

Institute of Transportation Studies
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Safety and Other Impacts of Vehicle Impound Enforcement

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PREFACE

This study was conducted by a team of researchers at the Institute of Transportation Studies, University of California at Berkeley, with funding from the California Office of Traffic Safety. Ted Chira-Chavala directed the study, coordinated the write-up of the final report, and wrote many chapters. Douglas Cooper was the key researcher, who performed the literature review, worked with key personnel of Upland Police Department to acquire essential data for the evaluation, analyzed the data, and contributed significantly to all chapters. David Gillen performed all time-series analyses and contributed very significantly to chapters four and five.

This study would not have been possible without the tireless assistance from Captain John Cannon of Upland's Police Department. He provided traffic citation, crash, personnel, and financial data essential for the evaluation. His cooperation is gratefully acknowledged.

Finally, the findings and opinions expressed in this report are solely those of the authors, and do not necessarily reflect or represent opinions of the sponsor or Upland Police Department.

EXECUTIVE SUMMARY

California Vehicle Impound Law

California vehicle impound law took affect on January 1, 1995. The law allows a police officer to seize a vehicle operated by a person whose license is suspended or revoked or who has never been issued a license. The seized vehicle shall then be impounded for 30 days. In California, a driver must be stopped for some other infraction before his/her license can be checked.

The City of Upland, located in western San Bernardino County, has a population of 67,453 residing in a 15.2 square-mile area. The city's 169 miles of roadways support about 600,000 vehicle-miles of travel daily. Upland Police Department implemented a vehicle impound program in January 1995 as part of its overall traffic enforcement. The number of impounded vehicles in Upland grew significantly from about 20 per month initially to about 130 per month at its peak.

Evaluation Objective

The purpose of this evaluation is to assess the impact of Upland's vehicle impound program on traffic safety (crashes and on-the-road behavior) and police department resources and operations.

Methodology for Evaluating Safety Impact

Traffic safety is generally measured by road-user behavior and frequencies of traffic crashes. Econometric models incorporating times-series analysis were used to evaluate the safety impacts of Upland's impound program. This analysis method has the advantage of being able to simultaneously account for the influences on safety of various important confounding and external factors such as:

- o A variety of other traffic enforcement activities such as speeding enforcement, DUI enforcement, seatbelt use compliance, and traffic checkpoints.
- o Changes in the levels of various enforcement activities and the number of traffic officers over time.
- o Inherent monthly and seasonal fluctuations in crashes and on-the-road behavior.

Behavioral outcomes examined in this evaluation include the amount of driving by drivers with suspended/revoked or no licenses, prevalence of DUI and other hazardous driving behavior, and criminal activity. Crash outcomes examined include fatal and injury crashes, hit-and-run crashes, and speeding related crashes.

Methodology for Evaluating Impact on Police Department

There are a number of areas that can be affected by implementation of a vehicle impound program including departmental organization, personnel requirements, levels of other traffic enforcement activities, infrastructure requirements, expenditures and revenues, and perceptions and morale of police department personnel. The evaluation of the changes brought about by the full implementation of the impound program was accomplished by comparing the pre and post implementation status of each area.

Data Sources

Traffic citation and crash data in Upland was provided by Upland Police Department. Crash data from the California's Statewide Integrated Traffic Reporting System (SWITRS) was used to supplement the Upland's data as necessary. Most data were available on a monthly basis, from January 1994 through June 1999.

Principal Findings

1. Upland's vehicle impound program appears to be beneficial in reducing the amount of driving by disqualified drivers. This benefit occurred no later than early 1998.

2. The continuous and long-term nature of Upland's vehicle impound program appears to be beneficial in reducing DUI offenses. However, it does not appear to have any significant effects on other behavior such as speeding, misdemeanor crimes, or felony crimes, which appear to be more responsive to overall police enforcement efforts.

3. The continuous and long-term nature of Upland's vehicle impound program appears to be beneficial in reducing fatal plus injury, hit-and-run, and speeding related crashes.

4. A caveat concerning the above mentioned benefits of Upland's vehicle impound program on crashes and DUI offense is in order:

- o These benefits appear to be slight.
- o If the vehicle impound enforcement had been put in place and then removed after only a few months, it is conceivable that these benefits might not have occurred. In other words, cities may not necessarily observe immediate or short term benefits from enforcing the vehicle impound law.
- o Upland's vehicle impound program was not implemented in isolation. Other traffic enforcement activities (e.g., DUI enforcement, traffic checkpoints, crime patrols, etc.) were also maintained at relatively high levels. There were considerable positive synergies among all of the enforcement activities that culminated in reductions in traffic crashes and some

risky on-the-road behavior. This implies that vehicle impound enforcement should be conducted in addition to (but not in place of) other police enforcement activities.

- o The current proportion of Upland's total police enforcement efforts dedicated to the vehicle impound program might be just about right as far as traffic safety benefits are concerned.

5. Upland's vehicle impound program called for addition manpower and new duties for some police personnel. For example, an additional clerk of Records Unit was needed for paper work and public relations in connection with the impound program. Officers in Uniform Patrol and Traffic Safety units spent approximately 1,700 person-hours per year in vehicle impound enforcement. The police lieutenant from the Records Unit spent considerable time in tow hearings and sales of unclaimed vehicles. These added activities took these police officers away from other duties. Nevertheless, the vehicle impound program did not significantly affect the levels of other police enforcement in Upland, thanks to the resource management capability of the police department.

6. Upland's vehicle impound program is financially self-supporting with revenues in excess of operating costs.

Conclusion

Results from this evaluation suggest that California vehicle impound law can help to enhance traffic safety. However, more evaluations concerning the safety impact of the enforcement of this law in several other cities are needed in order to derive more reliable estimates of the law's safety benefits. In addition, studies are also needed to determine the potential hardship on drivers whose vehicles are impounded and to understand the adjustments made by these drivers while their vehicles are impounded.

In light of the fact that Upland's vehicle impound program yielded safety benefits to the city and has been financially self-supporting, it may be used as a model for planning and implementing vehicle impoundment in other locales.

CHAPTER ONE: INTRODUCTION

The National Highway Traffic safety Administration (1989) reported that about 11% of all drivers involved in fatal crashes nationwide had invalid licenses. There has been ample evidence that license suspensions and revocations per se do not necessarily prevent disqualified drivers from driving, and that many people drive even though they have not been licensed (e.g., DeYoung et al. 1997, TRB 1995). Strategies to discourage disqualified drivers from driving have ranged from fines and imprisonment, to vehicle sanctions. Imprisonment of individuals driving without proper licenses has never been consistently implemented as few judges are willing to impose such severe penalties on offenders who do not cause harm to someone else. Further, the rate of imprisonment would have to be very high for a demonstrable reduction in traffic fatalities. In Minnesota, for example, in order to prevent 36 traffic fatalities, 36,000 offenders would have to be jailed for a period of at least four years, the cost of which would be prohibitive (TRB 1995).

Vehicle sanctions involve removing a vehicle from potential use by a disqualified driver. One vehicle sanction strategy involves confiscating and permanently retaining vehicles driven by disqualified drivers. However, states implementing such sanctions have often found that the law is likely to be under-enforced. Further, such laws often have undesirable financial consequences because the costs associated with vehicle towing, storing, and sale often exceed the revenue. Another form of vehicle sanction is vehicle impoundment, which involves a temporary removal of the vehicle driven by a disqualified driver for a specified period of time. The vehicle can be reclaimed by the owner after the specified time period and the owner pays all fees associated with the impoundment. This is a simpler law to administer by cities than the permanent vehicle retention option.

Vehicle Impound Law in California

California's vehicle impound law took effect on January 1, 1995 (Section 14602.6 of the California Vehicle Code), and is highlighted here. A police officer may cite a person driving a vehicle while his/her license is suspended or revoked or who has never been issued a license, and may seize the vehicle, which shall then be impounded for 30 days. The impounding agency must send a notice to the legal owner (who may or may not be the registered owner) of the vehicle within two working days of impoundment, informing the owner that the vehicle has been impounded. If the legal owner isn't notified within this time period the impounding agency is prohibited from charging for more than 15 days' impoundment when the legal owner redeems the impounded vehicle.

The registered and legal owner of a vehicle that has been impounded must be provided

with the opportunity for a hearing to determine the validity of the impoundment and/or to consider any mitigating circumstances. If it turns out that the vehicle should not have been towed or if the hearing officer feels that circumstances warrant, the vehicle can be released before 30 days.

There are a number of circumstances under which a vehicle may be released early including if the vehicle was stolen, if the legal owner is a financial institution, if the legal owner is another individual not the registered owner, or if the legal owner is a rental car agency . In order to be released, all towing and storage fees related to the seizure of the vehicle must be paid. If a legal owner obtains an early release of the vehicle, he may not release the vehicle to the registered owner of the vehicle until after the termination of the 30-day impoundment period and then only if the registered owner has a valid driver's license or valid temporary driver's license. The legal owner must make every reasonable effort to ensure that the license presented is valid.

If a vehicle has been impounded and held for 30 days, it cannot be released except upon presentation of the registered owner's or agent's currently valid driver's license to operate the vehicle and proof of current vehicle registration, or upon order of a court. Additionally, the registered owner is responsible for all towing and storage charges related to the impoundment as well as any authorized administrative charges . The California law fully intends for cities to recover reasonable costs associated with towing or storing impounded vehicles.

Enforcement of California vehicle impound law has varied considerably from city to city, and the impacts of such enforcement by individual cities on traffic safety and the city's resources have not been well documented.

This report describes the impact of Upland's vehicle impound program, including its effect on traffic safety and on the police department.

Evaluation Objective

The City of Upland has a very active program in impounding vehicles as part of its overall traffic enforcement. This evaluation seeks to assess the impact of Upland's vehicle impound program on traffic safety, including on-the-road behavior and crash experience as well as on police department operations and resources.

City of Upland and Its Traffic Enforcement

The City of Upland is located in the west end of San Bernardino County, approximately 35 miles east of Los Angeles and eight miles north of Ontario International Airport. The city has a population of 67,453 which resides in an area of 15.2 square miles. Due to Upland's location there is a great deal of transient traffic to and from the Los Angeles and Orange County metropolitan areas. The city has 169 maintained miles of roadway which support an estimated

590,600 daily vehicle miles of travel.

Upland Police Department

The Upland Police Department has 90 sworn police officers who, for traffic enforcement purposes, can be divided into two groups:

Traffic (or Motorcycle) Officers Of the 90 police officers, five are assigned to the traffic division, whose primary duty is traffic enforcement. Prior to April 1998, the traffic division had four officer. The addition of the fifth officer has been made possible by funding from the California Office of Traffic Safety (OTS). About 60% of traffic officers' time is spent on motorcycle patrol, and the other 40% on administrative duties (including crash reporting). Statistics kept by Upland's Police Department indicate motorcycle officers write about 42% of all moving violation citations and account for about 27% of impounded vehicles.

Patrol Officers Most of the city's police force are patrol officers, who do patrolling in cars. These officers only do traffic patrol as time permits (i.e., when they have no other duties). Thus, each patrol officer usually spends less than 10% of their time on traffic enforcement.

Vehicle Impound Program in Upland

Because driving without a valid license is a secondary enforcement law in California (i.e., a driver must be stopped for some other infraction before a license can be checked) the effect of the impound program has not changed the way traffic officers go about their duties - they still look for the same violations of the vehicle code such as speeding and hazardous driving. There is also little change in the number of stopped drivers who have their license status checked since it has always been the practice of officers to run such checks on stopped drivers. The primary change brought about by the impound program is that any police officer, having determined that a vehicle is eligible for impound, must then wait for the tow truck and accompany it back to the department's impound lot. After this, the officer turns in paperwork for that case at the station and returns to the field. The extra time spent in towing an impounded vehicle is about 45 minutes (one hour total less the 15 minutes it normally takes to cite and release a driver for, say, speeding). Overall, Upland's vehicle impound enforcement requires more than 1,700 person-hours of police patrol and traffic officers' time per year.

Tow hearings are conducted Monday through Thursday by a lieutenant to determine whether a driver was driving while suspended or unlicensed, and whether the registered owner knew or should have known about the driver's disqualification. The vehicle may be returned before 30 days if the owner was unaware that the driver was not properly licensed. About 40 tow hearings are conducted each month, and as many as eight tow hearings per day are scheduled. The tow-hearing fee of \$30 must be paid before a hearing takes place.

Table 1.1 shows a timeline associated with the vehicle impound program in Upland.

Table 1.1: Vehicle Impound Activity Timeline

Date	Activity
1/1/95	Vehicle Impound law goes into effect
2/24/95	DUI (nighttime) Checkpoint
3/1/95	Upland begins to impound cars
5/25/95	DUI (nighttime) Checkpoint
10/6/95	DUI (nighttime) Checkpoint
1/24/96	DL (driver license daytime) Checkpoint
4/19/96	DL (daytime) Checkpoint
7/25/96	DL (daytime) Checkpoint
9/25/96	DL (daytime) Checkpoint
12/20/96	DUI (nighttime) Checkpoint
3/5/97	DL (daytime) Checkpoint
7/20/97	DL (daytime) Checkpoint
11/7/97	DL (daytime) Checkpoint
1/1/98	Upland increases traffic law enforcement
3/23/98	Vehicle release fee raised to \$100
4/1/98	Fifth motorcycle officer added
5/22/98	DUI (nighttime) Checkpoint
5/26/98	Tow hearing fee established at \$30
6/3/98	DL (daytime) Checkpoint
7/3/98	DUI (nighttime) Checkpoint
7/8/98	Officer Briefing/Training - impound procedures
7/30/98	Initial Press Conference on Impound Program
9/23/98	DL (daytime) Checkpoint
10/22/98	Downtown Market Impound Publicity Booth
10/30/98	DUI (nighttime) Checkpoint
11/23/98	DL (daytime) Checkpoint
12/31/98	DUI Saturation Patrol
1/19/99	DL (daytime) Checkpoint
2/17/99	DL (daytime) Checkpoint
5/5/99	DL (daytime) Checkpoint
5/26/99	DL (daytime) Checkpoint

As part of its vehicle impound program, the Upland police department graded and fenced a vacant area adjacent to the police station, capable of storing 200 vehicles. It has worked out an agreement with local tow companies whereby the latter would tow vehicles to the police lot for a flat fee of \$70. The first impound vehicle first arrived at the lot in March 1995. By the end of that year, the tow rate had reached 71 vehicles per month.

The number of impounded vehicles in Upland has grown significantly from about 20 per month initially to about 130 per months at its peak (Table 1.2). It has easily surpassed its original goal of impounding 1195 vehicles per year by March 2000.

Table 1.2: City of Upland Impound Program

Time Period	Total Cars Impounded	Fees Collected*
1995 1st Quarter	14	
2nd Quarter	65	
3rd Quarter	56	
4th Quarter	147	
1996 1st Quarter	259	\$94,880
2nd Quarter	256	\$93,494
3rd Quarter	298	\$105,175
4th Quarter	296	\$98,699
1997 1st Quarter	255	\$92,297
2nd Quarter	413	\$139,411
3rd Quarter	451	\$146,416
4th Quarter	453	\$130,432
1998 1st Quarter	482	\$147,604
2nd Quarter	529	\$240,895
3rd Quarter	481	\$174,605
4th Quarter	428	\$144,108
1999 1st Quarter	382	\$152,187
2nd Quarter	362	\$141,882

*From all sources

Other Vehicle Impound Programs in North America

Experiences of vehicle impound enforcement in other locales are highlighted below:

(i) In Wisconsin, the average cost of impounding a vehicle was \$508, while the average value of an impounded vehicle was only \$295 (Eilers 1994; Crosby 1995). This resulted in a financial loss to the city because the vehicle owners, perceiving the value of the seized cars being less than their cost to retrieve them, simply abandon the vehicles, leaving the cost to the city.

(ii) In Delaware, where vehicle owners must pay a \$50 towing fee and \$10 per day of storage, impounding is used infrequently as most vehicles impounded are of such low value that it

is not worth it to the owner to pay the impoundment costs, thus leaving the costs to the state (Eilers 1994).

(iii) Evidence indicates that borrowed vehicles have represented a substantial number of vehicles driven by unlicensed drivers. For example, in Manitoba, Canada, 53.9% of the vehicles seized under the impoundment law were owned by someone other than the driver (Eilers 1994). In most instances, owners who were unaware of the unlicensed status of the driver were allowed to recover their vehicle after paying the towing and storage fees. Should the unlicensed driver be arrested again with the same vehicle, the owner could not claim lack of knowledge and the vehicle would be impounded. This policy has been widely adopted, including California.

CHAPTER TWO: LITERATURE REVIEW

This chapter presents a synthesis of literature concerning the behavior of drivers who operate vehicles while under license disqualification or having never been licensed, as well as the safety impacts of vehicle impoundment.

Traffic safety and law enforcement professionals believe that vehicle impound enforcement, by deterring disqualified drivers from driving, can help to reduce traffic crashes and unsafe behaviors on the road (e.g., fatal and injury collisions, alcohol/drug involved collisions, nighttime collisions, hit-and-run collisions, recidivism, uninsured vehicles, hazardous driving, and crimes).

The following findings from the literature review are presented:

- o Amount of driving by individuals with suspended/revoked or no licenses.
- o Recidivism rates among disqualified drivers.
- o Crash risk of disqualified drivers relative to the general population.
- o The impact of vehicle impoundment on unsafe behaviors.
- o The impact of vehicle impoundment on traffic crashes and injuries.

Amount of Driving by Drivers with Suspended/Revoked or No Licenses

There is substantial evidence in the literature that suspension and revocation of driver's licenses, per se, do not eliminate driving by disqualified drivers. Prior studies investigating this issue primarily relied on ad-hoc surveys. Hagen et al. (1980), based on a survey of drivers with suspended/revoked license, reported that about 70% admitted to continuing to drive while under disqualification. Smith et al. (1992) reported that about 36% of drivers who lost their license as a result of DUI or demerit points drove at least once while under sanction, with many driving considerably more than once while under sanction; about 9% of disqualified drivers admitted to driving more than 100 times! The authors also found differences in driving frequencies for such drivers by type of offenses that led to the license suspensions. About 50% of those having licenses suspended because of demerit points, 37% because of hazardous driving, and 30% because of DUI, admitted to having driven while disqualified. Ross et al. (1988) conducted a survey of drivers with suspended or revoked licenses, and reported that the majority admitted to having continued to drive while under disqualification but far less often than before. About five percent admitted to driving just as many miles during disqualification as before. Interestingly, the authors reported that many drivers adopted behaviors to prevent being stopped while under disqualification (e.g., avoiding driving after drinking, adhering to speed limits, using turn signals, and keeping the vehicle road-worthy). Many drivers reported that they purposely selected road types and times of day to minimize contact with police.

In addition to direct evidence from surveys, there is also indirect evidence (from the analysis of crash and/or traffic citation data) indicating that license suspensions or revocations, per se, do not totally eliminate driving by disqualified drivers. NHTSA (1989) reported that 11% of all drivers involved in fatal crashes nationwide had invalid licenses at the time of crash. Williams et al. (1984) studied multiple DUI offenders, and reported that during their one year suspension period, about 32% of such drivers had at least one traffic citation or record update (e.g., crash involvement, traffic infractions, offense, or failure to pay penalties for traffic citations). For drivers under a three-year revocation period, 61% of them had at least one record update.

Recidivism Rates Among Disqualified Drivers

License suspensions and revocations are widely used as sanctions for traffic offenders, and have generally been found to help reduce recidivism rates more significantly than even imprisonment. Eilers (1994) reported that DUI offenders and habitual offenders who had had their license's suspended or revoked have lower rates of recidivism than did control groups, or even those sentenced to jail. For multiple DUI offenders, license suspension/revocation were associated with reductions of subsequent traffic convictions and crashes. Three California studies (William et al, 1984b) reported that the mandatory application of license suspension (12 months) or revocation (36 months) in conjunction with fines and/or jail sentences for multiple DUI offenders reduced their traffic convictions and crashes by at least 30%, relative to similar drivers receiving only fines and/or jail sentences. An Australian study (Smith et al, 1992) reported that license disqualification was an effective countermeasure against subsequent traffic convictions.

DeYoung (1990), Jones (1987), NHTSA (1985), and Williams et al. (1984b) reported that "problem" drivers whose licenses were suspended or revoked had fewer subsequent crashes and traffic convictions while under disqualification than did similar "problem" drivers whose driving licenses were not withdrawn. Williams et al. (1984a) and Ross et al. (1988) explained that such positive impacts of license suspensions on recidivism rates and subsequent crash involvement rates were probably brought about by reduced driving and perhaps changes in driving practice while under suspension. That is, despite the fact that the preponderance of disqualified drivers continue to drive, license suspensions or revocations appear to have helped to reduce their mileage and increase safe driving practices.

Crash Risk of Disqualified Drivers

Notwithstanding reported positive effects of license suspensions and revocations on recidivism and crash involvement rates, the literature clearly indicates that crash risks of "problem" drivers (whose behaviors warrant license suspensions or revocations) are much higher

than those of the general population. For example, Gebers and Peck (1987) examined crash records of the general driver population and drivers who would soon become disqualified. They reported that probabilities of traffic convictions (DUI and other infractions) and crashes were 4-20 times higher for the latter than the former, depending on the types of convictions and crashes. For example, hit-and-run crash involvement probability was nearly 20 times higher for disqualified drivers (relative to the general population); DUI crash involvement probability was nearly 6 times higher, and DUI conviction rate was almost 4 times higher. Helander (1986) studied a subgroup of habitual traffic offenders in California, and reported that they had ten times the fatal/injury crash rate of the general driving population.

Safety Benefits of Vehicle Impoundment

The commonly expressed rationale for vehicle impoundment is that it can create general and specific deterrence effects among disqualified drivers to modify their behaviors on the roads. If so, this can ultimately lead to reductions in traffic crashes and injuries.

A general deterrence effect of vehicle impoundment refers to a phenomenon in which enforcement of vehicle impoundment creates enough fear of apprehension among drivers with suspended/revoked or no licenses to discourage them from driving while under license disqualification. A general deterrence effect influences the entire population of disqualified drivers

A specific deterrence effect of vehicle impoundment refers to a phenomenon in which disqualified drivers, having had their vehicles impounded due to driving while under license disqualification once, would be less likely to drive under disqualification again for fear of a repeated vehicle impoundment.

Evidence in the literature indicates that vehicle impound enforcement appears to have some specific deterrent effect on both subsequent crashes and traffic convictions. DeYoung (1998a), evaluated the specific deterrence effect of California vehicle impound law by examining the one-year subsequent traffic convictions and crashes of suspended/revoked and unlicensed drivers in California whose vehicles had been impounded due to driving while under disqualification (the treatment group), relative to the control group which was comprised of drivers with suspended/revoked or no licenses in the same study areas who were caught but did not have their vehicles impounded because their offenses occurred in 1994, a year prior to the law. The author reported that the treatment group as a whole had about 20% lower subsequent traffic convictions, and about 32% lower subsequent crashes, than the control group.

DeYoung (1998b) performed a further evaluation to determine whether vehicle impound might have a general deterrent effect, by examining the average number of crashes per driver for drivers with suspended/revoked licenses relative to the control group, the general driving population, during the three years before and two years after the impound law took effect in

California. The authors reported that there was no significant difference in the changes in crash rates (between the before and after periods) for the two groups. This led the authors to conclude that there was no evidence of a general deterrent effect of the California vehicle impound law on crash risks of drivers with suspended/revoked licenses.

In summary, the literature has indicates that:

- o License suspensions and revocations, per se, do not totally eliminate driving by disqualified drivers, even though some of these drivers may drive less while under disqualification.
- o Suspensions and revocations of licenses of "problem" drivers appear to help reduce subsequent recidivism, traffic convictions, and crash involvement because drivers with suspended/revoked licenses tend to reduce their driving mileage and possibly practice safer driving. Nonetheless, disqualified drivers as a group still show much higher crash rates than the general population.
- o Enforcement of vehicle impound appears to have some positive specific deterrent effect.

CHAPTER THREE: EVALUATION METHODOLOGY

This chapter describes the methodology for evaluating how Upland's vehicle impound program affected traffic safety and the city's police department.

Evaluation Method for Safety Impact of Vehicle Impoundment

The level of traffic safety is typically measured by road-user behavior and the number of traffic crashes. Traffic crashes, the most commonly accepted measure of safety, are the ultimate outcome of any safety programs. Road-user behavior is also an important measure because it can be a precursor or predictor of traffic crashes. Both crashes and road-user behavior are complex phenomena that can be affected by several factors.

Traffic enforcement is usually aimed at increasing traffic safety by penalizing, removing, or discouraging unsafe behavior on the road. Traffic enforcement can influence road users to act more safely, and police presence on the road can result in road users' perceptions that unsafe behavior could be penalized. Typical traffic enforcement activities include: speeding enforcement, DUI enforcement, seatbelt use compliance, traffic signals/signs compliance, traffic checkpoints, and vehicle impoundment, to name a few. The community or police department usually sets a policy concerning the desired levels of various traffic enforcement activities and enforcement strategies based on available resources.

The benefits provided by traffic enforcement activities are generally less tangible than outputs from, say, business firms. With firms, the output can be readily counted (cars, computers, clothing, etc.). Traffic enforcement is viewed as successful if it produces less (rather than more) crashes or risky behavior. Thus, the benefits of traffic enforcement have traditionally been expressed in terms of inputs (e.g., number of police deployed, frequencies of traffic checkpoints, etc.) rather than outputs. Limitations with this approach are that it is not possible to determine whether a particular enforcement activity indeed has the beneficial safety impact as intended, whether resources are being used efficiently, and whether some enforcement strategies are more successful than others.

This study takes a view that the benefits of traffic enforcement activities are measured by:

- o Frequencies of traffic crashes and injuries.
- o Prevalence of unsafe behavior on the road.

A higher level of traffic safety means that there are fewer crashes and less unsafe behavior on the road. Simply observing fewer crashes or less unsafe behavior, however, does not necessarily mean that the traffic enforcement in place is effective as there may many other factors at work. What is needed is the systematic determination of the correlations between crashes (or

unsafe behavior) and the traffic enforcement in place while controlling for other potentially influential factors/events.

Statistical Methods

A statistical method typically used for assessing the outcome of a safety program (e.g., frequencies of traffic crashes or risky behavior) is a "before-and-after" comparison incorporating a "control" group. The control group is typically an entity that displays some similarities to the treatment group but is not exposed to the safety program. The purpose of the control group is to account for the effects of time and other external factors on traffic crashes, so that the effect of safety program can be isolated.

Vehicle impoundment is a state law, to be implemented by all localities, making it virtually impossible to find a meaningful control city in California for Upland's impound program. Thus, an alternative statistical analysis method was needed and is presented below.

Time-Series Analysis

The primary purpose of the evaluation is to determine the safety impact (on crashes and behavior) of Upland's vehicle impound program which has been in place since 1995. This evaluation must account for the following factors that are operating at the same time as the impound program:

(a) Upland police department also conducts a variety of other traffic enforcement activities (all of which are aimed toward improving traffic safety) during the same period that the vehicle impound program is in effect. Chief among them are: speeding enforcement, DUI enforcement, seatbelt use compliance, and traffic checkpoints.

(b) Since the vehicle impound program began in 1995, the police department has changed policies and practices regarding the levels of various enforcement activities. For example,

- o It increased the level of DUI enforcement in late 1995.
- o It increased the level of overall traffic enforcement and citing of traffic violations in January 1998.
- o It added one more traffic officer (the fifth officer) in early 1998.

(c) During the evaluation period (from 1995 through June 1999), there were inherent monthly and seasonal fluctuations in crashes and on-the-road behavior. Also, there were inherent changes in the trends of crashes and on-the-road behavior over time.

An econometric model incorporating times-series analysis enables the effect of the vehicle impound program, as well as the effects of the above-mentioned factors, to be modeled simultaneously. In this way, the impact of the vehicle impound program on traffic crashes (or unsafe behavior) can be isolated from the effects of these other factors.

Behavioral Impact

The vehicle impound program in Upland can conceivably affect numerous on-the-road behaviors affecting safety. This evaluation focuses on the following behaviors for which data were available:

- o The amount of driving by drivers with suspended/revoked or no licenses.
- o Prevalence of DUI and other hazardous driving behavior.
- o Incidence of criminal activity.

Traffic Crashes

The impact of Upland's vehicle impound program is assessed on the following crashes:

- o Fatal and injury crashes.
- o Hit-and-run crashes.
- o Speeding related crashes.

The impact on DUI crashes is not analyzed because the number of DUI crashes per month in Upland is very small, making it impossible to perform a meaningful time-series analysis on this crash type.

Evaluation Approach for Impact on Police Department

In addition to its safety impact, Upland's vehicle impound program could also conceivably affect various aspects of the police department's resources and operations including:

- o Departmental organization and personnel
- o Levels of other traffic enforcement activities
- o Infrastructure requirement
- o Expenditures and revenues
- o Attitude and morale of police department personnel.

Evaluation of these impacts are based on before and after comparisons for each area.

Data Sources

This evaluation is primarily based on data available from two sources -- Upland Police Department and the California's Statewide Integrated Traffic Reporting System (SWITRS). The following data, on a monthly basis, during a period from January 1994 through June 1999, are available:

Crash Data:

Fatal and injury crashes

Hit-and-run crashes

Speeding related crashes.

Traffic Citation Data:

Total traffic Citations

DUI citations

Speeding citations

Other hazardous driving citations

Number of 30 day vehicle impounds (from March 1995)

Number of felony and misdemeanor crimes

CHAPTER FOUR: IMPACT OF VEHICLE IMPOUNDMENT ON DRIVER BEHAVIORS

This chapter presents the evaluation of the impact of Upland's vehicle impound program on on-the-road behavior such as the amount of driving by disqualified drivers while under disqualification, prevalence of DUI, speeding offense, and misdemeanor and felony crimes. The impacts of the vehicle impound program on crash experience and Upland police department are presented in the next two chapters.

Effect of Vehicle Impound Program on Amount of Driving by Disqualified Drivers

One important question about the safety impact of Upland's vehicle impound program is whether it helped to deter drivers with suspended/revoked or no licenses to reduce or stop driving while under disqualification. To ideally address this question, the amount of driving by disqualified drivers between the periods before and after the city began the vehicle impound program should be compared. Unfortunately, such data was not available, and would have been very difficult to obtain. Alternatively, the percent of total crash involvement by disqualified drivers in Upland between the periods before and after the vehicle impound program could be compared, from which inferences concerning the effect of Upland's vehicle impound program on the amount of driving by disqualified drivers could be made. Unfortunately, police crash records in California do not contain information whether drivers involved in crashes had valid driver licenses.

In the absence of these two kinds of ideal data, we attempted to determine whether Upland's vehicle impound program helped to reduce the amount of driving by disqualified drivers by examining available, indirect data sources such as the monthly number of vehicle impounds in Upland and other related data. It is conceivable that the number of monthly vehicle impounds in Upland could be influenced by many factors including:

- o The population of drivers in Upland whose licenses are suspended/revoked or who are never issued licenses, and the amount of driving by these drivers while under disqualification.
- o The level of various traffic enforcement activities in Upland (including the vehicle impound program).
- o The efficiency with which traffic officers in Upland carry out the vehicle impound operation.

We analyzed monthly enforcement and crash data from January 1994 (one year before the California impound law took effect) through June 1999, with a view to isolating the effect of the vehicle impound program on the amount of driving by disqualified drivers from the effects of

other variables that were operating at the same time such as changes in the disqualified driver population during the evaluation period (the exposure), the level of other traffic enforcement, and the efficiency with which police officers impound vehicles. Results of this series of investigations follow.

Trend of Disqualified Driver Population

We obtained data on the numbers of disqualified drivers (those with suspended or revoked licenses) in Upland at various times between 1993 and 1999 from the California Department of Motor Vehicles. These numbers do not exhibit an increasing or decreasing trend, but appear to fluctuate around an average of 2,737 disqualified drivers during this six-year period, implying that the disqualified driver population in Upland probably remained fairly constant between 1993 and 1999. What these DMV numbers cannot tell, however, is whether there were changes in the amount of driving by disqualified drivers in Upland between 1993 and 1999, which is a question to be addressed here.

Levels of Traffic Enforcement in Upland

Vehicle impoundment is a secondary enforcement law which means that a vehicle must be stopped for some other violation before the license status of the driver can be checked. Therefore, if overall traffic enforcement increases, more vehicles are likely to be stopped which, in turn, is likely to increase the number of vehicle impounds.

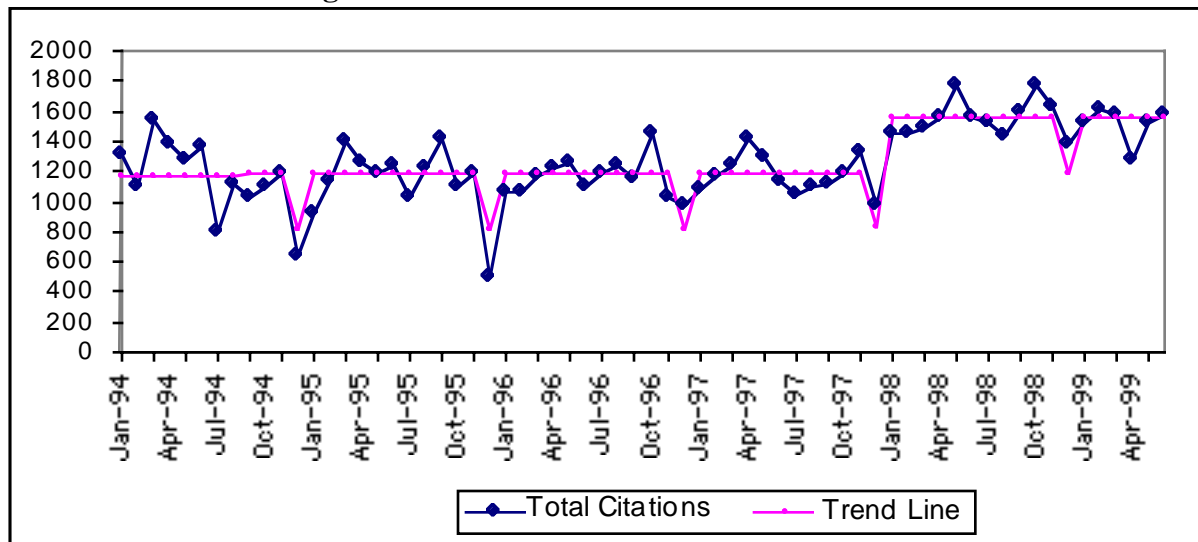
The level of traffic enforcement efforts can be measured by the total number of hours spent on traffic patrol. Unfortunately, Upland police department does not track this information. One indirect measure of the traffic enforcement level is the number of total traffic citations, which we examined from 1994 through May 1999 (Figure 4.1). The figure reveals that the total traffic-citation trend was affected by the following factors:

(i) There was a pronounced dip in the trend of monthly total traffic citations in December of every year, when the city conducts "holiday patrols" and many drivers are let off with just warnings. For brevity, this event will be called the "DECEMBER" factor.

(ii) In January 1998, monthly numbers of total traffic citations sharply increased to a higher level, and has remained at that level ever since. This is probably due to at least two major events. First, as of January of 1998, Upland police department directed its traffic police to be particularly vigilant about traffic enforcement and citing of traffic offenders. Second, the police department received OTS funding to support its various enforcement activities (including enforcing the vehicle impound law) in January 1998. This enabled the police department to add the fifth traffic officer. For brevity, these two events will be collectively referred to as the "PERSONEL" factor.

A time-series analysis was performed on monthly total traffic citations from January 1994 through May 1999 to determine the statistical significance of the effects due to the DECEMBER and PERSONEL factors on the total traffic-citation trend. The results indicate that both of these factors significantly influence the trend of total traffic citations (Appendix A contains the statistical results). The estimated trend line for monthly total traffic citations is plotted in Figure 4.1, which clearly shows two distinct levels of total traffic enforcement in Upland between 1994 and 1999, within each of which the enforcement effort was fairly constant. The enforcement level prior to 1998 was lower than that since January 1998 (about 1,200 versus 1,550 citations per month).

Figure 4.1: Total Traffic Citations



Efficiency of Impounding Vehicles

We examined monthly numbers of vehicle impounds in Upland since the program started (Figure 4.2). The figure indicates that the monthly number of vehicle impounds increased steadily from a few vehicles per month initially to the peak of about 180 vehicles per month by early 1998. Such a steady and rapid increasing trend is not unexpected, and one contributing factor is likely to be the "learning curve" phenomenon. Figure 4.2 suggests that:

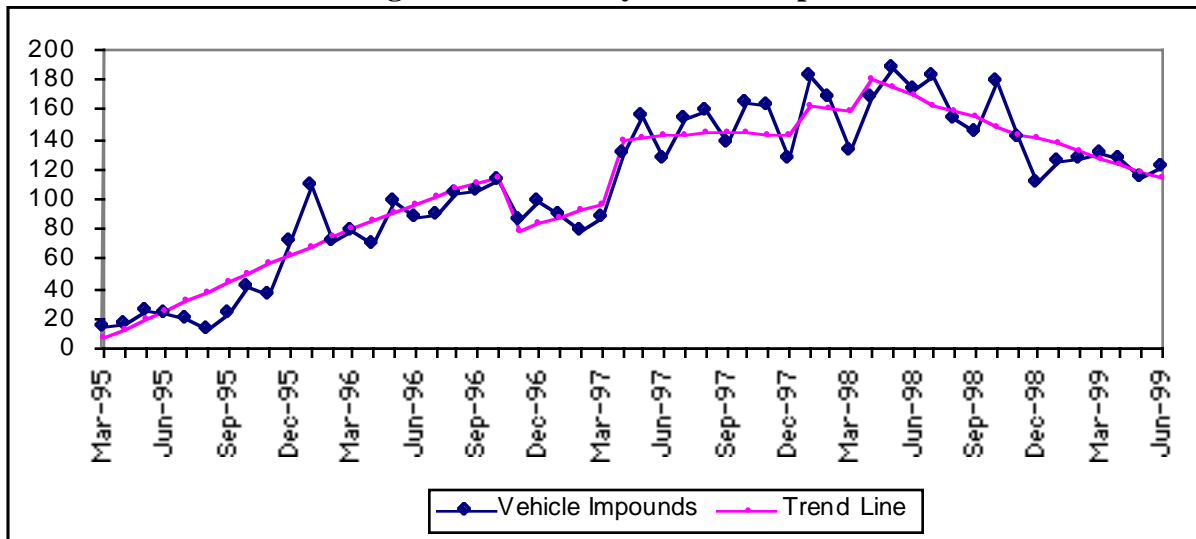
- o The "learning curve" probably leveled off no later than mid-to-late 1997.
- o Like the total traffic-citation trend, early 1998 was associated with higher monthly vehicle impounds than the preceding period.
- o Unlike the total traffic-citation trend, the vehicle impound trend does not show a pronounced dip in each December, implying that the city's "holiday patrols" did not let disqualified drivers off with just a warning. That is, Upland police

conducted "zero tolerance" vehicle impound enforcement.

- o Unlike total traffic citations, monthly vehicle impounds began to decrease steadily after having reached the peak in early 1998.

We performed a time-series analysis of monthly vehicle impounds to determine the statistical significance of the effect due to the PERSONEL factor. The results indicate that the PERSONEL factor significantly affected the trend of monthly vehicle impounds. That is, the vehicle impound trend since 1995 can be divided into two distinct phases. One is a period from early 1995 until December 1997, and the other is a period since January 1998. The first phase included the "learning curve" effect, in which monthly vehicle impounds steadily increased. The second phase started with the peaking of monthly vehicle impounds in early 1998, followed by a steady decline in monthly vehicle impounds ever since.

Figure 4.2: Monthly Vehicle Impounds



Benefits of Upland's Vehicle Impound Program

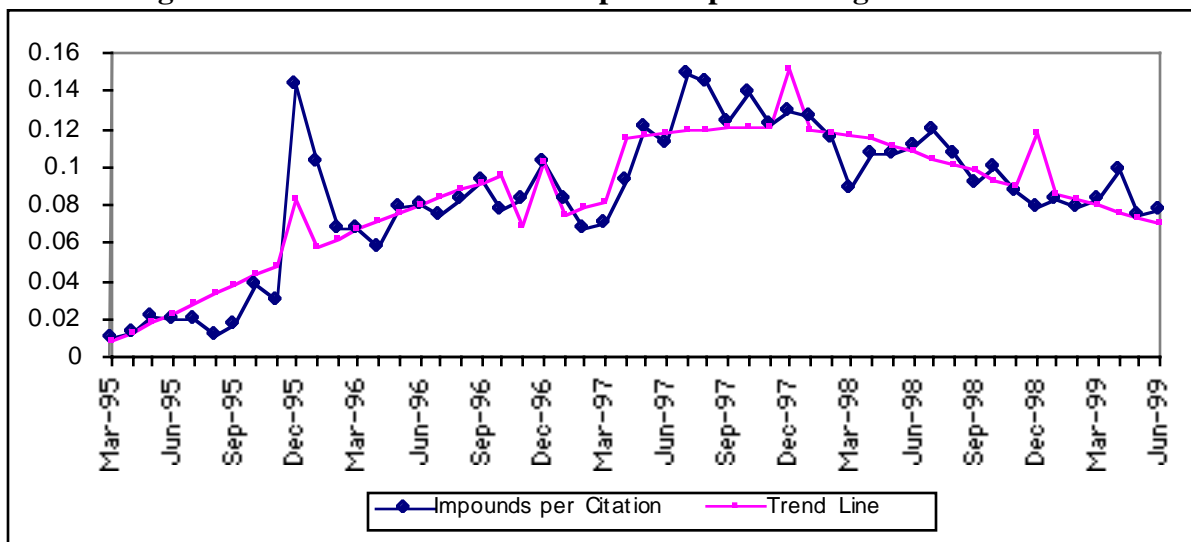
Results from the above series of analyses collectively imply that:

- o The disqualified driver population in Upland probably remained fairly constant between 1994 and 1999.
- o The level of traffic enforcement activity in Upland was fairly constant between 1994 and 1997, after which it increased to a higher level in January 1998 and remained fairly constant at that new level since.
- o The "learning curve" in impounding vehicles started to level off no later than mid-to-late 1997. That is, Upland's vehicle impound program has probably reached full efficiency before 1998.

What remains to be determined is whether there is evidence to suggest that the

disqualified driver population in Upland (which appear to have remained constant in their number since 1994) might have reduced the amount of driving while under disqualification since Upland started impounding vehicles. A plot of monthly vehicle impounds per traffic citation in Upland is shown in Figure 4.3. As mentioned above, a period after January 1998 can be said to be associated with the full efficiency in vehicle impound enforcement (i.e., free of the "learning curve" effect) and with a fairly constant level of overall traffic enforcement. Therefore, if Upland's disqualified driver population were driving more after January 1998, we would expect that more vehicles would be impounded, and the ratio of vehicle impounds to total traffic citations (a measure of the level of overall traffic enforcement) would be correspondingly higher. The opposite would also be true if disqualified drivers were driving less while under disqualification.

Figure 4.3: Number of Vehicle Impounds per Moving Violation Citation



We performed a time-series analysis on monthly vehicle impounds per traffic citation, and the estimated trend was plotted in Figure 4.3. The results indicate that the ratio of vehicle impounds to traffic citation, having reached the peak value in late 1997, gradually and steadily decreased from then on. Because the level of overall traffic enforcement in Upland did not change significantly, and there was no "learning curve" in impounding vehicles at play since January 1998, what could have contributed to this decrease in the ratio of vehicle impounds to traffic citation? One reasonable explanation is that there was a reduction in the amount of driving by disqualified drivers, which could conceivably have come about in the following ways:

(a) As more and more disqualified drivers had their vehicles impounded (for driving under disqualification), it might have discouraged drivers with prior impoundments from driving while

under disqualification (or from driving as much as before) for fear of again losing their vehicle. If so, a reduction in the amount of driving by disqualified drivers with prior impoundment records would represent the "specific" deterrent effect of the vehicle impound program.

(b) Over time, Upland's continued "Zero Tolerance" vehicle impound policy might have caused the city's disqualified driver population to realize the police department's commitment to removing them from the city's streets. This realization, combined with the potential penalties, might have served to reduce the amount of driving disqualified drivers. If so, this would represent the "general" deterrent effect of the vehicle impound program.

In light of the above evidence, it appears that Upland's vehicle impound program probably has the beneficial effect of reducing the amount of driving by disqualified drivers while under disqualification, at least as of early 1998.

Effects of Vehicle Impound Program on DUI Behavior

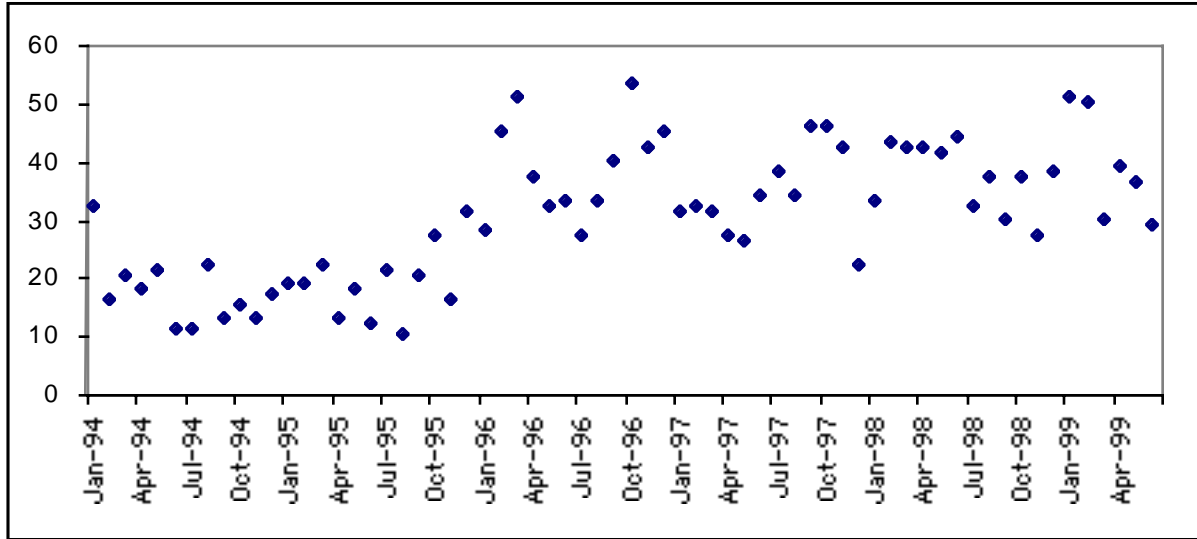
Unlike driving without a proper license, DUI is a primary enforcement law which allows a police officer to stop a vehicle if the officer believes the driver to be driving under the influence. Because DUI occurs primarily at night, a time when Upland's five motorcycle traffic officers are off duty, enforcement is typically carried out by patrol officers in police cars. In late 1995, Upland police department stepped up DUI enforcement, resulting in a sharp increase in monthly DUI citations (Figure 4.4). Since then, both the DUI enforcement level and monthly DUI citations have remained at that new level.

Besides DUI enforcement, other traffic enforcement activities in Upland (e.g., traffic checkpoints, speeding enforcement, and vehicle impound enforcement) could also conceivably affect the number of monthly DUI citations. A time-series analysis was performed to determine whether and how monthly DUI citations in Upland might have been influenced by the various traffic enforcement activities. Candidate independent variables include:

- o January 1996 (JAN96), a period following Upland stepping up DUI enforcement, a (0,1) dummy variable.
- o Number of monthly vehicle impounds (IMPOUND); cumulative vehicle impound (CUIMP), which is the total number of vehicles impounded from the start up to that month; and monthly vehicle impounds per traffic citation (IMPCIT). Each reflects the level of vehicle impound enforcement.
- o Deployment of traffic checkpoints (CHECK), a (0,1) dummy variable.
- o Number of monthly speeding citations (SPEED).
- o DECEMBER, a (0,1) dummy variable.
- o January 1998 (JAN98), the beginning of a policy to increase traffic enforcement and citing of traffic offenders in Upland, a (0,1) dummy variable.

- o The addition of the 5th traffic officer in early 1998 (OFFICER), a (0,1) dummy variable.
- o The time trend (TIME), which accounts for the inherent effect of the passage of time on the dependent variable.

Figure 4.4: Monthly DUI Arrests



Full results of the time-series analysis is shown in Appendix B, with highlights shown below. "DUI" in the equation below denotes the number of monthly DUI citations.

$$\text{DUI} = 18.907 + 9.860 (\text{JAN96}) - 0.008(\text{CUIMP}) - 0.822 (\text{CHECK})$$

JAN96, CUIMP, and CHECK are all statistically significant at a 0.10 significance level.

Interpretations of the effects on monthly DUI citations of these three significant independent variables follow:

(a) The coefficient of CUIMP (cumulative vehicle impounds) is negative, indicating that cumulative vehicle impounds are associated with reductions in monthly DUI citations. The elasticity of monthly DUI citations with respect to cumulative impounds is -0.509, which means that a 10% increase in cumulative impounds could result in a 5% decrease in monthly DUI citations, or about 1.7 DUI citations per month. Please note that an elasticity with respect to a particular independent variable is a measurement of the responsiveness of the dependent variable (in this case DUI arrests) to changes in the independent variable while holding all other independent variables constant. Calculations of elasticities are shown in Appendix B.

While cumulative vehicle impounds was found to be a significant explainer of monthly

DUI arrests, the number of monthly vehicle impounds was not. This implies that it is the longer-term nature of vehicle impound enforcement (due to continuous impound activity) that is likely to have the beneficial impact in reducing DUI offenses. That is, were vehicle impound enforcement to be put in place and then shortly removed, beneficial impact on DUI offenses would not be expected. Long-term and continuous vehicle impoundment may make the community recognize police commitment, resulting in DUI behavioral changes.

(b) The coefficient of JAN96 is +9.860, implying that the stepping up of DUI enforcement was followed by more DUI arrests. In Upland, such an action led to an increase in monthly DUI citations of 9.9 citations per month.

(c) The coefficient of CHECK (deployment of traffic checkpoints during a particular month) is -0.822, implying that conducting at least one traffic checkpoint in a given month can be expected to result in a decrease of 0.8 DUI citations per month (relative to months with no checkpoint activity). This in turn suggests that traffic checkpoints can help to discourage DUI behavior.

Collectively, the above three findings indicate that police traffic enforcement activity in any form, provided that they are on a regular or continuous basis, is likely to have beneficial effects in reducing DUI offenses and behavior.

Effects of Vehicle Impound Program on Speeding Offenses

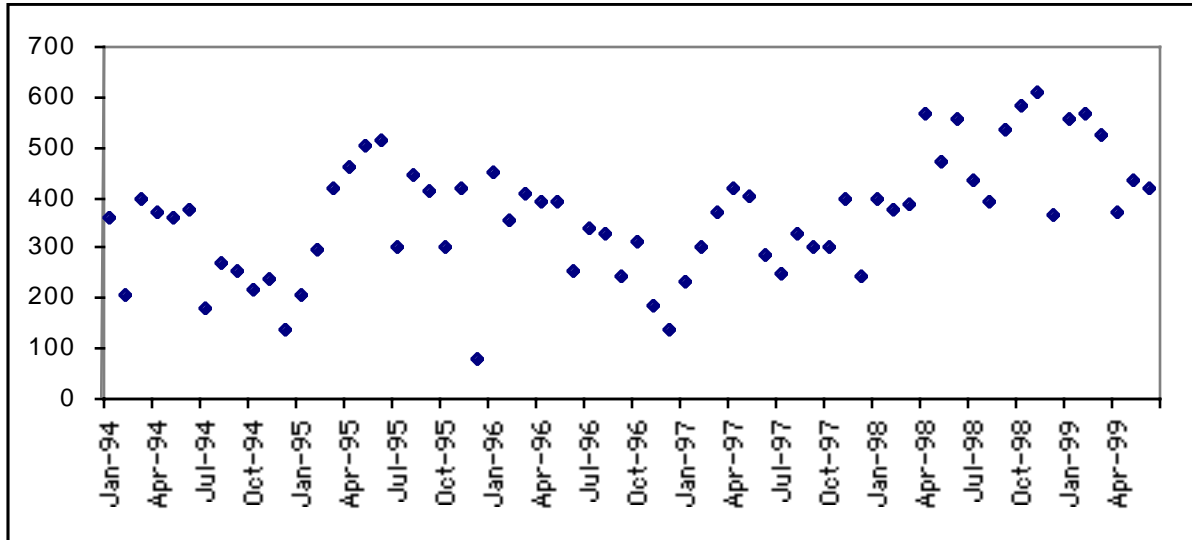
The number of monthly speeding citations in Upland from January 1994 through May 1999 are shown in Figure 4.5. Examination of the figure suggests that monthly speeding citations decreases in December of every year, probably due to drivers being let off with just warnings during the holiday period. Furthermore, monthly speeding citations appear to have remained at the same level from 1994 through January 1998, after which they increased to a higher level. This is likely to be due , as previously mentioned, to Upland's policy to increase traffic enforcement and the addition of the fifth traffic officer in early 1998.

A time-series analysis was performed to determine the statistical significance of the effects of various traffic enforcement activities on monthly speeding citations. Candidate independent variables include:

- o Number of monthly vehicle impounds; cumulative vehicle impounds (CUIMP); and monthly vehicle impounds per traffic citation(IMPCIT). Each reflects the extent of the vehicle impound enforcement effort.
- o The deployment of traffic checkpoints (CHECK), a (0,1) dummy variable.
- o Number of monthly DUI (DUI) citations.
- o DECEMBER, a (0,1) dummy variable.
- o January 1998 (JAN98), the beginning of a policy to increase traffic

- o enforcement/citing of traffic offenders, a (0,1) dummy variable.
- o The addition of the 5th traffic officer in early 1998 (OFFICER), a (0,1) dummy variable.
- o The time trend (TIME), which reflects the inherent effect of the passage of time on the dependent variable.
- o The number of monthly felony crimes (FELON).

Figure 4.5: Monthly Speeding Citations



Full model estimation results are shown in Appendix B. The best-fit model is:

$$\text{SPEED} = 177.743 + 143.358(\text{OFFICER}) + 94.803(\text{JAN98}) - 169.723(\text{DECEMBER}) + 0.925(\text{FELON})$$

All of the above independent variables are statistically significant at 0.10 significance level, except JAN98 which is significant at a 0.12 level.

Interpretations of these significant independent variables are as follows:

(a) Monthly speeding citations were positively correlated with both Upland's policy to increase enforcement/citations of traffic offenders and the addition of the 5th traffic officer in early 1998. The coefficient of JAN98 is +94.803, implying that the step-up in traffic enforcement increased monthly speeding citations by about 95 citations per month. Similarly, the coefficient of OFFICER is +143.358, indicating that the addition of the fifth traffic officer increased monthly speeding citations by about 143 citations per month.

(b) Monthly speeding citations were positively correlated with monthly felony crimes

committed, which suggests that criminal behavior carries over into speeding behavior. The elasticity of monthly speeding citation with respect to monthly felony crime is +0.698 (Appendix B), which means that a 10% increase in monthly felony crime could be accompanied by a 7% increase in monthly speeding citations, or about 27 citations, per month.

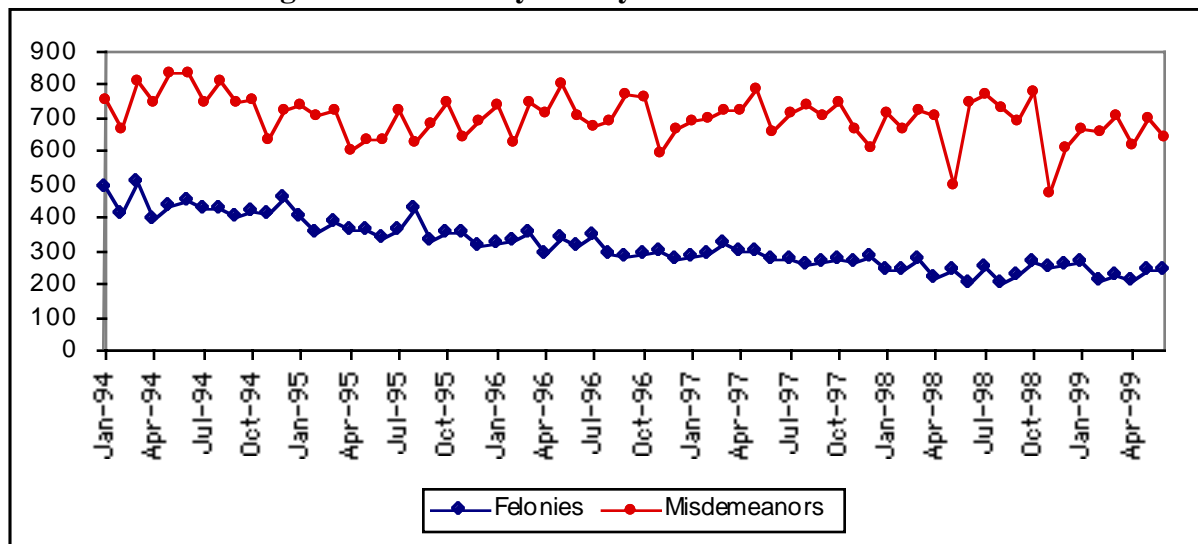
(c) Monthly speeding citations generally decreased in December, relatively to all other months. The coefficient of DECEMBER is -169.723, implying that there were, on average, about 170 fewer speeding citations in December than in any other months.

(d) Monthly speeding citations were not significantly affected by the vehicle impound program.

Effects of Vehicle Impound Program on Crimes

Many traffic enforcement professionals believe that vehicle impound laws can have a beneficial impact on crimes. Monthly felony and misdemeanor crimes in Upland are shown in Figure 4.6. A time-series analysis was performed to determine the effects of the various traffic enforcement activities in Upland on felony and misdemeanor crimes. The results for both types of crime are presented below.

Figure 4.6: Monthly Felony and Misdemeanor Crimes



Felony Crimes

Time-series analysis was performed with the monthly number of felony crimes (FELON) as the dependent variable, and the following as candidate independent variables:

- o Number of monthly vehicle impounds (IMPOUND); cumulative vehicle impounds (CUIMP); and monthly vehicle impounds per traffic citation

(IMPCIT). Each reflects the extent of vehicle impound enforcement.

- o Number of monthly DUI citations.
- o Number of monthly speeding citations (SPEED).
- o DECEMBER, a (0,1) dummy variable.
- o January 1998 (JAN98), a (0,1) dummy variable.
- o The addition of the 5th traffic officer (OFFICER), a (0,1) dummy variable.
- o Time trend (TIME).

Full results of the model estimation are shown in Appendix B. The best-fit model is:

$$\text{FELON} = 341.755 + 0.086(\text{SPEED}) - 1.375(\text{TIME})$$

Both SPEED and TIME are statistically significant at a 0.10 level.

This model indicates that the vehicle impound program (as measured by monthly vehicle impounds, cumulative vehicle impounds, or monthly vehicle impounds per traffic citation) had no significant effect on the number of monthly felony crimes in Upland. Only two factors were found to be significant:

(a) There appears to be a natural tendency for monthly felony crimes to decrease with time as shown by the coefficient of TIME, -1.375. This suggests that over the evaluation period, felony crimes in Upland decreased by about 1.4 crimes per month with every passing month.

(b) Monthly felony crimes were positively associated with monthly speeding citations. The elasticity of monthly speeding citations is +0.114, implying that a 10% increase in monthly speeding citations could be associated with about 1% increase in monthly felony crimes, or about 3.25 per month.

Misdemeanor Crimes

A time-series analysis was performed with the monthly number of misdemeanor crimes as the dependent variable, and with the same set of candidate independent variables as the analysis of felony crimes. Full results of the model estimation are shown in Appendix B. The modeling results indicates that misdemeanor crimes are not significant correlated with any of the traffic enforcement activities in Upland (including the vehicle impound program).

Effects of Vehicle Impoundment on Uninsured Vehicles

Data on citations for driving uninsured vehicles was not available. Therefore, we did not perform an evaluation of the impact of Upland's vehicle impound program on the number of uninsured vehicles.

CHAPTER FIVE: IMPACT OF VEHICLE IMPOUNDMENT ON TRAFFIC CRASHES

This chapter examines whether and to what extent Upland's vehicle impound program affected the number of traffic crashes, particularly fatal/injury, hit-and-run, and speeding related crashes. The monthly number of DUI crashes in Upland (about 2-4 per month) is too small to perform a meaningful time-series analysis.

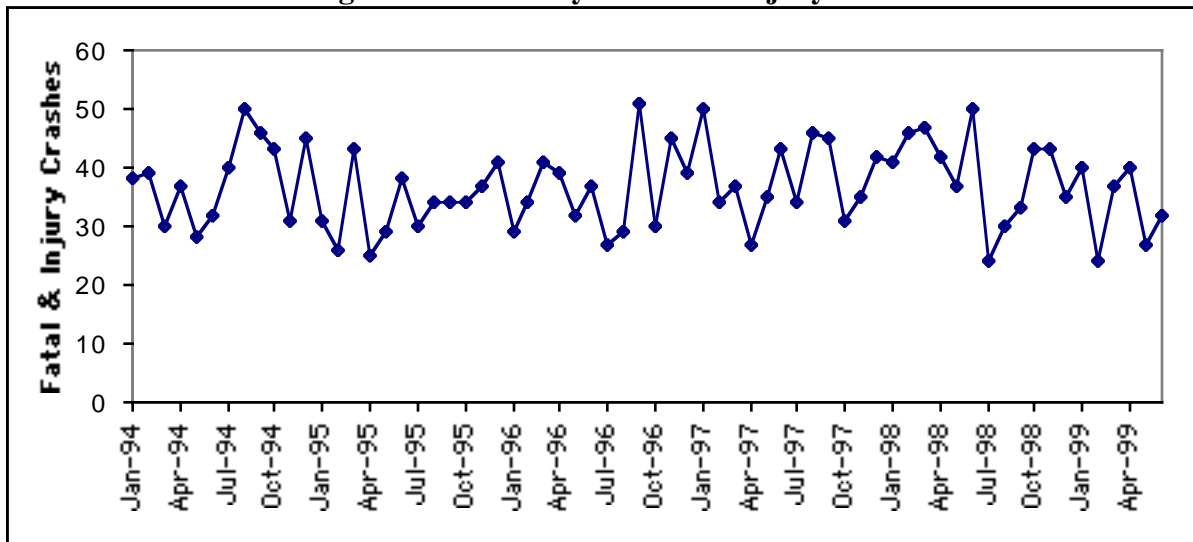
The results of time-series analyses of fatal plus injury, hit-and-run, and speeding related crashes are presented below. It was found that statistical correlations between traffic crashes and various enforcement factors are generally less pronounced (or weaker) than statistical correlations between traffic offenses/behavior and various enforcement factors.

Effect of Vehicle Impound Program on Fatal/Injury Crashes

Because monthly numbers of fatal crashes in Upland are very small, the time-series analysis combined fatal and injury crashes. For brevity, this combined category is referred to as "injury crashes".

Figure 5.1 shows the trend of injury crashes in Upland a period between 1994 and 1999.

Figure 5.1: Monthly Fatal and Injury Crashes



A time-series analysis was performed to investigate the effects of the various traffic enforcement activities in Upland on injury crashes in Upland. The dependent variable is the monthly number of injury crashes in Upland. Candidate independent variables include:

- o Number of monthly vehicle impounds (IMPOUND); cumulative vehicle impounds (CUIMP); and monthly vehicle impounds per traffic citation (IMPCIT). Each reflects the extent of vehicle impound enforcement.
- o The deployment of traffic checkpoints (CHECK), a (0,1) dummy variable.
- o Number of monthly speeding citations (SPEED).
- o Number of monthly DUI citations.
- o Number of monthly felony crimes (FELON).
- o Number of monthly misdemeanor crimes (MISD).
- o DECEMBER, a (0,1) dummy variable.
- o January 1998 (JAN98), when the city began to increase traffic enforcement/citing of traffic offenders, a (0,1) dummy variable.
- o The addition of the fifth traffic officer in early 1998 (OFFICER), a (0,1) dummy variable.
- o Time trend (TIME).

Full modeling results are show in Appendix B. The best-fit model is:

$$\text{Injury crashes} = 17.571 - 0.006(\text{CUIMP}) - 1.171(\text{CHECK}) + 3.255(\text{DECEMBER})$$

CHECK and DECEMBER are statistically significant at a 0.10 level, and "CUIMP" at 0.15 level.

The interpretation of each of these significant independent variables is as follows:

(a) Cumulative vehicle impounds is negatively correlated with monthly injury crashes.

The elasticity with respect to cumulative vehicle impounds is -0.344, implying that a 10% increase in the cumulative number of vehicle impounds could lead to a 3.4% reduction in injury crashes, or about 1.26 injury crashes per month.

Neither the monthly number of vehicle impounds nor the ratio of monthly vehicle impounds to total traffic citation significantly affect monthly injury crashes. The non-significance of monthly vehicle impounds (in the presence of cumulative impounds in the model) implies that it is probably the long-term effect of continuous vehicle impound activity (as opposed to its immediate impact) that is beneficial in reducing injury crashes.

(b) The deployment of traffic checkpoints in Upland in any one month was found to be associated with reductions in monthly injury crashes. The coefficient of checkpoints is -1.17, which means that traffic checkpoints could reduce, on average, 1.17 injury crashes per month relative to those months with no checkpoints.

(c) December was found to be associated with higher monthly injury crashes than other months. The coefficient of DECEMBER is +3.25, meaning that 3.25 more injury crashes, on

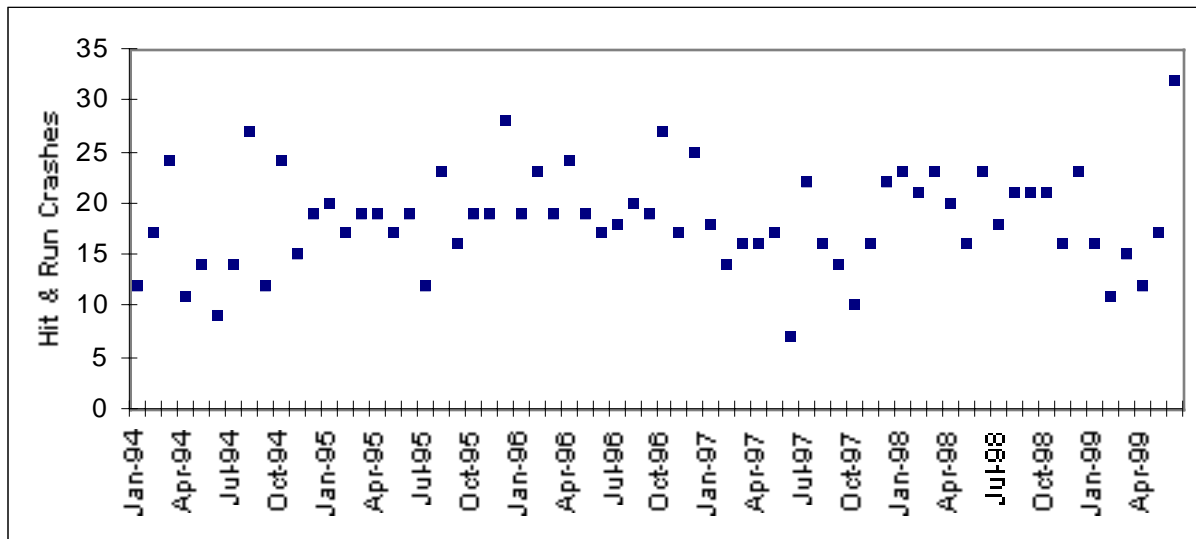
average, can be expected during this month.

(d) The effects of monthly DUI and speeding citations were found to be statistically non-significant, after accounting for the effects of cumulative vehicle impounds, traffic checkpoints, and December.

Effects of Vehicle Impound on Hit-and-Run Crashes

Many traffic enforcement professionals believe that vehicle impound laws can be an effective means for reducing hit-and-run crashes. The number of monthly hit-and-run crashes in Upland from January 1994 through June 1999 are plotted in Figure 5.2. These hit-and-run crashes include all reported hit-and-run collisions (including property-damage-only collisions) that occur on public and private property in Upland.

Figure 5.2: Hit-and-Run Crashes



A time-series analysis was performed to investigate the effects of various traffic enforcement activities in Upland on hit-and-run crashes. Candidate independent variables are the same as those shown in the above analysis of injury crashes.

Full model estimation results are shown in Appendix B. The best-fit model is:

$$\text{Log(HAR)} = 2.515 - 0.023\text{Log(CUIMP)} + 0.423(\text{DECEMBER})$$

Both CUIMP and DECEMBER are statistically significant at a 0.10 level.

Interpretations of the significant explainers of monthly hit-and-run crashes are:

(a) The number of cumulative vehicle impounds is negatively correlated with monthly hit-and-run crashes. The elasticity with respect to cumulative vehicle impounds is -0.023, meaning

that a 10% increase in cumulative impounds could reduce monthly hit-and-run crashes by 0.23%, or about 0.04 crashes per month.

Neither monthly vehicle impounds nor the ratio of vehicle impounds to total traffic citation were found to be statistically significant. Again, this implies that it is probably the longer-term nature of continuous vehicle impound activity that is beneficial in reducing hit-and-run crashes.

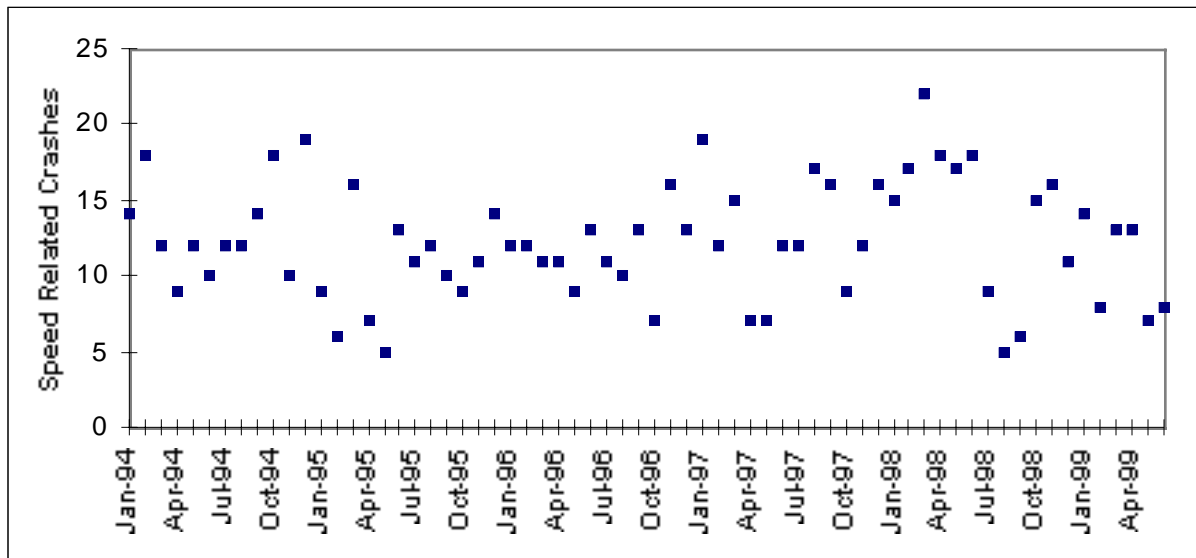
(b) December was found to be associated with increases in monthly hit-and-run crashes, relative to all other months. The coefficient of DECEMBER is +0.423, meaning that about 0.4 more hit-and-run crashes per month can be expected in December.

(c) Other traffic enforcement activities such as traffic checkpoints, DUI enforcement, and speeding enforcement were found to be non-significant, in the presence of the above significant independent variables.

Effects of Vehicle Impound on Speeding Related Crashes

Speeding related crashes are those in which speeding was reported to be the primary contributing factor. Only crashes resulting in fatalities or injuries were included in the analysis. Monthly numbers of speeding related crashes in Upland from January 1994 through June 1999 are plotted in Figure 5.3.

Figure 5.3: Monthly Crashes For Which Speed Was The Primary Collision Factor



A time-series analysis was performed to investigate the effects of various traffic enforcement activities in Upland on speeding related crashes. The dependent variable is the monthly number of speeding related crashes (SPDREL). Candidate independent variables are

those included in the above analysis of injury crashes.

Full model estimation results are shown in Appendix B. The best-fit model is:

$$\text{SPDREL} = 20.553 - 0.007(\text{CUIMP}) - 0.022(\text{MISD}) \\ + 7.531(\text{JAN98}) + 0.753(\text{TIME})$$

All independent variables in this model are statistically significant at the 0.05 level.

Interpretations of these significant independent variables are as follows:

(a) Cumulative vehicle impounds are negatively correlated with monthly speeding related crashes. The elasticity of monthly speeding related crashes with respect to cumulative vehicle impounds is -1.380, meaning that a 10% increase in cumulative vehicle impounds could lead to a 13.8% reduction in monthly speeding related crashes, or about 1.7 crashes per month. Monthly vehicle impounds and monthly vehicle impounds per total traffic citation were found to be non-significant in the presence of cumulative vehicle impounds, implying that it is the longer-term nature of continuous vehicle impound activity that is beneficial in reducing speeding related crashes.

(b) The number of monthly speeding related crashes is negatively correlated with monthly misdemeanor crimes. The elasticity with respect to monthly misdemeanor crime arrests is -1.234, implying that a 10% increase in misdemeanor crimes could result in 12.3% fewer speeding related crashes, or about 1.5 crashes per month.

(c) Monthly speeding related crashes in Upland increased during a period after January 1998 (relative to a period before 1998). The coefficient of JAN98 is +7.531, implying that the period after January 1998, on average, had about 7.5 more speeding related crashes per month than the period before January 1998. The available data is not sufficient to reliably identify a reason (or reasons) for this difference.

(d) The trend of monthly speeding related crashes slightly increases with the passage of time. The coefficient of "TIME" is +0.753, indicating an increase of about 0.75 speeding related crashes per month over time.

CHAPTER SIX: IMPACT OF VEHICLE IMPOUND PROGRAM ON UPLAND'S POLICE DEPARTMENT

This chapter describes the impact of Upland's vehicle impound program on the city's police department. The areas affected include:

- o Departmental organization and personnel
- o Levels of other police activities
- o Infrastructure requirement
- o Expenditures and revenues
- o Perceptions of the police department's personnel.

Departmental Organization and Personnel

Upland's Police Department is organized into four divisions -- Patrol, Investigation, Administration, and Special Services -- each of which is headed by a lieutenant. The implementation of the vehicle impound program did not require or result in any restructuring of the divisions or personnel. However, it has affected duties and workload of personnel within Patrol and Administration. These effects are elaborated below.

Patrol Division

Patrol Division consists of five units: Uniform Patrol, Uniform Reserve, Traffic Safety, Dispatch, and K-9. The vehicle impound program essentially affects personnel in all units (except K-9) to varying degrees, but particularly Uniform Patrol and Traffic Safety Officers as follows:

Uniform Patrol. Being the largest unit of Patrol Division, Uniform Patrol is comprised of 42 sworn officers whose primary duty is to respond to calls for service throughout the City. When not assigned to such duties, these officers perform traffic enforcement activities (which account for less than 10% of their time). In 1998, Uniform Patrol logged more than 38,471 service calls; wrote about 58% of all moving traffic violation citations (727 citations per month) and carried out about 73% of the city's vehicle impounds (116 vehicle impounds per month). During each of the day's three shifts, a patrol sergeant assumes the role of watch commander. Among his duties is the fielding of calls from individuals who have had their vehicles impounded.

Traffic Safety. Traffic Safety Unit has five motorcycle officers who are responsible for all traffic-related problems. Approximately 60% of the officer's time is spent patrolling on motorcycles with the other 40% taken up by administrative duties, taking accident reports, and various other activities. In 1998, the Traffic Safety Unit investigated 816 traffic collisions

(primarily fatal, injury, and hit-and-run), issued 6,444 moving violations, and impounded 525 vehicles.

Since driving without a valid license is a secondary enforcement law requiring that a driver be stopped for some other infraction before a license can be checked, the impound program has not changed the way traffic officers go about their duties - they still look for the same infractions of the vehicle code such as speeding and hazardous driving. There is also little change in the number of stopped drivers that have their license status checked it has long been the practice of officers to run such checks all stopped drivers. The major changes brought about by the program occur once the officer decides to impound the vehicle. These are:

- o The officer must complete a detailed tow form , the accuracy of which must stand up during the subsequent tow hearing.
- o The officer must wait for the tow truck and then accompany the towed vehicle back to the impound lot which is adjacent to the police station.

On average, the officer's time involved totals about one hour. This is because a typical traffic citation usually takes an officer about 15 minutes to write, while an additional 45 minutes are typically required in writing up, towing, and processing each impounded vehicle. At its peak operation, Upland's vehicle impound program requires at least 1,700 officer-hours per year.

Uniform Reserve. Uniform Reserve Unit is made up of individuals who volunteer their time performing regular police officer functions. The only ongoing role played by reserve officers in the impound program occurs when the department is conducting a drivers license or DUI checkpoint. Rather than take a sworn officer away from the checkpoint to accompany an impounded vehicle back to the lot, a reserve officer is used.

Dispatch. Dispatch Unit has 12 full-time and two part-time dispatchers as well as a dispatch supervisor. Three dispatchers are on duty during the peak hours of operation and at least two are on duty for the remainder of the day. The dispatch center is responsible for handling all 911 calls and all emergency line calls 24 hours a day. They also answer all business lines from 6:00 PM to 8:00 AM daily. The vehicle impound program affects the dispatch personnel in that they enter all impounded vehicles into the California Law Enforcement Telecommunications System (CLETS).

Personnel Within Administration Division

Administration Division is responsible for support functions. It has 15 full-time employees, 13 part-time employees and 20 volunteers. It is divided into the following units: Records, Volunteers in Police Service, Cadet Program, Management and Maintenance of Facilities and Fleet.

The vehicle impound program has particularly affected personnel and the operation of Records Unit, and to a much lesser extent, the Cadet Program. Workload of Records' staff increases significantly as the number of vehicle impounds grow, because:

- o Records' staff handles paperwork related to scheduling tow hearing, vehicle release dates, and collecting of fees.
- o Cadets accompany vehicle owners to the tow lot to release the vehicle or to let owners obtain property from impounded vehicles.
- o A Records Unit clerk inputs data into a tow database for use in tracking the disposition of vehicles and fees collected.
- o Record's staff answers inquiries and grievances from citizens, including those who are not happy about having their vehicles taken away for 30 days or confiscated if they cannot afford to pay the fees. In Upland, personnel work in this capacity work behind bullet-proof partitions.
- o It is departmental policy to give prompt assistance to any citizen approaching the Records Division's counter. The vehicle impound program has increased the number of such walk-ins significantly. These walk-ins require Records' staff to explain the impound process to them, which takes the staff away from their normal duties.

Because of the increased workload, an additional Records' clerk was hired in 1998.

The duties of the police lieutenant who commands the Records Unit are also significantly affected by the impound program. He conducts as many as 40 tow hearings per month, Monday through Thursday, from 2:00 to 4:30 PM. Each is a one-on-one hearing, lasting for 15 minutes, the purpose of which is to determine whether:

- o The person was driving while suspended or unlicensed.
- o The registered owner was the driver.
- o The registered owner knew or should have known the driver was under license disqualification.

The car is usually returned to the owner if he/she was unaware that the driver was improperly licensed. There have been very few occasions when vehicle owners obtained a court orders to get the vehicle prior to 30 days after having been denied a vehicle release at the tow hearing. There have also been few occasions when vehicle owners opposed the lien sale, which led to the matter to be resolved in a small claims court (for which the department prevailed each time). About 40% of impounded vehicles are not claimed and have to be lien sold. Every Tuesday, the lieutenant must handle the sale of these cars (usually 8-10 per week), which involves the viewing by prospective buyers, collection of bids, notification of the winning bidder at the end of the day, and completion of the paperwork required to transfer title.

Levels of Other Police Activities

Based on interviews with personnel of Upland Police Department and the examination of traffic citation and crime statistics, it appears that Upland Police Department has been able to implement the vehicle impound program without affecting the levels of other police activities.

Infrastructure Requirement

The key infrastructure requirement of a vehicle impound program is a "tow lot" for storage of vehicles. The Upland Police Department was fortunate in having available a large empty lot adjacent to police headquarters capable of storing as many as 200 cars. Owning the land on which the tow lot sits, and having the tow lot right next door to the police station offer several advantages that have enabled a relatively smooth vehicle impound operation. These include:

- o The department did not have to acquire or lease the land for use as a tow lot.
- o Security of the tow lot could be relatively easy to achieve thanks to its location next to the police station. The department fenced the lot, but did not put in extra lighting or security cameras.
- o Having the tow lot next to the police station reduces personnel workload in the vehicle impound process. For instance, it is convenient for a police officer to deposit a towed vehicle in the lot and then proceed immediately to the police station to complete necessary paperwork on the case. It is also easy for a Records Unit cadet to accompany the vehicle owner to the vehicle to retrieve personal property or to release the vehicle.

The department had to grow trees and plants to minimize the impacts of dust and noise generated by the tow lot on residents living on the east side of the lot.

Revenues and Expenditures

Upland's current fee structure reflects two changes that have occurred since the impound program was first established in 1995:

- o The release fee was raised from \$75 to \$100 on March 23, 1998.
- o The police department realized that they were not being compensated for the cost and time involved in tow hearings. On May 26, 1998, the city council adopted a tow-hearing fee of \$30 which, it was hoped, would reduce the number of hearings and increase revenues. Only the latter goal was realized.

With the exception of release fees and the two "pass through" fees (tow cost and lien sale processing fee), all revenues collected from the vehicle impound program goes directly into the city's general funds. Release fees go into the "Traffic Offender Fund," which is retained by the

police department specifically to fund the vehicle impound program.

Table 6.1: Upland Fee Structure

<u>Source</u>	<u>Amount</u>
Release Fee	\$100
Tow Hearing Fee	\$30
Storage Fee	\$15/day
Lien Sale Processing Fee (pass through)	\$25
Tow Cost (pass through)	\$70
Avg. Recovered per Released Vehicle	\$386
Avg. Recovered per Lien Sold Vehicle	\$186
Total Recovered From 1,921 Impounded Vehicles in 1998	\$707,212

The Upland Police Department does not keep itemized budget concerning expenditures specific to individual enforcement programs. A general idea of the financial impact of Upland's impound program can be obtained by computing the cost for each individual involved (e.g., dispatcher - .25 hours per vehicle x wage rate of \$21.52 per hour) as well as the ticket revenue lost because officers must spend time waiting for and accompanying the tow truck back to the lot rather than on traffic enforcement. Conservatively, an officer can write 1.25 tickets per hour worth approximately \$75 dollars apiece. The figures for 1998 are shown in Table 6.2.

Table 6.2: Operating Revenues and Costs To Impound 1,921 Vehicles

Category	Costs	Revenues
Total Fees Collected*		\$707,212
Direct Costs (wages)	\$207,005	
Tow Cost (\$70 per vehicle)	\$134,470	
Lien Sale Processing Costs	\$48,025	
Lost Ticket Revenue	\$270,188	
Total	\$659,688	\$707,212

*From All Sources

It can be seen that Upland's vehicle impound program is financially self-sufficient. An important factor in this, however, is the fact that they have their own impound lot adjacent to the police department. The only ongoing expenses the city incurs are maintaining the trees that were planted to screen the lot from neighboring houses, putting down additional gravel from time to

time, and repairing the fence after it is hit by tow trucks. Enforcement agencies that must acquire/lease a lot or contract out the storage of impounded vehicles would incur significant costs. Even if these costs were made up through higher storage and release fees, the economics of the program could change. One example would be the number of unclaimed vehicles that must be lien sold due to the inability, or unwillingness, of the owner to pay the higher fees.

Personnel Perceptions of Vehicle Impound Program

There has been considerable support for the vehicle program at all levels of command in Upland's police department. There was no difficulty in motivating officers to participate in a “zero tolerance” impound program as they are given credit for a tow in the same manner as arrests and citations, which are factors in rating job performance.

CHAPTER SEVEN: IMPLICATIONS OF FINDINGS

The evaluation results indicate that Upland's vehicle impound program appears to have beneficial safety impacts in reducing the amount of driving by disqualified drivers, DUI offenses, and fatal plus injury, hit-and-run, and speeding related crashes. These benefits were generally slight to moderate (although statistically significant), and probably came about in the following manner:

(a) It is the continuous and long-term enforcement of the vehicle impoundment that has yielded the observed benefits. That is, had the vehicle impound enforcement been put in place and then removed after several months, these benefits might not have occurred. The long-term and ongoing program, plus a "zero tolerance" impound policy, has probably helped to convince the community of the department's serious commitment to enforcing the vehicle impound law. An economic model to explain the safety effectiveness of Upland's impound program is that the program essentially increases the "cost" to drivers who violate the law. This "cost" to drivers can be expressed as the sum of two components. The first is the probability of being apprehended multiplied by the fees, and the second is the probability of being involved in a crash multiplied by costs associated with a crash, as follows:

$$\text{Driver cost} = (\text{Arrest Probability} \times \text{Fee}) + (\text{Crash Probability} \times \text{Crash costs})$$

Upland's impound program raised the expected cost to drivers by increasing the probability of being apprehended (if driving while under qualification) and imposing double penalties (i.e., loss of the vehicle for 30 days or more, followed by a large fee when the impounded vehicle is released).

(b) Upland's vehicle impound program was not implemented in isolation, but simultaneously with relatively high levels of other general traffic enforcement activities (e.g., DUI enforcement, traffic checkpoints, crime patrols, etc.). There were positive synergies among all of these enforcement activities, which have culminated in the above mentioned crash and DUI behavioral benefits. This in turn implies that cities should conduct vehicle impound enforcement in addition to (but not in place of) other police enforcement activities.

(c) The evaluation results appear to suggest that the proportion of Upland's total police enforcement efforts dedicated to the vehicle impound enforcement might be just about right as far as traffic safety benefits are concerned.

Among many risky on-the-road behavior examined, it appears that Upland's vehicle impound program only has influence on DUI behavior. Other behavior such as speeding, misdemeanor crimes, and felony crimes do not appear to be affected by the impound program.

Instead, they appear to be more responsive to overall police enforcement efforts.

Upland's vehicle impound program has called for addition manpower as well as changes in duties of police personnel as follows. An additional Records Unit clerk was hired to accommodate paper work and public relations. Officers of Uniform Patrol and Traffic Safety units spent a total of 1,700 person-hours per year in vehicle impound enforcement. The police lieutenant of Records Unit spends considerable time in tow hearings and sales of unclaimed vehicles. These added activities took these police officers away from other duties. However, the vehicle impound program has not resulted in lower levels of other police enforcement activities in Upland.

Conclusion

The evaluation of Upland's vehicle impound program suggests that California vehicle impound law can help to enhance traffic safety. However, more evaluations concerning the impacts of enforcement of such law in several other cities are needed in order to derive more reliable estimates of the law's safety benefits. This is particularly true because different cities are likely to approach the implementation of the law somewhat differently, depending on local factors and resources. Further studies are also needed to determine the potential hardship on drivers whose vehicles have been impounded, as well as to understand what adjustments these drivers have to make while their vehicles are impounded.

Upland's vehicle impound program has yielded both financial and safety benefits to the city. Therefore, it may be used as a model for implementing and/or planning vehicle impoundment in other locales.

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APPENDIX A

ANALYSIS OF MONTHLY TOTAL TRAFFIC CITATIONS

The total number of traffic citations (speeding, hazardous driving, and miscellaneous) is shown below. A trend analysis was performed with DECEMBER, JAN98, and TIME as the independent variables. The estimated model had an R^2 of .65. DECEMBER and JAN98 were significant at the 0.05 level while TIME was non-significant.

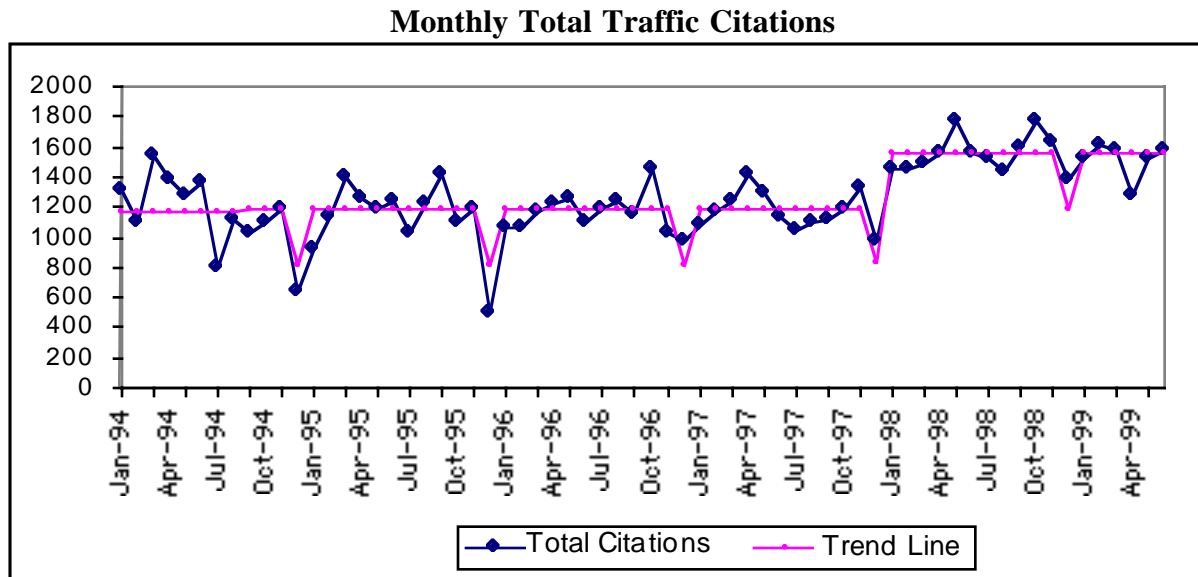


Table A1: Monthly Total Traffic Citations

Variable	Coefficient	t-Statistic
C	1173.357	27.539
JAN98	360.295	5.563
DECEMBER	-366.621	-5.282
TIME	0.450	0.297

Sample Size	66	Sum squared resid	1358696.39
R-squared	0.6531	Mean dependent var	1258.924
Adjusted R-squared	0.6363	S.D. dependent var	245.455
S.E. of Regression	148.035	F-statistic	38.901

APPENDIX B

TIME-SERIES ANALYSIS OF BEHAVIOR AND CRASHES

Variables and Notation

IMPOUND - Monthly vehicle impounds is the number of vehicles impounded under Vehicle Codes 12500 and 14601 for the month.

CUIMP - Cumulative vehicle impounds are the total number of vehicles impounded to date. For example, the value of CUIMP for June 1995 is the total of vehicles up to and include June 1995.

IMPCIT - Ratio of the number of vehicles impounded to the number of total traffic citations for the month.

CHECK - Deployment of traffic checkpoint is a (0,1) dummy variable. It takes on a value of "1" for a particular month if a driver license and/or a DUI checkpoint was deployed during that month. It takes on a value of "0" if no checkpoint is deployed during the month.

DECEMBER - Month of December is a (0,1) dummy variable that takes on a value of "1" for December, and "0" for all other months.

FELON - Monthly number of felony crimes committed.

MISD - Monthly number of misdemeanor crimes committed.

JAN98 - denotes the beginning of the policy to increase traffic enforcement and citing of traffic violators. It is a (0,1) dummy variable with the value of "1" for a period as of January 1998 until the end of the evaluation period and "0" for a period until December 1997.

JAN96 - denotes a period from January through December 1996 with increased DUI enforcement. It is a (0,1) dummy variable with a value of "1" for January through December 1996 and "0" for a period up to December 1995.

OFFICER - Addition of the fifth motorcycle traffic officer in early 1998 is a (0,1) dummy variable, with the value of "1" during a period when there are five motorcycle traffic officers and "0" for a period with only four motorcycle traffic officers.

SPEED - Monthly number of speeding citations for the month.

SPDREL - Monthly number of crashes for which speed was listed as the primary collision factor.

TIME - Time trend denotes an inherent effect of the passage of time on the trend of the dependent variable. It is a counting variable beginning with the number one for the first month of the evaluation period.

AR(1) and AR(2) are variables used in the model to correct for serial correlations, where it exists.

MODEL FOR MONTHLY DUI CITATIONS

The time-series analysis of monthly DUI citations yields the results shown in Table A1 below.

Table B1: Monthly DUI Citations

Variable	Coefficient	t-Statistic
C	18.90726	1.944975*
CUIMP	-0.00753	-2.021483*
JAN96	9.859832	2.666369*
CHECK	-0.82164	-2.592151*
SPEED	-0.02006	-1.262815
TIME	1.097102	1.138673
IMPCIT	58.08856	0.994068
DECEMBER	-4.70185	-0.974451
JAN98	5.864532	0.758864
OFFICER	2.898279	0.385798

Sample Size	52	Mean dependent var	33.80392
R-squared	0.585772	S.D. dependent var	10.31314
Adjusted R-squared	0.482214	Akaike info criterion	7.034946
S.E. of Regression	7.421057	Schwartz criterion	7.451615
Sum squared resid	2202.883	F-statistic	5.656506
Log likelihood	-168.3911	Prob (F-statistic)	0.000032
Durban-Watson stat	1.884882		

*Significant at ($\alpha = 0.10$)

With R^2 of 0.59, the model explains about 59% of total variation in monthly DUI citations. Significant explanators of monthly DUI citations at a 0.10 level are CUIMP, JAN96, and CHECK.

Elasticity With Respect to Cumulative Vehicle Impounds

Elasticity measures of the degree of responsiveness of the dependent variable with respect to a change in the value of a particular independent variable while holding all other independent variables constant. Calculation and interpretation of the elasticity of monthly DUI citations with respect to the one significant, non-dummy independent variables is shown below.

The elasticity of monthly DUI citations with respect to CUIMP is calculated as:

$$e = \frac{\Delta \text{DUI} / m_{\text{DUI}}}{\Delta \text{CUIMP} / m_{\text{CUIMP}}} = \frac{-0.0075 / 33.6}{1 / 2270} = -0.509$$

where: ΔDUI is the change in DUI citations
 $\Delta CUIMP$ is the change in cumulative impounds
 m_{DUI} is the mean number of DUI citations
 m_{CUIMP} is the mean number of cumulative impounds

This elasticity value implies that a 10 percent increase in cumulative vehicle impounds for a particular month is expected to reduce DUI citations for that month by 5.1 percent. This translates to a reduction of about 1.7 per month, as shown by the following calculation:

$$e = \frac{\% \Delta DUI}{\% \Delta CUIMP} = \frac{\Delta DUI / m_{DUI}}{\% \Delta CUIMP}$$

$$\Delta DUI = (e)(\% CUIMP)(m_{DUI}) = (-0.509)(.1)(33.6) = -1.7$$

Effects of CHECK and JAN96 on DUI Citations

As shown in the model, the dummy variables CHECK (representing the presence or absence of a checkpoint that month) and JAN96 (denoting a period of increased DUI enforcement during 1996) had a significant effect on DUI citations. During those months that had at least one checkpoint, DUI citations decreased by 0.8 citations per month. The period of increased DUI enforcement in 1996 was associated with an increase in DUI citations of about 29% (or nearly 10 citations per month).

MODEL FOR MONTHLY SPEEDING CITATIONS

The time-series analysis of monthly speeding citations yields the results as shown below in Table A2.

Table B2: Monthly Speeding Citations

Variable	Coefficient	t-Statistic
C	177.7429	0.791971
DECEMBER	-169.7229	-4.155648*
OFFICER	143.3579	2.291041*
FELON	0.925347	1.831025*
JAN98	94.80330	1.560709**
MISD	-0.181662	-1.021823
IMPOUND	0.455265	1.009503
TIME	-1.922119	-0.895862

Sample Size	52	Mean dependent var	380.1923
R-squared	0.631439	S.D. dependent var	114.9315
Adjusted R-squared	0.572805	Akaike info criterion	11.61667
S.E. of Regression	75.11946	Schwartz criterion	11.91687
Sum squared resid	248289.0	F-statistic	10.76905
Log likelihood	-294.0335	Prob (F-statistic)	0.000000
Durban-Watson stat	1934490		

*Significant at ($\alpha = 0.10$) ** Significant at ($\alpha = 0.05$)

With R^2 of 0.63, the model explains about 63% of total variation in the number of speeding citations. The model indicates that significant explanators of monthly speeding citations are DECEMBER, the addition of the fifth traffic officer (OFFICER), JAN98, and monthly felony crimes (FELON).

Elasticity With Respect to Felony Crimes

The elasticity with respect to FELON is 0.698, implying that a 10% increase in felony crimes per month tended to be associated with an increase in monthly speeding citations of 7% (or about 27 citations per month).

Effects of DECEMBER, OFFICER, and JAN98 on Monthly Speeding Citations

In the model, the coefficient of DECEMBER is -169.7, implying that December was associated with a reduction of about 170 speeding citations per month.

The coefficient of OFFICER is 143.4, implying that the addition of the fifth traffic officer increased speeding citations by about 143 citations per month.

Finally, the coefficient of JAN98 is 94.8, indicating that the period since January 1998 is associated with an increase in speeding citations of about 95 citations per month, relative to the period before January 1998.

MODEL FOR MONTHLY FELONY CRIMES

The time-series analysis results for monthly felony crimes is given in Table A3.

Model B3: Felonies Committed

Variable	Coefficient	t-Statistic
C	341.7550	18.19974*
TIME	-1.375370	-3.149962*
SPEED	0.085607	2.021999*
JAN98	-19.32501	-1.290476
OFFICER	-19.11768	-1.255255
IMPOUND	-0.243311	-1.094136
DECEMBER	12.55037	0.914029
IMPCIT	-160.3897	-0.601125
AR(1)	-0.331980	-2.201043

Sample Size	52	Mean dependent var	284.7843
R-squared	0.854041	S.D. dependent var	49.78928
Adjusted R-squared	0.826239	Akaike info criterion	9.062188
S.E. of Regression	20.75450	Schwartz criterion	9.403099
Sum squared resid	18091.47	F-statistic	30.71891
Log likelihood	-222.0858	Prob (F-statistic)	0.000000
Durban-Watson stat	2.026901		

*Significant at ($\alpha = 0.10$)

With R^2 of 0.85, this model explains about 85% of the total variation in the dependent variables. The independent variables that are statistically significant are SPEED and TIME.

Elasticity With Respect To Speeding Citations

The elasticity of monthly felony crimes with respect to monthly speeding citations is +0.1135, implying that a 10% increase in monthly speeding citations could be accompanied by a 1% increase in felony crimes, or about 3.25 per month.

Effects of TIME on Felony Crimes

The independent variable TIME represents or the inherent effect of time on the trend of monthly felony crimes. The coefficient of TIME is -1.375, implying that the passage of time (during the evaluation period) was associated with a decreasing trend in monthly felony crimes of about 1.4 per month.

Serial Correlation Correction

Also included in the model is the term AR(1), which is needed to correct for serial correlations. One assumption in the regression model is that the error term of a particular month ("residuals" or the difference between the estimated value and the actual observed value of the dependent variable for the month) is unrelated to the error term in subsequent

months. A common finding in time series regressions is that the residuals are correlated with their own lagged (previous) values. If such correlation is not corrected for, the model results may be rendered unreliable.

In order to correct for this problem, an autoregressive variable is added to the model with the designation "AR(#)." AR(1) indicates the first order component, AR(2) indicates the second order component. The AR(1) model incorporates the residual from the previous observation into the regression model for the current observation and this serves as a correction factor. The AR(2) model incorporates the residual from two observations ago into the regression model for the current observation and this serves as a correction factor. If these variables are significant it means the corrections are valid. A second check on the effectiveness of the use of the autoregressive component is to examine the Durbin Watson statistic and ensure it is 2.00 or near to 2.00.

MODEL FOR MONTHLY FATAL PLUS INJURY CRASHES

The results of the time-series analysis for monthly fatal plus injury crashes are shown below in table A4.

Table B4: Monthly Fatal Plus Injury Crashes

Variable	Coefficient	t-Statistic
C	17.57079	1.2103
DECEMBER	3.255126	2.2692*
CHECK	-1.170529	-1.9720*
CUIMP	-0.005553	-1.4943**
SPEED	-0.003011	-1.3717
TIME	0.692014	1.1769
IMPCIT	27.22491	0.8287
AR(1)	-0.164415	-1.1184

Sample Size	52	Mean dependent var	36.31373
R-squared	0.359922	S.D. dependent var	6.938271
Adjusted R-squared	0.323165	Akaike info criterion	6.831645
S.E. of Regression	6.857439	Schwartz criterion	7.134677
Sum squared resid	2022.052	F-statistic	5.169386
Log likelihood	-166.2069		
Durban-Watson stat	1.945085		

*Significant at ($\alpha = 0.10$) **Significant at ($\alpha = 0.05$)

With R^2 of 0.36, this model explains about 36% of total variations in monthly fatal plus injury crashes. Significant explanators of monthly fatal plus injury crashes are: CUIMP (cumulative vehicle impounds), CHECK (deployment of traffic checkpoints), and DECEMBER.

Elasticity With Respect To Cumulative Impounds

The elasticity of monthly fatal plus injury crashes with respect to CUIMP is -0.344, implying that a 10% increase in cumulative impounds could be associated with a 3.4% decrease in monthly fatal plus injury crashes, or about 1.3 crashes per month.

Effects of CHECK and DECEMBER on Monthly Fatal Plus Injury Crashes

The coefficient of CHECK is -1.171, implying that within any month in which at least a traffic checkpoint was deployed, fatal plus injury crashes for that month decreased by about 1.2 crashes per month, relative to months with no deployment of a traffic checkpoint.

The coefficient of DECEMBER is 3.255, implying that in the month of December, fatal plus injury crashes increased by about 3.2 crashes per month, relative to the other months.

MODEL FOR MONTHLY HIT-AND-RUN CRASHES

The results of the time-series analysis for monthly hit-and-run crashes are shown below.

Table B5: Monthly Hit-and-Run Crashes

Variable	Coefficient	t-Statistic
C	2.514616	2.438385*
DECEMBER	0.422679	2.470173*
LOG(CUIMP)	-0.02273	-1.6471*
LOG(SPEED)	0.102289	0.771014
CHECK	0.049309	0.651570
LOG(TIME)	0.118860	0.157764
AR(1)	0.160117	0.966580

Sample Size	52	Mean dependent var	
R-squared	.157613	S.D. dependent var	
Adjusted R-squared	.042742	Akaike info criterion	
S.E. of Regression	0.264524	Schwartz criterion	
Sum squared resid	3.078800	F-statistic	
Log likelihood	-0.780078		
Durban-Watson stat	1.921468		

*Significant at ($\alpha = 0.10$)

This model has a relatively low R^2 value of 0.16, which indicates that the model explains about 16% of the total variation in the dependent variable, statistically a relatively weak model. The significant independent variables are: CUIMP and DECEMBER.

Elasticity With Respect To Cumulative Impounds

The elasticity of monthly hit-and-run crashes with respect to CUIMP is -0.023, meaning that a 10% increase in cumulative vehicle impounds could result in a 0.2% decrease in hit-and-run crashes, or about .04 crashes per month.

Effect of DECEMBER on Monthly Hit-and-Run Crashes

The coefficient of DECEMBER is +0.423, implying that monthly hit-and-run crashes tended to be higher by about 0.4 crashes per month, relative to all other months.

MODEL FOR MONTHLY SPEED RELATED CRASHES

The time-series analysis of monthly crashes for which speeding was listed as the primary collision factor yields the best-fit model as shown in Table A7 below.

Table B7: Speed Related Crashes

Variable	Coefficient	t-Statistic
C	20.55303	1.975851
MISD	-0.021916	-2.675605*
CUIMP	-0.007434	-2.634725*
JAN98	7.531132	2.526964*
TIME	0.753464	2.328833*
JAN96	1.490101	1.293336
SPEED	-0.004673	-0.746409
FELON	0.007745	0.339967
OFFICER	-0.509136	-0.168805
AR(2)	-0.199171	-1.364463

R-squared	0.327549	Mean dependent var	12.18000
Adjusted R-squared	0.176248	S.D. dependent var	3.820941
S.E. of Regression	3.467916	Akaike info criterion	5.501841
Sum squared resid	4810578	Schwartz criterion	5.884246
Log likelihood	-127.5460	F-statistic	2.164879
Durban-Watson stat	1.911433	Prob (F-statistic)	0.045870

*Significant at (= 0.10)

With an R2 of .33, this model explains about 33% of total variation in monthly speed related crashes. The significant explanators of speed related crashes are MISD , CUIMP, JAN98, and TIME.

Elasticities With Respect To Misdemeanor Crimes and Cumulative Impounds

The elasticity of monthly speed related crashes with respect to MISD is -1.234, meaning that a 10% increase in misdemeanor crimes could result in a 12% decrease in speed related crashes, or about 1.5 crashes per month.

The elasticity of monthly speed related crashes with respect to CUIMP is -1.38, meaning that a 10% increase in misdemeanor crimes could result in a 14% decrease in speed related crashes, or about 1.7 crashes per month.

Effect of TIME on Speed Related Crashes

The independent variable TIME represents or the inherent effect of time on the trend of monthly felony crimes. The coefficient of TIME is 0.753, implying that the passage of time (during the evaluation period) was associated with an increasing trend in monthly speed related crashes of about 0.75 per month.

Effect of JAN98 on Monthly Speed Related Crashes

The coefficient of JAN98 is +7.53, implying that monthly speed related crashes tended to be higher by about 7.5 crashes per month, relative to the relative to the period before January 1998.