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Evaluation of Innovative State and Community Alcohol Projects: Breath Alcohol Testing Program Effectiveness, Impact and Transferability

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16. Abstract
Breath Alcohol Testing (BAT) programs in Albuquerque and Santa Fe, New Mexico are evaluated in regard to effectiveness, impact, and transferability of the special DWI enforcement squads and their use of BAT Mobiles. Squad activity effectiveness is measured with DWI arrests. Univariate time series analysis verifies that department DWI arrests generally double. Crashes are analyzed for impacts resulting from the BAT programs. Multiple time series analysis applied to Wednesday through Saturday Night (7:00 p.m. - 5:00 a.m.) Fatal and Injury (WSNFI) crashes, their complements and comparison series, crashes per travel exposure measured by fuel sales, show many impact forms. Albuquerque WSNFI abruptly fall 21 percent three months into BAT programs operations and gradually approach a 69 percent reduction or greater if the overall 1 percent per month trend continues. Albuquerque WSNFI/Fuel fall 5 percent if measured from onset, 7 percent three months after, and trend overall downward 0.2 percent per month following BAT program onset. Santa Fe WSNFI temporarily fall 80 percent. Santa Fe WSNFI/Fuel also fall 80 percent for the first month, possibly returning to 23 percent less than pre-BAT program onset, while Other Santa Fe FI/Fuel trend upward at 2.6 percent per month. The repeat of the BAT program effectiveness and impact in Santa Fe implies concept transferability.

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PREFACE

The results, conclusions, and opinions written do not necessarily reflect the beliefs or opinions of the National Highway Traffic Safety Administration (NHTSA), the U.S. Department of Transportation, or any other department, agency, or individual who contributed information and help.

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BREATH ALCOHOL TESTING PROGRAM EFFECTIVENESS, IMPACT AND TRANSFERABILITY IN ALBUQUERQUE AND SANTA FE, NEW MEXICO

In April of 1979, the Albuquerque Police Department, with seed money from the Traffic Safety Bureau, New Mexico Transportation Department, began a special enforcement program aimed at countering Driving While Intoxicated (DWI) problems. The special enforcement program is composed of a squad of police officers, Breath Alcohol Testing (BAT) devices, a van which houses a BAT device and is usable as a mobile BAT station, and a Bernalillo County Detention Center officer. On New Year's Eve, 1982, the Santa Fe Police Department began a similar BAT program.

These community level DWI countermeasures were established in Albuquerque and Santa Fe principally because of the relatively large population and resource bases of these municipalities with respect to New Mexico. The goal of the BAT programs is to reduce loss of life, health, and costs resulting from alcohol-related crashes. The evaluation goal is to determine the impact of the community level countermeasure program with respect to alcohol-related crashes. Three primary steps are taken to reach the evaluation goal:

1. Evaluate DWI-Enforcement Effectiveness: this step requires measuring and evaluating the contribution of the BAT program to DWI arrest efforts.

2. Evaluate Alcohol-related Crashes for impact: this step requires careful selection of crashes to reflect the alcohol-related problem and then analysis of that series for impacts resulting from the BAT programs.

3. Evaluate the BAT program concept with regard to the transferability to differing communities.

DWI arrest data for Albuquerque and Santa Fe were used to address the changes in enforcement effectiveness resulting from the BAT programs. DWI arrest data were obtained from the respective police departments. Further efforts to evaluate program efficiency are based on the information available from the police about inputs to the BAT programs.

Crash data were investigated in general in order to provide a framework within which the impact analysis is conducted. Impacts are tested on the crashes believed to be most alcohol-related while providing large enough counts to be analyzable with statistical techniques. The surrogate alcohol-involved crash occurs during Wednesday through Saturday Night (7:00 p.m. to 5:00 a.m.) and is a fatal or injury crash, WSNFI. Monthly counts were created over the years 1972 through 1984 for the 156 observation time series. In addition, WSNFI crashes were scaled to a measure of traffic exposure with data on fuel sales. Complementary data to WNSFI with respect to Albuquerque and Santa Fe and comparison WSNFI series were also analyzed.

Crash data were obtained from the New Mexico Transportation Department's Traffic Statistic Bureau. Fuel sales data were obtained from the New Mexico Taxation and Revenue Department.

Time series analysis techniques were applied to both DWI arrests and crash data. The impact evaluation utilized a multiple time series research design.

BAT program transferability was evaluated with a synthesis of information derived in the first two evaluation steps.

Results: The BAT programs in both Albuquerque and Santa Fe effectively result in increases in DWI arrests. In Albuquerque, DWI arrests asymptotically approach an increase of 436 DWI arrests per month over prior levels. In Santa Fe, the increase in DWI arrests is 52 a month. With respect to Department total DWI arrests, these increases represent at least a 50 percent increase in enforcement indices with little or no increase in officer-hours.

Crashes showed a gradual decline in frequency over the years 1978 to 1982; afterwards there is an increase in both Albuquerque and Santa Fe. However, the percentage of DWI citations issued in crashes and other indicators of alcohol-involvement show general increases in the relative portion of alcohol-involvement over the years 1978 to 1980 or 1981, and a decline thereafter.

Impacts on the alcohol-related population, as measured by proxy following the BAT programs, are detectable. In Albuquerque, when WSNFI are analyzed for impact, three forms of reduction are found; a three-month lagged step reduction of 19 WSNFI (-21 percent), a gradual permanent reduction of 64 WSNFI (-69 percent), and a downward trend of -1 WSNFI per month (-1 percent per month). When Albuquerque WSNFI/Fuel are analyzed for impact, an abrupt permanent step reduction at theoretical onset of -0.3 (-5 percent), a three-month lagged step reduction of -0.4 (-7 percent), and a downward trend of -0.01 (-0.2 percent per month) WSNFI/Fuel are found. No changes in Other FI or Other FI/Fuel are found in Albuquerque which correspond to the Albuquerque BAT program. In Santa Fe, abrupt temporary reductions of -80 percent are found for WSNFI (-12) and WSNFI/Fuel (-4). In contrast, an upward trend of 0.42 Other FI/Fuel per month (+2.6 percent per month) is found. It is hypothesized that actual or relative downward trend impact models provide a plausible explanatory framework for the results of the BAT programs in that the DWI problem is slowly but progressively reduced.

Although the BAT programs require some input from the police, they result in increases in DWI arrests and arrest rates, and have progressive impact on alcohol-involved crashes. Therefore, the BAT program concept appears transferable. There are at least two kinds of outcome and at least two specific police styles of input that are involved in discussing transferability. These are department and area populations and field service strategies.

BAT Program Effectiveness, Impact and Transferability

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LIST OF ABBREVIATIONS AND SYMBOLS

APD - Albuquerque Police Department

AR - Administrative Revocation of driver's license

ARIMA - Autoregressive Integrated Moving Average

B - Backshift operator

BAC - Blood Alcohol Concentration, 0.1 gram of alcohol in 100 milliliters of blood = 0.10 BAC.

BAT - Breath Alcohol Testing

BCDC - Bernalillo County Detention Center

BMDP - BioMedical Programs Statistical Software

δ - Delta, rate of change in level, $y_{t+1} = y_t + \delta y_{t-1}$

DUI - Driving Under the Influence (of Alcohol)

DWI - Driving While Intoxicated

FI - Fatal and Injury

I - Switching Operator

NHTSA - National Highway Traffic Safety Administration

NMSA - New Mexico Statutes Annotated

ω - Omega, change in level

PDO - Property Damage Only

%Δ - Percent change

RSS - Residual Sum of Squares

SAS - Statistical Analysis System

SFPD - Santa Fe Police Department

SLD - Scientific Laboratory Division, New Mexico Health and Environment Department

t - Statistic related to Student's t distribution

TSB - Traffic Safety Bureau, New Mexico Transportation Department

VMT - Vehicle Miles Traveled

WSN - Wednesday through Saturday Night

WSNFI - Wednesday through Saturday Night (7 p.m. to 5 a.m.) Fatal and Injury (Crashes)

INTRODUCTION

Deterring and controlling the intoxicated driver by special enforcement units and breath alcohol testing (BAT) mobile unit technology is the objective of the police departments in Albuquerque (APD) and Santa Fe (SFPD), New Mexico. These BAT programs' goal is to reduce the loss of life, health and costs that result from alcohol-related crashes. The evaluation goal is to determine the impact of the countermeasure programs with respect to alcohol-related crashes. Three related evaluation objectives are used to reach this goal.

Because the BAT technology is an enforcement tool it is necessary to first assess the effectiveness of enforcement operations and administration in utilizing the technology in the context of field service. The next objective is the determination of the actual impact on crashes; especially those involving DWI (Driving While Intoxicated) offenders. Finally, the circumstances of the programs, a seven year program beginning in April, 1979 in Albuquerque and a four year program in Santa Fe, beginning in January 1983, lend themselves to an assessment of the adaptability of the countermeasure concept with regard to widely differing communities. The third objective is to address the transferability of the BAT technology and special enforcement squads that comprise the BAT programs. This evaluation is structured in accordance with three general hypotheses to be tested:

- DWI-Enforcement Effectiveness Hypothesis: Does the BAT program increase apprehension of intoxicated drivers?
- Enforcement Effectiveness and Alcohol-related Crash Reduction Hypothesis: Can DWI enforcement effectiveness reduce DWI crashes?
- Transferability Hypothesis: Is the BAT technology and special enforcement program adaptable to various communities?

BAT TECHNOLOGY

The breath alcohol testing devices are infrared instruments used by officers certified by the Scientific Laboratory Division (SLD).[1] A fingerprint spectrum of a molecule is generated when infrared energy from a source passes a concentration of the molecule. The fingerprint is the

[1] Certification of police operator is performed once a year by the SLD, New Mexico Department of Health and Environment, to insure competency in the use of the Intoxilyzer 4011A and other secondary BAT devices. The SLD certified police officer is called a key operator. BAT devices are periodically calibrated and chronological logbooks of use are kept by the key operator.

energy absorbed at given wavelength associated with the resonant energies of the molecule. By using an appropriate filter and a photodetector the ethanol concentration is determined.[2] The BATs are placed in vans which the special DWI enforcement squads use as mobile stations. The vans, BAT Mobiles, are further equipped for use in the DWI countermeasure programs by the police. The vans are equipped with radio communications, a breath alcohol testing station, and a detaining bench. A notable feature of the Albuquerque area program is the addition of a corrections officer and a booking station, thereby facilitating the jailing process. When the machine takes a breath sample, and transforms the reading into an equivalent BAC measure, the data is printed out on a card which is kept as a record. APD has four intoxilyzers which are calibrated twice a week by chemists. Accuracy is reported to be excellent, + or - .01 of blood sample BAC tests.[3] The DWI Squad and DUI Squad, in Albuquerque and Santa Fe respectively, operate somewhat differently, although both utilize the BAT Mobiles as a BAT station for officers in regular patrol units making DWI arrests (see Operational Descriptions below).

BACKGROUND

An implicit assumption being made by the police is that increased enforcement activity will deter the would be DWI offender and control the already intoxicated driver. Controlling a DWI offender is possible only after apprehension. Apprehension is a product of enforcement level and incidence. The causal relationship between enforcement levels and deterrence is contended by theorists. Ross' review of research on traffic law and enforcement campaigns finds many cases that the public's perception of increased certainty of arrest for DWI has a temporary impact on serious motor vehicle crashes:

> Both enforcement campaigns and novel drinking and driving laws may increase public perception of the certainty of punishment for violators. Both the laws and enforcement campaigns are found to be effective but only in the short run.[4]

In contrast to that contention, Votey finds evidence that increases in enforcement efforts leading to higher probability of sanctions results in lower levels of serious motor vehicle crashes.

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[2] W.I. MacPherson, Prosecutors Manual for DWI Cases (Federal Traffic Safety Grant G-AL-84-02-02-06, Albuquerque, New Mexico: Institute of Public Law, University of New Mexico, 1984), 3-27 through 3-30.

[3] Machine evidence has apparently not been successfully disputed in court.

[4] H.L. Ross, Deterring the Drinking Driver: Legal Policy and Social Control (Lexington, Massachusetts: Lexington Books, 1982), 90.

> The tests conducted in this collection of studies support the hypothesis that law enforcement and existing sanctions against convicted drunken drivers have a statistically significant effect in reducing crashes.[5]

The foundation for these contentions is a model of simple deterrence[6] as a function of certainty of apprehension, severity of punishment, and celerity of consequences. In terms of simple deterrence theory, enforcement effectiveness represents the certainty of apprehension, penalties/sanctions for DWI represent severity, and celerity is the product of effective police, courts, and jails. The deterrence value is that extent to which changes in any level of the three elements result in changes in the population's behavior.

Although this evaluation is aimed at practical matters, it provides evidence in favor of Votey's hypothesis.

The operation of the BAT Mobiles constitutes community level DWI enforcement countermeasures. At the community level the DWI enforcement levels are further bolstered by the statewide countermeasures and dependent on implied consent and per se legislation, NMSA 24-1-22, 66-8-104 and 66-8-102(c).[7] The Traffic Safety Bureau (TSB), New Mexico Transportation Department, helped these community level programs get underway with funding, along with other community level programs, and was instrumental in suggesting recent statewide DWI countermeasures enacted by the legislature (Figure 1). The statewide DWI countermeasures are increased penalties/sanctions for DWI:

- Mandatory minimum forty-eight consecutive hours jail sentence for second and subsequent DWI offenses, NMSA 66-8-102,[8] March, 1982,
- Persons tested at or above 0.15 BAC must be tried on the charge of DWI, prohibiting plea bargaining or determination of guilt or innocence on lesser charges, NMSA 66-8-102.1,[9] March 1982, and
- Immediate drivers license revocation, under the administrative authority of the New Mexico Transportation Department, for ninety days

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[5] H.L. Votey, Jr., "Recent evidence from Scandinavia on deterring alcohol impaired driving," Crash Analysis and Prevention, Volume 16 Number 2 (1984) 137.

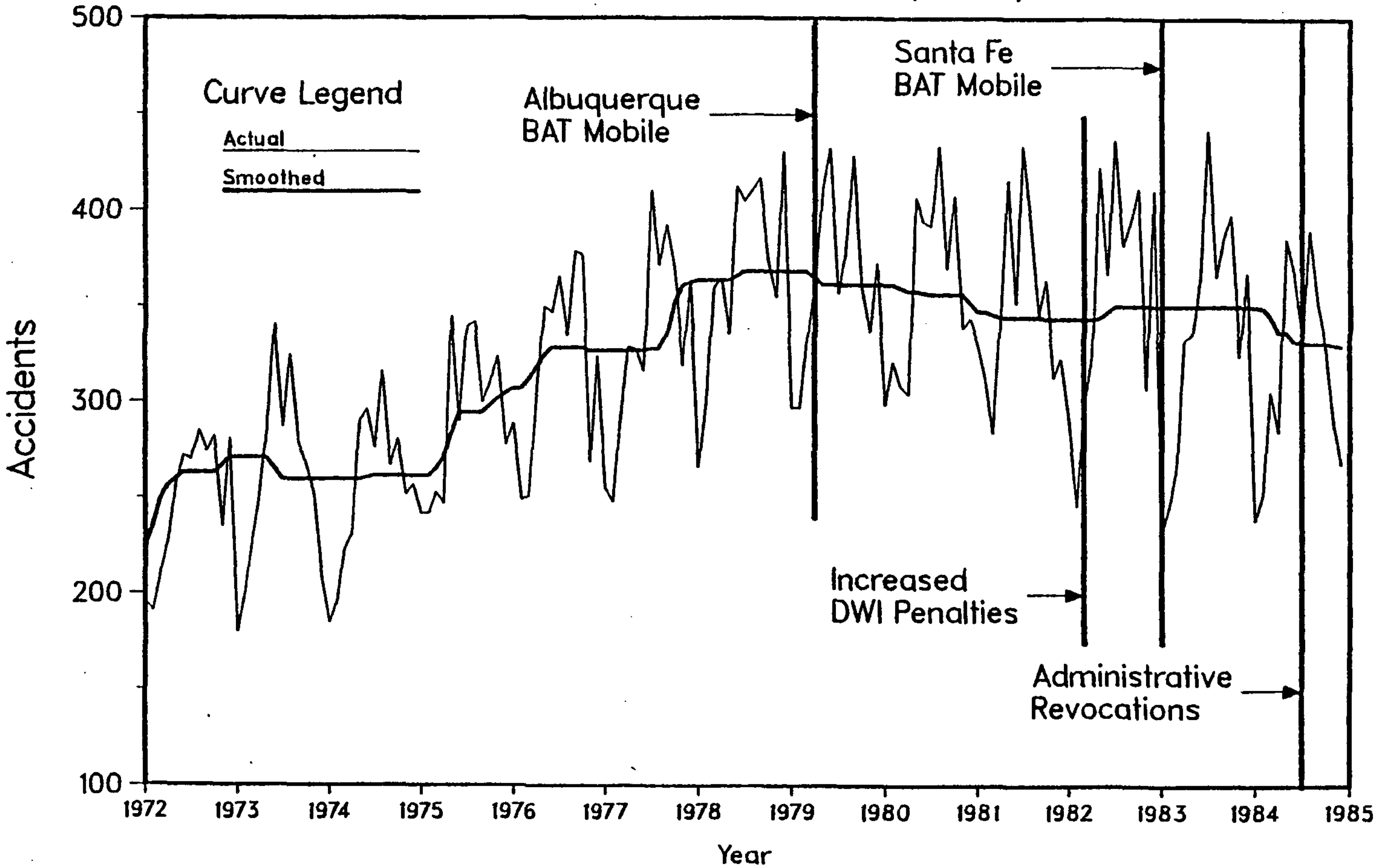
[6] Op. cit., Ross, 7-9.

[7] Op. cit., MacPherson, Appendix, 1984 Supplement.

[8] Ibid., 15-5 through 15-6.

[9] Ibid., Appendix, 1984 Supplement. In July, 1984 the BAC limit was reduced to 0.10.

Figure 1. New Mexico
Wednesday throutgh Saturday Night (7pm to 5am)
Fatal and Injury Accidents (WSNFI)



Note: Smoother is a double median 12.

for a DWI offense, NMSA 66-5-29, 66-5-32(B), 66-8-111, 66-8-111.1, and 66-8-112,[10] July, 1984.

This last sanction is referred to as Administrative Revocation (AR). For practical reasons the impact of AR is not addressed in this evaluation with analytical techniques. The reason that the AR impact is not analyzed is that too few observations were available for statistical robustness.

From the perspective of the police,[11] BAT Mobiles enhance the certainty of apprehension in at least three ways:

1. they allow more patrol time by reducing the excessive amount of time required to complete a DWI arrest, from 2 1/2 hours to 1/2 hour, thereby increasing arrests and arrest rates,

2. they eliminate unnecessary arrests and increase credibility in courts because of the ability to determine intoxication levels on a scientific basis,

3. they allow the officers to develop their tradecraft by honing their DWI acuity through the feedback provided by the detection, apprehension, and testing cycle of the DWI arrest and the BAC test.

Based on the presumed effectiveness of the BAT program in Albuquerque,[12] a similar program was begun in Santa Fe. The Santa Fe BAT program provides the same kind of services as the Albuquerque program, though tactical utilization of the BAT Mobile differs. The two strategies reflect some inherent differences in those communities. Local police must adjust and allocate their resources appropriately. Regardless of the differences in communities, the intent is the same.

OPERATIONAL DESCRIPTION

Albuquerque BAT Program: The APD Special Services DWI Squad operates five regular patrol cars (black and white units) and two specially equipped BAT Mobile vans four days each week; Wednesday through Saturday nights (WSN). The shift begins at seven p.m., with roll call and discussion. The squad usually rolls into service by eight p.m. The BAT Mobiles respond to requests by going to the calling officer. This is standard procedure until eleven p.m. when the two BAT Mobiles go to sta-

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[10] Ibid.

[11] Albuquerque Police Department and Santa Fe Police Department. Personal communications, 1985.

[12] R. Calderwood and B. Woods, "Impact Evaluation of the Breath Alcohol Testing Mobile in Albuquerque, New Mexico," Traffic Safety Evaluation Research Review, Volume 2 Number 4, (Winter 1983) 34.

tionary positions within the city limits and continue to provide BAT service. The positions are predetermined to maximize coverage areas and minimize travel time for regular patrol units. The Bernalillo County Detention Center (BCDC) also has a breath tester. These three locations provide for central locations for breath alcohol testing during the busiest hours, eleven p.m. to three a.m. The shift ends at five a.m. the following day.

In Albuquerque, a corrections officer rides in each of the BAT Mobiles. The BCDC officers facilitate booking an arrested DWI offender, which streamlines jailing procedures.

An added feature of the DWI squad operations involves regular rotation of officers that operate the BAT Mobiles to DWI patrol units. Regular patrol officers, non-DWI squad, are also given the opportunity to ride with the DWI squad so they may learn procedures and gain insights in detection and in dealing with individual DWIs.

In recent dialogues with DWI squad administration,[13] the most used and emphasized word was flexibility. The continuing success of the program, from the perspective of the police administrators, was attributed to the flexibility shown for what appears to be continually changing circumstances. The changing circumstances range from local events to statewide policies. Local events, such as the state fair, are characterized by a dramatic focus on the DWI problem area, and therefore necessitate changes in manpower allocations to concentrate enforcement effort. The fair is the number one DWI problem event. Another example of changing circumstances was the impact on police operations from AR authority, beginning July 1984. The AR process required that an affidavit be signed by a Notary Public, in addition to two other reports.[14] The first solution found was to make the DWI squad officers Notary Publics. As a consequence, DWI squad officers usually had to be contacted for every DWI arrest. This presented a different kind of problem -- extra demand on DWI squad officers. Another solution was sought and found -- do not require the affidavit to be notarized. This result came from the cooperative effort of the Transportation Department.

Santa Fe BAT Program: The Traffic Division Special DUI Shift of SFPD, operates the one BAT Mobile Unit on a regular schedule of seven p.m. to three a.m. of the following day, Tuesday through Saturday.[15] Two specially trained officers are on duty with the unit. A third officer is part of the squad, and is used for relief rotations. The DUI squad officers are

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[13] Lt. F. Lackenmeyer, Sgt. G. Najar, and Sgt. L. Heckroth, Albuquerque Police Department. Personal communications, 1985.

[14] Recent changes in the AR process have eliminated the cumbersome affidavit paperwork.

[15] Lt. V. Nasca and Sgt. T. Delgado, Santa Fe Police Department. Personal communications, 1985.

responsible for arresting, testing, and transportation.[16] Unlike the Albuquerque program, the Santa Fe BAT Mobile is not stationary.

The city of Santa Fe, 55 miles to the northeast of Albuquerque, is approximately a tenth the population of Albuquerque, a little over 50,000 residents. In addition to being the capital, Santa Fe also attracts a large tourist population on a regular basis for the opera and ski seasons.

[16] Generally, the second DUI officer patrols in a black and white unit. Occasionally, the BAT Mobile is out of service. When this happens, both DUI squad officers patrol in black and white units. The van's reliability and time in service appears to be good, 95 percent. The 5 percent down time includes some generator failures, fungi in the fuel, and other mechanical problems that occur to heavily used equipment.

DESIGN AND METHODOLOGY

In order to ensure that any impact results are reasonably attributable to the effect of the BAT programs and not other factors, the evaluation is addressed in three blocks, each with its own research design: 1) the effectiveness of DWI enforcement efforts utilizing the BAT Mobiles, 2) impact on alcohol-related crashes, and 3) transferability.

It is heuristically useful to think of the problems presented in the first two evaluation blocks in terms of three overlapping populations; police, crashes, and driving alcohol consumers. Although considering these three populations without regard to a larger social and legal system oversimplifies the real world it does enable discussions of fundamental definitions. BAT program effectiveness is measured with respect to the intersection of the police and alcohol populations. By using measures of DWI arrests and arrest rates the effectiveness of the police to increase the certainty of apprehension may be evaluated. A direct measure of police field service hours would be useful for an administrative evaluation of program efficiency. Unfortunately, only limited amounts of data are available from the police about manhours of field service. Information from informal dialogs about police activities are used to address issues with regard to the BAT program efficiency. Impact from the BAT program is measured with respect to the intersection of the crash and alcohol populations. A measure of change in alcohol-related crashes concurrent with the program onset will indicate the nature of the impact while trying to control for other explanatory effects. Multiple time series research designs are used and will be discussed with respect to the quasi-experimental methods. BAC records may indicate other changes in the alcohol population resulting from the deterrence impact from the BAT programs. If impacts are detected in the two communities, then program and technology transferability may be inferred.

EFFECTIVENESS

The operation of the DWI squad is considered first. With a seven year program in Albuquerque and the four year program in Santa Fe it is appropriate to evaluate and compare data and observations for both in order to provide more generalizable conclusions. The comparison of the two program sites allows a replication of tests of hypotheses on the effectiveness of the BAT program.[17]

A most basic question about enforcement relates to the first testable hypothesis:

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[17] Untestable information is also discussed because of the relevance of having informal dialogues with the police about the BAT programs.

- Does the use of BAT Mobile Units facilitate officer's DWI enforcement activities?

Enforcement Hypothesis: DWI arrests and the proportion of DWI arrests increase because of the BAT program, the squad and the BAT Technology.

In terms of administrative objectives, the successful BAT program ought to show significant increases in the number of DWI arrests without an increase in field service manhours. Further, because raw numbers of arrests may be misleading because of traffic or police population dynamics and their interactive effects, it is important to compute an "enforcement index" based on the ratio of arrests to those populations. An "enforcement index" ought to show an increase in the proportion of DWI arrests given that the program is successful. Lastly, the index ought to provide information about police input, at least in general terms. Without a direct measure of police input available alternative indices had to be based on information about known input with respect to traffic, DWI arrests, crashes, and DWI citations in crashes.

The available alternative way of assessing police input was to examine the police input with respect to crashes to look for changes that will bring to light police activity levels and other population dynamics.

- Do police efforts change with regard to the crash population at large?

1. Is there more or less traffic?

2. Are there more traffic crashes to be reported?

3. Are there more DWI arrests made in crashes as measured by reported DWI citations in crashes?

4. Are proxy measures of alcohol-involved crashes indicating change?

If overall police input is consistently proportional to the traffic population for all measures, then the additional field service activity of making DWI arrests without regard to crash involvement might be considered to be a benefit from the specialization in activities and technology, rather than from an increase in manhour input.

There are several other complications introduced into the problem of evaluating program efficiency, not only because of missing information on the number of field service manhours, but by the very nature of how the police departments define DWI duty. Currently the Albuquerque BAT program is a subset of Special Services Bureau. Special Services Bureau includes nine other squads in Operations Division. Special Services is only one of four Bureaus. There are more than 280 APD officers performing field services. All officers are expected to make some DWI arrests. DWI squad officers are expected to make many DWI arrests and provide some other kinds of police services. Prior to 1979, there were no such clear divisions in labor. Therefore, even if manhour data were available for pre- and post-BAT program there would be a problem of how to measure police inputs with generalized numbers and specific task duties to be evaluated.

DWI squad and BAT Mobile effectiveness is evaluated with the number of DWI arrests. The BAT program efficiency is evaluated with available information about police inputs and information from crash records which imply inputs from police.

This again relates to the heuristic model of the three overlapping populations of police, crashes, and alcohol. What can be directly measured are the populations at the intersections of these populations. Only limited conclusions may be drawn from these subpopulations about the larger three. The most definable of the three populations is crashes. Through analysis of crashes better understanding of the other two populations may be reached.

If, for example, crashes were to change because of changes in travel or another cause unrelated to DWI, and DWI-related crashes were proportionate to crashes, then the rate of citing for DWI per crash ought not to change. Alternatively, if there is a change in the rate there is prima facie evidence that enforcement reporting levels or DWI offenses have changed.

Changes in reporting procedures and criteria of crashes may complicate results. Fatal and injury (FI) crashes are much more likely to be reported than property damage only (PDO) crashes. Therefore, alcohol-involved crashes are looked at with regard to FI and all crashes (including PDO).

The alcohol population was studied through the crashes occurring at the intersection of the two populations. Two population measures were used. The measures were a proxy measure of alcohol-involved crashes and police reported alcohol-involvement. However, reported alcohol-involvement presents a paradox: while such data are unreliable for measuring true alcohol-involvement,[18] they measure the perspective of the police, to a limited extent, on the role of alcohol-involvement in crashes. If both the proxy measure and reported alcohol-involvement are used and indicate the same behavior then, again, consistent police input may be assumed.

One other element to consider is the endurance of the officers themselves. Because DWI duty has the down side of lots of exposure to intoxicated people, officers may lose enthusiasm for their duty. Therefore, routinization as an effect on enforcement is best addressed by comparing observations and information gathered from informal dialogues. The essential question is:

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[18] J. Waller, "Factors associated with police evaluation of drinking in fatal highway crashes," Journal of Safety Research, 3 (1971) 35-41.

- Do officers of the DWI squad lose enthusiasm and therefore enforcement effectiveness when in service for the selective enforcement of DWI laws?

Burnout Hypothesis: There is periodic high turnover in personnel.

Some transfer activity into and out of the DWI squad is expected because of the wide variability in individual officers' ambitions and interests. The difference between some turnover due to individuals needs and disproportionate turnover rates due to "burnout" from overexposure to intoxicated drivers is, to some degree, an administrative problem. In as much as this evaluation is undertaking the task of determining the efficacy of administration of the BAT programs, the notion of burnout is examined. If high turnover leads to fewer DWI arrests, there is evidence that administrators are not managing effectively.

Measures: In part, tests of hypotheses are based on the criterion that the data have the advantages of 1) existing as an objective source of information that have 2) been maintained over a period covering the time before and after the countermeasure.

The most direct measure on enforcement activities is the number of DWI arrests.[19] However, the use of the number of arrests alone does not indicate that arrests increase proportionately. The same problems hold true for other measures of efficacy; crash counts and DWI citations in crashes.[20] Raw counts are products of seasonal cycles and trends in the amount of road travel which in turn may be products of underlying dynamics in population, economic conditions, fuel supplies, and policy changes. Thus it is necessary to create proportional measures. The most straightforward proportional measures are percentages. Throughout the evaluation numerous rates are created and analyzed for different purposes. For the present purposes, evaluating the effectiveness of the BAT programs, the proportional measures are:

1. DWI arrests per driving population. Ideally the driving population would be represented by the number of licensed drivers. Unfortunately, reliable counts are not available for all the periods considered. Counts of registered vehicles are available and are used to represent the driving population.

2. The percent of DWI citations issued in crashes with respect to total crashes and the subset of FI crashes.

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[19] Specials Services Bureau, Traffic Analysis, Albuquerque Police Department and Traffic Division, Sata Fe Police Department.

[20] Crash records are received from the New Mexico Transportation Department, Traffic Statistics Bureau and maintained for use and analysis by the Division of Government Research, Institute for Applied Research Services, University of New Mexico for the Traffic Safety Bureau.

3. The proportion of DWI crashes to all others. This is measured in two ways. Since serious weekend nighttime crashes are more likely to involve alcohol than other crashes[21] it is useful to examine these DWI proxy crashes for changes in the frequency of DWI. The indirectness of the proxy measure may overestimate the levels of DWI because not all crashes are alcohol-related. On the other hand, when the rate of DWI citations issued in crashes to all other crashes is used to examine changes in the frequency of DWI, the level of DWI may be underestimated because not all DWIs have crashes. By using both DWI rate measures it is believed that a better representation will be available than if only one measure were used.

4. The percent of reported alcohol-involvement in crashes with respect to total and FI crashes.

5. The percent of DWI citations issued in crashes with respect to reported alcohol-involvement.

Analytical Techniques: While time series techniques are used within this evaluation to test hypotheses, where data support the technique, other tests are also required for evaluating effectiveness hypotheses. All statistical tests are at the conventional 95 percent confidence limit. Two tailed tests are also utilized because of the lack of assumptions about the direction in which measures may change. The rationale for the time series techniques are discussed in full in the section on impact and the appendices because of the prominence of the technique in those sections.

Research Design: Because the BAT Mobile/DWI squad programs are in nonrandomly selected sites the evaluation has to be based on quasi-experimental designs. The most rudimentary requisite is that information be available for periods both before and after an event. Furthermore, the validity of any measure must be unthreatened by changes in the monitoring mechanism. As noted at the outset of this section, the data used meet these minimal criteria. However, many threats to validity exist

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[21] R.L. Douglass, L.D. Filkins, and F.A. Clark, The Effect of Lowered Legal Drinking Age on Youth Crash Involvement, Final Report (No. UM-HSRI-AL-74-1, Ann Arbor, Michigan: Highway Safety Research Institute, University of Michigan, 1974). Sponsored by the National Highway Traffic Safety Administration.

R.K. Jones and K.H. Joscelyn, Alcohol and Highway Safety 1978: A Review of the State of Knowledge: Summary (Ann Arbor, Michigan: Highway Safety Research Institute, University Michigan, January 1978).

which may negate inferred conclusions.[22] These sources of threats to validity are history (temporally coincidental events), maturation (natural growth process), testing (performance on similar tests), regression (regression to the mean), mortality (loss of members of population), selection (initial differences in contrasted populations), and interaction between threats.

Types of errors related to these threats to validity are ameliorated when control groups are included and the number of observations is increased. History effects may be controlled for by examining observations from a group not expected to have an effect resulting from a quasi-experimental event. Regression artifacts diminish as larger numbers of observations are included for both the pre and post periods. Similarly maturation, testing, and mortality effects are reduced when large populations are drawn upon. Selection effects can be minimized by contrasting identical, except for the quasi-experimental event, populations. Unfortunately for research concerns, there are no identical municipalities in New Mexico. Interactions between initial differences due to selection and any of the other threats provide real hazards to inferential logic. While no quasi-experimental design can provide absolute control, the hazards are reducible with large numbers and wise selection of controls.

IMPACT

The determination of the impact is not a simple problem. The BAT programs are one community level countermeasure in a period with many other alcohol-related problem countermeasures. In addition, population and economic conditions also changed. There are many threats to validity as identified by Ross and Campbell and Stanley, discussed above. The impact on traffic is further dependent on the effectiveness of the police in providing enforcement. Fortunately, time series analysis techniques allow for a statistical test of hypotheses which meet the criteria for validity. Since enforcement levels are to be measured and assessed for effectiveness it is therefore possible to unambiguously address the impact of the BAT programs:

- Have BAT programs reduced losses of life, health, and property due to alcohol-related crashes, and by how much?
- Has the effort had an impact on the level of intoxication (BAC) of DWI violators?

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[22] H.L. Ross and R. McCleary, "Methods for Studying the Impact of Drunk Driving Laws, Crash Analysis and Prevention, Volume 15 Number 6 (1983) 420.

D.T. Campbell and J.C. Stanley, Experimental and Quasi-Experimental Designs for Research. (Chicago, Illinois: Rand McNally, 1966), 11.

Impact Hypothesis: The BAT programs change the frequency of alcohol-related crashes and the amount of alcohol involved (BAC).

The first impact question will be determined with multiple time series analysis techniques. The advantage of using multiple time series is that alternative explanations or rival hypotheses may be addressed. The time series are surrogate measures of alcohol-related crashes (see Measures below for specifics). The measure of impact will be based on intervention effect of the BAT programs on alcohol-related crashes. If a decline in the series appears to be attributable to the countermeasure a plausible alternative explanation may be made that the DWI offenders are now driving on other days. Therefore, complementary time series are also considered, a measure of non-alcohol-related crashes. Similarly, plausible arguments may be made that other pervasive factors, e.g., economic conditions, may make any impact measure spurious. There are two approaches made to control for these externalities:

1. Again, by including comparison crash series rival hypotheses may be evaluated. The comparison series are the corresponding crashes in comparable municipalities in New Mexico that do not have a BAT program.

2. A crash rate is derived in order to control for exposure.

A second indication of program effectiveness considered is the average level of intoxication as measured by BAC. This point reflects the feedback to officers with regard to their judgement in detecting DWI violators. In theory, as police acuity to DWI increases through the feedback provided by the BAT it is more likely the less visibly intoxicated driver will also be apprehended. This too complements the measure of impact as put forth in the second evaluation question.

Measures: Because "dark figures"[23] plague research on the DWI problem, indirect measures of DWI must be sought. The "dark figure" is the unknown population size. Often, what is known to the police is a small and distorted representation of a whole population. The impact assessment is made on alcohol-involved crash surrogates, proxy series, that are more likely alcohol-related than other crashes.[24] The proxy series is Wednesday through Saturday night (seven p.m. - five a.m.) fatal and injury (WSNFI) crashes. The proxy series provides sufficient counts and is likely to be sensitive to alcohol-related crashes. Note that the proxy series corresponds to the field service schedule of the BAT programs, largely because the police also perceive the period to be the normal DWI

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[23] Op. cit., Ross and McCleary, 415-428.

[24] U.S. Department of Transportation, Alcohol and Highway Safety 1984: A Review of the State of Knowledge, (DOT HS-806-569, Washington, D.C.: National Highway Traffic Safety Administration, February 1985), 82.

problem time.[25] The non-proxy crashes are also used, those fatal and injury crashes not occurring on Wednesday through Saturday night, Other FI.

A total of nine series are analyzed. Each series measures the monthly frequency of FIs. The two series where impacts might be found are Albuquerque and Santa Fe WSNFI. Series not expected to show impacts are complementary non-WSNFIs crashes in Albuquerque and Santa Fe and comparison WSNFIs in Farmington, Las Cruces and the aggregation of all other New Mexico urban communities of population greater than 5,000. The remaining two series are rural WSNFI and New Mexico total WSNFI. All nine series have monthly data from 1972 through 1984, 156 observations.

The rationale for using crash rates in the multiple time series analysis follows the argument discussed earlier in the section on measures of enforcement effectiveness, raw counts may be misleading. Traditionally, estimates of Vehicle-Miles-Traveled (VMT) are used to scale crashes proportionately to exposure in traffic. Since fuel sales, gasoline and ethanol, are available and are used in calculating VM estimates, and VMT estimates for urban areas on a monthly basis are not available,[26] gasoline and ethanol fuel sales are used to control for the possibility that post-intervention changes in crashes are due to changes in travel.

Creating a ratio of crashes to fuel sales may have ramifications in this evaluation. The first consequence relates to the effects of increased fleet fuel efficiency. This effect will tend to make for conservative impact measures, if any, because of the relative increase in exposure without an increase in consumption.

The second consequence follows the problems introduced through the inclusion of ethanol fuel sales. Both gasoline and ethanol fuel sales data ultimately come from the New Mexico Taxation and Revenue Department, which collects and analyzes the data with respect to revenues for the state. Ethanol sales records are not kept in the same detailed manner as gasoline sales data because of ethanol's different tax status. Although improvements are underway, monthly ethanol fuel sales were only available at the statewide level. In order to approximate ethanol fuel sales in each of the nine sites, the amount distributed to each site was set equal to that proportion of gasoline sold in that site to total gasoline sales in New Mexico. While this method is not exact and may over- or under-represent the true distribution of ethanol sales it is preferable to simply omitting ethanol sales altogether.

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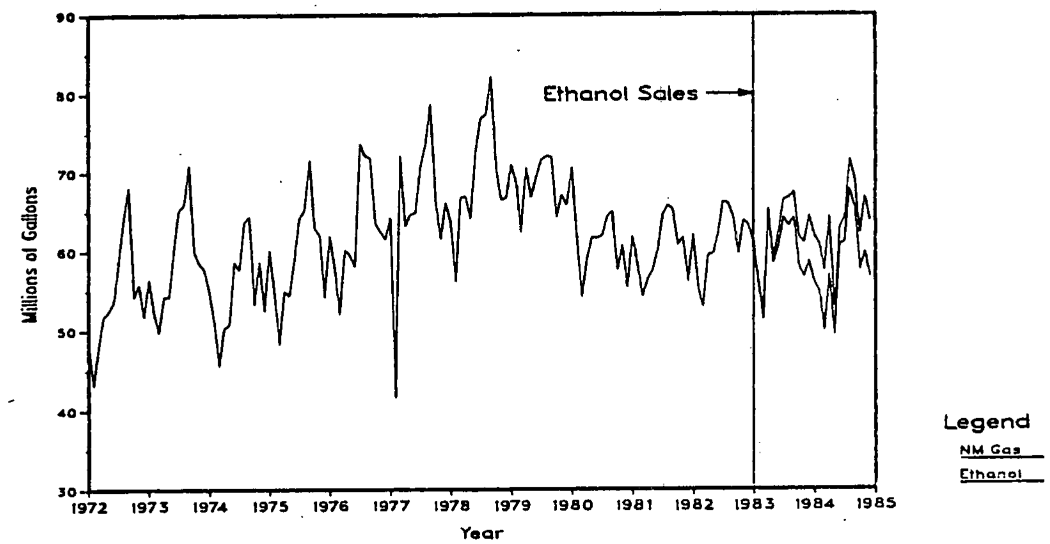
[25] Sgt. T. Delgado, Santa Fe Police Department. Personal communication, May 1985.

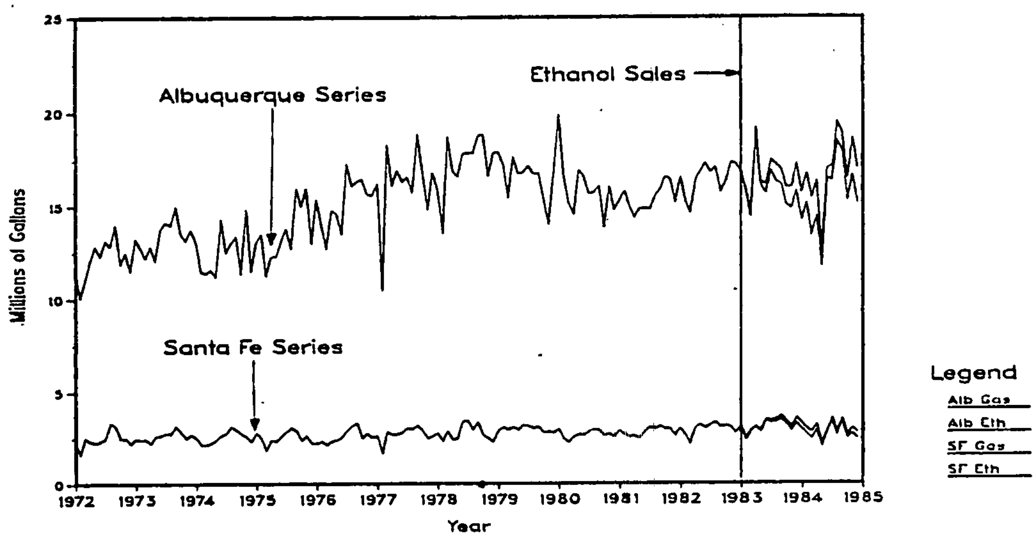
[26] VMT estimates are available at the system level in the form of average daily vehicle miles from the New Mexico State Highway Department.

Figure 2.
Gasoline and Ethanol Sales: New Mexico Total and Adjusted Municipalities.

New Mexico



Albuquerque and Santa Fe



Produced by the Division of Government Research, IARS, UNM
for the National Highway Traffic Safety Administration
Under Grant No. DTNH22-84-C-05051

Source: New Mexico Taxation and Revenue Department, and
New Mexico State Highway Department.

The amount of ethanol distributed to the two primary sites, Albuquerque and Santa Fe, is graphically represented in Figure 2, Gasoline and Ethanol Sales: New Mexico Total and Adjusted Municipalities. Those ratios are, on average, .25 and .05 for Albuquerque and Santa Fe, respectively. The 1984 average monthly sale of ethanol was 5.2 million gallons. With respect to Albuquerque, which has an average gasoline sale of 16 million gallons, the amount of ethanol assumed to be sold is 1.3 million gallons, roughly 9 percent of total fuel sales.

The other valuable impact measure is Blood Alcohol Concentration (BAC). Through the cooperative efforts of TSB, the Office of the Medical Investigator and SLD,[27] BAC records are now available for all tested individuals. This includes people tested for a DWI violation or fatalities in crashes. Though the computer based data do not extend far enough back through time to contribute to the evaluation of the Albuquerque BAT program, the data will support evaluation efforts with respect to Santa Fe.

Analytical Techniques: Even very effective countermeasures are unlikely to dramatically change the number of crashes since crashes have many causes. In this regard, time series analysis has been proven to be sensitive to real changes;[28] whether temporary, permanent, gradual or abrupt. Furthermore, time series analysis does control for the threats to internal validity promulgated by Campbell and Stanley.[29] Therefore, the impact of the BAT program is analyzed with time series techniques. In particular, a special class of transfer functions, intervention functions, are applied in order to determine the form and magnitude of the impact. The univariate time series analysis techniques are applied to all crash series to fill out the multiple time series design (Appendix B).

Traditional intervention analysis techniques[30] rely on two coefficients that indicate post-intervention change in the level of a series and the average rate of change per unit of time to reach the new level. These coefficient parameters of the intervention are included with a binary "dummy" variable which corresponds to 0 for pre-intervention period and a step to 1 for the appropriately timed change to post-intervention (Appendix A). If parameter estimates are significant, there is prima facie evidence that the series changes. However, the measure of the average rate of change per unit of time must be bounded to less than 1 and greater

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[27] The SLD is responsible for a statewide computer network that records site specific BAC tests and aggregates all reporting.

[28] Op. cit., Ross, 17.

[29] Op. cit., Campbell and Stanley.

[30] D. McDowell, R. McCleary, E.E. Meidinger, and R.A. Hay, Jr., Interrupted Time-Series Analysis, Series: Quantitative Applications in Social Sciences, Paper 21, Sage University Papers, ed. by John L. Sullivan (Beverly Hills, California: Sage Publications, 1980), 64-87.

than 0. If the roots of the characteristic equation do not lie outside the unit circle, the model is unstable.[31] Prior experience[32] showed the need for a technique for modeling destabilizing impacts. One solution is to have the "dummy" variable introduce a trend and to measure the trend with the change in level parameter (see Appendices A and B).

Research Design: Univariate time series analysis techniques were applied to all crash series in the multiple time series design. Each series was diagnosed individually for the underlying autoregressive integrated moving average process. Parameters were estimated and then the model was analyzed for adequacy of fit. Each series was then tested for evidence of impact from each of the three identified DWI countermeasures one at a time: the Albuquerque BAT program, increased DWI penalties through strengthened laws, and the Santa Fe BAT program. Multiple input impact models were then tried on series indicating two or more individually significant impacts (Appendix B).

BAC levels are examined for rough changes in Santa Fe with the use of contingency tables. Because BAC data is not available for periods earlier than 1982 it is not possible to examine changes in Albuquerque with respect to the Albuquerque program. The aggregate of all other BACs collected during 1982 through 1984 are also provided in order to insure that any changes detected in the Santa Fe BACs are unique to the onset of the Santa Fe BAT program.

TRANSFERABILITY

The rationale for including two countermeasure areas is twofold. First, the Santa Fe area provides for a duplication of the DWI deterrence experiment in Albuquerque. Secondly, having the newer program in a different city allows program transferability to be evaluated.

Although the two urban areas under consideration run BAT Mobiles as part of the DWI countermeasure program, there are differing circumstances involved in each program's operation. Most notably, Albuquerque is roughly ten times the population of Santa Fe, 500,000 versus 50,000 people respectively. Other crucial differences also exist in the utilization of the BAT Mobiles. The Albuquerque area DWI Squad has two BAT Mobile units and four regular black and white patrol car units whereas the Santa Fe DWI squad has the one BAT Mobile and usually one black and white unit. Further differences exist in the definition of DWI duty for each department. In Albuquerque, DWI squad officers are specialists in DWI procedures and laws. APD DWI squad officers spend essentially all service

[31] G.E.P. Box and G.M. Jenkins, Time-series Analysis: Forecasting and Control (San Francisco, California: Holden-Day, 1976), 346.

[32] Op cit., Calderwood and Woods, 28.

hours performing DWI arrests or related services.[33] In Santa Fe, the DUI squad are also specialists, however, their duties involve somewhat more diversity.[34] Officers in SFPD DUI squad are sometimes called on for assistance in felony cases, pursuit, or investigations. The diversity in duties appears to be related to the relatively small size of SFPD which may prohibit complete specialization in all situations. The Albuquerque program is seven years old. The Santa Fe program is four years old. Shift hours and operations differ between the two programs (see Operational Descriptions). In fact it seems that one of the few things that are in common is the BAT Mobile and the special enforcement program. For these reasons only the most rudimentary comparison may be made:

- Does the BAT program have the desired impact in both situations?

Transferability Hypothesis: The BAT program concept increases special enforcement effectiveness and decreases alcohol-related crashes in differing communities.

Research Design: Information derived from the two prior evaluation steps about effectiveness and impact is reviewed and discussed with regard to the transferability hypothesis.

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[33] Observations made in "ride alongs" with Albuquerque Police Department DWI squad officers, 1985.

[34] Observations and informal dialogues with Santa Fe Police Department DUI squad officers, 1985.

RESULTS

EFFECTIVENESS

Albuquerque DWI Arrests and Santa Fe DWI Arrests increase following the introduction of the BAT programs (Figures 3 and 4). Standard time series analysis techniques support this result (Appendix A). While the number of DWI arrests represent department totals, the increase above baseline levels is attributed to the BAT programs.

A significant gradual and possibly permanent increase in DWI arrests, as long as patrols persist, in Albuquerque resulted from the impact on enforcement effectiveness.

However, there also appears to be two moderate declines in DWI arrests over the long run. The first decrease is likely a consequence of a "burnout" period. This appears to happen in about two and a half years, almost 1982. The average number of months to "burnout" was reported to be 20. If a number of DWI squad officers were to "burnout" at once, that might result in a reduction in the frequency of DWI arrests. Interestingly enough, there are 20 months from the first peak of DWI arrests, early 1980, to the last peak, in late 1981. Burnout is discussed again later.

The second decrease appears to be related to the anticipation and onset of AR (Administration Revocation). While the data here will not support an impact measure in the time series, informal dialogues with both administrators and DWI squad officers helped support such a hypothesis.[35] Initially, DWI squad officers found the adjustment to the AR paperwork time consuming, perhaps adding twenty minutes to each arrest. A second problem arising out of the AR countermeasure is the increased demand placed on officers to attend formal AR hearings.[36] Administrators and officers worked out ad hoc procedural changes to relieve pressure points in the system. An outstanding example was the creation of a police/court/AR hearing liaison person. The liaison helps coordinate duty time, court dates, and AR hearing dates, ensuring officers get days off, time and notification for court and AR hearings, and service time. At the Transportation Department, affidavit and report paperwork problems were reduced through innovation, thereby easing paperwork problems for the police. Since the AR countermeasure is an immediate sanction, with more penalties to follow, its objective is not to increase arrests but to deter by celerity and severity. This is tantamount to saying DWI arrests would not decrease if AR onset was outside the time frame of the

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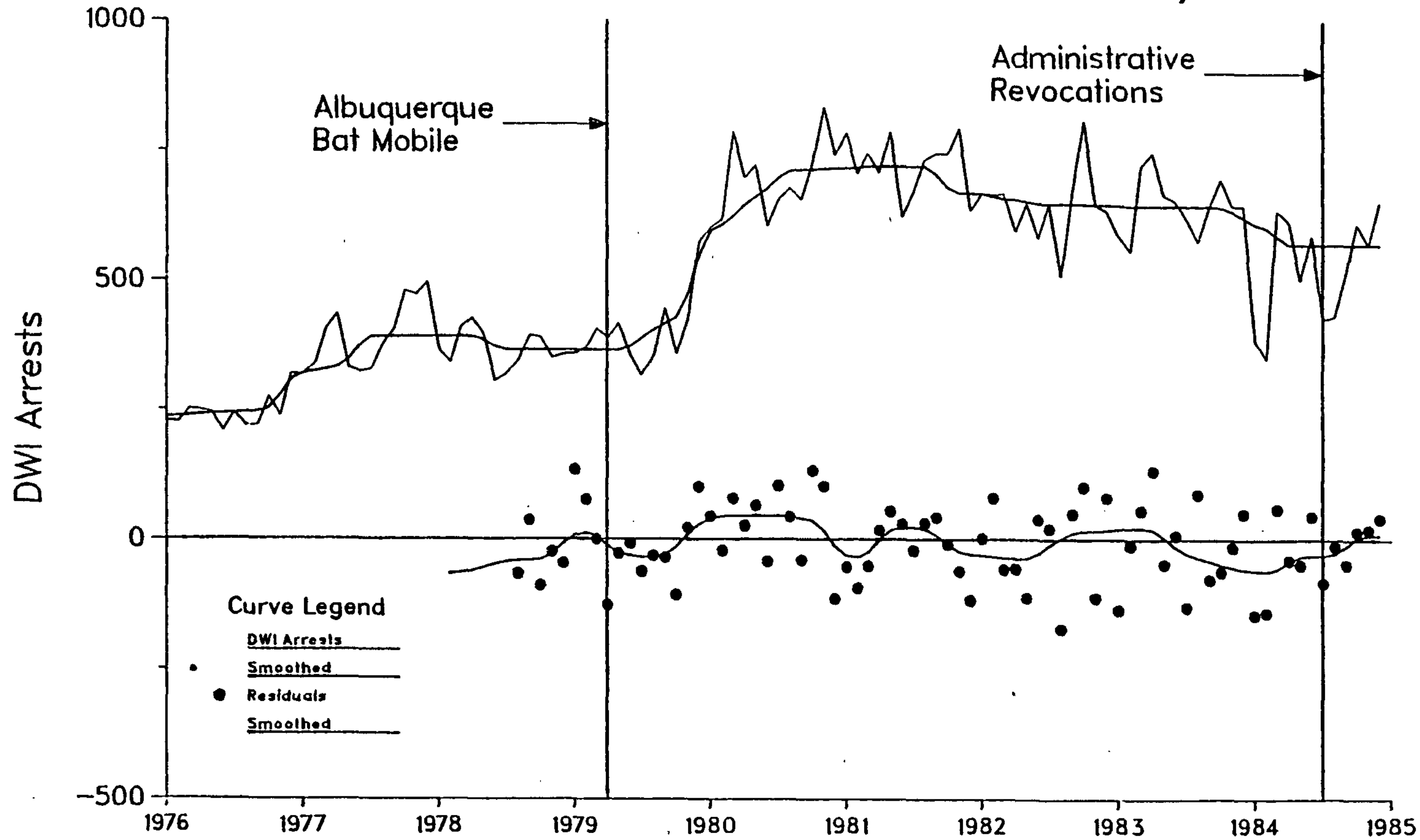
[35] Op. cit., APD and SFPD (see Footnotes 11 and 13).

[36] The AR hearings are administered by Transportation Department officials.

Figure 3.
Albuquerque DWI Arrests and Time Series Analysis Residuals



Note: Heavy curves are double median 12 and 4253H smoothers, for DWI arrests and residuals, respectively.
Residuals are from fitting model 1.6.2 (Appendix A), an autoregressive model with a gradual permanent impact.

evaluation. With respect to AR, it is possible that any decrease in arrests may be as temporary as the problems encountered at onset.

Even with the hypothetical impact on DWI arrests from AR, there is a well defined increase in DWI arrests shortly after with the onset of the BAT programs. The DWI arrests asymptotically approach a change in level of 436 more DWI arrests per month (Appendix A, Model 1.6.1.2). This roughly doubles the DWI arrests made prior to the BAT program.[37]

For the eight officers of the DWI squad this translates into 0.27 DWI arrests per manhour (assuming 2,000 hours of officer time per year).

It is known that police inputs in 1984 were 282 officers providing field services. Therefore, each officer would make 0.01 DWI arrests per manhour.

Because of the specialization of the DWI squad, the number of DWI arrests per manhour for the DWI squad and that for all officers is dramatically different. Police services not only changed the way DWI arrests were targeted with BAT programs, many other services were given over to special service squads. Although, there is not absolute division in task for police services, the more specialized those services the more one begins to compare very different things with general numbers. With respect to the police department as a whole, the program evaluation is about a small unit, 3 percent of field services. Therefore, an alternative way of assessing efficiency is to examine enforcement indices with respect to the populations to which police services are rendered.

The vehicle population shows an increase throughout the period 1976 to 1982, after which there is a large decrease in 1984 (Table 1, Albuquerque DWI Enforcement Index). The 1983 vehicle population is only slightly less than in 1982. The best explanation for the decrease in 1984 is the exodus to surrounding counties of vehicle registrations because of a mandatory auto emissions inspection program. Driver's license patterns definitely demonstrated this behavior.[38]

An enforcement index of DWI arrests to registered vehicles indicates an increase in the proportion of DWI arrests, in 1980, that does not decline until 1984, when AR begins. Table 1 (Albuquerque DWI Enforcement Index), shows a percent change of greater than 70 percent more DWI arrest per vehicle population from 1979 to 1980. Given that the program had a warm-up period, the dramatic increase in DWI arrests per vehicle population further supports the hypothesis of an increase in enforcement effectiveness and efficiency.

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[37] This finding is similar to outcomes of the Alcohol Safety Action Project in U.S. Department of Transportation, Results of National Alcohol Safety Action Projects, (DOT-HS-804-033, Washington, D.C.: National Highway Traffic Safety Administration, May 1979), 5-17.

[38] K. Smith, "1984 Driver Counts." A communication to the Traffic Safety Bureau, New Mexico Transportation Department, October 23, 1984.

TABLE 1

Albuquerque DWI Enforcement Index

Year	1976	1977	1978	1979	1980	1981	1982	1983	1984
Total DWI Arrests(1)	2,917	4,714	4,398	4,769	8,314	8,661	7,734	7,739	6,277
Monthly Average	243	393	366	397	693	722	645	645	523
Registered(2) Vehicles(X10,000) County	30.7	30.6	33.1	34.6	34.9	35.1	39.3	38.7	36.4
Enforcement Index	1.0%	1.5%	1.3%	1.4%	2.4%	2.5%	2.0%	2.0%	1.6%

1 Source: Special Services Bureau, Albuquerque Police Department.

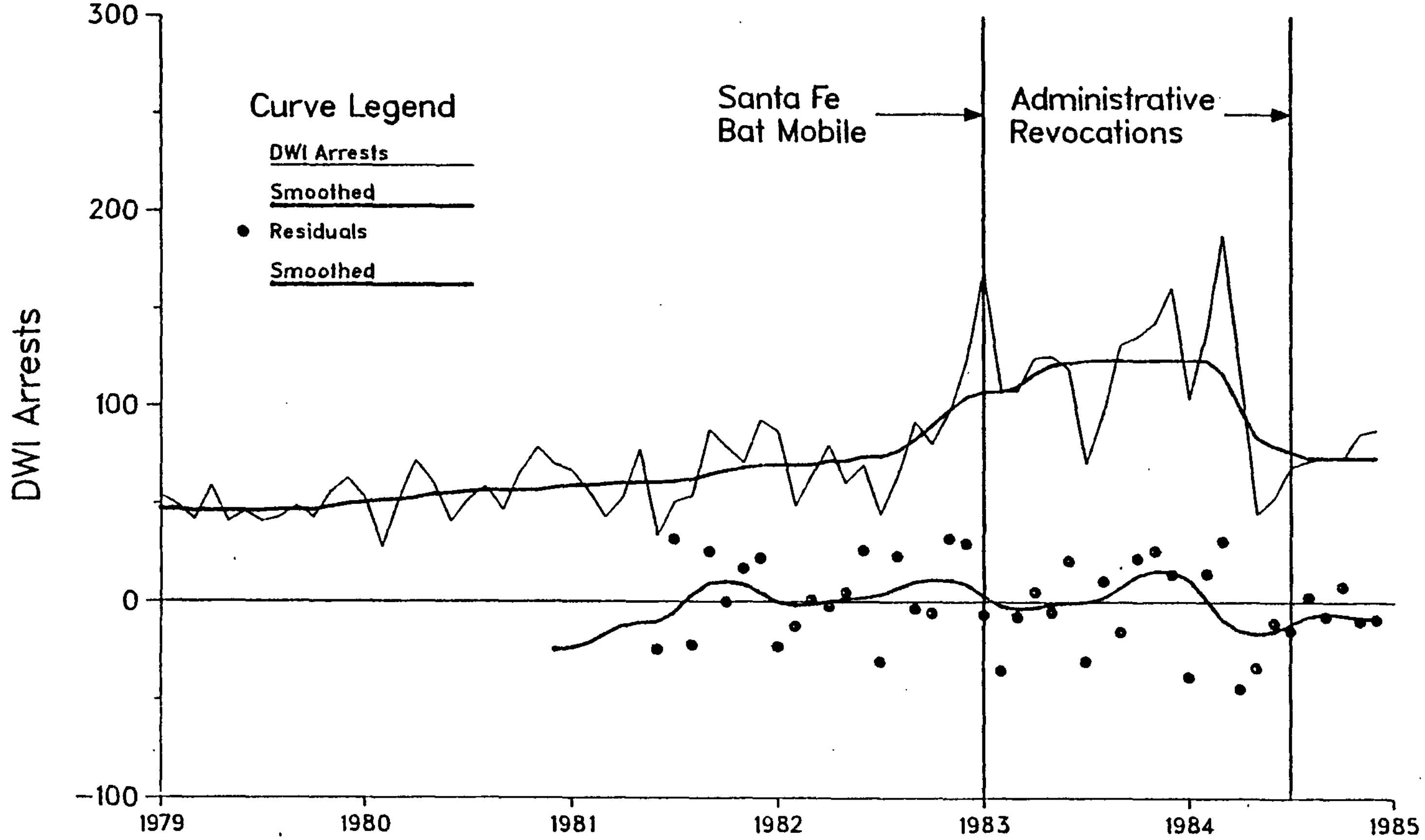
2 Source: Highway Statistics and Related Information, prepared by New Mexico State Highway Department, Planning Division, in cooperation with the U.S. Department of Transportation, Federal Highway Administration. Vehicle counts include passenger cars, trucks, motorcycles, and recreation vehicles.

Note: Vehicle counts are in tens of thousands.

In regard to the low enforcement index in 1984, the true value is probably even lower. Even though vehicle registrations may have migrated to surrounding counties, the urban traffic volume continued an increase over the prior year.[39] This implies further that the most immediate consequences of the onset of Administrative Revocations is a reduction in enforcement effectiveness. However, this does not devalue the effectiveness of the BAT Program.

[39] B. Woods, "FY84 100 Million Vehicle Miles of Travel Estimates by County and System." A communication to the Traffic Safety Bureau, New Mexico Transportation Department, November 30, 1984.

Figure 4.
Santa Fe DWI Arrests and Time Series Analysis Residuals



Note: Heavy curves are double median 12 and 4253H smoothers, for DWI arrests and Residuals, respectively.
Residuals are from fitting 1.7.1.2 (Appendix A), an autoregresive model with an abrupt permanent impact.

TABLE 2

Santa Fe DWI Enforcement Index

Year	1979	1980	1981	1982	1983	1984
Total DWI Arrests(1)	587	680	767	913	1,494	1,108
Monthly Average	49	57	64	76	125	92
Licensed Drivers(2)						
City	.	44,291	46,953	50,302	52,293	54,042
County	.	46,467	50,353	54,571	57,265	59,517
Enforcement Index						
City	.	1.5%	1.6%	1.8%	2.9%	2.1%
County	.	1.5%	1.5%	1.7%	2.6%	1.9%
Registered Vehicles(3)						
County	57,574	63,527	64,006	70,554	75,422	72,709
Enforcement Index	1.0%	1.1%	1.2%	1.3%	2.0%	1.5%

1 Source: Santa Fe Police Department, Traffic and DUI Division Unit.

2 Source: Project Area Problem Summary, produced for The New Mexico Traffic Safety Bureau by the Division of Government Research, Institute for Applied Research Services, University of New Mexico.

3 Source: Highway Statistics and Related Information, prepared by the New Mexico State Highway Department, Planning Division, in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

The Santa Fe DWI arrest series shows an increase in DWI arrests following the startup of the BAT program (Figure 4). Time series analysis indicates an abrupt permanent increase associated with the BAT program (Appendix A, Model 1.7.1.1). This abrupt increase is in contrast to the gradual and permanent increase found in the Albuquerque series. The dramatic increase in DWI arrests may be best described and understood from the perspective of the SFPD DUI squad officers and administrators. Although the first night of field service for the BAT Mobile in Santa Fe was New Year's Eve 1982, the DUI squad had been formed earlier that year and had received a BAT Mobile unexpectedly after problems erupted in a fledgling BAT program in another section of the state. In other words, the program had a warmup period prior to the actual onset. This is apparent in Figure 4. Further, the detection of an abrupt as opposed to gradual increase may also be an artifact of the unusually large number of DWI arrests made that first month, January 1983.

The change in level is up 52 arrests a month. The percent change increase in arrest rates from 1982 to 1983 is 64 percent. For the two officers of the SFPD DUI Squad this translates into 0.11 DWI arrests per manhour.

What is known about SFPD inputs is that there were roughly 90 officers before the program and roughly 130 officers currently providing field services.[40] With these numbers it appears that the department's rate of DWI arrests is perhaps 0.004 DWI arrests per manhour, both before and after the BAT program.

Enforcement indices show increases in the proportion of DWI arrests in Santa Fe in 1983, and a decline in 1984. It is suspected that this decline is related to problems encountered with AR procedures, as in Albuquerque.

Recall that the curve of DWI arrests by APD definitely shows a warm-up period for the program, perhaps as long as one year to reach an apparent maximum effectiveness. The same curve for SFPD shows a generally increasing trend and even a greater increasing trend beginning as early as four to six months prior to the official BAT program start up date. The differences in the curves may be explained by the different start ups of the programs. The Albuquerque program began without prior experience and the Santa Fe program, which was preceded by the formation of the special enforcement squad within the Traffic Division, had the benefit of consultation from the APD DWI Squad in a one week intensive training session, and then received a BAT Mobile.

In both BAT program sites, Albuquerque and Santa Fe, the raw number of DWI arrests practically doubled and the proportion of DWI arrests per population also dramatically increased. This is supportive evidence for the hypothesis that the BAT programs are effective enforcement tools.

Although DWI arrests and DWI arrest rates, with respect to the vehicle and probably the driver populations, increased and continue at higher

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[40] Sgt. T. Delgado, Traffic and DUI Division, Santa Fe Police Department. Personal communications, March, 1986.

levels, it is yet undefined if and how the BAT programs relate to the crash population. One thing is clear, most DWI arrests on the alcohol population are made before crashes occur. The number of DWI citations issued in crashes (Table 3) ranges from 45 percent in 1978 to 14 percent in 1982 of the total number of DWI arrests (Table 1). In a crash a citation may be issued but an arrest may depend on hospitalization or other outcome.

DWI citations are issued in about 8 percent of all crashes reported by APD. The number of crashes reported by APD per year is, on average, 14,644. This means the intersection of the two populations, DWI arrests and crashes in general, is small. However, as was expected, the intersection with fatal and injury crashes (FI) is larger, with an average 25 percent of DWI citations issued in FI crashes.

TABLE 3

Albuquerque Crashes and DWI Citations in Crashes

Year	1978	1979	1980	1981	1982	1983	1984
Crashes	16,964	15,983	13,619	13,223	12,788	14,735	15,193
FI	4,847	4,930	4,422	4,368	4,486	4,960	5,232
DWI Citations	1,311	1,285	1,332	1,213	1,057	1,189	1,029
% DWI/Total	7.7	8.0	9.8	9.2	8.3	8.1	6.8
% DWI/FI	27.0	26.1	30.1	27.8	23.6	24.0	19.7

Note: The data were restricted to crashes reported by APD. Means of %DWI are 8.3 and 25.5, for Total and FI, respectively.

Crashes decline from 1978 through 1982, and increase in 1983 and 1984. FI crashes follow a roughly equivalent pattern, showing a decline from 1979 through 1981, and an increase thereafter. If the DWI problem were a constant proportion of the crash population and if police citation habits were consistent over the years, then the number of DWI citations issued in crashes would also follow the crash patterns of decline and increase. However, the number of DWI citations in crashes does not follow the same general patterns. This is evident in the table of the %DWI (citations in crashes)/Total (crashes) and %DWI/FI. DWI citations, in proportion to the crash population, increase from 1978 to 1980 and then decrease, even as the crash population begins to increase.

With respect to Santa Fe, crashes also decline, in general, over the years 1978 through 1981, and increase from 1982 through 1984 (Table 4). The relative portion of DWI citations in crashes, in general, increases during the period 1978 through 1982 when crashes are decreasing, and decreases in 1983 through 1984 when crashes are increasing.

Table 4

Santa Fe Crashes and DWI Citations in Crashes

Year	1978	1979	1980	1981	1982	1983	1984
Crashes	2,877	2,762	2,185	2,091	2,176	2,276	2,481
FI	949	993	779	729	719	770	888
DWI Citations	251	264	271	227	254	254	187
% DWI/Total	8.7	9.6	12.4	10.9	11.7	11.2	7.5
% DWI/FI	26.4	26.6	34.8	31.1	35.3	33.0	21.1

Note: The data were restricted to crashes reported by SFPD. The mean of % DWI/Total is 10.3 and % DWI/FI is 29.8.

There is some reason to believe that the overall pattern in crashes could be moderately related to economic factors, such as increased fuel prices, subsequent decrease in consumption, and therefore travel.[41] This evidence would seem to indicate that the DWI population and their intersection with crashes are responding to differently weighted factors.

If the BAT programs were to coincide with reporting changes in crashes because changing emphasis on detecting the alcohol problem in traffic, then one would expect to see an increase in the frequency of DWI citations in proportion to the number of crashes. In Santa Fe, the opposite occurs, the proportion decreases 4 percent and 6.5 percent from 1982 to 1983, for DWI/Total and DWI/FI respectively. However, in Albuquerque there is an increase of 22.5 percent and 15 percent from 1979 to 1980, for DWI/Total and DWI/FI, respectively. The same sort of increase also occurs in Santa Fe from 1979 to 1980.

This may mean one of three possible explanations is true. The first explanation for the coincidental increase in the relative proportion of DWI citations in crashes with the BAT program in Albuquerque is that police reporting was motivated by internal administrative decisions. The second interpretation is that DWI population behaviors changed.[42] The third is that random fluctuations in DWI citations occured.

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[41] U.S. Department of Transportation, Alcohol Involvement in United States Traffic Crashes: Where it is changing, (Technical Report, DOT HS-806-733, Washington, D.C.: National Highway Traffic Safety Administration, November 1983), 20 and 28.

[42] R. Calderwood and S. Flint, "FY82 DWI Citations in Albuquerque Cras-

There are two alternate measures of alcohol-involvement. The first is reported alcohol-involvement, reported by the police. The second is a proxy measure of alcohol-involvement. The proxy used here is the crash occurring during the period Wednesday through Saturday Night (7:00 p.m. - 5:00 a.m.), WSN, which is serious, fatal or injury, WSNFI.

As noted at the outset of this text, reported alcohol-involvement tells more of the police's perspective on the role of alcohol in crashes than of actual involvement of alcohol as a causal variable in crashes. In Albuquerque, police report alcohol-involvement in crashes as occurring an average of 13 percent of the time. Alcohol-involvement in FIs is reported as occurring roughly 40 percent of the time (Table 5). The same averages for Santa Fe differ by only 0.5 percent.

Table 5

Reported Alcohol-Involvement and Percentages

Year	1978	1979	1980	1981	1982	1983	1984
Albuquerque	1,616	2,154	2,202	1,992	1,763	1,896	1,584
% Total	9.5	13.5	16.2	15.1	13.8	12.9	10.4
% FI	33.3	44.0	49.8	45.6	39.3	38.2	30.8
Santa Fe	287	316	315	419	363	308	236
% Total	10.0	11.4	14.4	20.0	16.7	13.5	9.5
% FI	30.2	31.8	40.4	57.5	50.5	40.0	26.6

Note: The means of reported alcohol-involvement in Albuquerque per total crashes and FIs are 13.1 percent and 40.1 percent, respectively. In Santa Fe the means are 13.6 percent and 39.6 percent for the percents of reported alcohol-involvement in total and FI crashes, respectively.

All four percentages vary systematically in a pattern that begins increasing up to relative peaks and then decreases thereafter. In Albuquerque, reported alcohol-involvement peaks in 1980, as does the frequency of DWI citations. The proportions of reported alcohol-involvement to total and FI crashes also change slope in 1980. In Santa Fe, the relative peaks for reported alcohol-involvement and the proportion to total and FI crashes happens in 1981.

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hes," A communication to the Traffic Safety Bureau, New Mexico Transportation Department, February 2, 1983.

In Santa Fe in 1981, when reported alcohol-involvement was at a high point, DWI citations issued in crashes were down. This is evident when the relative proportion of DWI citations to reported alcohol-involvement is examined (Table 6).[43]

Table 6

Percentage of DWI Citations in Crashes and Reported Alcohol-Involvement

Year	1978	1979	1980	1981	1982	1983	1984
APD %	81.1	59.7	60.5	60.9	60.0	62.7	65.0
SFPD %	87.5	83.5	86.0	54.2	70.0	82.5	79.2

The proportion of DWI citations in crashes to reported alcohol-involvement for the Albuquerque police is remarkably consistent, 61 percent, with the exception of 1978. The overall average is 64 percent. When 1978 is not included, the average of the remaining years is 61 percent. Despite the anomaly, there does not seem to be any other indication that the population at the intersection of crashes, alcohol, and police enforcement was affected by police policy or reporting.

The relationship of DWI citations and alcohol-involvement is not as consistent for SFPD. The overall average for SFPD is 78 percent. The deviation from the mean is larger for SFPD than for APD (11.80 versus 7.65, respectively). The greatest source of variance for SFPD is 1981. What can be said is that DWI citations were down in 1981, not because of crashes, alcohol-involvement, or administrative decisions with regard to the BAT program. The Santa Fe BAT program was not in operation.

When an alcohol proxy and all other crashes were observed there was a similar behavior observed in the relative proportion of DWI citations in crashes to crash (Table 7). In Albuquerque, the ratio increased from 1978 to 1980, and thereafter the ratio declined. Whereas the ratio for Santa Fe does not behave in as smooth a manner, it could be construed to be similar.

[43] Alcohol-involvement is reported by police when they suspect it from something observed and/or found whereas DWI citations are issued when evidence will support the action.

Table 7

Alcohol Involved Proxy Crashes and Percentages

Year	1978	1979	1980	1981	1982	1983	1984
Albuquerque							
WSNFI	1,294	1,296	1,184	1,090	1,060	1,121	1,137
All Other	19,076	18,049	15,482	15,002	14,648	16,524	17,276
%	6.8	7.2	7.7	7.3	7.2	6.8	6.6
Santa Fe							
WSNFI	247	193	202	173	190	162	160
All Other	2,947	2,795	2,223	2,117	2,205	2,308	2,495
%	8.4	6.9	9.1	8.2	8.6	7.0	6.4

Note: Data are all crashes reported within the boundaries of the cities of Albuquerque and Santa Fe.

Regardless of subtle changes, several clear patterns are now apparent:

1. The relative proportion of DWI citations in crashes and reported alcohol-involvement is reasonably constant,

2. The relative proportions of

   a. Reported alcohol-involvement and crashes,

   b. Proxy alcohol-involved crashes and all other crashes, and

   c. DWI citations in crashes with respect to all crashes,

   all show similar initial increases and then a decrease following the very early 1980's,

3. Raw crash counts

   a. Total crashes,

b. Fatal and Injury crashes,

c. Alcohol proxy crashes, and

d. Non-proxy crashes,

all show relative initial declines and then increases following the mid-1980's, and

4. DWI arrests increase dramatically with the onset of BAT programs.

In other words, the DWI problem (alcohol population), as reflected in crashes, behaves in a different manner than overall crash patterns. It has been suggested that overall crash patterns are, in part, reflections of more macroscopic factors like economic conditions.[44] Measures that indicate some kind of alcohol-involvement are roughly inverse to raw crash patterns during the time frame of this evaluation. If anything, this suggests a change in DWI behavior differing from change in overall crash patterns, rather than a clear indication of changes in enforcement effort with respect to crashes.

The results of the impact analysis address this last hypothesis specifically. For the time being, I would like to present one more way of summarizing. Consider the three overlapping populations; crashes, police and alcohol. The intersection of alcohol-involvement, in general, and police is summarized under item 4, above. The intersection of crashes and police is summarized under item 3, above. The intersection of crashes and alcohol is summarized under item 2. The intersection of all three populations is summarized under item 1.

With regard to the "burnout" hypothesis there are only a few relevant observations to report. In Albuquerque there has been a 100 percent turnover in personnel since 1982. No one denies that there is a burnout problem. However the periods of duty for officers in the BAT program have been as long as two years for some officers. One BCDC corrections officer was with the program for all of the first five years. One of the shortest tours of duty was one month - this happened in Santa Fe. It turns out that that officer just didn't like DWI duty. The average stay is 20 months. In this light, it would seem that BAT program administrators manage to keep the BAT programs running smoothly.

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44 Op. cit. U.S. Department of Transportation, Alcohol Involvement in United States Traffic Crashes: Where it is changing.

IMPACT

Because the target population of the BAT programs is the DWI offender, it is essential that the correct population be measured for impact. Without a direct means of measuring the DWI population the next best measure is the population at the intersection of DWI offenders and crashes, the WSNFI series.

At a first glance at WSNFI crashes in Albuquerque (Figure 5) there appears to be a noticeable reducton in WSNFI coinciding with the onset of the BAT program. The drop is emphasized with the display of predicted values based on the trend observable in the period 1974 through 1978.

Two alternative ways were found to model Albuquerque WSNFI and many ways to detect change in the series that indicate an intervention effect from the BAT program. The more conservative and common noise model, 2.1.0, Appendix B, revealed three forms of detectable intervention effect, and the alternate noise model, 2.1.1, revealed six forms of intervention. Between the two approaches to modeling Albuquerque WSNFI there is agreement in the detection of a lagged step, gradual and permanent, and a trending reduction. These three forms of impact consistently result in the lowest residual sum of squares.

Albuquerque averages 92 WSNFI per month. The estimated lagged impact, model 2.1.0.6, is an average reduction of 19 WSNFI per month, a 21 percent reduction. The more continuous impact model (2.1.0.3) estimates the eventual reduction of WSNFI by 64 per month, a 70 percent reduction. The trend in WSNFI following the BAT program, model 2.1.0.5, indicates a less than one percent reduction each month.

However, because it has been observed that all Albuquerque crashes show a decline during the period 1979 through 1981, the detected decline in WSNFI with respect to the BAT program could be spurious. Therefore, to control for such errors, WSNFI crashes are compared to Albuquerque Other FI and the frequency of WSNFI crashes with respect to exposure and amount of travel, a ratio of WSNFI to fuel. Analysis is performed on series that have BAT programs, Albuquerque and Santa Fe, their complements, and series not having BAT programs, the comparison series. Comparisons to series other than complements are based on the ratio of WSNFI/Fuel. The analysis tests for coincidental impacts in the given series that fit to the onset of important DWI countermeasures (Appendix B).

Albuquerque Time Series: WSNFI Crashes, Fuel, and WSNFI/Fuel, provides graphics of the three series and a vertical line for indicating the initiation of the BAT program (Figure 6). For visual aid, centered, or smoothed, lines are shown.[45]

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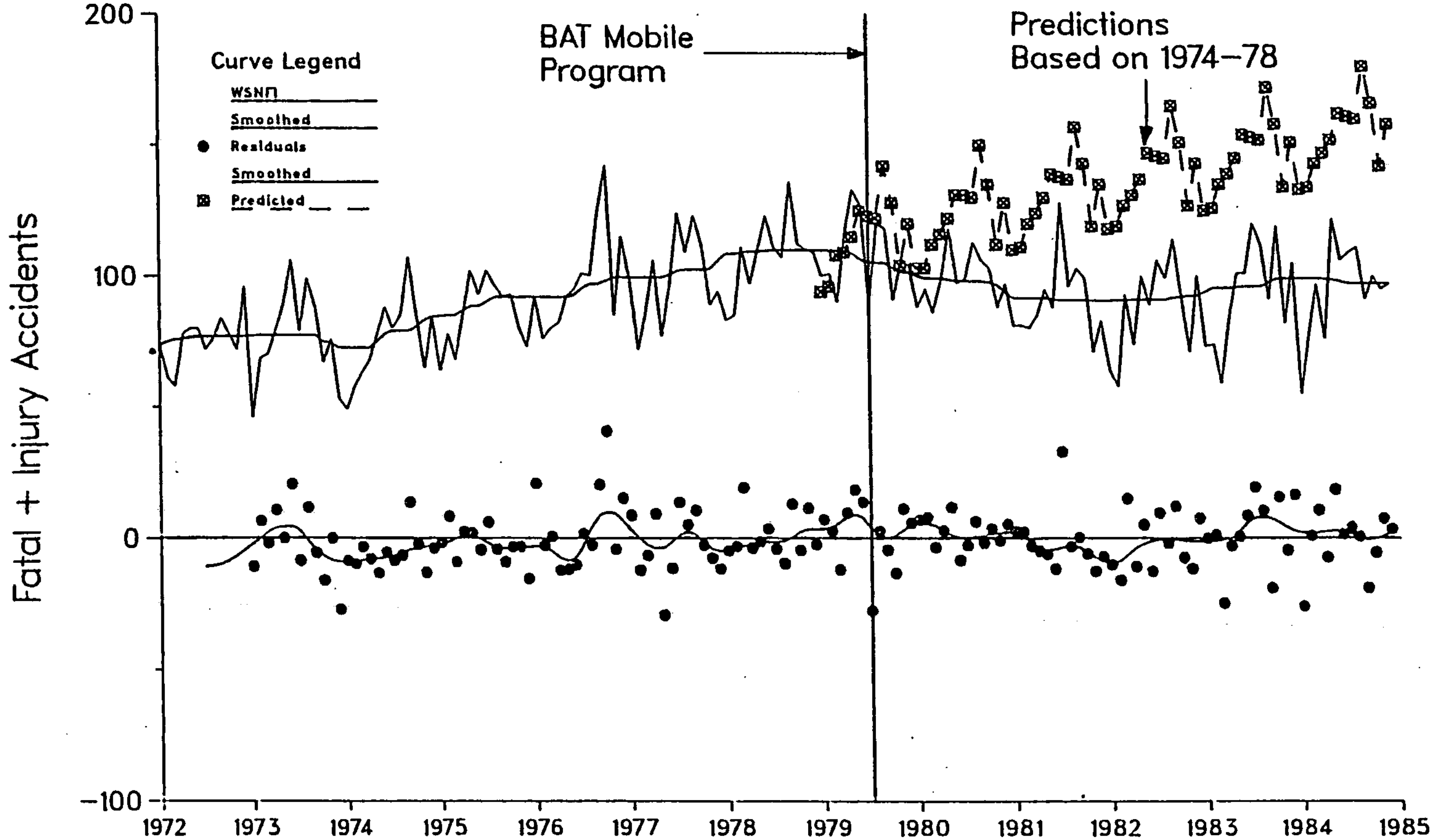
[45] A double 12 median smoother was used.

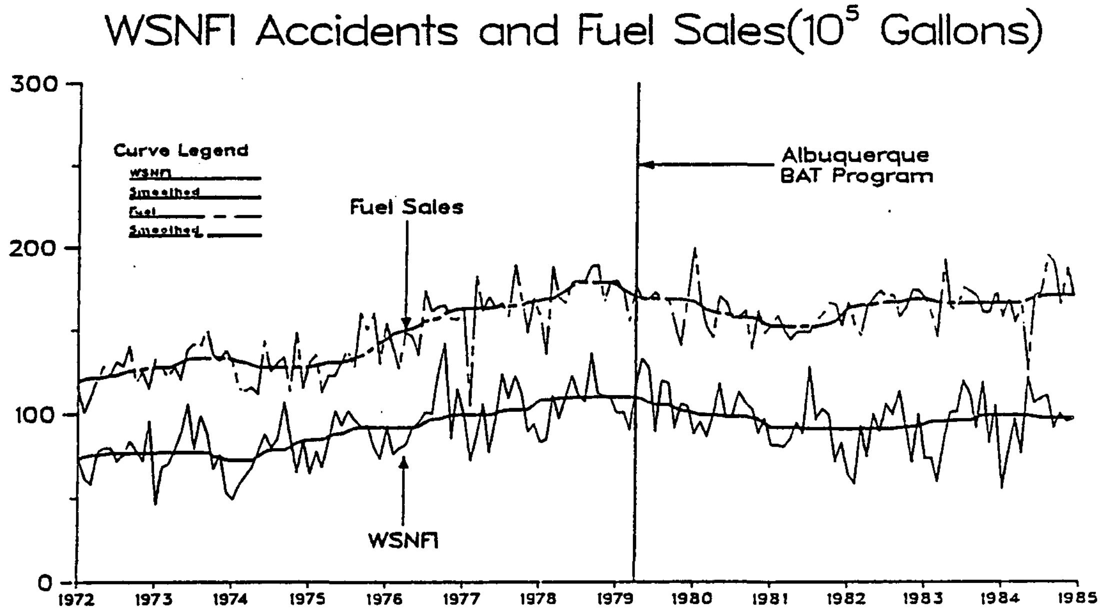
Figure 5. Albuquerque
Wednesday–Saturday Night(7pm–5am) Fatal + Injury (WSNFI) Accidents
and Time Series Analysis Residuals

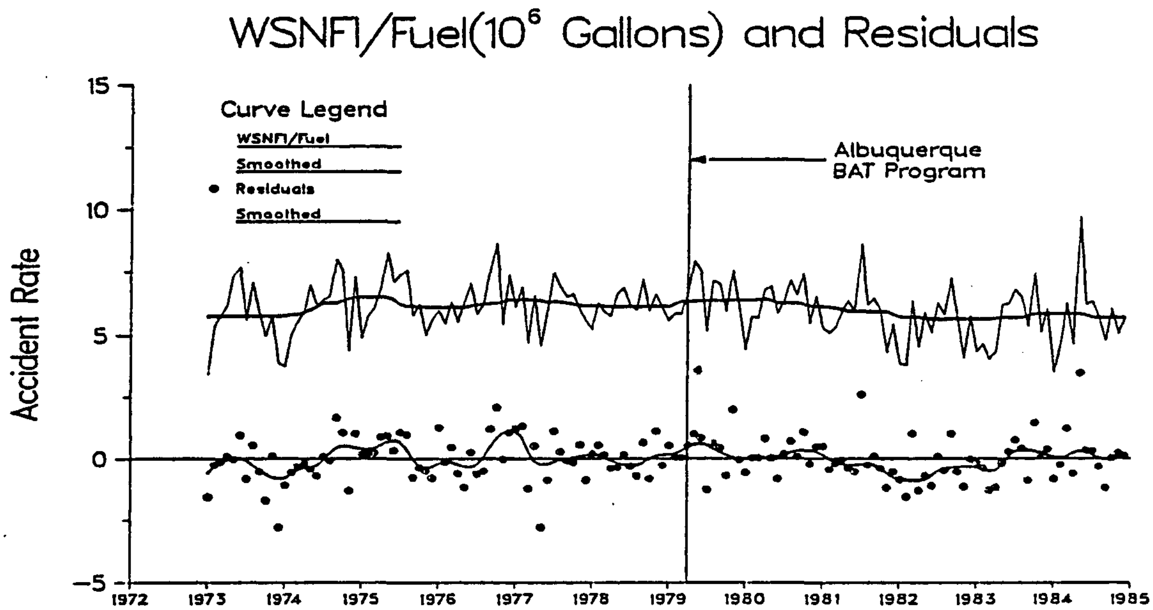


Note: Heavy curves are double median 12 and 4253H smoothers for WSNFI and residuals, respectively. Predictions are based on Model 2.1.2. Residuals are from fitting Model 2.1.3.3.

Figure 6.

Albuquerque Time Series: WSNFI Accidents, Fuel, and WSNFI/Fuel





Note: Smoothers are double median 12 for all but residuals, which are smoothed by a 4253 H procedure. Residuals are from fitting model 2.2.1.5 (Appendix B).

The rate series, WSNFI/Fuel, shows a level series, at least with regard to the apparent positive slopes in WSNFI and the Fuel series up to 1979. Following 1979, a decrease in fuel sales is mirrored in a similar decrease in WSNFI crashes.

WSNFI crashes may be made stationary with first and seasonal differencing (Model 2.1.0). The ratio of WSNFI/Fuel is stationary when seasonally differenced (Model 2.2.0). This indicates that the relationship between WSNFI and Fuel is highly related at the first lag and is seasonally variable. There are seasonalities in the behavior of DWIs for which fuel sales do not account.

The rate series also show intervention effects following the Albuquerque BAT program. Three forms of impact are statistically significant: a step reduction at theoretical onset of -.3 (Model 2.2.0.1), a lagged step reduction of -.4 (Model 2.2.0.6), and a trend of -.01 WSNFI/Fuel per month (Model 2.2.0.5). The average number of WSNFI/Fuel per month is 6 WSNFI per million gallons of fuel sold. The amount of fuel sold each month in Albuquerque is roughly 16 million gallons. Both permanent and abrupt step reductions measure a 5 to 7 percent change in Albuquerque WSNFI/Fuel, respective to theoretical and lagged onset. After five years the trend in reducing WSNFI/Fuel could amount to 10 to 12 percent fewer WSNFI/Fuel per month.

The trend downward is neither a gradual nor abrupt step function, usually considered for intervention analysis. Prior experience[46] and recent research demonstrated the lack of fit from standard approaches. In particular, estimates of the ratio of change in level consistently remain too close to the bounds of stability.

Time series analysis techniques were also applied to the Albuquerque WSNFI/Fuel series to test for impacts coinciding with either strengthened DWI penalties (state law) or the Santa Fe BAT program. No changes were detectable with respect to these other DWI countermeasures. The only improvement in amount of noise remaining in the stochastic series that could be found was from introducing impacts associated with the Albuquerque BAT program.

If the ratio were not used, the relative decline in WSNFI crashes might be mistaken for a decline due to economic conditions.

The complement of WSNFI is Other FI. Albuquerque Other FI, Fuel, and Other FI/Fuel are shown in Figure 7. No changes were evident in the Other FI series, models 2.3.1 through 2.3.3. When the Albuquerque Other FI/Fuel series was analyzed with time series techniques no evidence was found that Other FIs changed with respect to the Albuquerque BAT program (Appendix B, Models 2.4.1.1 -.5). However, three forms of change were found to occur following 1983. After 1983, Albuquerque Other FI increased. A gradual permanent increase was detected in Albuquerque Other FI/Fuel with respect to the Santa Fe BAT program onset (Model 2.4.3.3). An upward

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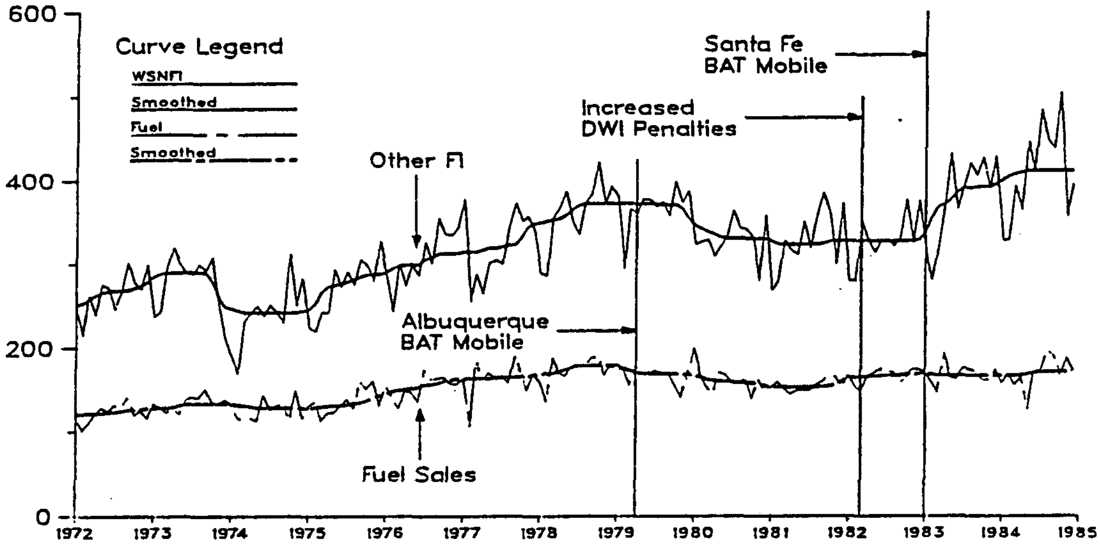
[46] Op. cit., Calderwood and Woods, 28.

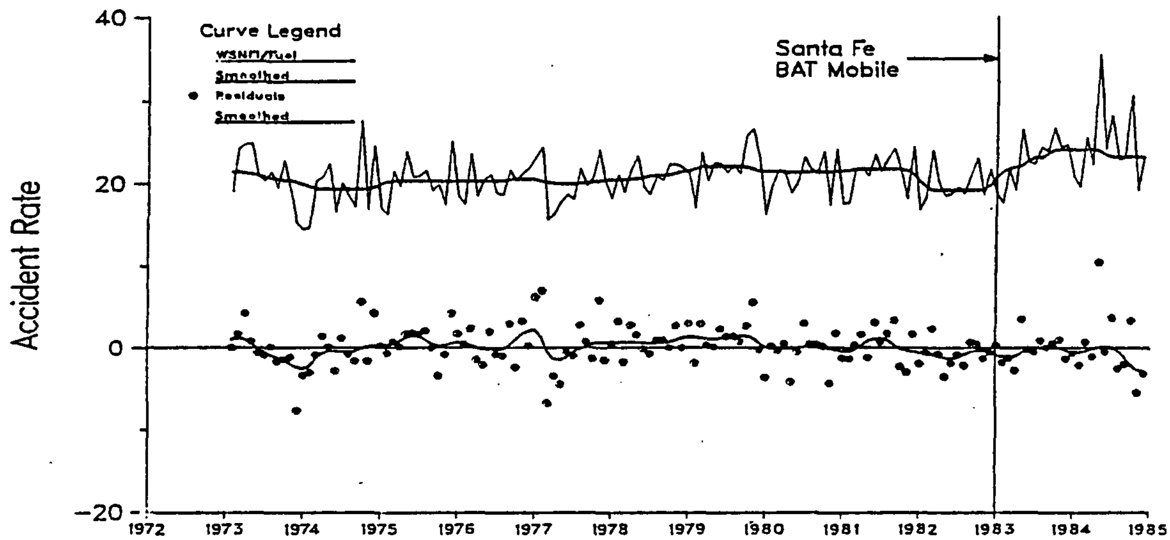
Figure 7.

Albuquerque Time Series: Other FI Accidents, Fuel, and Other FI/Fuel

Other FI Accidents and Fuel Sales(10^5 Gallons)



Other FI/Fuel(10^6 Gallons) and Residuals



Note: Smoothers are double median 12 for all but residuals, which are smoothed by a 4253 H procedure. Residuals are from fitting model 2.3.3.3 (Appendix B).

trend and a four month, lagged step impact were also found, models 2.4.3.5 and 2.4.3.6, respectively.

Santa Fe Time Series: WSNFI Crashes, Fuel, and WSNFI/Fuel (Figure 8), shows the series with the BAT program startup marked with a vertical line. The rate series indicates great variability. For example, a most curious "bump" in the rate series occurs from early 1977 through 1979.

Santa Fe averages 15 WSNFI per month from 1972 through 1984. In January 1983 there was a significant drop in WSNFI that apparently lasted only one month (Model 2.10.3.2). The dramatic reduction of 80 percent (-12 WSNFI) occurred the same month the Santa Fe BAT program began. Because the impact was temporary this suggests that the reduction was a consequence of deterrence rather than control.

The Santa Fe WSNFI/Fuel series was adequately modeled as a first order moving average process after being stabilized with a first order differencing (Model 2.11.0). The mean of the undifferenced series was 5 WSNFI/Fuel per month. The only clearly discernable impact, among all countermeasures, was an abrupt temporary impact of magnitude -4.1 WSNFI/Fuel (- 80 percent) for the Santa Fe BAT program. A smaller abrupt but permanent impact of magnitude -1.17 (t = -1.81, Model 2.11.3.1) does not meet statistical requirements but may be an alternative way of viewing impact. That impact was a permanent reduction in WSNFI on the order of 23 percent. It is possible that the extremely large spike found the first month of 1983 effectively overshadows subtler impact models. Further, the high variability throughout the series may also make it unlikely that other rival explanatory impact models could be detected. The abrupt impact mirrors the Santa Fe DWI arrest series, which might support the alternate view of a more sustained impact as opposed to a temporary impact.

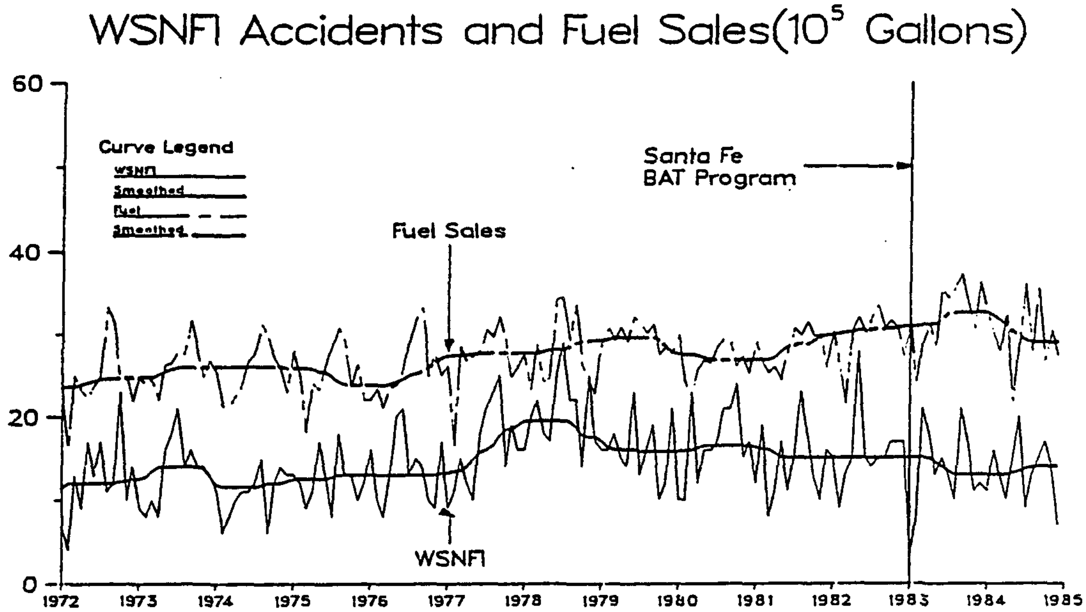
However, if the police enforcement were to have a consistent and sustained impact through control and deterrence of the DWI offender population a different kind of impact would be seen. If the DWI population were a fixed size and police were to continually remove members of the population, assuming recidivism was less than 100 percent, then the population would be reduced in proportionately increased rates. This is the kind of impact suggested in the Albuquerque findings.

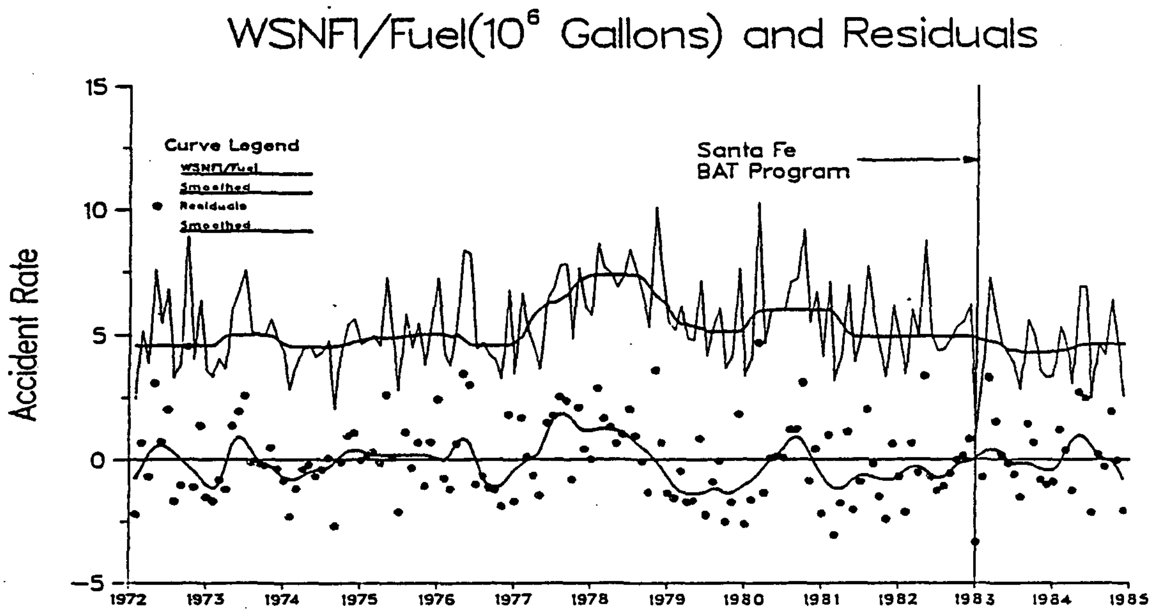
No other expected DWI countermeasure had any detectable impacts on the Santa Fe WSNFI/Fuel series.

The complement series in Santa Fe, Other FI, and Other FI/Fuel (Figure 9), also show a curious "bump" in FI crashes, as does WSNFI/Fuel. The "bump" appears to lag a year or so from a similar "bump" in the WSNFI series. Furthermore, there are no changes in fuel sales which helps explain the "bump". The lagged relationship between Santa Fe WSNFI and Other FI should be investigated later. For the time being, there appears to be some interactions with impact assessment of non-Santa Fe BAT program countermeasures and the "bump".

Figure 8.

Santa Fe Time Series: WSNFI Accidents, Fuel, and WSNFI/Fuel



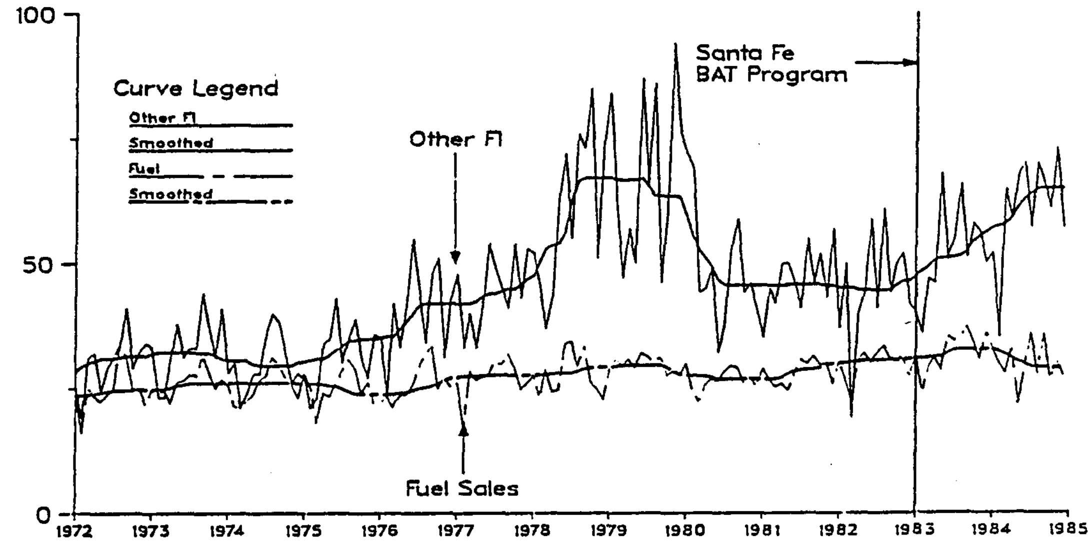


Note: Smoothers are double median 12 for all but residuals, which are smoothed by a 4253 H procedure. Residuals are from fitting model 2.9.3.1 (Appendix B).

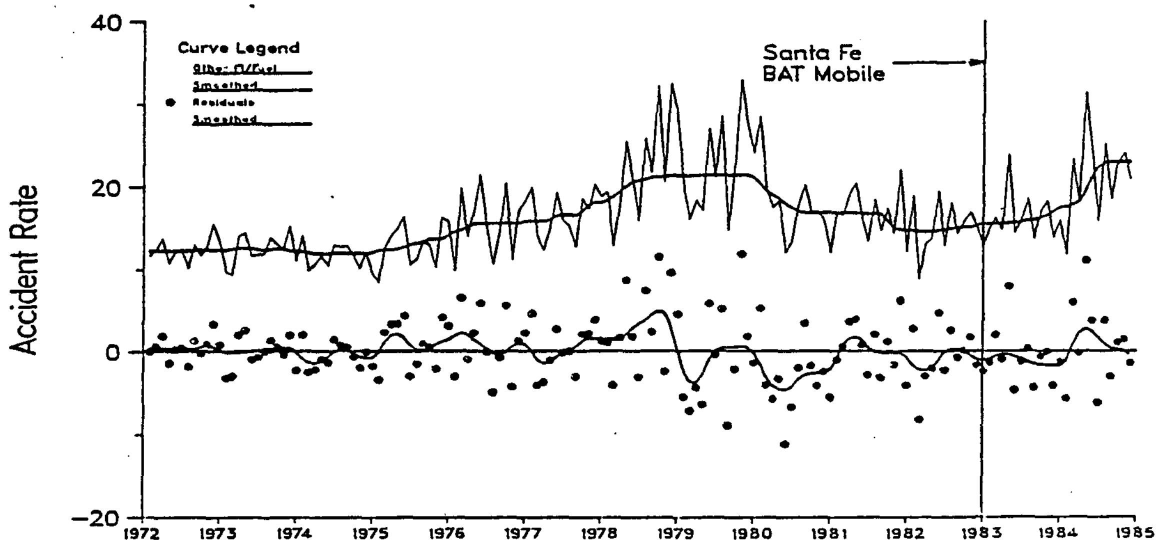
Figure 9.

Santa Fe Time Series: Other Fl Accidents, Fuel, and Other Fl/Fuel

Other Fl Accidents and Fuel Sales(10^5 Gallons)



Other Fl/Fuel(10^6 Gallons) and Residuals



Note: Smoothers are double median 12 for all but residuals, which are smoothed by a 4253 H procedure.
Residuals are from fitting model 2.10.3.5 (Appendix B).

Santa Fe averages 45 Other FI per month. An increase in Other FI was detected coinciding with a two month lagged Albuquerque BAT program intervention onset date and a temporary decrease coinciding with increased DWI penalties onset date (Model 2.12.4).

The Other FI/Fuel series has a detectable increasing trend coinciding with the Santa Fe BAT program (Model 2.13.3.5). This trend toward higher rates of Other FI/Fuel is in contrast to the WSNFI/Fuel series. The WSNFI/Fuel series drops 80 percent temporarily, perhaps averaging 23 percent over a longer period, and Other FI increase. Note that in the rate series for Santa Fe Other FI there was less than confident evidence for intervention effects for either intervention effect detected in the raw series. There is an anomalously low number of Other FI in early 1982. The relatively flat WSNFI departs from the otherwise increasing rate of Other FIs.

Regardless of the impact form there is agreement in detecting impacts coinciding with BAT program in both the Albuquerque and Santa Fe series: WSNFI are reduced. Albuquerque and Santa Fe Other FI/Fuel series show an inverse impact with respect to the Santa Fe BAT program onset. It seems more logical that the increase in Albuquerque Other FI/Fuel with respect to the Santa Fe BAT program onset is related to a more global effect than Santa Fe DWI offenders abruptly taking off to Albuquerque during non-DWI squad service hours. To complete the quasi-experimental design, the five other series, in two groupings, are examined in turn.

Consider Farmington, Las Cruces, and the aggregate of all other New Mexico urban sites with a population over 5,000 people as a class of comparison series, other New Mexico urban WSNFI/Fuel. These series have underlying ARIMA models that are similar in form. Each of the three series is adequately modeled with a first and seasonal moving average process after being differenced at lag one (Models 2.5.0, 2.6.0., and 2.8.0).

When impacts from any of the three DWI countermeasures are tested individually, one at a time, for each of the other New Mexican urban WSNFI/Fuel series, numerous coincidental impacts are found.

The Farmington WSNFI/Fuel time series has a relative low point in April of 1983. Intervention analysis indicates that four months following the theoretical onset of the Santa Fe BAT program there is a step reduction in WSNFI/Fuel. However, it appears that this point is in the later part of a decreasing trend in Farmington WSNFI/Fuel. The pervasiveness of the trend makes it difficult not to view the analytical results as susceptible to other effects.

The Las Cruces series has two significant impacts when countermeasures are tested: a five month lagged abrupt permanent increase coinciding with the Albuquerque BAT program (Figure 11), and a temporary decrease coinciding with the Santa Fe BAT program (Model 2.6.5). The increase is 1.85 WSNFI/Fuel and the decrease is an initial -4.05 and then a return to earlier central tendencies.

The time series analysis of the aggregate of the remaining other New Mexico urban WSNFI/Fuel showed changes in the series with respect to increased DWI penalties and the Santa Fe BAT program (Model 2.8.5). The model to emerge as significant indicated WSNFI/Fuel increased an abrupt 0.4 coincidental with increased DWI penalties and trends downward at -0.06 with the Santa Fe BAT program.

Two series for final consideration are New Mexico total and rural WSNFI/Fuel. The New Mexico WSNFI/Fuel series indicates that a decrease in the series coincided with the Santa Fe BAT program (Model 2.7.3.5) The rural series also showed a downward trending impact coincidental with the Santa Fe BAT program (Model 2.8.3.5).

The rural series presents a unique problem in that the relationship between crashes and travel in rural areas is much less directly proportional to rural fuel sales. Rural fuel sales decline dramatically at the end of 1979 and begin to level off slowly around 1982. WSNFI crashes, however, do not drop off until 1983. Therefore, the ratio of WSNFI/Fuel shows an increase during the same time as fuel sales drop off. One explanation is that much of rural travel is by non-rural residents who, likely, purchase fuel in more urban locations because of price and convenience.

In summary, the Albuquerque BAT program is reasonably represented as a lagged step, gradual and permanent or small continuous trending reduction in WSNFI and WSNFI/Fuel in Albuquerque. Although coincidental impacts are found with respect to increased DWI penalties, the only place impacts did not wash out when tried and tested in multiple input models was for the other urban WSNFI/Fuel series, and there the indicated impact was an increase.

The corresponding intervention analysis of the Santa Fe BAT program does not resolve in as clear a manner. First, there is a corresponding increase in the Albuquerque Other FI/Fuel series. Second, in the comparison WSNFI/Fuel series other than Albuquerque and Santa Fe, there are measurable decreases in WSNFI/Fuel beginning in 1983. While many decreases are unrelated, the overwhelming presence of detectable decreases coinciding with the Santa Fe BAT program encumbers clear results and conclusions. In both Santa Fe WSNFI and WSNFI/Fuel series the impact coinciding with the Santa Fe BAT program was a very large but temporary reduction. These reductions are on the order of -80 percent for the first month of the program, January, 1985. After January, WSNFI and WSNFI/Fuel frequencies return to prior value ranges. An alternate form of intervention effect is a smaller but more permanent reduction on the order of -20 percent. However, the alternate intervention forms do not meet statistical requirements.

TABLE 8a

Summary of Time Series and Interventions:
BAT Program Series

Series	Mean	Interventions		
		I_{AlbBAT}	$I_{Penalties}$	I_{SFBAT}
Albuquerque WSNFI	92	-19.14[3], -1.91[0] /1-0.97B, or -0.71_t		
Albuquerque WSNFI/Fuel	6	-0.32[0], -0.40[3], or -0.01_t		
Santa Fe WSNFI	15			-11.61[0](1-B)
Santa Fe WSNFI/Fuel	5			-4.07[0](1-B)

Note: I_{AlbBAT}, $I_{Penalties}$, and I_{SFBAT} represent intervention onset of the Albuquerque BAT program, increased DWI penalties, and the Santa Fe BAT program, respectively. The numbers in brackets indicate lag structure. The subscript 't' indicates the slope of a trend. The letter 'B' represents the backshift operator.

Considering the meaning of the abrupt temporary impact, temporary is one month, an approximate 80 percent reduction is very abrupt. Although a similar spike is found in the DWI arrest series it is unlikely that an enforcement campaign alone could create such a dramatic reduction. It is here that Ross'[47] theories help explain: the combination of public perceptions of increased risk and enforcement campaigns have short term effect. However, while the Santa Fe WSNFI and WSNFI/Fuel series may return to prior value ranges after a brief BAT program impact, Santa Fe Other FI might and Other FI/Fuel increase. According to model 2.12.3.6, Santa Fe Other FI may have increased 24 percent. Santa Fe Other FI/Fuel trends upwards at roughly 3 percent per month. With respect to Santa Fe FI, WSNFI diminishes relative to Other FI, following onset of the BAT program. It is plausible then that a more long term impact reflects a more realistic effect of the BAT program in Santa Fe.

[47] Op. cit., Ross.

TABLE 8b

Summary of Time Series and Interventions:
Non-BAT Program Series

Series	Mean	Interventions		
		I_{AlbBAT}	$I_{Penalties}$	I_{SFBAT}
Albuquerque Other FI	322			
Albuquerque Other FI/Fuel	21			3.80[4], 0.98[0] /1-0.86B,or 0.28_t
Farmington WSNFI/Fuel	2			-1.39[4]
Las Cruces WSNFI/Fuel	5	1.85[5]		-4.05[0](1-B) /1-0.64B
New Mexico WSNFI/Fuel	5			-0.05_t
Other Urban WSNFI/Fuel	3		0.39[0]	-0.06_t
Rural WSNFI/Fuel	9			-0.13_t
Santa Fe Other FI	46	16.84[2]	-26.77[0](1-B)	
Santa Fe Other FI/Fuel	16			0.42_t

Note: I_{AlbBAT}, $I_{Penalties}$, and I_{SFBAT} represent intervention onset of the Albuquerque BAT program, increased DWI penalties, and the Santa Fe BAT program, respectively. The numbers in brackets indicate lag structure. The subscript 't' indicates the slope of a trend. The letter 'B' represents the backshift operator.

Just how these reductions are caused by the special enforcement squads and BAT Mobiles has been explained in terms of simple deterrence theory. The objective of BAT programs is to reduce the alcohol-involved population and the amount of alcohol, BAC, under the assumption that the higher the BAC, the higher likelihood of becoming part of the crash population. The means to the objective are the legal threat as a function of certainty of apprehension, severity of sanctions, and celerity. The police represent certainty. The deterrence value, then, is some product of the effect on size and intensity. The study of BAC's sheds some additional information, particularly with regard to the intensity of BAC.

TABLE 9

Blood Alcohol Concentration Test Levels and BAT Programs

Year	1982	1983	1984	Overall
BAT Programs				
APD: N	7,414	4,792	5,790	17,996
% < 0.10	16.5	15.8	12.8	15.1
% ≥ 0.10	83.5	84.2	87.2	84.9
SFPD: N	651	1,306	1,052	3,009
% < 0.10	9.5	13.4	9.9	11.4
% ≥ 0.10	90.5	86.6	90.1	88.6
Total: N	8,065	6,098	6,842	21,005
% < 0.10	15.9	15.3	12.4	14.6
% ≥ 0.10	84.1	84.7	87.6	85.4
Other: N	7,118	10,860	10,305	28,283
% < 0.10	7.5	7.3	7.4	7.4
% ≥ 0.10	92.5	92.7	92.6	92.6

Earlier, in Methodology, it was noted that the BAC data are available for the years 1982 through 1984. This makes any statement about the Albuquerque BAT program infeasible with this data set. What can be addressed is a hypothetical consequence of the BAT program with respect to Santa Fe.

Although the data presented are yearly figures, there are a few notable observations. BAC tests recorded at or over 0.10 outside of the BAT program areas are consistently 92.6 percent of the total number of tests. The average proportion of BAC's at or over 0.10 reported in the BAT program areas is 84.9 percent. However, this average is not consistent, in fact it starts below and increases over the average at the close of the period. The proportion of BAC's under 0.10 reported in BAT program areas moves in the opposite direction. When APD and SFPD are separated it appears that these patterns are weighted by APD. The relative proportions of BAC tests by SFPD change in 1983. More BAC's were taken below 0.10 than in either 1982 or 1984. This is also a year in which the number of BAC tests at least doubled in Santa Fe. This indicates some tradeoff between sensitivity and volume, at last in a fledgling program. In turn, the increasing proportion of BAC's taken at or above 0.10 by APD in 1983 might appear to be a consequence of reduced volume. However, the volume increases in 1984 and the relative proportion of BAC's taken at or above 0.10 also increases. This may be interpreted as meaning the tradeoff between volume, sensitivity and acuity, is less in more mature programs and that, in Albuquerque, the more "hard core" DWIs have been selected for by a gradual reduction in the less "hard core" members of the alcohol population.

TRANSFERABILITY

In a most basic way, BAT programs are transferable. The essential components are the BAT technology, the mobile testing stations, and a special enforcement squad, which may be set up anywhere. It is also assumed that the purpose in setting up a BAT program would be to accomplish the same goal expressed by both APD and SFPD: reduce losses from alcohol-involved crashes. The crucial issue is, then, not whether or not a BAT program can be set up, rather, it is what is needed to make the BAT program effective enough to have an impact.

The differences between the two BAT programs in Albuquerque and Santa Fe help illuminate important elements in the task of creating an effective program that can have the desired impact.

Most outwardly, the urban characteristics differ in size, layout, and resource bases. Albuquerque, being the larger of the two cities has the larger DWI squad; eight DWI squad officers and one full-time sergeant. Santa Fe, with roughly one tenth the population of Albuquerque, has three DUI squad officers, of which only two are on duty at a given shift, and one sergeant with split duties. With the Albuquerque area population at approximately 500,000, the number of people per DWI squad officer is roughly 62,500. In contrast, the number of people per DUI squad officer is around 25,000 in Santa Fe. It takes close to $195,000 per year to run the Albuquerque BAT program and $70,000 per year to run the Santa Fe BAT program.[48] The costs are close to $20,000 per squad member.

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[48] A BAT Mobile costs $52,000, roughly, and is not considered part of the operating costs.

TABLE 10

BAT Program Costs and Manpower

	APD	SFPD
Dollars/year	195,000	70,000
DWI Officers	8	3
Sergeant	1	0.5

It is probably consequential to the size and population of Albuquerque, with respect to Santa Fe, that the first program was set up in Albuquerque. Hence, the Albuquerque BAT program is three years more mature than the Santa Fe program. As suggested earlier in the text, there appears to be at least one important advantage to be gained through a mature program in contrast to the new program. While a new BAT program is very likely to boost the number of DWI arrests, it ought to be anticipated that the increase in volume, in the initial period, will be partially made up of drivers under the per se limit of 0.10 BAC. As the program and oficers mature and better field sobriety methods are employed, e.g. gaze Nystagmus test,[49] the tradeoff between volume and accuracy diminishes. This is seen as a result of improved DWI acuity developed through the feedback officers receive via the detection, stop, field sobriety test, arrest, and BAT cycle of the DWI arrest. Because officers do burnout, on average every 20 months, the maturation process is interrupted at the individual level. However, the maturation of the squad as a whole is somewhat moie continuous. The continuity is somewhat related to the size of the squad. Assuming that officer burnouts are staggered, larger DWI squads will be less effected by turnover in personnel than smaller squads. With more experienced officers as part of the squad, some of the gains in DWI acuity are more readily passed about and the overall performance of the squad will be less encumbered by the turnover. Therefore, the size of the city, and therefore the enforcement manpower, is a relatively important consideration in the transferability of a BAT program.

In New Mexico, urban density is also a relevant factor to consider. It is the differences in density that has a large determinant component in field service strategies. Recall that the Albuquerque BAT program

[49] J. Burnett, G.H. Bursley, and P. Boldman, Deficiencies in Enforcement, Judicial, and Treatment Programs Related to Repeat Offender Drunk Drivers (NTSB/SS-84/04, USG, Accession #PB84-917007, Washington, D.C.: National Transportation Board, Safety Study, 1984) 1-5.

strategy involves placing BAT Mobiles in fixed strategic locations while the Santa Fe BAT Mobile roves continuously. Albuquerque is essentially an urban box and Santa Fe is more amorphous with four or five pockets of densely populated neighborhoods and some almost rural neighborhoods.

Of course, service patrol strategies are only one element in many that comprise overall effectiveness. Effective DWI enforcement is also a matter of focus. For example in Santa Fe, while DUI squad officers primarily focus on DWI offenses, they also fulfill more generalized policing duties because the whole police force needs them. This helps explain the differences between APD and SFPD in effectiveness as measured by DWI enforcement indices.

TABLE 11

Measures of DWI Enforcement Effectiveness

	APD	SFPD
DWI Arrests/Vehicle	2.1%	1.7%
DWI Arrests/Manhour	0.27	0.11

These measures, Table 11, contrast sharply with much cruder measures of enforcement, population per officer. In Albuquerque, this ratio is 62,500 people per DWI squad officer, and in Santa Fe it is 25,000 people per DUI squad officer.

The higher enforcement indices in Albuquerque correspond to a relatively well defined and desirable impact, a progressive impact. Recall again the impact measures found for the BAT programs in Albuquerque and Santa Fe. In Albuquerque a continuing, trending, decrease in WSNFI and WSNFI/Fuel is found. Since WSNFIs are trending downward this is interpreted as a progressive impact on the DWI (alcohol) population. In contrast, the impact found in the Santa Fe WSNFI and WSNFI/Fuel series is less well defined. There is either an abrupt temporary decrease or a more moderate step reduction. This impact is not progressive. At best, a small gain is made, but a new, albeit lower, level problem continues. However, Santa Fe Other FI/Fuel are increasing in 1983 and 1984. In juxtaposition to Other FI/Fuel, WSNFI/Fuel can be seen as departing progressively from Other FI in Santa Fe and relative to the BAT program onset.

It appears that while there is some gain on the DWI problem in Santa Fe with the BAT program at their level of enforcement effectiveness, a more desirable reduction in WSNFI may be obtainable with a small, 0.35 percent, increase in that effectiveness, as measured by the index of DWI arrests per vehicle population. While the addition of manpower may increase this measure of effectiveness, the more direct, less costly route would be to increase DWI arrests per manhour. This can occur, apparently, as stricter specialization in police tasks are observed.

In summary, while the BAT program is physically transferable, the crucial element is the effectiveness of the BAT programs in the new setting.

CONCLUSIONS

In New Mexico, at the time of this writing, two more programs have begun service. One BAT Mobile is in use in Las Cruces, and two more are in use by the Navajo police. These, and other newest BAT programs, demonstrate that the enforcement belief is that they work. This research has produced some evaluative measures on effectiveness impact, and transferability of relatively more mature, older, BAT programs in Albuquerque and Santa Fe. Effectiveness measures are DWI arrests and anecdotal numbers of officer hours. Effectiveness is an increase in DWI arrests and minimal change in officer hours. Impact measures are alcohol-related proxy crashes, their complements, alcohol-related proxy crashes relative to travel, comparative rates, and BAT program intervention effects. Impact is interpreted from intervention analyses. Transferability is the repeatability of effectiveness and impact. This narrowly defined research supports the enforcement belief.

Throughout the body of this evaluation, the BAT programs in Albuquerque and Santa Fe have been researched and presented in relationship to a narrowly defined system involving three intersecting populations; police, alcohol, and crashes. Within this framework, the special police enforcement programs utilizing the BAT Mobiles have been shown to increase DWI arrests and DWI arrest rates.

DWI arrests in Albuquerque and Santa Fe increased 113 percent (+436 DWI arrests/month) and 79 percent (+52 DWI arrests/month), respectively. The special police enforcement squads arrested nearly 300 to 3,000 percent more DWIs per hour than the Department's average number of DWI arrests per hour. In Albuquerque, the rate of DWI arrests per hour for all of APD field services was 0.01 and the DWI squad's average was 0.27 DWI arrests per hour. In Santa Fe, the Department's field services averaged 0.004 DWI arrests per hour and the DUI squad averaged 0.11 DWI arrests per hour. As a result of the specialization of the three percent of the departments' field services, the index of DWI arrests per registered vehicle increased 70 percent in Albuquerque and 64 percent in Santa Fe.

The BAT programs enable the police to apprehend larger numbers of DWIs effectively and efficiently. DWI arrests increase gradually and permanently as long as the program is unencumbered. Since officers tend to "burnout" every 20 to 24 months, on average, squads will be effected by turnover in personnel.

The BAT programs further coincide with reductions in WSNFI crashes. Intervention analyses reveal several views on the form of BAT program effect: abrupt permanent step, lagged permanent step, gradual permanent, or trend.

While more difficult to comprehend, the prevailing impact form is a small but progressive reduction in alcohol-related crashes, a trend. One of the reasons this impact form prevails is that the estimates of reductions in alcohol-related crashes fall between other estimates.

TABLE 12

BAT Program Impact Form

Form	Temporary	Permanant Abrupt	Lagged	Gradual	Trend
Albuquerque					
WSNFI			-21%[3]	-69%	-0.8%/Mn.
WSNFI/Fuel		-5%	-7%[3]		-0.2%/Mn.
Other FI					
Other FI/Fuel					
Santa Fe					
WSNFI	-77%	-21%*			
WSNFI/Fuel	-82%	-24%*			
Other FI			+24%[4]*		
Other FI/Fuel					3%/Mn.

Note: Numbers are percentage of change. Numbers in brackets are intervals of lagged structure. Starred items fall below the 95 percent apriori confidence limit and above a 80 percent confidence.

Estimates of reduction in surrogate alcohol-related crashes, WSNFI, in Albuquerque are -69 percent if form is gradual and permanent, -21 percent if form is abrupt, permanent and lagged 3 months, and 1 percent per month if form is a trend. After a three year period the result of a -1 percent WSNFI per month trend would be -36 percent. Estimates of reductions in the relative frequency of WSNFI/Fuel (travel) are -5 percent if form is abrupt and permanent, -7 percent if lagged, and -1/10 percent per month if form is a trend. The trend results in a 6 percent reduction after five years. While trends cannot continue forever, in the relatively short time frame considered, real changes in WSNFI are perhaps best explained with a trend line in Albuquerque.

In Santa Fe there are enormous temporary reductions in WSNFI and WSNFI/Fuel, -77 percent and -82 percent respectively. It is unclear how much WSNFI or WSNFI/Fuel were reduced in the long run. It is possible that on average both actual and relative WSNFI were reduced permanently by 21 percent and 24 percent, respectively. In either case, Santa Fe Other FI and Other FI/Fuel contrast with a lagged increase of 24 percent and an 8 percent per month upward trend, respectively. This might also be interpreted to mean that the impact in Santa Fe from the Santa Fe BAT program on WSNFI/Fuel is a proportionate downward trend in WSNFI to all FIs. In this regard, the BAT programs have very desirable results.

It would appear that the police departments in Albuquerque and Santa Fe were able to actualize their goal of reducing the losses resulting from alcohol-involved crashes with BAT programs. It is surmised that one causal pathway in which this is accomplished is the small, gradual impact on the alcohol population through actual apprehension and deterrence. Even though it is virtually impossible to measure the actual alcohol population from which DWIs are apprehended, it is of a limited size. Given that the alcohol population is a limited size, even a small but consistent effort to remove members has a progressive effect. This progressive effect derives from the proportionately increasing number of members being withdrawn from a fixed population: as the population is reduced each month, the next month's number of apprehensions is a bigger proportion of the remaining population.

While this is a nice and convenient explanation given to a constricted model of the real world, it is a plausible explanation for the long term trend in reducing WSNFIs in Albuquerque. In the real world setting there are many ways in which the alcohol population changes. Some influx to the alcohol population continues to occur as people of all ages become alcoholic. Recidivism is known to be large. And, finally, as the theoretical alcohol population shrinks the police will have fewer interactions. These limiting events will eventually result in a stable level, albeit much lower than without enforcement efforts.

One consequence of this model of enforcement and alcohol is that as time passes and many casual members leave the alcohol population the more police will encounter recidivists and repeaters, people with alcoholic tendencies.

RECOMMENDATIONS

The BAT program evaluation was limited to a narrowly defined system even though some elements outside that system were discussed. In particular, the legislated increases in DWI penalties were addressed. As the system constraints are relaxed and broader understandings sought, the complexity and difficulty in identifying the many inputs to the system and their results increases rapidly. Certainly the police are not the only people one deals with in a DWI arrest. The legal system is extensive and only begins with the police. Other members of the legal system involve corrections officers, bonds persons, judges, sometimes lawyers, probation oficers, DWI screening program officials, DWI school personnel, and Transportation Department officers.

The closer the inspection of any one of the facets of the legal system, the more it is possible to see bottlenecks and other problems arising out of the DWI problem and increased enforcement efforts resulting in increased DWI arrests.[50] It is possible to see that even effective BAT programs may reach limits of enforcement efforts quickly if one or any number of the elements in the legal system fail.

It is, therefore, a first recommendation that new BAT programs and evaluation efforts consider more thoroughly the existing legal systems and the effects on DWI countermeasure efforts.

As problem definitions are relaxed in order to address broader DWI issues, the analytical problems are going to compound. Traditional time series analysis techniques are clumsy, at best, as the number of variables introduced to the model increase. The most promising methodological approach appears to be through Vector ARIMA techniques. It is therefore recommended that monies and time be allocated for future research that will allow the use of Vector ARIMA software and techniques.

Another shortcoming of this report is the inability to analyze for impacts in relationship to Administrative Revocations. The inability to perform analysis is tied to a lack of data. However, the necessary data will be available to address the effects of Administrative Revocations on the crash population. The inclusion of Administrative Revocations would greatly enhance evaluation efforts aimed at testing the theories of simple deterrence because Administrative Revocations represents the missing component, celerity of consequences for DWI. With Administrative Revocations being analyzable, it should be possible to explicitly test the relative contribution to deterrence as represented by celerity (Administrative Revocations), severity (increased DWI penalties) and certainty (BAT program). It is therefore recommended that further studies be made with respect to the various contributions made to deterrence in New Mexico

[50] Mayor's Task Force on Alcohol/Drug Abuse and Crime, Final Report, The City of Albuquerque, P.O. Box 1293, Albuquerque, NM 87103, July 15,1986.

from BAT programs, increased DWI penalties, and Administrative Revocations.

It has been problematic that better representation of police input were not available. I would recommend that specific studies be made of the police inputs to all service areas before further conclusions are reached about DWI countermeasure efficacy.

APPENDIX A. DWI ARREST TIME SERIES ANALYSIS

Quasi-experiments based on Intervention Analysis are interpreted from the generalized time series model

$$Y_t = N_t + f(I_t;\ \omega,\delta). \qquad (1.1)$$

Where Y_t is a time series, N_t is a noise component, and $f(I_t;\ \omega, \delta)$ is a function of a dummy variable which represents an intervention in the series.

The noise component, N_t, is composed of Autoregressive Integrated Moving Average (ARIMA) parameters.[51] Analysis begins with the identification of the noise component, the estimation of the ARIMA parameters, and a diagnosis of the "best" fit model.[52]

Autoregressive parameters are interpretable as the portions of preceding observations in the series composing the current observation plus a random shock:

$$Y_t = \phi Y_{t-1} + \ldots + \phi_n Y_{t-n} + a_t. \qquad (1.2)$$

A first order autoregressive model is expressed as

$$y_t - \phi_1 y_{t-1} = a_t, \text{ or}$$
$$(1-\phi_1 B)Y_t = a_t. \qquad (1.2.1)$$

Where B is the Backshift operator, $Y_t B = Y_{t-1}$, and a_t represents independently identical and normally distributed random shocks.

The moving average parameters are the proportions of preceding random shocks that compose the current observation:

$$Y_t = a_t - \theta_1 a_{t-1} - \ldots - \theta_n a_{t-n} \qquad (1.3)$$

A first order moving average model is

$$Y_t = (1-\theta_1 B)a_t. \qquad (1.3.1)$$

The functions used to model interventions, $f(I_t;\ \omega,\ \delta)$, are a special case of the class of functions used to model exogenous variables acting on an observed series. The intervention function is distinguished from other

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[51] Op. cit., Box and Jenkins, 438-569.

[52] Numerous descriptions exist for the process of identification/estimation/diagnosis model building. Interested readers unencumbered with math anxiety should begin with Box and Jenkins, ibid. The rest of us should begin with Interrupted Time Series Analysis, as in McDowell, et. al., op. cit., or similar texts.

transfer functions in that the function is set to 0 until the onset of a countermeasure at a specified time. Typically, I_t is considered a switching function accompanied by parameters of the function. The parameters of the function correspond to two elements: The first element is ω, omega, the change in level, which may be expressed as a polynomial. However, most countermeasure interventions require only one ω parameter. The second element is δ, delta, the rate of change in level. The δ parameter is a polynomial, but is usually only a first order polynomial. At the time of an intervention the series may be expressed as

$$y_t - \delta y_{t-1} = I_t \omega, \text{or} \quad (1.4)$$

$$y_t = I_t \omega / (1 - \delta B).$$

where

$$y_t = Y_t - N_t. \quad (1.5)$$

In theory, intervention analysis is concerned with the process or form of change in a series, whereas in practice the interest is the interval of change and the lag structure. In methodological terms this means that, theoretically, impact measurement ought to be detectable at counter measure onset; I_t. Furthermore, the functional model of the intervention should indicate the form and duration of intervention effect. Most intervention analyses are conducted with respect to measuring the intervals between levels in a series and the lag structure, the delay in time, of countermeasure onset and detectable impact. In order to close the gap in the two prescribed methodological approaches, form and lag structure are analyzed.

Equation 1.4 is a generalized functional description of common intervention forms. When I_t is a binary dummy variable, 0, prior to an intervention and 1 thereafter, two theoretical forms of permanent impacts may be modeled. When the δ polynomial is omitted and the ω parameter is statistically significant, the impact is interpreted as an abrupt permanent change in the series of magnitude ω. If both parameters are included and both are statistically significant, then the impact is gradual and permanent. When I_t is defined to be 0 prior to an intervention, 1 during a countermeasure, and 0 afterwards two types of temporary impact may be fitted. These types are, again, abrupt and gradual, following the same logic for the permanent changes.

For some of the problems encountered throughout this evaluation work a fifth intervention form, a trend function, was found useful. The trend model necessitates defining I_t as a nonbinary and nonrandom variable: 0 prior to an intervention, 1 at the onset, and i thereafter, where i is the number of iterations since the intervention onset. In this case, the slope of the trend is ω, henceforth ω_t, for trend. This impact measure may be conceptualized in two ways. The first meaning would be that at each interval an additional unit of input is brought into the countermeasure. A second interpretation is that the actual result of a countermeasure increases and is measurable at each interval.

In practice, ω is parameterized with regard to time and analyzed for the number of time units between theoretical onset and observable impact effect. The number of units of delay is referred to as the lag structure. Lag structure is interpreted from the cross correlation function of the pre-whitened input series (intervention series) and the filtered output series (observed series of DWI arrests and alcohol-involved crashes). The lag structure is noted as any number of units of delay, #, following the measure of change in level, ω(#).

Two statistics are utilized for the determination of significance; one for model parameters, t-Ratio, and the other, Box-Ljung Q-Statistic,[53] for the adequacy of the whole model. A parameter is considered significant at the 95 percent confidence level if the estimate's t-Ratio is greater than or equal to 1.96. The Q-value indicates the amount of non-stochastic elements remaining in the overall series. This means that the lower the Q-value the better the model under consideration fits the data. In general, the "cut-off" value is 32 with 24 degrees of freedom (df). A third statistical number is the residual sum of squares, RSS. This number is useful for comparing analytical models.

All univariate time series and intervention analyses were estimated with the statistical analysis system BMDP,[54] procedure 2T. In addition, SAS[55] software was used for data handling and graphics were produced with TELLAGRAF.[56] Each software system is maintained by the University of New Mexico.

The Albuquerque DWI Arrest time series consists of monthly totals beginning January, 1976 and ending in December, 1984. The Albuquerque BAT program began in April, 1979. The Santa Fe series also consist of monthly totals, covering the period January, 1979 through December, 1984. The Santa Fe BAT program began New Year's Eve, 1982.

Both the Albuquerque and Santa Fe DWI Arrest series were first diagnosed for underlying noise models without regard to pre- or post-intervention divisions. Following the identification of an adequate noise model, impact measures were then introduced into the model.

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[53] G. Ljung and G.E.P. Box, "On a measure of lack of fit in time series models," Biometrika, 65 (1978) 297-304.

[54] BMDP Statistical Software, 1981 edition, edited by W.T. Dixon. (Berkeley, California: UCLA Press), 1981.

[55] SAS User's Guide, (Cary, North Carolina: SAS Institute), 1982.

[56] TELLAGRAF User's Manual, (San Diego, California: ISSCO Graphics), 1984.

Albuquerque DWI Arrests: The noise model, N_t, to be most parsimoniously modeled, required seasonal (lag twelve) differencing and two autoregressive parameters:

$$\text{Model} \quad (1-\phi_1 B-\phi_3 B^3)\ Y_t(1-B^{12}) = a_t \qquad (1.6.0)$$

Parameter	Estimate(t-Ratio)	RSS
ϕ_1	0.73(9.35)*	548,440
ϕ_3	0.39(3.70)*	

Q-value = 13, df = 12
Q-value = 29, df = 24

Note: Starred t-Ratios are significant at the 95 percent confidence level. The residual sum of squares is presented under RSS.

The DWI arrest series (Figure 3, page 21) shows an annual non-stationarity that is made stationary through ordinary seasonal differencing. Thereafter, N_t is composed of periodic autoregressive proportions of preceding DWI arrests. In particular, DWI arrests in one month are related to the number of arrests made the month before. The additional autoregressive parameter tells of the other predominant intervals and the magnitude of the contribution to the present observation of those preceding observations. Therefore, the Albuquerque DWI arrests appear to be a function of DWI arrests made last month and three months ago. Perhaps the autogressive parameter at lag 3 is related to performance evaluations, changes in policy, or changes in DWI behavior. It is more likely due to the fact that there are more weekends in one specific month of a quarter than the others, and therefore, more DWI arrests.

When trend constant parameters were fitted they were found to be statistically insignificant and the fit of the overall model was not improved.

From the descriptions given by the police about the BAT programs we anticipated a gradual and permanent increase in DWI arrests. This is also apparent in Figure 3, page 21. Therefore, the impact analysis involved first a gradual and permanent intervention function.

The test of the hypothesis that DWI arrests increase with the BAT program substantiates the descriptions and apparent form:

Model $y_t = I_{AlbBAT}\omega(0)/1 - \delta B.$ (1.6.1.2)

Parameter	Estimate(t-Ratio)	RSS
ω	34.86(2.08)*	505,804
δ	0.92(18.68)*	

Q-value = 11, df = 12
Q-value = 27, df = 24

The improvement in the fit of the model is noted in the reduction in RSS and Q-values from model 1.6.1 to 1.6.1.2. In addition, autoregressive parameter estimates of 1.6.1 became more moderate, the two parameter sum to less than 1.

The gradual permanent intervention function verifies that the BAT program coincided with an increase in DWI arrests. The increase in the number of DWI arrests is estimated to eventually be an additional 436 per month.

In order to ensure the fortuitous analysis of Albuquerque DWI Arrests was appropriate, other intervention forms and lag structure were investigated. The only other qualified model was 1.6.1.6. The change in level for the number of DWI arrests was roughly 200 per month eight months after the onset of the BAT program according to model 1.6.1.6.

Impact		Estimate(t-Ratio)	RSS	1.6.1
Permanent				
Abrupt:	$\omega(0)$	34.32(0.64)	545,692	.1
Gradual:	$\omega(0)/1-\delta B$	34.86/0.92(2.08/18.68)*	505,804	.2
Temporary				
Abrupt:	$\omega(0)(1-B)$	-2.16(-0.05)	543,914	.3
Gradual:	$\omega(0)(1-B)/1-\delta B$	5.57/-0.50(0.18/-0.21)	543,667	.4
Trend:	ω_t	3.12(0.67)		.5
Lagged:	$\omega(8)$	201.4(4.33)*	436,975	.6

In either case, the evidence indicates a large increase in the number of DWI arrests per month. That is the extent of shared information between the two models 1.6.1.2 and 1.6.1.6. If the sole criterion were RSS, then the lagged model would be the better choice. However, the Q-values for the lagged model, 1.6.2.6, were 15 and 40, for df=12 and df=24, respectively. Furthermore, a strict interpretation of model 1.6.2.6 is that there was no change in level until the eighth month. While a large increase is observable eight months after onset, there appear to be other increases even later. Therefore, in the case of Albuquerque DWI arrests, the more gradual form and larger increase was a better model.

Santa Fe DWI Arrests: The Santa Fe series was made stationary with a first order differencing. Thereafter, the N_t component was parsimoniously modeled as a lag two autoregressive process.

Model $$(1-\phi_2B^2)Y_t(1-B) = a_t. \qquad (1.7.0)$$

Parameter	Estimate(t-Ratio)	RSS
ϕ_2	-0.42(-3.83)*	35,213

Q-value = 14, df = 12
Q-value = 32, df = 24

The onset of the BAT program in Santa Fe was best represented as an abrupt permanent increase in DWI arrests:

Model $$y_t = I_t\omega(0). \qquad (1.7.1.1)$$

Impact	Estimate(t-Ratio)	RSS	1.7.1
I_{SFBAT}			
$\omega(0)$	52.11(2.62)*	31,992	.1
$\omega(0)/1-\delta B$	54.25/-0.40(2.70/-1.51)	30,487	.2
$\omega(0)(1-B)$	48.47(3.56)*	29,386	.3
$\omega(0)(1-B)/1-\delta B$	50.72/0.07(2.65/0.17)	29,372	.4
ω_t	-1.20(-0.36)	35,146	.5
$\omega(1)$	-45.92(2.23)*	32,532	.6

Two of the three statistically significant impact models, 1.7.1.1, .3, and .6 are interpreted to mean DWI arrests increased with the BAT program in Santa Fe, even though each tells of a different kind of impact. Model 1.7.1.1 represents a permanent increase of 52 DWI arrests above prior levels. Model 1.7.1.3 represents a one month temporary increase of 48 DWI arrests over baseline levels. Finally, model 1.7.1.6 is the result of an investigation of the lag structure of the Santa Fe BAT program. Diagnosis of the cross correlation function indicated two possible lag models: the zeroth lag, equivalent to the theoretical onset, and lag one (shown in 1.7.1.6). Model 1.7.1.6 measured a decline in DWI arrests one month after the official onset of the BAT Mobile program in Santa Fe.

An interpretation of these findings supported model 1.7.1.1, a sustained increase of 52 DWI arrests per month, on the average, following the onset of the Santa Fe BAT Mobile program, when Figure 4 (page 25) was also taken into consideration. Both analytically and visually, the official start up of the Santa Fe BAT Mobile program, January, 1983, was marked with an apparent peak in DWI arrests. This peak is analytically defined by model 1.7.1.3. Model 1.7.1.6 measures the downside of the initial aggressive pursuit of DWIs in Santa Fe. However, after onset, DWI arrests are generally more frequent than before. This observation supports model 1.7.1.1.

APPENDIX B. CRASH TIME SERIES ANALYSIS

The impacts of the BAT programs are evaluated with respect to monthly counts of fatal and injury (FI) crashes. The series of FIs begins in 1972 and ends in 1984, 156 observations.

The intervention of these countermeasures on the crash series are set by dummy variables, $f(I_t; \omega, \delta)$. In addition to the two intervention functions for the BAT programs, one for Albuquerque and the other for Santa Fe, a third intervention function is also introduced. This third intervention represents the onset of increased statewide penalties for DWI. For the Albuquerque BAT program the onset is defined as,

I_{AlbBAT} = 0, If date is less than
April, 1979, and
1 or 1 + i thereafter.

The increase in DWI penalties is defined as occurring after the end of the legislative session in which they were enacted.

I_{Pen} = 0, if date is less than
March, 1982, and
1 or 1 + i thereafter.

The Santa Fe BAT Mobile program onset is defined as

I_{SFBAT} = 0, If date is less than
January, 1983, and
1 or 1 + i thereafter.

Countermeasure intervention analyses on fatal and injury crashes is conducted on complementary and comparative series in order to provide as much control information as possible for non BAT program related changes. In this manner, the alcohol-involved crash measure for either BAT program is balanced by comparison to off hour, other urban, New Mexico total, and proportionate FI crashes. FIs are proportioned to travel, as measured by fuel sales.

Seven of the nine series considered are counts of FIs occurring from seven p.m. to five a.m. the following morning, Wednesday through Saturday, WSNFI. The two other series are FIs occurring at any other time, referred to as Other FI. WSNFI and Other FI are complementary. In the text, the nine series are addressed in three groups: BAT Program related WSNFI series and their complements, Other Urban control series, and New Mexico total and Rural WSNFI. These nine series are presented alphabetically in this appendix.

Albuquerque WSNFI: The analysis of the Albuquerque WSNFI series began with one kind of model and ended with a second type of model. When the series was first examined as a whole it appeared to be parsimoniously modeled as a regular month to month (lag one) and seasonal (lag twelve) moving average process.

Model $$(1-B)(1-B^{12})Y_t = (1-\theta_1 B)(1-\theta_{12} B^{12})a_t. \qquad (2.1.0)$$

Parameter	Estimate(t-Ratio)[57]	RSS
θ_1	0.83(18.82)*	22,439
θ_{12}	0.88(36.13)*	

Q-value = 17.0, df = 12
Q-value = 36.0, df = 24

Note: Asterisks represent significant t-Ratios.

Model 2.1.0 is typical of time series analysis of crashes in that crashes often have strong seasonal components and are understood better as a moving average process than an autoregressive process. The two differencings are interpreted as indicating normal (lag one) and seasonal (lag twelve) dynamics.

When the Albuquerque BAT program intervention effects were explored, three different impact models were found, 2.1.0.3, 2.1.0.5, and 2.1.0.6.

Impact	Estimate(t-Ratio)	RSS	2.1.0
$\omega(0)$	-2.28(-0.33)	22,424	.1
$\omega(0)(1-B)$	15.46(1.29)	22,261	.2
$\omega(0)/1-\delta B$	-1.91/0.97(-3.71/90.13)*	20,825	.3
$\omega(0)(1-B)/1-\delta B$	21.71/0.52(1.87/1.32)	21,922	.4
ω_t	-0.71(-2.51)*	21,669	.5
$\omega(3)$	-19.14(-2.81)*	21,257	.6

[57] Reported estimates throughout were derived with backcasting methods in the procedures of BMDP 2T.

The three impact forms confirm that WSNFI crashes decreased following the BAT program onset. Model 2.1.0.3 depicts the decrease as a very gradual process, eventually decreasing by 64 WSNFI per month from pre-BAT program levels. The value of δ is extremely close to 1, too close to be valid. As δ approaches 1, the intervention function becomes a trend, with no defined plateau signifying the end of a period of change. The explicit trend function, model 2.1.0.5, the second of the three significant models of intervention effect, describes a decreasing trend of -1 WSNFI every month following onset. The number of saved WSNFI per month is roughly 50 by the end of the period. Model 2.1.0.6 describes an abrupt and permanent decrease of 19 WSNFI three months after the onset.

When an alternate modeling approach was tried, more information was made available. The primary difference in the two N_t equations, 2.1.0 and 2.1.1, is that model 2.1.1 uses a constant. In a differenced equation, a constant represents a linear trend component.

Model $$(1-B^{12})Y_t = c + (1-\theta_3 B^3)(1-\theta_{12} B^{12}) + f(I_t,\omega,\delta) \qquad (2.1.1)$$

Impact	Estimate(t-Ratio)	RSS	2.1.1
$\omega(0)$	-10.76(-2.02)*	25,097	.1
$\omega(0)(1-B)$	25.86(2.14)*	24,739	.2
$\omega(0)/1-\delta B$	-1.94/0.96(-4.75/120.70)*	18,378	.3
$\omega(0)(1-B)/1-\delta B$	29.53/0.81(3.04/7.92)*	23,610	.4
ω_t	-0.67(-6.24)*	20,614	.5
$\omega(3)$	-24.27(-4.76)*	21,985	.6

The intervention functions of the BAT program are all statistically significant with respect to parameter estimates. Each of the impact models contributes enough information to indicate a preferred model.

The two short-term impact models describe an immediate increase in WSNFI. Model 2.1.1.2 shows a one month jump of 26 WSNFI following onset, and then a return to prior level. Model 2.1.1.4 shows a jump of 30 WSNFI and a gradual return to prior level.

All permanent impact models indicate a decrease in WSNFI. Both the step intervention functions, models 2.1.1.1 and 2.1.1.6 indicate a drop of 11 to 24 WSNFI per month following onset, respectively. The two more continuous forms of intervention functions also indicate decreases in WSNFI. Model 2.1.1.3 describes a reduction of up to 50 WSNFI after a gradual process of reaching this lower level. However, the δ parameter is again too close to 1. The trend impact, model 2.1.1.5, fits nicely.

The intervention functions associated with model 2.1.1 provide larger impact measures, largely because the series of WSNFI up to 1979 does trend upward, and decreases thereafter. Balancing the long-term effects, decreased WSNFI, against the short-term, increased WSNFI, reveals that the BAT program began operations as WSNFI crashes were increasing. It is unlikely that the program caused more WSNFI in the light that the long-term impact models showed definite decreases in WSNFI. The difference in the two permanent step impact models is that the lag structure indicated a larger decrease in three months. The permanent step impact means that in one month the average permanent reduction is established. In contrast, the more continuous forms of impact describe a more gradual, less noticeable impact. As noted in the analysis of DWI arrest, the transition from pre- to post-DWI arrest frequencies ocurred gradually. This further supports an interpretation of the intervention effect of the BAT Mobile program to be gradual and more continuous. Of the continuous models, the more acceptable model is 2.1.1.5, the trend impact.

The question that then had to be answered was were there other DWI countermeasures that were contributing to the detectable decrease in Albuquerque WSNFI. For this reason, the statewide increase in DWI penalties was tested for results in the frequencies of WSNFI. Intervention effects from the Santa Fe BAT program were also tested. Intervention functions were introduced separately to N_t, model 2.1.0, for the WSNFI crashes. No other interventions were found.

Impact	Estimate(t-ratio)	RSS	
I_{Pen}			2.1.2
$\omega(0)$	5.32(0.70)	22,362	.1
$\omega(0)(1-B)$	18.90(1.57)	22,165	.2
$\omega(0)/1-\delta B$	16.24/-.078(1.53/-2.90)	22,047	.3
$\omega(0)(1-B)/1-\delta B$	16.72/-0.64(1.58/-2.15)	21,996	.4
ω_t	0.19(0.41)	22,428	.5
$\omega(0)$	see 2.1.2.1		.6
I_{SFBAT}			2.1.3
$\omega(0)$	0.25(0.03)	22,439	.1
$\omega(0)(1-B)$	2.52(0.21)	22,542	.2
$\omega(0)/1-\delta B$	-7.36/-0.95(-0.86/-7.75)	22,222	.3
$\omega(0)(1-B)/1-\delta B$	-5.93/-0.92(-0.96/-7.59)	22,224	.4
ω_t	0.16(0.30)	22,438	.5
$\omega(10)$	-1.02(-0.14)	21,576	.6

The precautions taken to validate any inferred impact resulting from the BAT programs include controls for rival explanations related to instrumentation, testing, regression, selection, history, and interactions between these threats. Two remaining sources of rival hypotheses are from maturation and mortality. The approach taken to provide precautions against these threats to validity is to create a ratio of FIs to exposure and to contrast this and other FIs to Albuquerque WSNFI. Exposure is measured in terms of fuel sold, which is proportional to the number of people driving and the amount they drive. Therefore, detectable changes coinciding with the onset of the DWI countermeasures ought to reflect true impacts, with respect to the more global effects introduced by the economic system, population dynamics, and technology. By examining Albuquerque Other FI, it is also possible to imply affects of changing exposure. Analysis of Albuquerque Other FI will follow the analysis of the ratio of Albuquerque WSNFI and fuel sales.

Albuquerque WSNFI/Fuel: The N_t component of the WSNFI/Fuel series required only that it be seasonally adjusted, a lag twelve differencing and moving average parameter:

Model $$(1-B^{12})Y_t = (1-\theta_{12}B^{12})a_t. \qquad (2.2.0)$$

Parameter	Estimate(t-Ratio)	RSS
θ_{12}	0.88(35.18)*	126

Q-value = 20.0, df = 12
Q-value = 25.0, df = 24

When a trend constant was tried, it was found insignificant and, therefore, inappropriate. The interpretation of 2.2.0 is that there are seasonal effects. In contrast with 2.1.0 or 2.1.1, which indicated first and seasonal effects, the ratio of WSNFI to fuel "controls" for growth and decline in fuel sales, therefore, travel. This apparent "control" effect can be seen in Figure 6, page 39. Both WSNFI and fuel sales generally increase up to 1979; afterwards, both tend to decline. The ratio, WSNFI/Fuel, does not show the increase or decrease that either raw series does. However, when WSNFI/Fuel was analyzed, there did appear to have been BAT program impact.

Impact	Estimate(t-Ratio)	RSS	2.2.0
$\omega(0)$	-0.32(-2.08)*	122	.1
$\omega(0)(1-B)$	0.84(0.91)	124	.2
$\omega(0)/1-\delta B$	-0.02/0.98(-1.20/31.25)	116	.3
$\omega(0)(1-B)/1-\delta B$	0.84/0.88(1.50/7.54)	122	.4
ω_t	-0.01(-3.39)*	116	.5
$\omega(3)$	-0.40(-2.58)*	114	.6

The lagged impact model, 2.2.0.6, shows a larger decrease than does the non-lagged model, 2.2.0.1, -.32 versus -.40 WSNFI/Fuel respectively. However, both of these models depict a step-like decrease which is in contrast to the very subtle changes indicated by the more continuous forms of intervention described by model 2.2.0.5.

Because of the relatively small but persistent increase in enforcement indices following the onset of the BAT program, we had expected a gradual permanent impact. The transfer function used to model that impact was inadequate. An explicit trend function was introduced, with success, to provide a model for a destabilizing impact (Model 2.2.0.5).

The Albuquerque WSNFI/Fuel Series was also analyzed for any impacts resulting from increased DWI penalties and/or coincidental changes with the Santa Fe BAT program. Each countermeasure was tested separately of others and, then, in conjunction with the others, as multiple input models, so as to not overlook possible complementary or interactive effects.

Impact	Estimate(t-Ratio)	RSS	
I_{Pen}			2.2.1
$\omega(0)$	-0.56(-3.23)*	117	.1
$\omega(0)(1-B)$	-0.84(-0.90)	124	.2
$\omega(0)/1-\delta B$	-0.08/-1.18(-0.61/-197.67)	124	.3
$\omega(0)(1-B)/1-\delta B$	0.86/-0.76(1.15/-2.64)	123	.4
ω_t	-0.02(-2.20)*	121	.5
$\omega(0)$	see 2.2.1.1		.6
I_{SFBAT}			2.2.2
$\omega(0)$	-0.43(-2.16)*	122	.1
$\omega(0)(1-B)$	-0.30(-0.32)	124	.2
$\omega(0)/1-\delta B$	-0.73/-0.78(-2.02/-1.59)	121	.3
$\omega(0)(1-B)/1-\delta B$	-0.84/0.93(-1.71/13.98)	120	.4
ω_t	-0.02(-1.50)	124	.5
$\omega(12)$	-0.29(-1.11)	113	.6

Model $$y_t = I_{AlbBAT}\omega_t + I_{Pen}\omega_t + I_{SFBAT}\omega(0). \quad (2.2.3)$$

Parameter		Estimate(t-Ratio)	RSS
I_{AlbBAT}	ω_t	-0.02(-2.86)*	115
I_{Pen}	ω_t	0.02(0.94)	
I_{SFBAT}	$\omega(0)$	-0.07(-0.13)	

Q-value = 7.6, df = 12
Q-value = 12.0, df = 24

Model $y_t = I_{AlbBAT}\omega_t + I_{Pen}\omega(0) + I_{SFBAT}\omega$ (2.2.4)

Parameter		Estimate(t-Ratio)	RSS
I_{AlbBAT}	ω_t	-0.01(-1.49)	115
I_{Pen}	$\omega(0)$	0.31(0.79)	
I_{SFBAT}	$\omega(0)$	0.40(1.15)	

Q-value = 7.6, df = 12
Q-value = 12.0, df = 24

Model $y_t = I_{AlbBAT}\omega_t + I_{SFBAT}\omega(0).$ (2.2.5)

Parameter		Estimate(t-Ratio)	RSS
I_{AlbBAT}	ω_t	-0.02(2.74)*	116
I_{SFBAT}	$\omega(0)$	0.32(0.97)	

Q-value = 7.7, df = 12
Q-value = 13.0, df = 24

Although the representation of the multiple input models is brief, in comparison to all possible combinations, it does display the most obvious combinations as determined by the individual tests for impacts. The first multiple impact model (2.2.3) shows a significant impact, the trend impact of the Albuquerque BAT program. When another combination was analyzed, model 2.2.4, no impacts were found. However, when the most ill-fit parameter was dropped from model 2.2.4, resulting in model 2.2.5, the outcome was the same as 2.2.3. No other impact in the Albuquerque WSNFI/Fuel series was detectable except that coinciding with the Albuquerque BAT program.

Albuquerque Other FI: The complement to Albuquerque WSNFI, Other FIs, is similar in that both series generally increase up to 1979 and for the next couple of years decline. Other FI were adequately modeled with first and seasonal differencing and moving average parameters:

Model $(1-B)(1-B^{12})Y_t = (1-\theta_1 B)(1-\theta_{12}B^{12})a_t.$ (2.3.0)

Parameter	Estimate(t-Ratio)	RSS
θ_1	0.60(8.91)*	113,025
θ_{12}	0.86(33.72)*	

Q-value = 11.0, df = 12
Q-value = 30.0, df = 24

The similar pattern of increasing FIs for both Albuquerque WSNFI and Other FI, followed by decreasing FIs, indicates that some population growth and shrinkage was occuring, with the inflection about the same period as the start up of the Albuquerque BAT program. If the analysis of the Other FI series for intervention effects were to indicate a similar reduction in FIs coinciding with the BAT program, then the detected impact in the WSNFI series would be better understood in terms of the more general conditions in Albuquerque than the BAT program. There was no detectable change in Other FI with respect to the BAT program.

Impact	Estimate(t-Ratio)	RSS	
I_{AlbBAT}			2.3.1
$\omega(0)$	-7.10(-0.32)	112,934	.1
$\omega(0)(1-B)$	4.43(0.18)	112,338	.2
$\omega(0)/(1-\delta B)$	-6.48/0.94(-1.35/15.49)	111,358	.3
$\omega(0)(1-B)/1-\delta B$	6.15/0.82(0.26/0.50)	112,321	.4
ω_t	-1.22(-0.63)	112,712	.5
$\omega(9)$	-19.99(-0.89)	108,147	.6
I_{Pen}			2.3.2
$\omega(0)$	6.06(0.27)	112,963	.1
$\omega(0)(1-B)$	34.82(1.40)	110,820	.2
$\omega(0)/(1-\delta B)$	-3.78/-0.95(-0.22/-2.42)	112,975	.3
$\omega(0)(1-B)/1-\delta B$	39.05/0.31(1.51/0.46)	110,554	.4
ω_t	1.50(0.67)	112,773	.5
$\omega(8)$	22.56(1.01)	108,044	.6
I_{SFBAT}			2.3.3
$\omega(0)$	11.78(0.53)	112,859	.1
$\omega(0)(1-B)$	4.54(0.18)	112,338	.2
$\omega(0)/1-\delta B$	10.28/0.86(1.18/5.54)	111,289	.3
$\omega(0)(1-B)/1-\delta B$	1.33/-0.94(0.13/-1.16)	112,351	.4
ω_t	1.81(0.72)	112,747	.5
$\omega(12)$	-25.33(-1.14)	103,603	.6

Albuquerque Other FI/Fuel: Albuquerque Other FI, Fuel Sales, and Other FI/Fuel may be observed in Figure 7, page 40. The rate series was most parsimoniously modeled as a first and seasonal differencing and moving average process:

Model $(1-B)(1-B^{12})Y_t = (1-\theta_1 B)(1-\theta_{12} B^{12})a_t.$ (2.4.0)

Parameter	Estimate(t-Ratio)	RSS
θ_1	0.85(20.01)*	1,020
θ_{12}	0.87(32.59)*	

Q-value = 7.1, df = 12
Q-value = 21.0, df = 24

Depicted on the Figure 7 is the only significant change that was detected, I_{SFBAT}.

Model $y_t = I_t f(\omega, \delta).$ (2.4.1 - .3)

Impact	Estimate(t-Ratio)	RSS	
I_{AlbBAT}			2.4.1
ω(0)	0.42(0.30)	1,019	.1
ω(0)(1-B)	-0.52(-0.21)	1,020	.2
ω(0)/1-δB	0.02/1.03(0.34/24.70)	1,016	.3
ω(0)(1-B)/1-δB	0.88/0.91(0.52/2.52)	1,019	.4
ω_t	-0.01(-0.39)	1,020	.5
ω(9)	-2.23(-1.49)	988	.6
I_{Pen}			2.4.2
ω(0)	-0.99(-0.69)	1,017	.1
ω(0)(1-B)	2.85(1.11)	1,011	.2
ω(0)/1-δB	0.72/-1.03(0.66/-19.43)	1,006	.3
ω(0)(1-B)/1-δB	-2.73/0.91(-1.67/7.82)	1,004	.4
ω_t	0.13(1.82)	1,007	.5
ω(0)	see 2.4.2.1		.6
I_{SFBAT}			2.4.3
ω(0)	2.83(1.86)	1,060	.1
ω(0)(1-B)	0.14(0.05)	1,079	.2
ω(0)/1-δB	0.98/0.86(2.42/13.64)*	991	.3
ω(0)(1-B)/1-δB	0.97/-0.99(1.00/-14.61)	1,059	.4
ω_t	0.28(2.84)*	1,048	.5
ω(4)	3.80(3.73)*	927	.6

Each of the three significant impact models describes an increase in Other FI/Fuel occuring in 1983, coincidental with the Santa Fe BAT program.

Farmington WSNFI/Fuel: The Farmington rate series (see Figure 10) was most parsimoniously modeled as a lag one differencing and first and twelfth lag moving average process.

Model $$(1-B)Y_t = (1-\theta_1 B)(1-\theta_{12}B^{12})a_t. \quad (2.5.0)$$

Parameter	Estimate(t-Ratio)	RSS
θ_1	0.92(28.47)*	540
θ_{12}	0.24(-3.09)*	

Q-value = 10.0, df = 12
Q-value = 27.0, df = 24

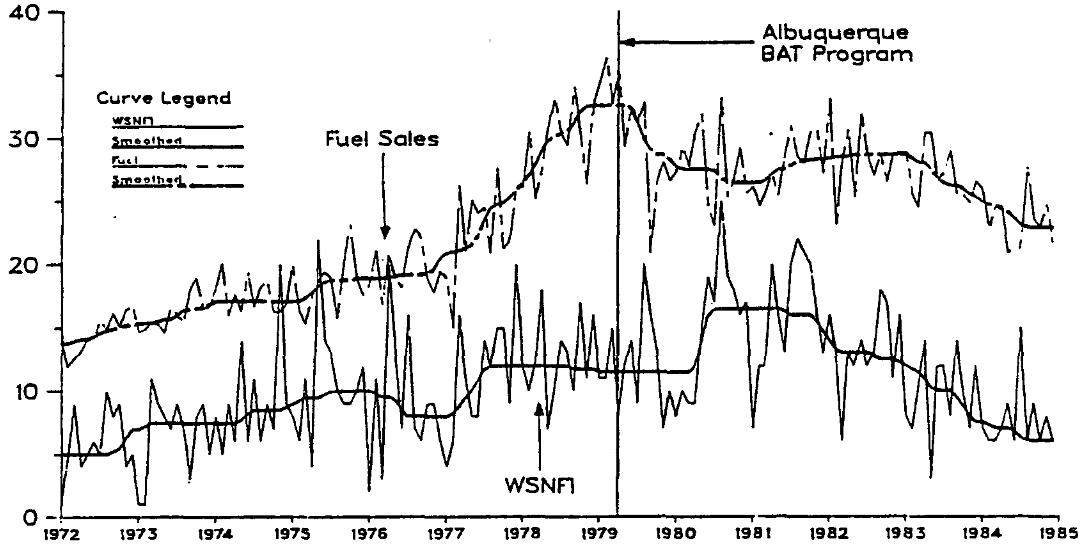
No evidence of coincidental changes were found in the Farmington WSNFI/Fuel series for either the Albuquerque BAT program or increased DWI penalties. The only evidence of statistically significant change in the series was found to be the fourth month of 1983, Model 2.5.3.6. However, the fourth month appears as an extremely low value in the later half of a generated downward trend in the 1980's. It is likely that this single moment of significant change is unrelated to any of the DWI countermeasures considered in this evaluation.

Impact	Estimate(t-Ratio)	RSS	
I_{AlbBAT}			2.5.1
$\omega(0)$	0.02(0.03)	539	.1
$\omega(0)(1-B)$	-2.27(1.25)	537	.2
$\omega(0)/1-\delta B$	0.12/0.89(0.56/4.37)	536	.3
$\omega(0)(1-B)/1-\delta B$	-2.25/-0.03(-1.24/-0.03)	537	.4
ω_t	-0.02(-0.63)	538	.5
$\omega(4)$	1.01(1.21)	527	.6
I_{Pen}			2.5.2
$\omega(0)$	-1.58(-1.49)	588	.1
$\omega(0)(1-B)$	-2.78(-1.55)	533	.2
$\omega(0)/1-\delta B$	-0.14/0.94(-0.62/6.68)	593	.3
$\omega(0)(1-B)/1-\delta B$	-2.92/0.35(-1.65/0.68)	532	.4
ω_t	-0.06(-0.86)	594	.5
$\omega(0)$	see 2.5.2.1	594	.6
I_{SFBAT}			2.5.3
$\omega(0)$	-1.37(-1.27)	590	.1
$\omega(0)(1-B)$	-1.41(-0.78)	540	.2
$\omega(0)/1-\delta B$	-1.57/-0.11(-0.85/-0.08)	515	.3
$\omega(0)(1-B)/1-\delta B$	-1.14/1.02(-1.63/30.91)	518	.4
ω_t	-0.05(-0.59)	596	.5
$\omega(4)$	-1.39(-2.72)*	513	.6

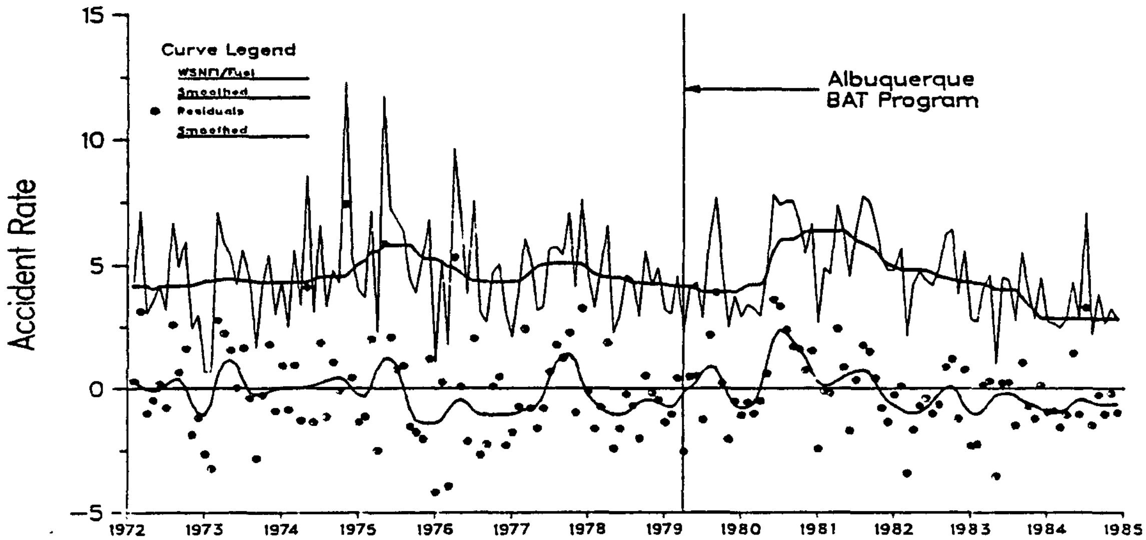
Figure 10.

Farmington Time Series: WSNFI Accidents, Fuel, and WSNFI/Fuel

WSNFI Accidents and Fuel Sales(10^5 Gallons)



WSNFI/Fuel(10^6 Gallons) and Residuals



Note: Smoothers are double median 12 for all but residuals, which are smoothed by a 4253 H procedure. Residuals are from fitting model 2.3.5 (Appendix B).

Las Cruces WSNFI/Fuel: It is interesting to note that many of the urban proxy series are trending upwards up to 1979. The Las Cruces WSNFI/Fuel series is similar to the Farmington series in that the most parsimonious model also required that the N_t component have a first order differencing.

Model $$(1-B)Y_t = (1-\theta_1 B)a_t. \quad (2.6.0)$$

Parameter	Estimate(t-Ratio)	RSS	2.6.0
θ_1	0.90(27.70)*	432	
θ_{12}	-0.18(-2.09)*		

Q-value = 6.7, df = 12
Q-value = 14.0, df = 24

Intervention functions introduced to the base model of Las Cruces WSNFI/Fuel, model 2.6.0, indicated that in Las Cruces about the same time as the Albuquerque BAT program there was an increase in WSNFI/Fuel and that about the same time as the Santa Fe BAT program there was a temporary decrease in WSNFI/Fuel.

Impact	Estimate(t-Ratio)	RSS	
I_{AlbBAT}			2.6.1
$\omega(0)$	1.82(3.77)*	419	.1
$\omega(0)(1-B)$	0.04(0.04)	431	.2
$\omega(0)/1-\delta B$	0.91/0.50(0.94/0.95)	418	.3
$\omega(0)(1-B)/1-\delta B$	-0.23/-0.67(-0.19/-0.30)	431	.4
ω_t	0.01(0.51)	431	.5
$\omega(5)$	1.80(3.89)*	415	.6
I_{Pen}			2.6.2
$\omega(0)$	0.60(0.84)	430	.1
$\omega(0)(1-B)$	0.03(0.02)	431	.2
$\omega(0)/1-\delta B$	0.41/0.35(0.29/0.15)	429	.3
$\omega(0)(1-B)/1-\delta B$	0.81/0.94(0.89/5.65)	429	.4
ω_t	0.00(0.04)	432	.5
$\omega(8)$	-1.01(-1.27)	411	.6
I_{SFBAT}			2.6.3
$\omega(0)$	-1.38(-1.75)	424	.1
$\omega(0)(1-B)$	-2.73(-1.66)	424	.2
$\omega(0)/1-\delta B$	-2.27/-0.67(-1.94/-1.55)	421	.3
$\omega(0)(1-B)/1-\delta B$	-4.29/0.67(-2.95/3.89)*	416	.4
ω_t	0.00(-0.06)	432	.5
$\omega(0)$	see 2.6.3.1		.6

When multiple input models were tried, it was found that the lagged impact model coinciding with the Albuquerque BAT program and the temporary decrease model coinciding with the Santa Fe BAT program were significant (see model 2.6.5).

Model $y_t = I_{AlbBAT}\omega(0) + I_{SFBAT}\omega(0)(1-B)/1-\delta B.$ (2.6.4)

Parameter		Estimate(t-Ratio)	RSS
I_{AlbBAT}	$\omega(0)$	1.88(3.10)*	416
I_{SFBAT}	$\omega(0)$	-1.00(-1.13)	
	δ	-0.73(-1.13)	

Q-value = 6.1, df = 12
Q-value = 15.0, df = 24

Model $y_t = I_{AlbBAT}\omega(5) + I_{SFBAT}\omega(0)(1-B)/1-\delta B.$ (2.6.5)

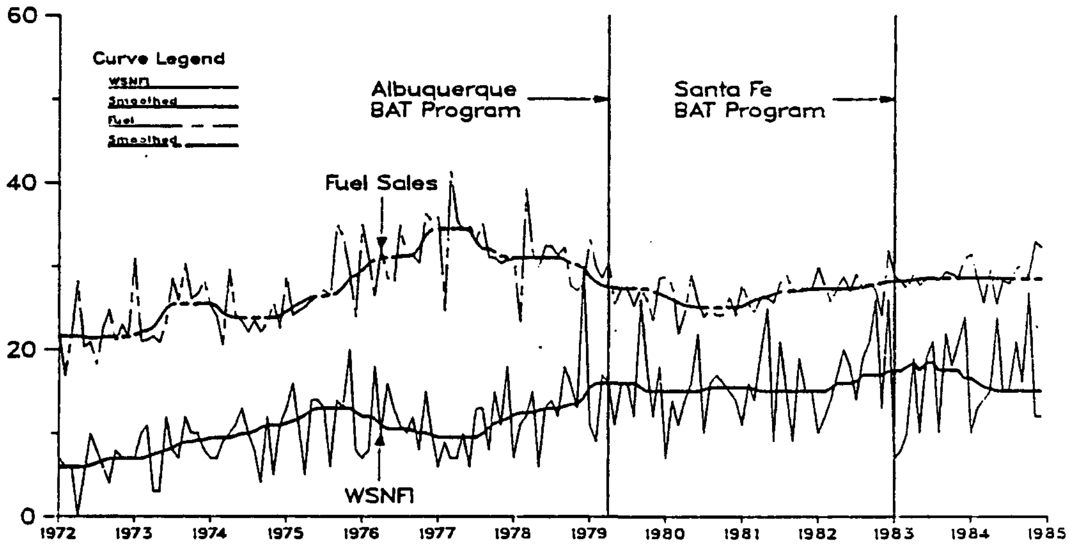
Parameter		Estimate(t-Ratio)	RSS
I_{AlbBAT}	$\omega(5)$	1.85(3.98)*	390
I_{SFBAT}	$\omega(0)$	-4.05(-2.75)*	
	δ	0.64(3.47)*	

Q-value = 8.3, df = 12
Q-value = 18.0, df = 24

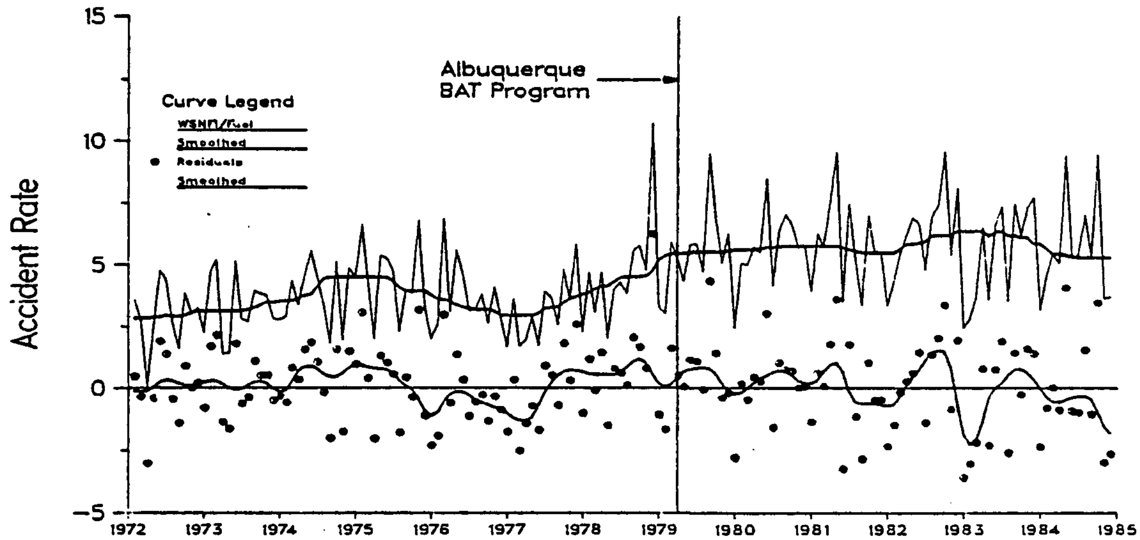
Figure 11.

Las Cruces Time Series: WSNFI Accidents, Fuel, and WSNFI/Fuel

WSNFI Accidents and Fuel Sales(10^5 Gallons)



WSNFI/Fuel(10^6 Gallons) and Residuals



Note: Smoothers are double median 12 for all but residuals, which are smoothed by a 4253 H procedure. Residuals are from fitting model 2.5.1.1 (Appendix B).

New Mexico WSNFI/Fuel: The New Mexico rate series was stabilized with a first and seasonal differencing and moving average process.

Model $$(1-B)(1-B^{12})Y_t = (1-\theta_1 B)(1-\theta_{12})B^{12}a_t. \qquad (2.7.0)$$

Parameter	Estimate(t-Ratio)	RSS
θ_1	0.82(16.19)*	39
θ_{12}	0.84(27.19)*	

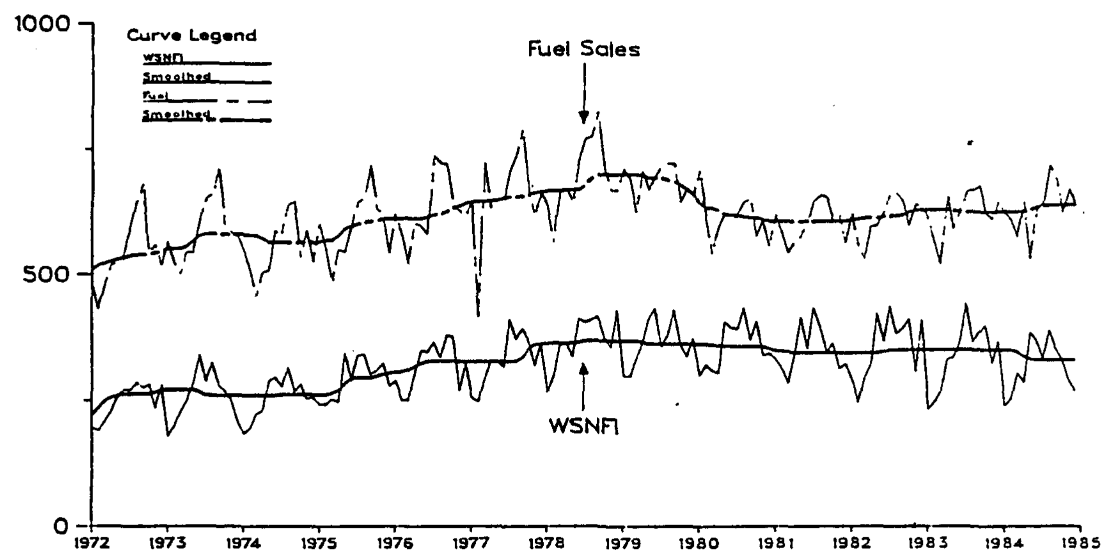
Q-value = 15.0, df = 12
Q-value = 31.0, df = 24

Impact	Estimate(t-Ratio)	RSS	
I_{AlbBAT}			2.7.1
ω(0)	0.10(0.33)	39	.1
ω(0)(1-B)	-0.06(-0.11)	39	.2
ω(0)/1-δB	0.19/-0.77(0.47/-0.74)	39	.3
ω(0)(1-B)/1-δB	-0.02/1.11(-0.75/77.02)	36	.4
ω_t	-0.02(-0.96)	39	.5
ω(3)	-0.05(-0.16)	39	.6
I_{Pen}			2.7.2
ω(0)	0.22(0.71)	39	.1
ω(0)(1-B)	0.08(0.15)	39	.2
ω(0)/1-δB	0.19/0.21(0.39/0.10)	39	.3
ω(0)(1-B)/1-δB	0.40/0.94(1.19/5.68)	39	.4
ω_t	-0.04(-3.70)*	38	.5
ω(10)	-0.67(-2.34)*	37	.6
I_{SFBAT}			2.7.3
ω(0)	-0.67(-2.41)*	38	.1
ω(0)(1-B)	-0.71(-1.41)	39	.2
ω(0)/1-δB	-0.88/-0.34(-1.94/-0.56)	38	.3
ω(0)(1-B)/1-δB	-0.23/1.09(-1.61/45.29)	36	.4
ω_t	-0.05(-3.26)*	38	.5
ω(12)	-0.68(-2.57)*	36	.6

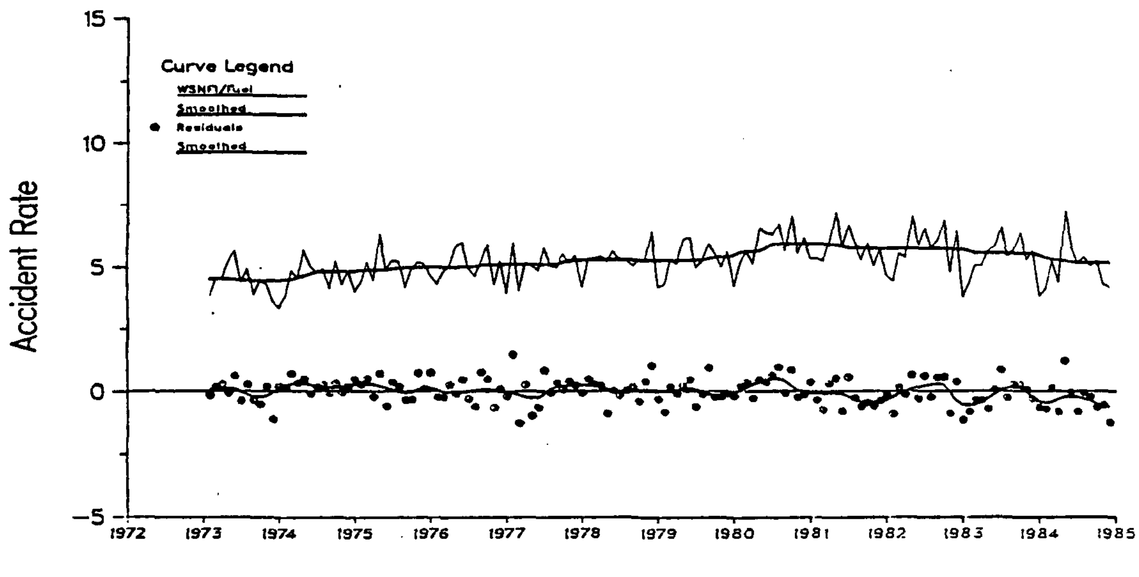
Figure 12.

New Mexico Time Series: WSNFI Accidents, Fuel, and WSNFI/Fuel

WSNFI Accidents and Fuel Sales(10^5 Gallons)



WSNFI/Fuel(10^6 Gallons) and Residuals



Note: Smoothers are double median 12 for all but residuals, which are smoothed by a 4253 H procedure. Residuals are from fitting model 2.6.0 (Appendix B).

The detected impacts associated with the intervention effects of increased penalties and the Santa Fe BAT program occur during an apparent general decline in the rate in the 1980's (see figure 12, page B-17). This is somewhat verified when the single impacts are investigated as multiple imput models, 2.7.4 through 2.7.6. Note that of the combinations of various impact models only three of the six are displayed. The multiple input models not shown were unestimatable because of high correlations among parameter estimates.

Model $$y_t = I_{Pen}\omega_t + I_{SFBAT}\omega(0). \qquad (2.7.4)$$

Parameter	Estimate(t-Ratio)	RSS
I_{Pen} ω_t	-0.03(-1.68)	38
I_{SFBAT} $\omega(0)$	-0.34(-1.06)	

Q-value = 13.0, df = 12
Q-value = 31.0, df = 24

Model $$y_t = I_{Pen}\omega_t + I_{SFBAT}\omega_t. \qquad (2.7.5)$$

Parameter	Estimate(t-Ratio)	RSS
I_{Pen} ω_t	-0.02(-0.85)	38
I_{SFBAT} ω_t	-0.03(-0.80)	

Q-value = 14.0, df = 12
Q-value = 30.0, df = 24

Model $$y_t = I_{Pen}\omega(10) + I_{SFBAT}\omega_t. \qquad (2.7.6)$$

Parameter	Estimate(t-Ratio)	RSS
I_{Pen} $\omega(10)$	-0.42(-1.50)	36
I_{SFBAT} ω_t	-0.04(-2.13)*	

Q-value = 10.0, df = 12
Q-yalue = 28.0, df = 24

Other Urban WSNFI/Fuel: The other urban series is the aggregate of all New Mexico municipalities not already used and with populations greater than 5,000 people. The series required first order differencing and a first and seasonal moving average process.

Model $$(1-B)Y_t = (1-\theta_1 B)(1-\theta_{12} B^{12})a_t. \quad (2.8.0)$$

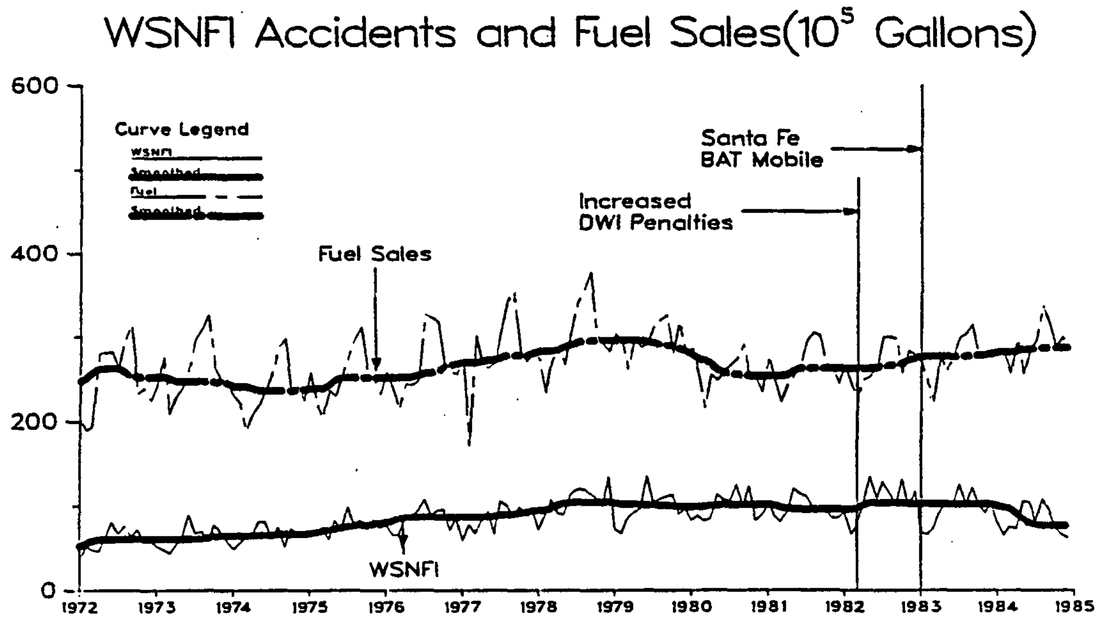
Parameter	Estimate(t-Ratio)	RSS
θ_1	0.86(20.07)*	50
θ_{12}	-0.31(-4.00)*	

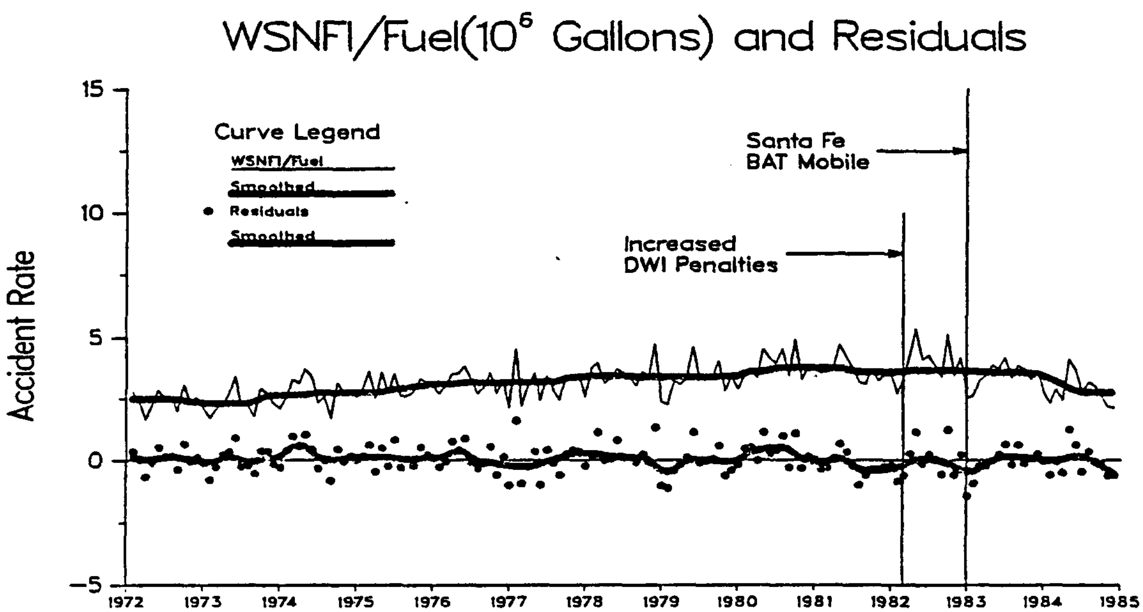
Q-value = 8.5, df = 12
Q-value = 26.0, df = 24

Impact	Estimate(t-Ratio)	RSS	
I_{AlbBAT}			2.8.1
$\omega(0)$	0.14(0.47)	50	.1
$\omega(0)(1-B)$	-0.19(0.37)	50	.2
$\omega(0)/1-\delta B$	0.34/-0.95(0.96/-11.75)	50	.3
$\omega(0)(1-B)/1-\delta B$	0.14/0.99(0.47/7.38)	50	.4
ω_t	-0.01(-0.69)	50	.5
$\omega(2)$	0.28(0.97)	49	.6
I_{Pen}			2.8.2
$\omega(0)$	0.62(2.15)*	49	.1
$\omega(0)(1-B)$	-0.26(-0.05)	50	.2
$\omega(0)/1-\delta B$	0.48/0.33(1.01/0.50)	48	.3
$\omega(0)(1-B)/1-\delta B$	0.82/0.94(2.63/13.91)*	48	.4
ω_t	-0.03(-2.06)*	49	.5
$\omega(3)$	0.09(0.30)	49	.6
I_{SFBAT}			2.8.3
$\omega(0)$	-0.62(-2.15)*	48	.1
$\omega(0)(1-B)$	-0.92(-1.73)	49	.2
$\omega(0)/1-\delta B$	-0.01/1.10(-0.82/13.33)	48	.3
$\omega(0)(1-B)/1-\delta B$	-1.01/0.54(-1.97/1.57)	49	.4
ω_t	-0.05(-2.83)*	48	.5
$\omega(0)$	see 2.8.3.1		.6

Figure 13.

Other Urban Time Series: WSNFI Accidents, Fuel, and WSNFI/Fuel





Note: Smoothers are double median 12 for all but residuals, which are smoothed by a 4253 H procedure. Residuals are from fitting model 2.7.5 (Appendix B).

Model $y_t = I_{Pen}\omega(0) + I_{SFBAT}\omega(0).$ (2.8.4)

Parameter		Estimate(t-Ratio)	RSS
I_{Pen}	$\omega(0)$	0.55(1.94)	47
I_{SFBAT}	$\omega(0)$	-0.63(-2.31)*	

Q-value = 7.0, df = 12
Q-value = 25.0, df = 24

Model $y_t = I_{Pen}\omega(0) + I_{SFBAT}\omega_t.$ (2.8.5)

Parameter		Estimate(t-Ratio)	RSS
I_{Pen}	$\omega(0)$	0.39(2.00)*	20
I_{SFBAT}	ω_t	-0.06(-4.48)*	

Q-value = 12.0, df = 12
Q-value = 22.0, df = 24

Model $y_t = I_{Pen}\omega(0)/1-\delta B + I_{SFBAT}\omega(0)$ (2.8.6)

Parameter		Estimate(t-Ratio)	RSS
I_{Pen}	$\omega(0)$	0.65(2.03)*	47
	δ	0.97(12.67)*	
I_{SFBAT}	$\omega(0)$	-0.51(-1.20)	

Q-value = 7.0, df = 12
Q-value = 26.0, df = 24

Model $y_t = I_{Pen}\omega(0)/1-\delta B + I_{SFBAT}\omega_t$. (2.8.7)

Parameter		Estimate(t-Ratio)	RSS
I_{Pen}	$\omega(0)$	0.60(1.69)	39
	δ	-1.02(11.29)	
I_{SFBAT}	ω_t	-1.64(-2.46)*	

Q-value = 5.9, df = 12
Q-value = 21.0, df = 12

Model $y_t = I_{Pen}\omega_t + I_{SFBAT}\omega(0)$. (2.8.8)

Parameter		Estimate(t-Ratio)	RSS
I_{Pen}	ω_t	-0.02(-0.87)	48
I_{SFBAT}	$\omega(0)$	-0.45(-1.35)	

Q-value = 8.5, df = 12
Q-value = 29.0, df = 24

Model $y_t = I_{Pen}\omega_t + I_{SFBAT}\omega_t$. (2.8.9)

Parameter		Estimate(t-Ratio)	RSS
I_{Pen}	ω_t	0.02(0.58)	48
I_{SFBAT}	ω_t	-0.07(-1.80)	

Q-value = 11.0, df = 12
Q-value = 29.0, df = 24

An interpretation of the multiple input models (2.8.4 - .9) is that there was an increase in 1982 and a decreasing trend from 1983 through 1984 in Other Urban WSNFI/Fuel. The least ambiguous and statistically adequate model describing these events, which coincide with increased DWI penalties and the Santa Fe BAT program, is model 2.8.5.

Rural WSNFI/Fuel: The Rural rate series is composed of those crashes reported on all the rural roads. The uninterrupted series was modeled as a first and seasonal differencing and moving average process.

Model $$(1-B)(1-B^{12})Y_t = (1-\theta_1 B)(1-\theta_{12}B^{12})a_t. \quad (2.9.0)$$

Parameter	Estimate(t-Ratio)	RSS
θ_1	0.79(17.90)*	250
θ_{12}	0.86(33.04)*	

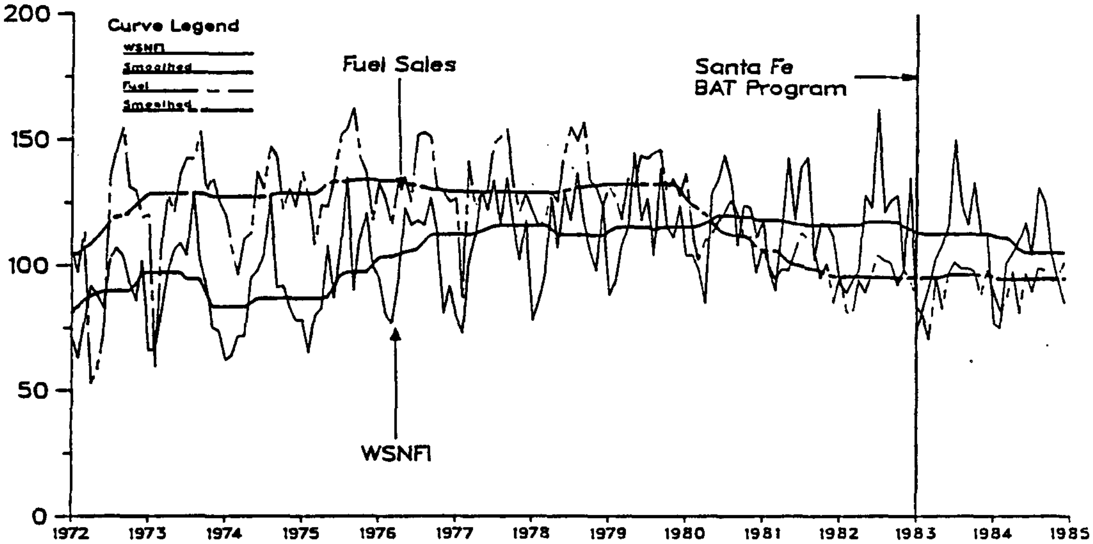
Q-value = 11.0, df = 12
Q-value = 25.0, df = 24

Impact	Estimate(t-Ratio)	RSS	
I_{AlbBAT}			2.9.1
$\omega(0)$	-0.15(-0.19)	250	.1
$\omega(0)(1-B)$	-0.19(-0.16)	229	.2
$\omega(0)/1-\delta B$	-0.53/-1.01(-1.15/-83.81)	244	.3
$\omega(0)(1-B)/1-\delta B$	-0.00/1.13(-0.09/8.70)	520	.4
ω_t	0.04(0.87)	250	.5
$\omega(2)$	-0.43(-0.53)	232	.6
I_{Pen}			2.9.2
$\omega(0)$	0.20(0.24)	250	.1
$\omega(0)(1-B)$	0.05(0.04)	229	.2
$\omega(0)/1-\delta B$	0.05/-1.18(-0.33/-126.04)	240	.3
$\omega(0)(1-B)/1-\delta B$	0.00/-1.164(0.00/-136.79)	220	.4
ω_t	-0.09(-1.57)	245	.5
$\omega(2)$	1.08(1.31)	228	.6
I_{SFBAT}			2.9.3
$\omega(0)$	-1.05(-1.29)	248	.1
$\omega(0)(1-B)$	-1.80(-1.51)	225	.2
$\omega(0)/1-\delta B$	-0.04/1.15(-0.19/28.52)	230	.3
$\omega(0)(1-B)/1-\delta B$	-0.83/1.17(-1.15/314.35)	209	.4
ω_t	-0.13(-2.09)*	241	.5
$\omega(0)$	see 2.9.3.1		.6

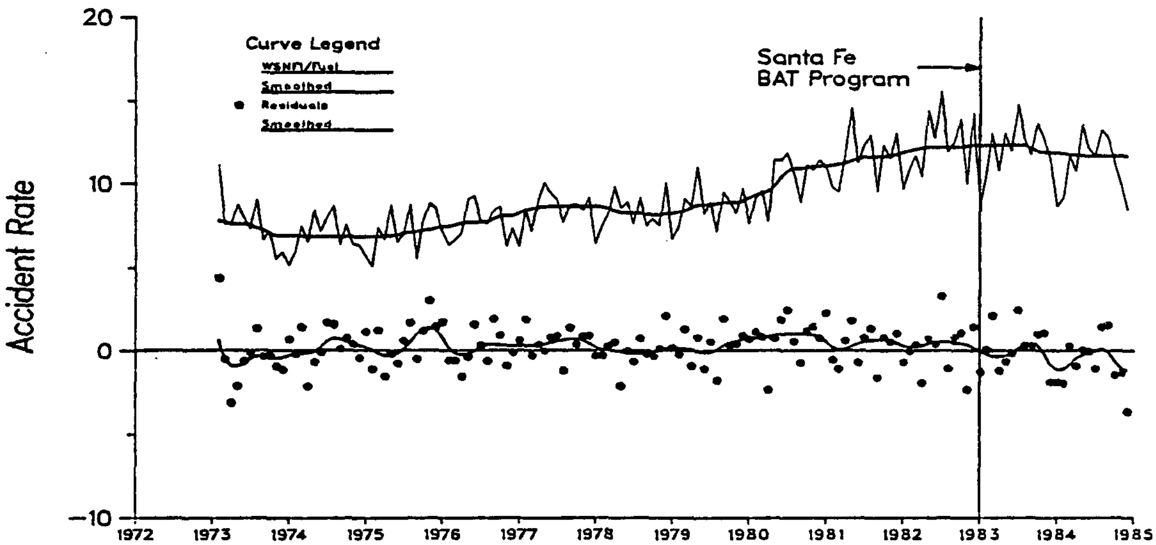
Figure 14.

Rural New Mexico Time Series: WSNFI Accidents, Fuel, and WSNFI/Fuel

WSNFI Accidents and Fuel Sales(10^5 Gallons)



WSNFI/Fuel(10^6 Gallons) and Residuals



Note: Smoothers are double median 12 for all but residuals, which are smoothed by a 4253 H procedure. Residuals are from fitting model 2.8.3.5 (Appendix B).

Santa Fe WSNFI: The series of Santa Fe WSNFI is displayed in Figure 8, page 42. The series is parsimoniously modeled with a first order differencing and first and seasonal moving average parameters:

Model $(1-B)Y_t = (1-\theta_1 B)(1-\theta_{12} B^{12})a_t$. (2.10.0)

Parameter	Estimate(t-Ratio)	RSS
θ_1	0.88(24.40)*	3,003
θ_{12}	-0.20(-2.55)*	

Q-value = 12.0, df = 12
Q-value = 20.0, df = 24

Although visually there seems to be a decline in WSNFI after 1983, the start up of the Santa Fe BAT program, the only analytically significant change is a temporary, one month, reduction in WSNFI, model 2.10.3.2.

Parameter	Estimate(t-Ratio)	RSS	
I_{AlbBAT}			2.10.1
ω(0)	-3.61(-1.78)	2,942	.1
ω(0)(1-B)	-1.62(-.039)	2,940	.2
ω(0)/1-δB	-3.511/-0.03(-0.82/0.03)	2,941	.3
ω(0)(1-B)(1-δB)	1.88/-0.79(0.60/-1.59)	2,933	.4
ω_t	-0.07(-0.89)	2,988	.5
ω(3)	-3.58(-1.77)	2,862	.6
I_{Pen}			2.10.2
ω(0)	1.85(0.81)	2,990	.1
ω(0)(1-B)	-1.75(0.41)	2,940	.2
ω(0)/1-δB	-0.07/-1.182(-0.12/-37.7)	3,002	.3
ω(0)(1-B)/1-δB	1.88/-0.78(0.53/-1.17)	2,932	.4
ω_t	-0.01(-0.68)	2,994	.5
ω(2)	2.51(1.11)	2,913	.6
I_{SFBAT}			2.10.3
ω(0)	-3.22(-1.50)	2,958	.1
ω(0)(1-B)	-11.61(-2.84)*	2,795	.2
ω(0)/1-δB	-5.30/-0.44(-1.58/-0.63)	2,938	.3
ω(0)(1-B)/1-δB	-12.33/0.22(-3.02/0.70)	2,775	.4
ω_t	-0.08(-0.56)	2,997	.5
ω(2)	1.56(0.68)	2,928	.6

Santa Fe WSNFI/Fuel: The Santa Fe rate series is a curiosity in many ways. To begin with, the series is the only one that does not have an identifiable seasonal component. The series is a simple first order moving average process after a first order differencing.

Model $$(1-B)Y_t = (1-\theta_1 B)a_t. \qquad (2.11.0)$$

Parameter	Estimate(t-Ratio)	RSS
θ_1	0.90(26.88)*	408

Q-value = 9.2, df = 12
Q-value = 14.0, df = 24

Again, as in model 2.10.3.2, there is a significant one month reduction in WSNFI/Fuel, model 2.11.3.2. Although not significant, the model of a permanent reducton, model 2.11.3.1, may represent an impact.

Impact	Estimate(t-Ratio)	RSS	
I_{AlbBAT}			2.11.1
$\omega(0)$	-1.16(-1.65)	401	.1
$\omega(0)(1-B)$	-1.23(-0.78)	400	.2
$\omega(0)/1-\delta B$	-1.38/-0.20(-0.88/-0.15)	400	.3
$\omega(0)(1-B)/1-\delta B$	-1.58/0.86(-1.38/4.57)	395	.4
ω_t	-0.03(-1.74)	402	.5
$\omega(3)$	-0.93(-1.35)	393	.6
I_{Pen}			2.11.2
$\omega(0)$	-0.16(-0.21)	407	.1
$\omega(0)(1-B)$	0.89(0.56)	400	.2
$\omega(0)/1-\delta B$	0.71/-0.86(0.60/-1.77)	407	.3
$\omega(0)(1-B)/1-\delta B$	1.41/0.72(1.07/1.99)	398	.4
ω_t	-0.04(-1.09)	405	.5
$\omega(10)$	-1.18(-1.76)	354	.6
I_{SFBAT}			2.11.3
$\omega(0)$	-1.17(-1.81)	400	.1
$\omega(0)(1-B)$	-4.07(-2.62)*	384	.2
$\omega(0)/1-\delta B$	-1.83/-0.45(-1.56/-0.58)	398	.3
$\omega(0)(1-B)/1-\delta B$	-4.20/0.18(-2.71/0.52)	382	.4
ω_t	-0.03(-0.66)	406	.5
$\omega(0)$	see 2.11.3.1		.6

Santa Fe Other FI:

Model $(1-B)y_t = (1-\theta_1 B)(1-\theta_{12} B^{12})a_t.$ (2.12.0)

Parameter	Estimate(t-Ratio)	RSS
θ_1	0.72(13.02)*	15,853
θ_{12}	-0.20(-2.54)*	

Q-value = 8.8, df = 12
Q-value = 24.0, df = 24

Impact	Estimate(t-Ratio)	RSS	
I_{AlbBAT}			2.12.1
$\omega(0)$	2.28(0.32)	15,842	.1
$\omega(0)(1-B)$	-3.53(-0.38)	15,758	.2
$\omega(0)/1-\delta B$	9.60/-0.95(1.46/-19.36)	15,536	.3
$\omega(0)(1-B)/1-\delta B$	0.32/1.06(0.16/15.30)	15,678	.4
ω_t	-0.04(-0.09)	15,852	.5
$\omega(2)$	16.36(2.19)*	15,269	.6
I_{Pen}			2.12.2
$\omega(0)$	-12.63(-1.78)	15,539	.1
$\omega(0)(1-B)$	-26.76(-2.97)*	14,901	.2
$\omega(0)/1-\delta B$	0.45/1.02(0.52/12.61)	15,721	.3
$\omega(0)(1-B)/1-\delta B$	-28.64/0.35(-3.16/1.23)	14,781	.4
ω_t	0.63(1.13)	15,728	.5
$\omega(0)$	see 2.12.2.2		.6
I_{SFBAT}			2.12.3
$\omega(0)$	0.32(0.05)	15,853	.1
$\omega(0)(1-B)$	-5.86(0.63)	15,731	.2
$\omega(0)/1-\delta B$	1.14/0.97(0.77/8.99)	15,692	.3
$\omega(0)(1-B)/1-\delta B$	2.87/-0.99(0.80/-10.88)	15,614	.4
ω_t	0.83(1.26)	15,698	.5
$\omega(4)$	10.75(1.54)	15,477	.6

A test of a multiple input model of a lagged increase in Santa Fe Other FI two months following the onset date of the Albuquerque BAT program and a one month temporary reduction occurring at the onset date for increased DWI penalties further verifies detection of each event.

Model $$y_t = I_{AlbBAT}\omega(2) + I_{Pen}\omega(0)(1-B).$$ (2.12.4)

Parameter		Estimate(t-Ratio)	RSS
I_{AlbBAT}	$\omega(2)$	16.84(2.28)*	14,405
I_{Pen}	$\omega(0)$	-26.77(-3.03)*	

Q-value = 8.2, df = 12
Q-value = 20.0, df = 24

Santa Fe Other FI/Fuel: The other FI/Fuel series was parsimoniously modeled by first differencing at order one and then the inclusion of first and seasonal moving average process:

Model $$(1-B)Y_t = (1-\theta_1 B)(1-\theta_{12} B^{12})a_t.$$ (2.13.0)

Parameter	Estimate(t-Ratio)	RSS
θ_1	0.78(15.72)	2,340
θ_{12}	-0.21(-2.47)	

Q-value = 7.4, df = 12
Q-value = 14.0, df = 24

Impact	Estimate(t-Ratio)	RSS	
I_{AlbBAT}			2.13.1
ω(0)	-0.51(-0.21)	2,339	.1
ω(0)(1-B)	-3.02(-0.83)	2,327	.2
ω(0)/1-δB	-0.32/0.95(-0.71/10.39)	2,326	.3
ω(0)(1-B)/1-δB	-4.27/0.39(-1.18/0.52)	2,316	.4
ω_t	-0.01(-0.05)	2,340	.5
ω(2)	4.08(1.60)	2,299	.6
I_{Pen}			2.13.2
ω(0)	-3.88(-1.59)	2,302	.1
ω(0)(1-B)	-6.98(-1.94)	2,281	.2
ω(0)/1-δB	0.07/1.07(0.46/13.09)	2,299	.3
ω(0)(1-B)/1-δB	-7.80/0.53(-2.23/1.62)	2,257	.4
ω_t	0.22(1.30)	2,315	.5
ω(4)	-0.07(-0.03)	2,332	.6
I_{SFBAT}			2.13.3
ω(0)	0.18(0.07)	2,411	.1
ω(0)(1-B)	-2.61(-0.71)	2,400	.2
ω(0)/1-δB	0.29/1.03(0.95/14.70)	2,344	.3
ω(0)(1-B)/1-δB	-2.78/0.32(-0.75/0.27)	2,399	.4
ω_t	0.42(2.21)*	2,347	.5
ω(5)	-1.43(0.57)	2,324	.6

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