divided by ten and weighted by year and type of crime to form a distribution of total annual arrests by type of crime for all of the 137 jurisdictions. The weighting technique reinstated the yearly variation in arrest volumes that was lost as a result of averaging population and arrest values over the ten year period.

Weights were calculated from state total rural reported crime volumes as designated by the uniform crime reports Crime in the United State 1971 to 1980.

Weights were calculated as follows:

$$W_c^t = \frac{C_c^t}{\bar{C}_c^{1971-1980}}$$

where W_c^t is the weight for crime c at year t, $\bar{C}_c^{1971-1980}$ is the mean numbers of crime c between 1971 and 1980 and C_c^t is crime c at year t. Weights for burglary, larceny and auto theft were calculated together using rural property crime totals. Weights are shown in table 14 and the resulting distribution of estimated arrests follow in table 15.

TABLE 14
RURAL WEIGHTS
1971 to 1980

	Murder	Rape	Robbery	Assault	Property
1971	.70	.66	.68	.58	.69
1972	1.20	.57	.82	.65	.77
1973	.90	.80	.56	.74	.86
1974	1.05	.60	.99	.66	.95
1975	1.35	.59	1.24	.74	1.05
1976	.90	.89	.85	1.02	1.03
1977	1.50	1.30	1.05	1.07	1.04
1978	.80	1.55	1.40	1.16	1.13
1979	.75	1.50	1.21	1.60	1.22
1980	1.50	1.52	1.55	1.78	1.27

TABLE 15
ESTIMATED ARRESTS DISTRIBUTION
137 JURISDICTIONS UNDER 5000 POPULATION
1971 to 1980

	Murder	Rape	Robbery	Assault	Burglary	Largeny	Auto Theft	Total
1971	2	8	15	95	509	944	161	1734
1972	4	7	18	107	568	1054	180	1938
1973	3	9	12	121	635	1177	201	2158
1974	4	7	22	108	701	1300	222	2364
1975	5	7	27	121	775	1437	245	2617
1976	3	11	19	167	760	1409	241	2610
1977	5	16	23	175	768	1423	243	2653
1978	3	18	31	190	834	1546	264	2886
1979	3	18	26	262	900	1669	285	3163
1980	5	18	34	292	937	1738	297	3318
Total*	37	119	227	1638	7387	13697	2339	25441

*May not sum to calculated totals in Table 13 due to rounding error.

By comparing the totals in table 15 to the statewide arrest totals in table 4 it can be seen that these estimates comprise less than 6% of total (estimated + reported) arrests.

ARREST ESTIMATION METHOD

JURISDICTIONS UNDER 5000 POPULATION WITH GOOD REPORTING

1971 to 1980

30 jurisdictions in the under 5000 population estimate category had enough reporting to establish an individual estimate base. Jurisdictions in this category had a mean of about 7 years of reporting - only one had less than 5 years of reporting (from 1971 to 1980).

The method used to estimate nonreported data from these jurisdictions is almost identical to that used for individual estimates of jurisdictions over 5000 population. Since that procedure is explained in detail in the following section this discussion will only summarize the method.

In each case where there was an individual estimate made for a jurisdiction under 5000 population a mean arrest rate was calculated from the existing data. The mean arrest weight was then applied to the population for each nonreported year. The product of these two factors was then weighted by year and type of crime with the weights shown in table 14. The final calculation of these three factors was then used as the estimate of arrests for a given year for a given jurisdiction. The procedure is defined by

$$\hat{A}_C^t = \bar{R}_C \times \hat{P}^t \times W_C^t \quad (1)$$

where \hat{A}_c^t is estimated arrests for crime c at time t. \bar{R}_c is the mean arrest rate and it may be expanded to

$$\bar{R}_c = \frac{\sum_{i=1}^n A_c^n}{n \sum_{t=1971}^{1980} \hat{P}^t} \quad (1a)$$

where the numerator $\sum_{i=1}^n A_c^n$ is the total number of actual arrests for crime c summed over n= the number of reported years, and the denominator is the mean population from 1971 to 1980.

\hat{P}^t is the OFM intercensal estimate of the population at time t.

The calculation of W_c^t is reserved for the following section and appendix 4. The use of the rural weights (shown in table 14) is the one factor distinguishing this method from that used for individual estimates of jurisdictions over 5000 population.

ARREST ESTIMATION METHOD
JURISDICTIONS OVER 5000 POPULATION
1971 to 1980

Table 10 shows that there were 80 jurisdictions in the over 5000 category and 33 that required estimates between 1971 and 1980 (no jurisdictions over 5000 population required estimates in 1981 or 1982). These nonreporting jurisdictions represented an average of about 14 percent of the state's population each year. Because there were a relatively few jurisdictions in this category and because they accounted for the bulk of missing arrest data, a more complex and detailed method of making individual estimates for each jurisdiction was developed. This method relied upon the available reported arrest data for each individual jurisdiction as an estimate base, and upon each jurisdiction's own reported crime data for calculation of weights.

Only 4 jurisdictions of the 33 requiring estimates had insufficient data to form a reliable estimate base. These were Thurston County, Olympia, Centralia and Kelso. The number of years reported for these jurisdictions was far below the range of other jurisdictions in the estimate group. The 29 other jurisdictions had a mean of 6.7 years of reporting (between 1971 and 1980) while these 4 averaged less than 2 years of reporting. Consequently, mean arrest rates from jurisdictions judged to be similar to these were applied to their population for all nonreporting years. Resulting arrest totals were then weighted with the weights shown in table 14. Jurisdictions used to calculate arrest rates and the reasons for choosing them are shown below.

Thurston Co. - Clark and Whatcom counties: Both are associated with a large metropolis that is nearby but not in the same county, both are on the I-5 corridor. Whatcom county has a college town similar in size to Olympia (also a college town).

Olympia - Bellingham: College town, similar size and location (I-5 corridor, Puget sound, etc.)

Centralia - Chehalis: Propinquity

Kelso - Longview: Propinquity

The remaining 29 jurisdictions were estimated individually. It should be pointed out that Seattle is not among these 29 jurisdictions even though it failed to report for 4 years. Seattle was a special case because it was the only jurisdiction from the states' largest cities that was missing a significant amount of data. This created a disproportionately large source of potential error because given its population, Seattle accounts for a disproportionately large number of arrests. As an example, Seattle's 1980 population was 12% of the state total, yet Seattle's 1980 part I arrests accounted for 20% of state total part I arrests. (This is not because Seattle is a particularly criminal place, but because urban areas in general are more criminal, and Seattle is a very large urban area). Since so large a proportion of arrests may be attributed to Seattle, no estimates of arrests were made for it. Instead data was received from the Seattle police department for nonreporting years.

The method of estimating arrests for jurisdictions over 5000 population is defined by equation (1),

where \hat{A}_c^t is the estimated arrests for crime c at time t, \bar{R}_c is the mean arrest rate for crime c, \hat{P}^t is the estimated intercensal population at time t and W_c^t is the weight for crime c at time t.

This is a weighted ratio method of estimation where \bar{R}_c is the ratio of actual mean arrests to the actual mean population over the 10 year period. \bar{R}_c is the ratio given by (1a)

$$\bar{R}_c = \frac{\frac{\sum_{i=1}^n A_c^n}{n}}{\frac{\sum_{t=1971}^{1980} \hat{P}^t}{10}} \quad (1a)$$

where $\sum_{i=1}^n A_c^n$ is the sum of actual arrests for n years of arrest reporting for crime c. Divided by n this gives mean arrests per year of reported arrests for a given jurisdiction. The denominator in (1a), $\frac{\sum_{t=1971}^{1980} \hat{P}^t}{10}$, is the mean population of that jurisdiction over the entire ten year period.

The intercensal estimate of population, \hat{P}^t , for each nonreporting year is then multiplied by the mean arrest rate \bar{R}_c to give a mean estimated volume of arrests for each type of crime. Since these are mean arrest volumes and they do not reflect annual variation in crime and arrest trends, they are weighted to reflect the individual jurisdiction's trend in crime. Weights are calculated from the crime reports of each jurisdictions being estimated, given by equation (1b):

$$w_c^t = \frac{C_c^t}{\frac{1980}{10} \sum_{t=1971}^{1980} C_c^t} \quad (1b)$$

where C_c^t is the volume of crime c at time t . Thus each weight is the ratio of crimes during a given year to mean crimes over the entire period. For high crime years this ratio is greater than 1 and it is less than 1 for low crime years (See appendix 4 for a complete discussion of weighting techniques).

Equation (2) shows the expanded form of Equation (1), using equation (1a) and (1b).

$$\hat{A}_c^t = \left(\frac{\sum_{i=1}^n A_c^n}{\frac{1980}{10} \sum_{t=1971}^{1980} P^t} \right) \hat{P}^t \left(\frac{C_c^t}{\frac{1980}{10} \sum_{t=1971}^{1980} C_c^t} \right) \quad (2)$$

As in all other cases, this technique was used to estimate missing data only. All actual arrests were used in arrest totals, supplemented by estimates of arrests for nonreported years.

ARREST ESTIMATION METHOD
JURISDICTIONS OVER 5000 POPULATION
WITH VERY POOR REPORTING

Equation (1a) in the previous section shows the mean arrest rate \bar{R}_c to be calculated from the mean of actual arrests. In some cases actual arrest data was too biased to form a realistic estimate base. Biases occurred when there were only three or four years of reporting all from extreme ends of the ten year period, creating a situation where mean arrest values were too high or too low to accurately represent actual mean arrest volumes. In these cases actual mean arrests were replaced by an estimate of mean arrests based on the actual data.

A weighting procedure was used to shift actual arrest volumes toward the mean. The weight used (Z_c^n) was the reciprocal of that shown in equation (1) in the previous section and defined in that section in equation (1b). Thus A_c^n becomes \hat{A}_c^n , calculated by equation (1)

$$\hat{A}_c^n = A_c^n Z_c^n \quad (1)$$

where Z_c^n is the weight for reported year n for crime c , expanded below in equation (1a)

$$z_c^n = \frac{1}{\left(\frac{C_c^n}{\frac{1980}{t=1971} \sum C_c^t} \right)}$$

$$= \frac{\sum_{t=1971}^{1980} C_c^t}{10C_c^n} \quad (1a)$$

and the expanded form of equation (1) becomes:

$$\hat{A}_c^n = \frac{A_c^n \sum_{t=1971}^{1980} C_c^t}{10C_c^n} \quad (2)$$

Since most jurisdictions reporting did not cluster at one end at the ten year period this procedure was used infrequently.

Although actual mean arrests are replaced with an estimate for the purposes of estimating missing data in these cases, no estimates were used in lieu of actual data in the arrest totals.

ARREST ESTIMATION METHOD

1981 and 1982

Arrest data for 1981 and 1982 were not available at the outset of this study. As these data became available the decision was made to include them so the analysis would be as current as possible.

Estimates of arrests for 1981 and 1982 were greatly simplified by the fact that only jurisdictions in the under 5000 population category required estimates. Four jurisdictions with populations greater than 5000 failed to report during these years. These were: Seattle, Bellevue, Edmonds and Toppenish. However, it was possible to obtain annual arrest totals directly from all of these jurisdictions except Toppenish. The 1980 census population of Toppenish was 6517, with an estimated small change to 6560 in 1981 and 6550 in 1982. Toppenish was treated as an under 5000 jurisdiction, so with the data received from Seattle, Bellevue and Edmonds jurisdictions over 5000 population all reported for 1981 and 1982.

Reporting of jurisdictions under 5000 population was also greatly improved during this period. The total nonreporting population of jurisdictions in this category (including the population of Toppenish) was less than 5 percent of the state's total population for both 1981 and 1982. (This was in fact the extent of nonreporting for all jurisdictions because there was full reporting in the over 5000 category)*.

*There was however some partial reporting, i.e., months during which some jurisdictions did not report. Consequently estimated arrest totals shown for 1981 and 1982 in Table 2 are somewhat greater than 5 percent of the total arrests for those years.

Because reporting was so improved it was possible to use a less complex method for estimation of missing arrest data than was previously used. The same method as used by the FBI to estimate annual crime totals was employed. This involved establishing arrest rates for each type of crime for the reporting population during each year and applying it to the total population for each year. This is calculated by:

$$\hat{A}_C^t = R_C^t \times \hat{P}^t \quad (1)$$

where \hat{A}_C^t is estimated arrests for crime c at time t (1981 or 1982), R_C^t is the arrest rate for crime c at time t and \hat{P}^t is the total population at time t.

R_C^t is the arrest rate for each type of crime over the reporting population, given by:

$$R_C^t = \frac{A_C^t}{P_R^t} \quad (1a)$$

where A_C^t is actual arrests for crime c at time t and P_R^t is the reporting population at time t.

P^t is the total population at time t, ie, the reporting plus the nonreporting population:

$$P^t = P_R^t + P_{\bar{R}}^t \quad (1b)$$

Thus the expanded form of equation (1) is:

$$\hat{A}_C^t = \left(\frac{A_C^t}{P_R^t} \right) P_R^t + P_{\bar{R}}^t \quad (2)$$

In practice the total reporting population P_R^t did not include the population of Seattle, Bellevue or Edmonds because their arrest totals were not included in the data source being used. The populations of Tacoma and Pierce county were also not included in the total reporting population because they reported for only 3 and 6 months in 1981 and 1982, respectively. However, these partial totals had been included in the data source, so they were subtracted from total actual arrests (A_C^t) before the arrest rates (R_C^t) were calculated. Reported arrest totals for Seattle, Bellevue and Edmonds, and estimated arrest totals for Tacoma and Pierce County were then added to the estimated arrest total (\hat{A}_C^t).

APPENDIX 4
WEIGHTING

Weighting

For both categories of jurisdictions weights were used to replicate yearly variations in crime patterns for the arrest estimates. For under 5000 population jurisdictions weights were calculated from state total reported crime data, because those were the only other data available that pertained to jurisdictions with poor arrest reporting. However, regardless of the source of crime data weights were calculated in the same way for all sizes of jurisdictions. This discussion shall use as an example the weighting technique for over 5000 population jurisdictions from 1971 to 1981.

The practice of weighting is essentially the practice of increasing or decreasing a known value to an estimated value by multiplying it by a "control factor", or weight. In the following example weights were employed to take a mean value for arrests over the 1971 to 1981 period and lower or raise it to replicate the trend in crime over this period.

Suppose there were reported crime data available for all years 1971 to 1981 for a given jurisdiction. If one were to calculate a set of weights for one type of crime for that jurisdiction it would involve simply calculating the mean number of crimes for that crime type over the 11 year period and dividing each yearly crime total (for that type of crime) by the mean.

The following example shows this with numbers. Here two weights are calculated, for 1971 and 1981 for a given crime. Assume the mean of crimes $\bar{C}_c = 100$ and the

number of crimes in 1971 is $C_c^{1971} = 50$ and the number of crimes in 1981 is $C_c^{1981} = 200$, then:

$$W_c^{1971} = \frac{C_c^{1971}}{C_c} = \frac{50}{100} = .5 \quad (1)$$

$$W_c^{1981} = \frac{C_c^{1981}}{C_c} = \frac{200}{100} = 2 \quad (2)$$

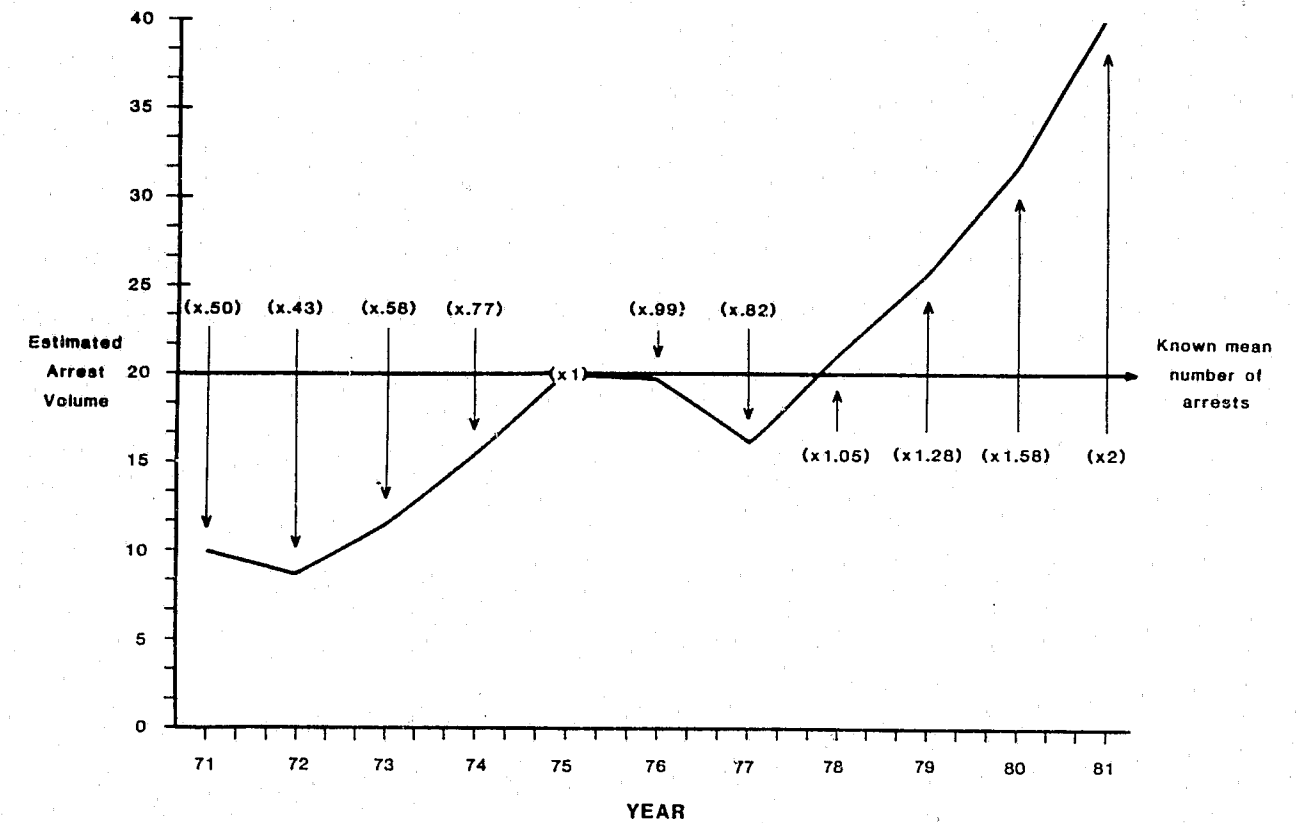
Weights are calculated for each year, so there are 11 weights for each type of crime. The following table is an example of this process for one crime type.

TABLE 16
EXAMPLE CALCULATION OF REPORTED CRIME WEIGHTS
ONE CRIME TYPE

Year	Reported Crime Volume	Mean Crime Volume	Weight
1971	50	100	.50
1972	43	100	.43
1973	58	100	.58
1974	77	100	.77
1975	100	100	1.00
1976	99	100	.99
1977	82	100	.82
1978	105	100	1.05
1979	128	100	1.28
1980	158	100	1.58
	(1100 - 11 = 100)		

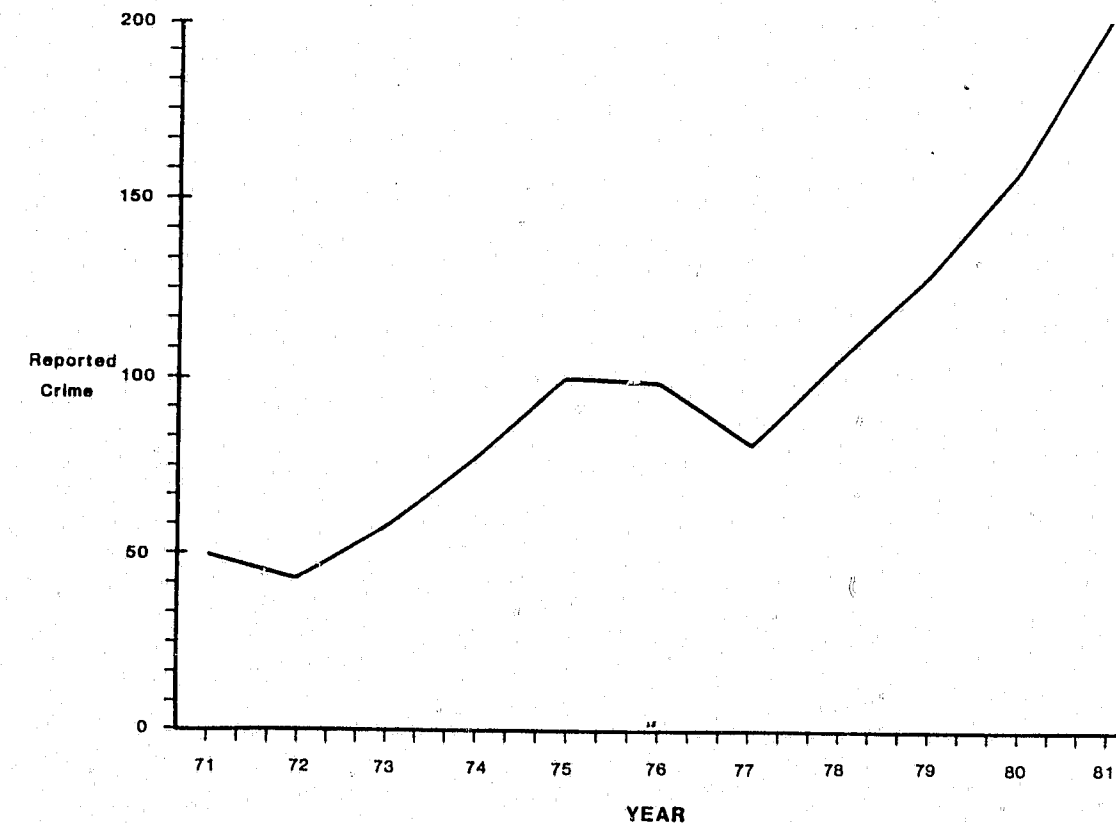
Continuing the example, there is a known mean number of arrests for this type of crime for a given jurisdiction. By multiplying this mean times each weight an eleven year estimated pattern of arrests is established that is exactly proportional to the reported crime data. The following chart shows this graphically, using 20 as the mean of arrests, $\bar{A} = 20$.

Graph 9
Example.
EFFECT OF WEIGHTING A KNOWN MEAN VALUE



This causes the arrest curve to assume the same shape as the reported crime curve, plotted below.

Graph 10
Example.
PLOT OF REPORTED CRIME VALUES USED FOR WEIGHTS



Special Case Use of Reciprocal

For most estimated jurisdictions over 5000 population there was enough reported arrest data to establish a reliable value for mean arrests. However, consider the following case:

<u>Year</u>	<u>Arrest Volume</u>
1971	no reporting
1972	no reporting
1973	no reporting
1974	no reporting
1975	no reporting
1976	no reporting
1977	no reporting
1978	22
1979	29
1980	35
1981	47

Because arrests followed a generally increasing trend, clearly any mean established on the available data here would be upwardly biased. In cases like this the reciprocals of reported crime weights for a jurisdiction were applied to the existing data to "pull" it toward the probable mean. A mean was then calculated on these adjusted values. Suppose that the weights shown table 16 are those that would be used in this case. Then these values would be adjusted as follows:

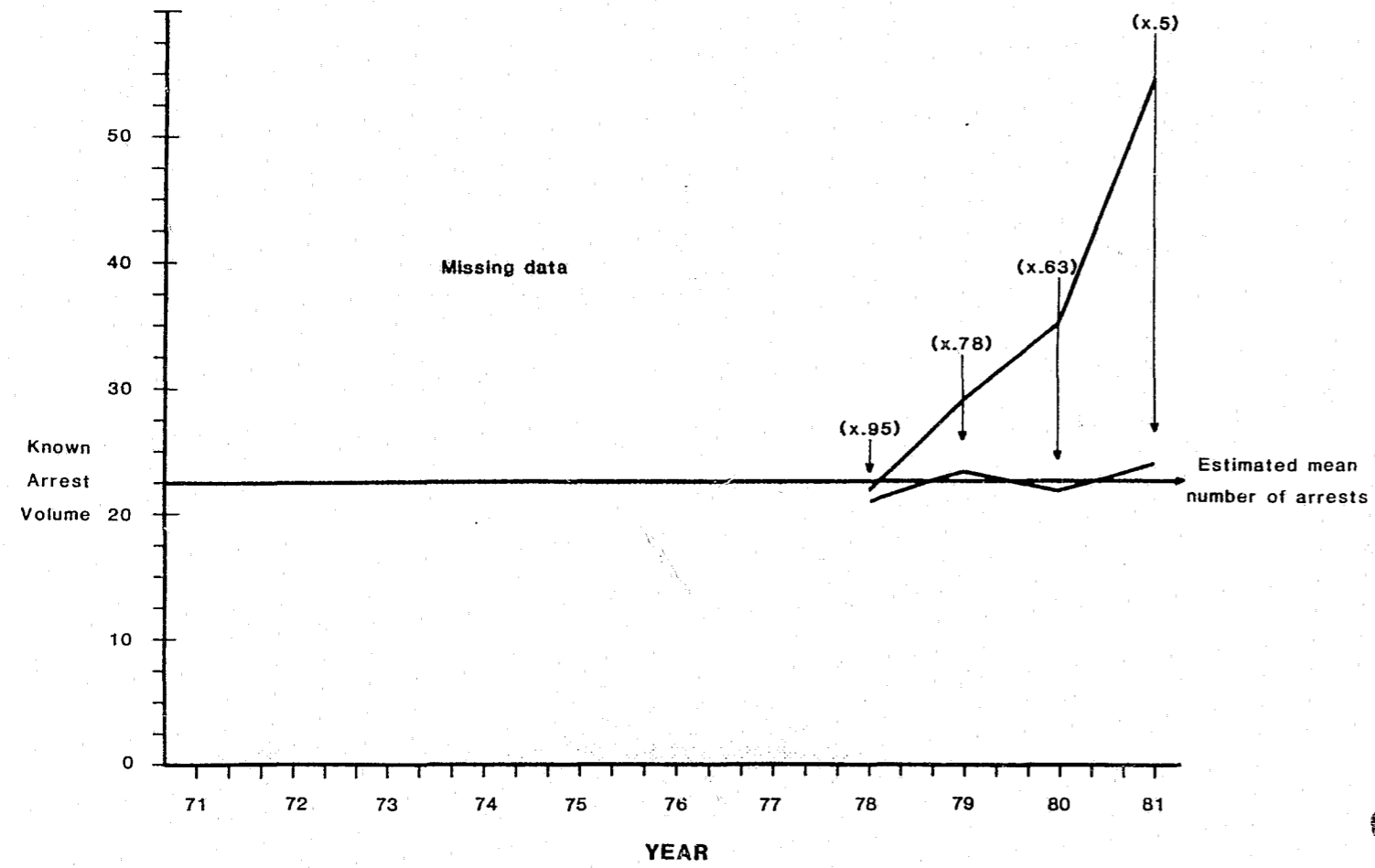
TABLE 17
EXAMPLE
ADJUSTING MEAN ARRESTS

<u>Year</u>	<u>Weight</u>	<u>Reciprocal</u>	<u>Arrest Volume</u>	<u>Adjusted Arrests</u>
1971	.50			
1972	.43			
1973	.58			
1974	.77			
1975	1.00			
1976	.99			
1977	.82			
1978	1.05	1/1.05=.95	22	21
1979	1.28	1/1.28=.78	29	23
1980	1.58	1/1.58=.63	35	22
1981	2.00	1/2.00=.50	47	24

Originally mean arrests would have been $\bar{A} = 33.25$; but corrected mean arrests is $\hat{A} = 22.5$. This corrected value is then used as the value for mean arrests in all further computations of estimates. However, corrected mean arrest values were never used in place of actual values when arrests for a jurisdiction were totaled.

The effect of adjusting arrest data is shown in the following graph. In general, data available at more extreme ends of the study period are more heavily effected by the weighting procedure.

Graph 12.
Example
EFFECT OF ADJUSTING ARREST DATA



APPENDIX 5
DIFFERENCE OF SLOPES TEST

Since a fundamental research topic of this report is the relationship between crime and arrest volumes over time, a test of the similarity of the slopes (b) between crime and arrest volumes was calculated. This test was devised by Gregory C. Chow (1960) to evaluate the similarity of slopes obtained from two different models.

*The test begins with the null hypothesis that the slope of one curve equals the slope of another curve or, $a_1 = b_1, a_2 = b_2, \dots, a_k = b_k$ in the general models shown below.

$$Y_i = b_1 + b_2 X_{2i} + \dots + b_k X_{ki} + E_i \quad (1a)$$

$$Y_j = a_1 + a_2 X_{2j} + \dots + a_k X_{kj} + E_j \quad (1b)$$

In equation (1a) there are $i=1$ to n observations and in equation (1b) there are $j=1$ to m observations.

First an unrestricted residual sum of squares is calculated. This is given by the sum of SS_1 and SS_2 so that $SS_{UR} = SS_1 + SS_2$, where SS_1 is the residual sum of squares for equation (1a) and SS_2 is the residual sum of squares for equation (1b).

If the null hypothesis is true then all observations may be gathered into one equation.

*The following discussion was adopted from Econometric Models and Economic Forecasts, by Pindyck and Rubinfeld.

$$Y_i = b_1 + b_2 X_{zi} + \dots + b_k X_{ki} + E_i \quad (1c)$$

with i now running from 1 to n+m. The residual sum of squares from this equation is the restricted sum of squares SS_R .

In the specific case of this report equations (1a) and (1b) are

$$Y_{ic} = b_{1c} + b_{2c} X_{ic} \quad (2a)$$

$$Y_{ia} = a_{1a} + a_{2a} X_{ia} \quad (2b)$$

and the null hypothesis is $b_{1c} = a_{1a}$, $b_{2c} = a_{2a}$, where the subscripts c and a indicate observations of crimes and arrests, respectively. Equation (1c) becomes

$$Y_{ica} = b_{1ca} + b_{2ca} X_{ica} \quad (2c)$$

As in equation (1c) i now runs from 1 to n+m. The subscripts c and a have been included to emphasize the fact that this equation is estimating both crimes and arrests by pooling crime and arrest data (X_{ica}). This calculation would be meaningless if crime and arrest data were left in their non-standardized forms, therefore Z-scores have been calculated to standardize both data sets.

To estimate (2c) ordered pairs of data were entered so that each year (X_{ica}) was paired first with a crime Z-score (Z_{ic}) and then with an arrest Z-score (Z_{ia}). Therefore to estimate (3) for a given crime there were 24 observations.

$$(71, Z_{1c}), (71, Z_{1a}), (72, Z_{2c}), (72, Z_{2a}) \dots (82, Z_{12c}), (82, Z_{12a})$$

Recalling that the unrestricted residual sum of squares, SS_{UR} is equal to SS_1 , the residual sum of squares from (2a), plus SS_2 the residual sum of squares from (2b) and that the restricted residual sum of squares SS_R is from (2c), the following F statistic is calculated,

$$F(k, n+m-2k) = \frac{(SS_R - SS_{UR})/k}{SS_{UR}/(n+m-2k)} \quad (3)$$

where k is the number of restrictions (in this case k=2).

If the F statistic is less than the critical value, the null hypothesis is not rejected and the slopes do not differ significantly. The following table shows the F statistic for each crime. In all cases restrictions = k = 2 and $df = n+m-2k = 12+12-4 = 20$. The critical value of the F distribution with 2 and 20 degrees of freedom (at the .05 level) is 3.49.

TABLE 18
DIFFERENCE OF SLOPES F VALUES

Crime	Standardize b for Crime Data	Standardized b for Arrest Data	F(k, n+m-2k)
Murder	.25435218	.25776337	.00256
Rape	.27185932	.27539504	.01526
Robbery	.25837075	.25056175	.01254
Assault	.26586159	.27111382	.01428
Burglary	.26101654	.24522836	.04872
Larceny	.26707513	.27245447	.19418
Auto Theft	.13281370	.02591941	.92951

In all cases F is below the critical value therefore the slopes are not significantly different.

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