LICENSE PLATE RECOGNITION TECHNOLOGY (LPR)

IMPACT EVALUATION AND COMMUNITY ASSESSMENT

SPAWAR SYSTEMS CENTER ATLANTIC

GEORGE MASON UNIVERSITY

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FINAL REPORT

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IMPACT EVALUATION AND COMMUNITY ASSESSMENT

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LICENSE PLATE RECOGNITION TECHNOLOGY PROJECT

The Project

George Mason University's Center for Evidence-Based Crime Policy was tasked by SPAWAR and the National Institute of Justice to carry out three tasks to strengthen the evidence base of license plate recognition (LPR) technology. These tasks included (1) determining the extent of LPR use across the United States, (2) evaluating the deterrent effect of LPR on crime, and (3) providing an understanding of LPR's potential impact on communities. Towards these goals, we conducted three studies for this project: (1) a random-sample survey of large and small law enforcement agencies across the U.S.; (2) a two-jurisdiction randomized controlled experiment evaluating the specific and general deterrent effects of LPR patrols on crime; and (3) a random-sample community experimental survey and legal assessment of the effects of LPR on citizen perceptions and beliefs about law enforcement's use of LPR.

The Locations of Study

The national survey included agencies across the United States. The locations used for the experimental studies were Alexandria City and Fairfax County, Virginia, two adjacent jurisdictions both located within the Washington DC Metropolitan area. The police agencies of each contributed their staff, expertise, and time to this project. Their collective experience and cooperation made this research project a success.

The Findings

The GMU Research Team discovered that LPR technology is rapidly diffusing into U.S. law enforcement. Over a third of large police agencies have already adopted LPR, and many are on their way to acquiring the technology. However, we also discovered this rapid adoption is occurring in a low-information environment; the evidence-base for the effectiveness and effects of LPR is weak. Indeed, only one other rigorous evaluation, conducted by colleagues at the Police Executive Research Forum (PERF) has ever been conducted on LPR technology, and very few agencies have engaged in any type of assessment of this technology. Further, we discovered a relative dearth of empirical information about the realities of community concerns with LPR.

Our randomized controlled experiment mirrored the findings from the PERF experiments in that the use of LPR in autotheft hot spots does not appear to result in a reduction of crime generally or autotheft specifically, during the period of time measured. This may be due to the intensity of the patrols during the experiment, which were limited by resources and shift constraints, or the base of data in which the LPR units accessed. However, the findings may also provide a true indication of the crime prevention effectiveness of LPR in crime hot spots, and therefore, more testing of different applications and broader uses of data are warranted.

Finally, in our community assessment and legal analysis, we tested various perceptions and receptivity to uses of LPR by introducing a number of potential applications of the technology in searching for specific types of crime as well as collecting, storing, and sharing data. We discovered that concerns about LPR were not singular, but could vary depending upon the uses and connotations behind various uses. We suggest that exploring a *continuum of LPR use* may be a fruitful way for researchers to develop and test hypotheses about this and other police technologies.

The Products

Two major products were created from this study. The first is the Final Report, which includes four chapters that detail the process of our evaluations and assessments as well as the findings from each study.

In addition to this final report, we present to the law enforcement community the **LPR Web Portal**, located at http://gemini.gmu.edu/cebcp/LPR/index.html . The goal of the LPR Web Portal reflects the mission of the Center for Evidence-Based Crime Policy at GMU more generally: to provide law enforcement agencies and the communities they serve with information, research and analytic guidance about how LPR units can be deployed in more effective *and* legitimate ways. Various parts of this final report are deconstructed into the portal, and a variety of videos, deployment guides, and links to other evidence-based policing resources are provided. The portal is divided into sections specific to officer deployment, police leadership, community policing, crime analysis, and evaluation research.

The Team

The George Mason University LPR study was conducted by Dr. Cynthia Lum (Principal Investigator), Dr. Linda Merola (co-PI), Julie Willis and Breanne Cave (Research Assistants). Providing expertise to the team were the command and patrol staffs of the Alexandria and Fairfax County Police Departments, Matt Snyder and Joey Pomperada (SPAWAR), Dr. Bruce Taylor (National Opinion Research Center of the University of Chicago), Dr. Christopher Koper (Police Executive Research Forum), Dr. Devon Johnson and Ms. Naida Kuruvilla (George Mason University), Julie Wan (copyeditor), and Jason Lutjen (Slonky, Associates). For further information, please contact the CEBCP at cebcp@gmu.edu .

GEORGE MASON UNIVERSITY

LICENSE PLATE RECOGNITION (LPR) TECHNOLOGY

IMPACT EVALUATION AND COMMUNITY ASSESSMENT FOR LAW ENFORCEMENT

1. DOES LICENSE PLATE TECHNOLOGY "WORK"?

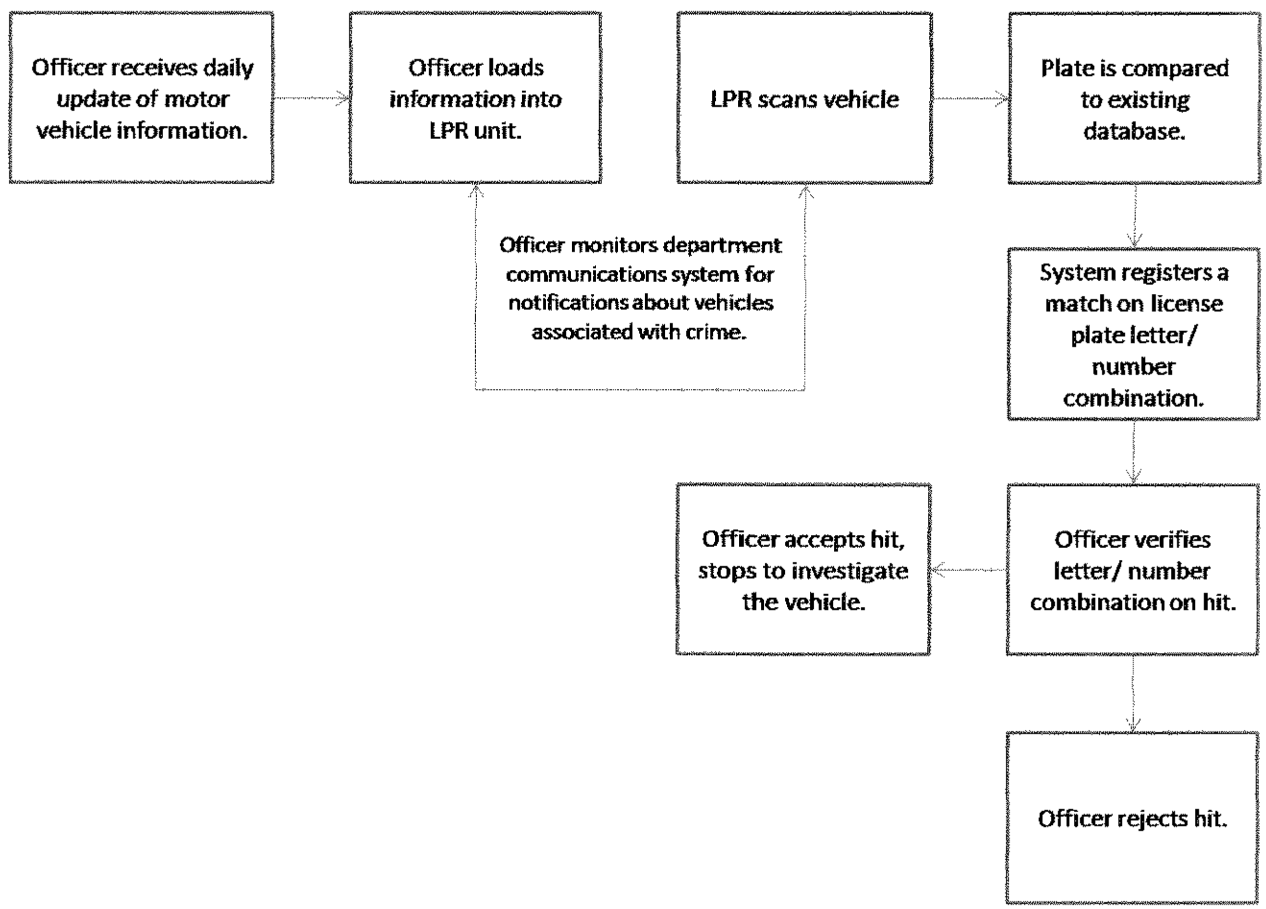
Overview: *George Mason University's Center for Evidence-Based Crime Policy was tasked by SPAWAR and the National Institute of Justice to carry out three tasks to strengthen the evidence base of license plate recognition (LPR) technology. These tasks included (1) determining the extent of LPR use across the United States, (2) evaluating the deterrent effect of LPR on crime, and (3) providing an understanding of LPR's potential impact on communities. As an introduction, this chapter emphasizes the importance of building this evidence base and of the need for police departments to differentiate between "efficiency" and "effectiveness" in evaluating the capabilities of any technology to help reduce crime.*

LPR Technology

As an operational tool for law enforcement, the license plate reader is a straightforward and easily understood piece of sensory technology (Figure 1.1). LPRs scan the license plates of moving or parked vehicles and can do so while either mounted on a moving patrol car or attached to a fixed location, such as a toll plaza. Once a plate is scanned and its alphanumeric pattern is read by the LPR system, the technology compares the license plate against an existing database of plates that are of interest to law enforcement. Plates "of interest", for example, might include those on vehicles which have been recently stolen, or whose registered owners have open warrants. When a match is made, a signal alerts the officer to proceed with further confirmation, investigation and action. Hundreds of cars can be scanned and checked in very short periods of time.

LPR technology thereby automates a process that, in the past, was conducted manually, slowly, tag-by-tag, and with much discretion. In this manual approach, officers would see a car that appeared suspicious and provide the dispatcher with the plate number, who would check the plate against a database such as National Crime Information Center (NCIC) to see whether the vehicle was stolen. The dispatcher would then radio the officer back with the status of the vehicle. LPRs replace this ad-hoc, tag-by-tag approach with an automated and speedy system.

Figure 1.1: Using License Plate Readers—A Simple Process



In addition to their quick scanning and matching capabilities, LPR is, in a broader sense, an information technology system. These systems can collect and store large amounts of data (plates, dates, times, and locations of vehicles) for future record management, analysis, and dataset linking. For example, license plates collected by a reader mounted on a toll plaza might be stored and then accessed in the future to confirm a suspect's alibi or whereabouts at a particular date and time. Data might also be used for predictive purposes. For instance, LPR units could be used to scan and record vehicular activity in front of high-risk locations. Unusual patterns of traffic by one or multiple vehicles that emerge from analyzing collected data might alert agencies to a heightened risk or concern. In theory, with enough saved LPR data, longitudinal information related to places and individuals could be constructed over time. In one case of a missing Alzheimer's patient in the Washington DC area, police were able to locate the person using recent scans from LPR data of his vehicle. LPRs, as information technologies, also have the capability to encourage interagency data sharing.

Because of the sheer volume of tags that LPR can scan in minutes and because of its information technology capabilities, LPR, in theory, can act as a force multiplier to many crime prevention and homeland security efforts. However, the effective use of LPR is primarily limited by three factors: the system's ability to read license plates accurately, the quality and relevance of the data accessed by LPR to compare with scanned plates, and the way in which police departments deploy the machines. Thus, it follows that improvements and refinements in scanning, data access, and police deployment strategies could potentially improve LPR's effectiveness in controlling and preventing crime. At the same time, as with many other police tactics, advances in each of these functions can challenge other equally important facets of policing. These might include legal concerns about how long data can be stored, to what extent data might be mined, the balancing of values of privacy with security, and the broader concern of police legitimacy within communities.

The Current State of the Research Evidence on LPR Technology

Although a wide variety of agencies use license plate recognition technology, only one outcome evaluation measuring its effect on reducing crime has been conducted prior to this study. This evaluation was conducted by the Police Executive Research Forum (Taylor, Koper and Woods, 2010). The more common types of LPR research have focused on the function of the technology itself — its effectiveness in scanning license plates and detecting for stolen automobiles in various settings, such as highways, parking lots, or toll booths (e.g., see Maryland State Highway Authority 2005); comparisons of brands of LPR technology; or counts of misreads or other system errors. Nonetheless, as Bateson (2009) states and as Taylor et al. (2010) demonstrate, LPR technology is amenable to quantitative, experimental evaluation. LPR can serve a constructive function in finding stolen autos, which may lead to more frequent arrests of auto thieves and ultimately to deterrence of auto theft, if used with sufficient frequency.

The U.K. has been at the forefront of the funding, use, and evaluation of "ANPR" (automatic number plate recognition) technology in policing. From 2003 to 2007, a series of evaluations of ANPR were published by the Home Office and PA Consulting Group. These studies tracked the efficiency of LPR in increasing the recovery of stolen vehicles and goods, as well as increasing drug and weapon seizures. Results from the pilot and follow-up studies indicated that license plate readers significantly enhanced the ability of officers to make arrests, particularly when officers were dedicated specifically to a specially-designed ANPR unit, but any change in rates of crime that resulted from these increased arrest rates was not documented (PA Consulting Group, 2003, 2004; Police Standards Unit, 2007).

"...despite the undisputed advantage of LPR being more efficient and perhaps even fairer than manual approaches, the question still remains as to whether this technology is more *effective* in reducing or preventing crime."

Three assessments of LPR technology in policing contexts have occurred in North America. In 2005, the Ohio State Highway Patrol conducted a four-month evaluation of plate reader technology to determine the effectiveness of LPR in the detection of stolen vehicles and stolen vehicle plates in highway and turnpike systems and to assist with development of Homeland Security programs (Ohio State Highway Patrol, 2005). In that study, the use of LPR increased stolen vehicle recoveries and arrests compared to the previous year. Another study analyzed data concerning the rates of "hits" (scanned plates that matched a hot list or database) for uninsured, prohibited, unlicensed, or stolen vehicle drivers (Cohen, Plecas, & McCormick, 2007). The research team found that no matter where LPR units were placed, more hits were associated with more scans per patrol.

Most recently, the Police Executive Research Forum (PERF) conducted the first rigorous evaluation of the crime reduction outcome effectiveness of license plate readers using a randomized controlled experiment in Mesa, Arizona (Taylor, Koper and Woods, 2010). The PERF researchers measured the effect of LPR systems on rates of vehicle theft along "hot routes" or traffic corridors that were suspected of having a high rate of auto theft traffic. The findings suggest that, while LPR technology significantly enhances rates of license plates "reads", the number of plates scanned in and of itself does not predict a reduction of vehicle theft rates.

Efficiency Does Not Equal Effectiveness

The existing research on LPRs, with the exception of the experimental evaluation conducted by PERF, assesses the *efficiency* of LPR units (speed in scanning and detecting), not necessarily its effectiveness in reducing crime. Indeed, increased stops, arrests, and recoveries related to vehicle crimes may not lead to measurable crime reduction effects, just as increases in drug or gun seizures, for example, may not lead to reduction in drug distribution/use or gun crimes. In police evaluation research, this distinction between implementation efficiencies and outcome effectiveness is crucial, precisely because the second does not naturally follow from the first.

For example, with regard to efficiency of scanning, while there may be differences across vendors, there is little question that license plate readers are more efficient than previous (and, in many cases, current) police practices for checking license plates. Two common approaches have included the officer "ad-hoc" investigation and the "look-out lists" approach. The ad-hoc approach involves officers finding out more about the automobile and its driver by visually reading a plate from their patrol car or a fixed location and then calling dispatch on the radio, or else running the plate on their mobile terminals. The decision regarding which vehicles to investigate involves some combination of officer discretion, intuition, and memory of all-points-bulletins. Similarly, the "look-out lists" approach is one in which officers are given a list of recently stolen tags, automobiles, and other vehicles of interest and asked to "look out" for tags that appear on that list. Again, officer discretion is a major factor in this tactic; officers can choose when to look at the list and when to focus their attention on passing vehicles.

Both of these approaches stand in stark contrast to the more efficient and less discretion-oriented usage of LPR units. LPR can mimic these ad-hoc and lookout list approaches with greater speed, more efficiency and, perhaps most importantly, less reliance on individual discretion, which can be prone to bias. License plate readers can continuously scan hundreds of plates in minutes without the officer paying attention to vehicles passing by or taking up radio airtime that might be used for more pressing communications. Because of these efficiencies, LPR may contribute not only to reduced discrimination in traffic stops, but also to reduced distractions and accidents while driving.

"...the technology has often not been used in ways that could lead to effective crime reduction. The strong culture of reactivity and reliance upon case-by-case approaches in policing can act as a distorting filter thwarting the effective use of technological innovations..."

However, despite the undisputed advantages of LPR being more efficient and perhaps even fairer than manual approaches, the question still remains as to whether this technology is more *effective* in reducing, preventing, or even detecting crime. Especially with law enforcement technologies, efficiency is often mistakenly interpreted as effectiveness, which can perpetuate a false sense of security and a mythology that crime prevention or progress is occurring (Lum, 2010). Further, especially in the case of license plate readers, efficiency may not be significantly connected to effectiveness. The most accurate license plate readers might be used by law enforcement officials in ways that have no specific or general deterrent, preventative, or detection effect whatsoever. Some have even argued that if LPRs can at least reactively catch a car thief, then it does not matter what its crime deterrent effect might be. At $20,000 to $25,000 per unit, such assertions seem, at best, naïve and, at worst, very expensive.

The problems caused by equating efficiency and effectiveness in police technology cannot be overstated. Many advances in police technology have not been shown to be used effectively. More discouragingly, such "advances" have further solidified reactive, case-by-case, random, and ad-hoc policing approaches which do not facilitate crime prevention. One example is computer-aided dispatch, or CAD/911 technologies. CAD/911 was widely adopted by police across the world to improve the police response to crime and, in turn, the satisfaction of the public. We now realize that, although 911 systems have improved police response time and the reporting of incidents, their use may not necessarily be connected to increased crime prevention or even improvements in police legitimacy[1] (National Research Council, 2004; Spelman & Brown, 1981; Sherman et al. 2002).

Another example of the confusion between efficiency and effectiveness is in the use of crime-mapping technology. Despite the rapid and recent diffusion of computerized crime mapping as a law-enforcement innovation (Weisburd & Lum, 2005) and despite the strong evidence that hot-spot policing using such maps will reduce crime (National Research Council, 2004; Sherman & Weisburd, 1995; Weisburd & Eck, 2004; Braga, 2005), police continue to allocate patrol in a manner unrelated to the concentration of crime at places (Weisburd, 2008). As with 911 and LPR, the efficiency of computerized crime-mapping over hand-mapping is clear. Yet, the technology has often not been used in ways that could lead to effective crime reduction. The strong culture of reactivity and reliance upon case-by-case approaches in policing can act as a distorting filter, thwarting the effective use of technological innovations (Lum, 2010).

This difference between efficiency and effectiveness has resulted in two types of evaluations of LPR technology, as mentioned previously. These include evaluations which assess (1) whether LPR physically and mechanically does what it is supposed to do (for example, how accurately and quickly it scans, reads, and matches license plates); and (2) whether the use of LPR actually results in greater detection and deterrence for preventing and reducing crime. The first is the more common technical research available on LPR (see Cohen, Plecas, & McCormick, 2007; Maryland State Highway Authority, 2005; Ohio State Highway Patrol, 2005; PA Consulting Group, 2003, 2004; Home Office, 2007). Outcomes measured might include the number of plates accurately scanned within an hour, the number of accurate "hits," or even the number of arrests made by LPR units. These and other internal assessments within police agencies are largely concerned with how accurate and quickly the technology works compared to the previous manual, tag-by-tag approach.

This type of evaluation also focuses on detections as an important crime measure of the success of LPR. However, what is often measured is the number of detections made, rather than whether an increase in detections had a preventative or deterrent effect. Arrests and detections using LPR may increase, but actual auto thefts might also increase and at greater rates. Placing LPRs in hot spots of crime may also lead to more detections, but the

[1] In fact, as Tyler (1990) and Tyler and Huo (2002) suggest, police legitimacy may be more successfully derived from procedural actions (how a person is treated, how a case is dealt with) than with more mechanical distributive justice as implicated by 911 systems (whether the case was responded to quickly or in a similar manner to other cases).

question then becomes, "as compared to what?" Placing a specialized unit in a hot spot may also increase detection rates without the use of LPR units, simply because the probability of detection is higher, no matter the mechanism used.

Unlike these assessments of LPR's efficiencies, there have been no evaluations of the effectiveness of LPR on crime outcomes until very recently. Currently, only one other study exists, which this project partially replicates. This is the experimental evaluation conducted by colleagues at the Police Executive Research Forum (see Taylor, Koper and Woods, 2010). In that randomized controlled trial, also funded by the National Institute of Justice, the authors examined both the efficiency of LPR units and their crime control effectiveness compared to other approaches. More on the PERF studies will be discussed in Chapter 3.

The Need for Evidence, Evaluation, and Leadership

The current George Mason University evaluation seeks to add to the evidence base regarding how LPRs, if used, can be more effectively deployed for crime prevention *and* without reducing police legitimacy. This effort is crucial, as LPR technology is rapidly diffusing into law enforcement without regard for the existence or need of such evidence. In 2007, even prior to any evidence of the effectiveness of LPR on crime, the International Association of Chiefs of Police set forth a resolution promoting the use of LPR and supporting its purchase through federal legislation and with federal funds. In 2008, the Department of Homeland Security Urban Area Security Initiative (UASI)[2] did just that, and, in Northern Virginia and the District of Columbia alone, $4.4 million was allocated for jurisdictions to acquire LPR (Virginia Department of Emergency Management, 2008). Our national random sample survey of police agencies, conducted for this project (Chapter 2), confirms this rapid adoption. Even before these trends in the United States, such diffusion had been seen in the United Kingdom (PA Consulting Group, 2004; Home Office, 2007).

This rapid diffusion within an environment of little information, yet complex and competing agendas regarding its use, necessitates a leadership role for both early adopters and entities such as the National Institute of Justice. The determination of ways in which this technology may be used to detect and reduce crime effectively, cost-effectively, and fairly are core concerns in democratic policing. The National Institute of Justice, and those who conduct research for it, can provide structured information to law enforcement agencies with regard to addressing and promoting discourse and awareness about common challenges and concerns about LPR systems, as well as guiding agencies toward more optimal crime control implementation of these systems. Currently, such guidance is coming from vendors themselves, who tend to focus on the efficiencies of LPR rather than

[2] In a recent report by *USA Today*, a spokesperson for ELSAG, one of the major manufacturers of LPR systems, estimated that approximately 40 agencies in the DC metropolitan are using LPR systems (see Hughes, 2010).

operational effectiveness and its effects on communities. However, law enforcement agencies need the following information to optimize their use and decisions regarding LPR:

- empirical knowledge about effective policing tactics and strategies generally, and for LPR technology, specifically,
- knowledge that is derived from high quality field experiments, action research and demonstrations, and
- a mechanism by which such information can be translated and disseminated, such as the GMU LPR web portal (see http://gemini.gmu.edu/cebcp/LPR/index.html).

Building the Evidence-Base for LPR Technology

The goal of this project is to add to and strengthen the evidence base for LPR in these ways. Building this evidence base requires more rigorous impact evaluations, such as field experiments. Such evaluations have two positive effects. The first and most obvious is an increased understanding of the connection between LPR use and crime control. Related to this, these studies will also provide law enforcement officials with better information regarding *how and where* technologies like LPRs should be deployed in order to optimize the prevention of crime.

In building this evidence base, a number of issues should be considered. First, the deterrent effect of LPR on crime depends on the data that is loaded into LPR units. If the data is limited only to license plates connected to auto thefts or within a specific jurisdiction, then LPR's deterrent capability will likely also be limited to this particular crime or area. If the data is only updated once a day (as opposed to automatically), then the crime control effect of LPR is limited to those autos that were reported stolen prior to the last update (the previous night). When the source of data used by the LPR is expanded and connected to other types of information about individuals (such as open warrants, court orders, sex offender registries, repeat offender databases, and the like) the deterrent effects of LPR technology may increase. However, this expansion may also lead to heightened concerns about the legality of LPR use and also the effect its use has on police legitimacy in the eyes of the community (see Chapter 4). All of these questions can be tested empirically.

In addition to the quality and quantity of data used by LPR systems, the effectiveness of LPR also depends on how the technology is deployed. Field experiments and evaluation tests of various deployment approaches can illuminate the tactics that optimize the effective use of LPR. For example, we know from the Evidence-Based Policing Matrix (Lum, Koper and Telep, 2009)[3] that targeted efforts at very small geographic units using proactive and focused strategies based on data analysis are much more effective than reactive strategies that focus on individuals. A number of studies have already discovered that crime concentrates at small places (see Sherman et al., 1989; Sherman and Weisburd, 1995; Weisburd et al., 2004). Further, the concentration of auto theft has also been repeatedly shown (Henry and Bryan, 2000; Kennedy 1980; Plouffe and Sampson, 2004; Rengert, 1996; Rice and Smith, 2002). Thus, an evidence-based strategy for the most effective use of LPR systems is one in which LPRs are deployed in locations where the probability of passing a stolen automobile or wanted individual connected to a license plate is very high.

Additionally, hot spots deployment can be enhanced by the Koper Curve Principle. Koper (1995) found that the returns on deterrence could begin diminishing after a short period of time (e.g., 15 minutes). Thus, the deployment of LPR units in crime hot spots for long periods of time may be less effective than moving LPR units around to randomly selected hot spots every 15 to 30 minutes. Further, as Weisburd and Eck (2004) and Lum, Koper, and Telep (forthcoming) both suggest, more tailored approaches at crime hot spots may be more fruitful than vague, general approaches. Again, this may suggest that the optimal use of LPR units in crime hot spots for the short time they are there should involve highly tailored and structured deployment. Finally, LPR can also have a more general deterrent effect (see Sherman and Weisburd, 1995; Sherman, et. al., 1995). Potential thieves may see or know about the LPR patrol units and be deterred because of the presence of the technology, rather than its application.

Although these assertions are based on existing evaluation evidence, they remain hypotheses until empirically and rigorously tested in the context of LPR specifically. Early testing has already been conducted by the Police Executive Research Forum. Using randomized, controlled experiment of the effects of LPR in Mesa, Arizona, researchers discovered that LPR use at hot spots of crime leads to more positive scans for auto theft and stolen plates, as well as to more stolen vehicle recoveries, than a manual approach (Taylor, Koper, & Woods, 2010). However, when comparing the deterrent effect of a specialized unit manually checking plates versus using LPR, the manual checking was associated with lower auto theft rates than both the LPR use group and the control ("business as usual") group (though the effects of the manual plate checks were short-lived). Nor did LPR use deter auto theft relative to the control condition. In the PERF study, no crime reduction impact was found from LPR use on auto theft in hot spots. But further testing of different types, intensities, and breadth of data of LPR use must be examined to

[3] See http://gemini.gmu.edu/cebcp/matrix.html

see if these are ways that LPR can be effectively deployed. Such a goal is important given that some agencies have already invested in them.

Despite the nuances to think about when evaluating LPR, the value of an evidence-based perspective in deploying LPR is clear. It forces us to move beyond the efficiencies and the mechanics of the technology itself to begin using it in ways that reflect our knowledge about the prevention mechanisms that work best in patrol deployment. And, aside from telling agencies to "use it," it provides ideas on how best to deploy the technology in the framework of deployment schemes that we already know are successful in reducing crime (based on existing scientific research).

Additional Knowledge-Building: Legality and Legitimacy

In addition to building the evidence base on LPR's crime control effectiveness, there is also a lack of empirical evidence regarding the legal and legitimacy concerns that could arise with LPR use. To this point, a small number of legal analyses have been published (see IACP 2009), each dealing with different aspects of the potential legal implications of LPR. Generally, claims and guesses about community concerns fall under a number of categories, from general "big brother" worries that the government is monitoring citizens to very specific cares about the security of information collected and saved by the police. Yet, at this point, discussion of these issues is mere speculation about what is important to the community and how these concerns might alter views of police effectiveness and legitimacy. Evidence-based testing can challenge preexisting notions of privacy and legitimacy, just as it can with assertions of "effectiveness," by rigorously assessing the extent and nature of the concerns.

These questions become particularly relevant in the case of LPR, as various uses of LPR require access to and retention of different types of data. As more data becomes associated with license plate records, police gain an investigatory tool that can allow immediate access to a broad range of information on individuals whose plates are scanned by the system. Additionally, this investigatory tool may become more potent (and the potential legitimacy concerns more severe) as the ability for police departments to save past LPR data expands through technological upgrades. The legitimacy questions associated with LPR technology are therefore nuanced and cannot be answered by addressing the legitimacy of the system in general — varying applications of this technology challenge the police and its community in different ways. Consequently, a second goal of this study is to begin to develop an evidence base with respect to the legitimacy questions associated with various applications of LPR. (Chapter 4)

The George Mason University Study

The George Mason University (GMU) Center for Evidence-Based Crime Policy was commissioned by SPAWAR, as part of the National Institute of Justice's Science and Technology Information Led Policing portfolio, to add to the existing evidence base related to the use of license plate readers by law enforcement. We depart from existing evaluations of the efficiency, speed, and accuracy of LPR units and focus on the relationship between LPRs and crime control, as well as legitimacy outcomes. Toward this goal, the GMU research team completed four tasks:

(1) We conducted the **first random-sample national survey** of police agencies, assessing not only the extent and nature of LPR use, but also the concerns and challenges agencies face prior to and after acquiring LPR. This is currently the only random-sample study assessing LPR use across U.S. law enforcement agencies and is presented in Chapter 2.

(2) Then, following the experimental model of the Police Executive Research Forum's (PERF) current experimental evaluation in Mesa (AZ), we add the **first adjacent-jurisdiction, randomized controlled experiment** on the impact of LPR on crime. This is partially a replication of the PERF experiments, with a number of differentiating caveats. Working with our law enforcement partners, the Alexandria (VA) Police Department and Fairfax County (VA) Police Department, we report our findings of this randomized controlled trial involving auto crime hot spots across two jurisdictions that share a border. Our goal in using two jurisdictions sharing a common border was to emphasize that boundaries often matter little to criminal offending and to compare effects within and across boundaries. To do this, we randomly allocated LPR deployment in half of all hot spots across two jurisdictions to test whether LPR use yields a specific deterrent effect on auto thefts and a more general deterrent effect on crimes. These results are presented in Chapter 3, along with a shorter, supplemental document in the LPR Web Portal (see below) that provides police departments with policy recommendations on using LPR.

(3) We also conducted the **first random-sample community survey-experiment related to LPR** in Fairfax, Virginia, in which we sampled 2,000 residents to assess their receptivity to LPR use by their police agency. Not only did we incorporate general police legitimacy questions in the survey, but we also asked people to react separately to various types of LPR use. The presentation of these scenarios of LPR use was varied randomly across respondents, providing an experimental test of how various applications of LPR technology impact citizens' perceptions of police legitimacy. The results of this survey are presented in

Chapter 4, along with a "continuum of LPR use" to aid in the consideration of legal/legitimacy issues and the further testing of legal and legitimacy claims.

(4) Finally, the research team created **a unique evidence-based LPR Web Portal** to aid police in using LPR technology. The web portal translates research information for dissemination to five communities: police officers, police leaders, community members, researchers, and crime analysts. The processes and findings from this project and others are summarized in the portal, and videos, policy guides, and suggestions are also included. The web portal can be accessed at http://gemini.gmu.edu/cebcp/LPR/index.html).

2. LAW ENFORCEMENT TRENDS IN LPR USE

A NATIONAL SURVEY

Overview: *To add to the evidence-base of license plate recognition technologies, we begin with a national survey of LPR use in the United States. We randomly sampled law enforcement agencies to determine their use, concerns, and challenges in using LPR. We also explore both issues of effectiveness of LPR as a crime control intervention and the potential effects of LPR on police legitimacy and legal concerns. This survey is the first random sample national survey of agencies to gauge these issues.*

A National Assessment of LPR Use

The research team's first task was to gain a sense of the extent and nature of LPR use across the United States. This exercise makes tangible the extent of the diffusion of this innovation and provides agencies knowledge of what to expect prior to and after they adopt LPR. National surveys are important, as they provide agencies a benchmark for comparison, and a platform for sharing concerns about tactics and technologies. A random-sample survey is also important since surveys of agencies based on convenience or membership in professional organizations may bias results to the characteristics of those specific memberships.

Although no national assessment that is focused on LPR currently exists, two surveys provide a useful start. The first— the most recent (2007) Law Enforcement Management Administrative Survey (LEMAS)[4] asks a single question about whether agencies used LPR in 2007. As of the printing of this report, the 2007 LEMAS results have yet to be released. The second was a broader survey on many types of technologies conducted by the Police Executive Research Forum of its membership[5] (Koper et al., 2009). In that study, Koper et al. found that over one-third of the PERF membership agencies had adopted LPR, with a large majority finding the technology useful. Of those who had not adopted LPR, the majority anticipated acquiring it sometime in the future.

[4] See the Bureau of Justice Statistics, http://bjs.ojp.usdoj.gov/index.cfm?ty=dcdetail&iid=248. The LEMAS surveys all agencies with 100 or more officers and a representative sample of smaller U.S. agencies.
[5] The PERF membership consists of self-selected police executives from various agencies in the United States. The membership is not representative of the population of law enforcement agencies and tends toward larger, more progressive departments.

The PERF study suggests a rapid diffusion of LPR technology at least among large agencies. Understanding the extent of this diffusion across departments of various sizes and documenting their concerns is an important start to building an evidence-base on the use of license plate readers.

Specifically, our survey had three objectives:

(1) Given LPR's rapid diffusion indicated in the PERF study, we sought to measure the prevalence of the use of license plate readers in police agencies in the United States: roughly, what proportion of large and small agencies currently used license plate reader systems and how many agencies were planning to acquire the system in the future.

(2) Given our interest in evaluating the effectiveness of license plate readers, we sought to identify how LPR was being used: for what purpose, by whom, and how frequently.

(3) Given the challenges that LPR might pose with respect to information privacy and, therefore, the relationship between police and communities, we wanted to understand from the police perspective their concerns about how LPR might affect their legitimacy with the community. We later gauge the community's perspective through our citizen survey in Chapter 4.

The Survey Sample

To select our random sample, we used the most recently available Law Enforcement Management and Administrative Statistics (LEMAS) Data—the 2003 survey.[6] The LEMAS is a relatively current and complete compilation of state, county, and local law enforcement agencies in the United States. It surveys all agencies with 100 or more (herein, "large") sworn officers and a representative sample of agencies with fewer than 100 officers (herein, "small") (see Bureau of Justice Statistics, 2009). The LEMAS also enjoys a high response rate: In 2003, 95% of large and 89% of small agencies responded. Because adoption of LPR and many other technologies occurs more often in larger agencies, we decided to over-sample from the population of large agencies collected by the LEMAS. Thus, we selected a random sample of 200 agencies from the LEMAS agencies. These samples included a random sample of 100 "large" agencies and a random sample of 100 smaller agencies.

[6] We used the LEMAS 2003 data because we wanted to connect information about organizations from the LEMAS to our sample, especially information about technology uses in those agencies. As of the completion of this survey in 2010, the 2007 LEMAS data, including the agencies sampled, was not yet to be made available.

There are limits to this sampling approach, which should be considered in the interpretation of the results below. First, we used the LEMAS 2003 data because we wanted to connect information about technological traits of organizations to our sample, which are only found in the LEMAS. However, because the 2007 LEMAS was still unavailable at the time of conducting this study, the sample is drawn from an older survey. The information presented below in table 2.4, for example, should be interpreted as traits agencies that have and do not have LPR now, had in 2003. More explanation is given below. Second, given the limited resources for this portion of this project, we limited our sample size target to 200 agencies. However, given that there are approximately 18,000 law enforcement agencies in the U.S. (over 1,000 with 100 or more sworn officers), the statistical power of our test is limited as the confidence intervals are large. Caution should therefore be taken in the interpretation of these results.

As compared to the overall LEMAS large and small agency populations, our selected sample showed no significant differences in terms of agency size, population served, or type of agency. Table 2.1 depicts the mean agency size and jurisdiction population in our selected sample of agencies as compared to the overall LEMAS populations divided into the large and small agency groupings.[7]

Table 2.1: Mean number of sworn officers and population served in agencies samples

	SMALL		LARGE*	
	Agency size	**Population served**	**Agency size**	**Population served**
Our sample	27	17,032	416	343,126
LEMAS	27	24,768	432	413,731

* The differences between small and large agencies were non-significant at the .05 level using a two-tailed t-test.

Table 2.2 depicts the types of agencies (large and small) in our sample compared to the LEMAS. Our small agency sample contained a larger proportion of municipal police agencies and a smaller proportion of sheriff's agencies than the LEMAS small agency sample, and this difference was statistically significant at the .05 level. In our sampling of agencies, we excluded those sheriff's agencies that did not have law enforcement functions that would necessitate the use of license plate readers, which may have caused

[7] A note to the reader: In our random sampling, we happened to select the New York City Police Department (NYPD), which is significantly larger than all other agencies in LEMAS. However, whether we include or exclude NYPD in our comparisons, the differences between our sample and the overall LEMAS data remained non-significant.

these differences. No significant differences were found between our sample and LEMAS in the large agency category.

Table 2.2: Comparison of large and small agencies in LEMAS and sample

	SMALL		LARGE	
	Our sample	**LEMAS**	**Our sample**	**LEMAS**
Municipal Police	80 (80%)**	1,363 (69.3%)	63 (63%)	526 (59%)
Sheriff	19 (19%) **	582 (29.6%)	33 (33%)	281 (31.5%)
Tribal Police	1 (1%)	15 (.8%)	0 (0%)	2 (.2%)
State Agency	0 (0%)	0 (0%)	2 (2%)	49 (5.5%)
County Police	0 (0%)	6 (.3%)	2 (2%)	33 (3.7%)
Regional Police	0 (0%)	2 (.1%)	0 (0%)	0 (0%)

**Differences in proportions are significant at the .05 level.

The Survey Instrument and Data Collection Methodology

The survey instrument is included as Appendix A and consists of two sections, both of which were given to all selected agencies. If agencies did not use LPR technology at the time of the survey, they were instructed to complete only the first section, which consisted of two questions: (1) whether the agency was interested in acquiring the systems, and (2) the types of concerns that the agency associated with the purchase and use of LPR. Agencies were offered a range of answer choices reflecting potential concerns, including the cost of the system, the availability of data for the system, the operational demands of the system, and the legitimacy concerns associated with the system.

If agencies did use LPR systems, they were instructed to answer only the second section of the survey. This section had 10 questions: five related to the operational uses of LPR and five related to legitimacy concerns associated with the system. Questions related to the use of LPR addressed the agency's funding source for the system, the number of LPR units the agency had acquired, the system's vendor, the types of uses (including operator, place of use, platform for the device, and amount of time during the day that the system was used), and whether or not the agency had conducted an evaluation of the system's effectiveness. Questions related to the legitimacy of the system addressed the agency's preparations for the use of the system, the agency's concerns regarding potential legal challenges related to the system, the public's concerns about the use of the system (if any had been expressed to the agency), and any legal challenges experienced by the agency regarding its use of LPR.

To maximize our response rate, we used multiple survey methods to contact agencies, to distribute the survey, and to obtain responses. These included email, telephone, fax, regular U.S. postal service, and an online submission system. Our initial contact occurred on July 14, 2009 and by September 20, 2009, four rounds of contact efforts were conducted. We began by contacting the chief, commissioner, or other chief executive officer of the agency; this individual either answered the survey him/herself (29% of our surveys were directly answered by the head of an agency) or passed it along to an individual familiar with the agency's LPR, patrol, or traffic enforcement functions. The response rate for this survey at the time of this report was 84.5% (n=169). Roughly, the same proportion of small (82%) and large agencies (87%) responded to our survey.[8]

The Survey Results

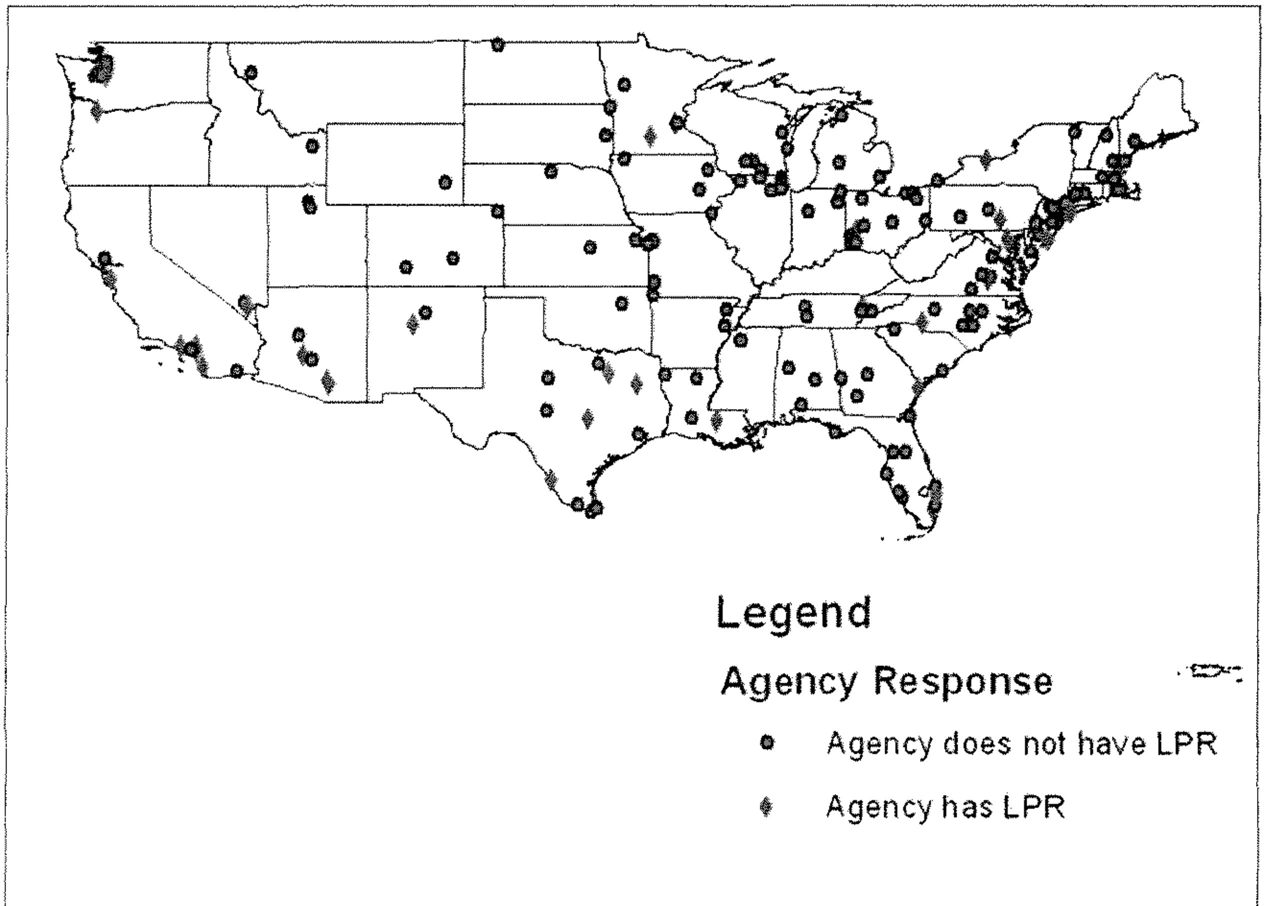
PREVALENCE AND FREQUENCY OF LPR USE IN THE UNITED STATES

Figure 2.1 shows the geographic distribution of the respondents, coded by LPR use.[9] The geographic location of responding and non-responding agencies was fairly dispersed; no particular region had a significantly higher or lower rate of response than the average response rate of the sample. When comparing agency size and population served between those who responded and those who did not respond, no significant differences were noted.

[8] Interestingly, although the non-response proportion of our sample from small agencies and large agencies was similar, the relative size of agencies that did not respond within each grouping tended to be larger.

[9] No police agency in Hawaii or the District of Columbia was randomly selected during the sampling process.

Figure 2.1: Geographic distribution of survey responses



*Anchorage, Alaska, Police Department had just acquired LPR and responded as an agency that did not use LPR.

Table 2.3 shows the distribution of LPR use between small and large agencies who responded to our survey. The larger agencies were more likely to have access to and use LPR systems than the smaller ones (37% of large agencies as compared with less than 4% of smaller agencies). This was consistent with the PERF technology study, which found a similar prevalence of LPR use (38.1%) among member agencies with 100 or more sworn officers (see Koper et al., 2009). Additionally, our survey discovered a significant interest in license plate reader technology among agencies more generally, speaking to the possibility of its further rapid diffusion. Twenty-one non-use agencies (16 of which were large agencies) that responded that they did not have LPR indicated that they planned to obtain this technology in the next 12 months. Thus, by the time of the printing of this report, over 50% of large agencies, and almost 10% of small departments are estimated to have acquired LPR or have access to it.

Table 2.3: Distribution of LPR use among large and small police agencies

	Small Agencies (n=82)	Large Agencies (n=87)
Use LPR	3 (3.7%)	32 (36.8%)
Do not use LPR	79 (96.3%)	55 (63.2%)

Of the 35 agencies in our sample that responded that they currently use LPR, the vast majority (85.7%) used four or fewer LPR devices. Most of these agencies received funding for LPR systems through state or federal grant programs, although a significant number (10 agencies) used asset forfeiture funds, resources from private vehicle insurance companies, and other non-grant or agency budgetary sources to purchase LPR systems. It is clear the diffusion of this technology seems supported by external funding sources.

This technological diffusion strengthens the case for more scientific evaluations of the effect of LPR and other police technologies. Like many police-adopted technologies, acquiring LPR has been based less on scientific research about its connection to crime reduction and more on other factors and assumptions. But rapid diffusion into a low-information environment can also contribute to misuse and waste. Thus, ***this rapid diffusion should not be interpreted as making the case for continued acquisition of LPR, but rather, as establishing a more pressing need for more information about the effects and effectiveness of LPR.***

CHARACTERISTICS OF LARGE AGENCIES BY LPR USAGE

Because only three agencies within our small agency sample responded that they used LPR, we focus this section on the differences between organizational and jurisdictional aspects of large agencies that do and do not use license plate readers. Table 2.4 depicts characteristics of large agencies in the sample according to their LPR use and their various organizational characteristics from the 2003 LEMAS. We included a number of agency characteristics that might indicate a level of technological sophistication that may support LPR systems. These include mobile computer units, computerized crime mapping/analysis, or the access to motor vehicle records and interagency information systems.

Table 2.4: Characteristics of large agencies (≥ 100) with and without LPR[10]

	Use LPR (n=30)	Do not use LPR (n=53)	t test
Mean size of agency	498	211	**2.968****
Mean population served	287,269	187,645	**2.175****
% with crime analysis	80%	68%	1.176
% that have any mobile computer units	87%	79%	.838
% with computerized crime mapping	63%	56%	.593
% that do hot spot identification	53%	42%	1.033
Have access to motor vehicle records	73%	75%	-.213
Have access to inter-agency information system	37%	53%	-1.418
Surveyed public satisfaction with police services	50%	43%	.716
Did not survey public	47%	51%	-0.228

*p<.05

As previously mentioned, it is important to interpret this information as the traits that an agency had in 2003 who have (or do not have) LPR *today*. Some of variables are likely to be similar now (such as size of agency and mean population served). But with regards to technological traits that change rapidly, the information here should be interpreted within a diffusion of innovations context (see Rogers, 1995; Weisburd and Lum, 2005). For example, LPR as a mobile computer technology might rely on the prior implementation (as reflected in the 2003 LEMAS) of other technologies to make easier the acceptance and use of LPR today. Because the Bureau of Justice Statistics has not made available the results of the LEMAS 2007, this perspective should be taken with Table 2.4.

Table 2.4 indicates that agency size matters. This makes sense given that larger agencies are likely to exist in places with greater traffic related responsibilities and auto-related crimes. Larger agencies can more likely afford the maintenance and support of this

[10] The NYPD, which has adopted LPR, was excluded from this analysis, as it is an outlier. Further, in 2007, the LEMAS survey asked agencies if they had specialized auto theft units. Had this data been available in 2003, it would have been a useful addition to this table, as we discovered a large proportion of agencies that used LPR had specialized units that employed them. Anchorage PD and two state police departments were excluded for response type (Anchorage PD has LPR but responded as if it did not), and the lack of comparability in population served (the two state police departments' "population served" was the entire population of the state).

technology or more readily articulate needs when LPR proposals are solicited by federal grant providers. Although these differences were not statistically significant, agencies with LPR were more likely to use mobile computer technology and crime analysis, both which can be used to support LPR use.

However, agencies that currently use or do not use LPR did not differ on other traits in 2003. Both types of agencies were similar in terms of computerized crime mapping use and hot spot identification. They were equally likely to have high levels of access to motor vehicle records and lower levels of access to interagency information sharing systems. LPR and non-LPR agencies were also similar in their survey outreach to the public.

HOW LPR SYSTEMS ARE USED

For those agencies in our sample that used LPR (n=35), the most common function of LPR was detecting stolen motor vehicles and license plates (91%) and also motor vehicle violations (40%) as Table 2.5 indicates. We previously labeled this type of data connection to LPR as "primary" (see also the "continuum of uses" in Chapter 4) because it involves scanning vehicle plates directly and comparing them to a single database concerning the status of those plates (and the cars attached to them).

Table 2.5: Types of Uses for LPR

	%
Detect stolen vehicles or tags	91.4%
Detect motor vehicle violations (expired registration, unpaid tickets, etc.)	40.0%
Connect licenses to a secondary database (sex offender registry, child support, warrants) for further investigation	40.0%
Monitor or record vehicles entering high-crime locations	22.9%
Monitor security in high-risk locations (government buildings, key infrastructure)	17.1%
Other	11.4%

"Secondary" data connection with LPR—i.e., connecting license plates to non-vehicular data to alert officers to other types of offenses or risks of the owners of vehicles—was also employed by 40% of agencies. It should be noted that this was a common practice prior to LPR use and involved officers calling into the dispatch or typing a tag into their mobile computer units, finding the name of its registered owner, and then running that name against another database. These might include connecting registered owners to their open warrants, violations of child support, convicted sex offender registries, or those found guilty of selling drugs around schools. Between 17 and 23 percent of agencies using LPR also noted that they use readers for other purposes, including monitoring of high risk/crime locations.

The frequency of LPR use varies, with 40% of agencies turning them on and off for a few hours or for a shift. However, in a quarter of the agencies that use LPR, at least one device is left on at all times (Table 2.6).

Table 2.6: Daily frequency of use

	%
Devices are turned on and off during the shift for a few hours	40.0%
At least one device is always in operation 24 hours a day, 7 days a week	25.7%
Devices are turned on at an ad-hoc basis for specific operational purposes	22.9%
Other	25.7%

Tables 2.7 and 2.8 show that the primary user of LPR systems is a uniformed patrol officer in a marked patrol unit. The vast majority of agencies who use LPR do not use them in an undercover capacity. Agencies most frequently mounted systems on marked police vehicles (83%) and then on unmarked vehicles (40%). The use of fixed LPR systems or LPR systems integrated into a suite of electronic surveillance systems was relatively rare.

Table 2.7: Location of LPR Unit

	%
Devices are mounted on marked police vehicles	82.9%
Devices are mounted on unmarked vehicles	40.0%
Devices are mounted at fixed positions along highways or other traffic areas	5.7%

Table 2.8: Operator of LPR Unit

	%
Uniformed officers in general patrol	77.1%
Officers who are a part of a LPR-dedicated or specialized unit	34.3%
Civilian and non-sworn agency employees	0.5%
Personnel in a command center	0.5%
Other	2.0%

DO POLICE AGENCIES EVALUATE THEIR LPR USE?

It is uncommon for police agencies to conduct outcome evaluations of their operations using rigorous evaluation methods. The same is even truer of police technologies like LPR. Lum, Koper and Telep (ONLINE FIRST, 2010), in their Matrix on policing evaluations show no evaluations or police technology with respect to crime outcomes prior to the PERF and GMU studies. Most agencies only evaluate the process of tactics or the efficiency of technologies, concluding "success" if an arrest is made or if the technology works faster. Of the 35 agencies that use LPR, only five (four large and one small) conducted any type of assessment of LPR use, and none conducted impact evaluations.

LAW ENFORCEMENT CONCERNS ASSOCIATED WITH LPR

Our literature review revealed at least some degree of public discourse and concern about license plate reader systems. Because such technologies can quickly connect a visible identification number (license plate) with information about the vehicle and the driver, these systems have provoked debates and discussions about data security and privacy. Therefore, understanding the concerns of citizens may assist law enforcement agencies in their decision to adopt this technology.

For those agencies that already use license plate reader technology, we gauged concerns about system legitimacy in two ways. First, we asked agencies how they prepared themselves to obtain and use LPR. This question allowed us to understand the process of planning to use LPR in terms of both technical preparation and preparation for concerns that citizen or community groups might raise. Second, we asked agencies to indicate their concerns with acquiring LPR. Table 2.9 reports the types of preparations carried out by agencies using LPR.

Table 2.9: Agencies With LPR: Preparations for LPR technology

	%
Reviewed research on LPR technology	77.1%
Attended a demonstration of the technology by the manufacturer or vendor	77.1%
Consulted with another police agency regarding the use of LPR or attended an LPR training session hosted by another agency	60.0%
Announced the use of the technology through press release or other media campaign	42.9%
Upgraded computer / information technology to accommodate LPR technology needs	42.9%
Consulted with the agency's attorney or researched the legal implications of the technology	42.9%
Created standard operating procedures for the use of LPR	40.0%
Created or collected the data to be used by the LPR system	20.0%
Consulted with community leaders on the implementation of the technology	14.3%
Conducted a needs assessment for the use of LPR	5.7%
Other	2.8%

Most of the preparation for the acquisition of license plate readers focused on understanding the technology through reviewing the literature and attending demonstrations by manufacturers. Consultation with other agencies was also a regular practice, which adds salience to Weisburd and Lum's (2005) finding regarding the influence of early adopters in the diffusion of police technologies. Upgrading existing technology to accommodate LPR was also somewhat important to technology acquisition, as was creating standard operating procedures for how to use them.

Interestingly, preparing for legal or community-based ramifications was less of a concern for police agencies. The most common type of preparation with the community was in the form of media releases or campaigns to inform the community of LPR acquisition. Approximately 43% agencies consulted the agency attorney regarding possible legal challenges to the use of the system or conducted some sort of research on the legal implications of LPR use. Agencies less frequently consulted with community leaders (14%), and only 6% of agencies who responded conducted a needs assessment on the technology itself.

Table 2.10 shows the results of the concerns that agencies, regardless of whether they used LPR, had with license plate readers more generally (agencies were asked to check all which applied). Table 2.10 indicates the proportion of agencies that checked the specific concern listed. As the survey in Appendix A indicates, we asked slightly different sets of questions to those who did and who did not have LPR, which is why just the proportions are listed here, rather than testing for differences between those with and without LPR. The "N/A" denotes those questions that were relevant to one group and not the other.

Table 2.10: Agency concerns related to LPR

	Use LPR	Do not use LPR
Cost of technology or ongoing maintenance	54.3%	29.9%
Concerns about technological problems with LPR systems	22.9%	4.5%
Potential for legal or privacy concerns	17.1%	1.5%
Concerns about vandalism of LPR units	11.4%	N/A
Lack of familiarity with LPR systems	11.4%	23.9%
Concerns about driver distraction when using LPR in police vehicles	8.6%	5.2%
Not enough information on the benefits or best practices associated with LPR technology	5.7%	20.1%
Concerns about misuse or hacking of data stored in LPR database	5.7%	3.7%
Concerns about complaints from citizens or community groups	5.7%	3.0%
Other	0.0%	12.7%
Lack of outside funding available to purchase LPR systems	N/A	46.3%
Agency is focused on other priorities	N/A	37.3%
Data files or downloads are not available to support LPR technology	N/A	9.0%

Cost of the technology and its ongoing maintenance was one of the concerns most frequently cited by agencies in our sample that already acquired LPR. This result is mirrored in the sample of agencies without LPR in terms of concerns about maintenance costs and funding the purchase of LPR systems. The responses in Table 10 also indicate a tendency for both types of agencies to be concerned with technological problems, lack of familiarity with the system, and lack of information about its effectiveness and use/best practices, which is mirrored in the evaluation literature as well (the lack of an evidence-base for LPRs).

Finally, of interest in these findings is that agencies that do not use LPR are less concerned about privacy or legal issues related to LPR systems than those that do use the system. Even more interesting is that many more agencies identified concerns related to privacy and legality as more significant than concerns about complaints from citizens or community groups. When we asked agencies if they had received complaints from citizens or community groups about LPR, seven of the agencies surveyed had experienced some sort of challenge to their use of LPR, either by voiced concerns by citizen groups (five agencies) or by legal challenges to the use of the system (two agencies). Neither of the two agencies who faced legal challenges had made legal preparations prior to beginning to use LPR technology. Overall, however, the vast majority of agencies did not indicate concerns regarding either legal/privacy issues or community issues. Even when one potential privacy issue was framed in a slightly different manner—as a potential concern about "misuse or hacking of data"—very few agencies responded that this was a concern.

Conclusions

Given that our sample of 200 agencies is small compared to the total population of small and large police agencies in the U.S., these findings should be taken cautiously. However, the findings do suggest important considerations for the study, acquisition, and use of LPR technology. LPRs are rapidly diffusing to police agencies throughout the United States. We estimate from our study that over a third of all large police agencies already use LPR systems and that at least 30% of the large agencies that don't have LPR now will be acquiring this technology within the next 12 months. The primary use of LPR systems has been exactly what they were initially intended for—to detect and reduce auto theft. Because of this, it is not surprising that while agencies are sometimes concerned with privacy or community complaints regarding the use of this technology, it appears the greatest concerns center on costs and mechanical maintenance problems.

However, the national survey also reveals interesting nuances about the prevalence, use, and concerns associated with license plate readers. First, there is a disconnect between the rapid diffusion of this innovation and the lack of concern about its outcome effectiveness. Very few agencies have actually assessed LPR and none has conducted even a moderately rigorous impact evaluation of its use. Furthermore, we learned the primary use of LPR is with mobile, uniformed patrol. This finding is important when building operational policies about its use. We now turn to the next section, which will explore this issue.

3. THE IMPACT EVALUATION

A TWO-JURISDICTION RANDOMIZED CONTROLLED EXPERIMENT

Overview: *In this chapter, we present the methodology and results of a randomized controlled experiment evaluating the general and specific deterrent effects of license plate reader hot-spot patrol on levels of crime in hot spots. These experiments were conducted in partnership with the Alexandria Police Department (APD) and the Fairfax County Police Department (FCPD), two Northern Virginia Police Departments in the Washington, DC, metropolitan region. This study adds to the first LPR experiments by the Police Executive Research Forum (PERF) in two ways: First, this experiment provides the opportunity to compare 15 randomly selected hot spots that received LPR patrol across two border-sharing jurisdictions with 15 hot spots that did not. Second, we used an intervention that combines a tailored approach with the Koper Curve timing principle (see Koper, 1995). Findings, lessons learned, and advice to agencies are detailed.*

Evaluating the Effectiveness of License Plate Readers

Law enforcement agencies and their chief executives are becoming more and more responsible for proactively *reducing* and *preventing* crime, not just detecting and reactively responding to 911 calls. Thus, outcome measures of deterrence and prevention, rather than arrest or response time, have become just as, if not more, important performance measures for the police. The effectiveness of LPRs relies not only on detecting and responding to auto thefts but also on its ability to prevent and deter those crimes (and others) more generally.

In Section 1, we emphasized the difference between assessing the efficiency and effectiveness of license plate readers: LPR may be more efficient and faster in scanning plates and matching them to a database, but without outcome evaluations we do not know whether this scanning technology is more effective in reducing and preventing crime. This is a key distinction for law enforcement agencies seeking to optimize the effectiveness of LPR (or any technology) use. *Even if more arrests are made*, the most accurate LPR systems can lead to little change in crime problems if they target places with low probability of crime, if there is limited reference data for the LPR unit to scan plates against, or if they are not used in ways that maximize their effects.

The effectiveness of LPR is also important when considering whether to invest in the technology. Readers can range from between $20,000 to $25,000 per unit, representing a significant burden to agency budgets. Additionally, there are costs for training, maintenance, and adapting existing information and technology to the units. Consequently, agencies with LPR units but without matching crime reduction or prevention effects may fail

"Even if more arrests are made, the most accurate LPR systems can lead to little change in crime problems if they target places with low probability of crime, if there is limited reference data for the LPR unit to scan plates against, or if they are not used in ways that maximize their effects."

to convince either government funders or the public of the need for such technology for their agency.

The results of the national survey in Section 2 emphasized the importance of considering effectiveness and costs. LPR is rapidly diffusing into a "low-information environment." There is little evidence on whether readers are effective in preventing crime or on the nature of LPR's impact on police legitimacy with the community. However, our agency survey indicates that police executives are very much concerned with not only the impact of LPR use on crime, but on citizen privacy and police legitimacy.

Given these concerns, in this chapter we report on our evaluation of the crime prevention effects of LPR, and in the next chapter, our findings about community concerns. Similar to and with the consultation of the PERF team (see Taylor, Koper and Woods, 2010), we examine the crime control impact of license plate readers on crime using the "gold standard" of evaluation research—a randomized controlled field experiment. We replicated PERF's efforts in Mesa, AZ, with some similarities and some differences. First, we test for the specific deterrent effects that LPR deployment has on vehicle theft, theft from auto, and other auto-related crimes (i.e., driving while intoxicated and reckless driving) as well as LPR's general deterrence effects on crime and disorder. To do this, we identified hot spots of auto theft in both jurisdictions and then randomly allocated a specific type of LPR deployment (discussed in detail below) in half of all hot spots across two jurisdictions in order to test whether that deployment yields a deterrent effect.

This study is a randomized controlled trial of the effects of LPR use at auto crime hot spots in two adjacent jurisdictions in the Washington, D.C. area. Crime, especially car theft, moves seamlessly across boundaries in the Washington, DC, metropolitan region; it is common for cars to be stolen and recovered in two separate states, counties, or cities. By conducting a multi-jurisdiction approach, we wanted to determine if such an operation could be conducted, both in research and in practice. We also used an intervention that included a combination of "sweeping" hot spots by the LPR unit and then "sitting" at key areas after the initial sweep. We asked officers to follow the Koper Curve principle by reducing the time officers were asked to stay in one hot spot to 30 minutes.[11]

While results show no statistically significant reductions on crime in experimental hot spots, we hypothesize this could be due to the weak intensity of the intervention, given the availability of LPR units for our study. However, this may also be due to a lack of effect. For example, compared with other manual, non-LPR hot-spot approaches, the PERF research team in Taylor et al. (2010) also did not discover significant reductions in crime in experimental hot spots. We detail how future assessments might be conducted given enough resources and provide ideas about evidence-based deployment strategies using existing LPR technologies. We encourage officers, first-line supervisors, and command staff to visit the George Mason University LPR Web Portal,[12] where we convert much of this and other information into usable deployment guides, including tips by officers and command staff from our partner police agencies, video demonstrations, slide shows, and links to other agencies that are also studying and providing useful information (e.g., PERF, IACP, and the National Policing Improvement Agency [NPIA] in the United Kingdom). Given what seems to be the inevitable adoption of LPRs by at least medium to large jurisdictions, finding the right and legitimate way of using LPRs to yield a crime prevention advantage is an important goal for this study.

The Tested Intervention: What is the Optimal Deployment of LPR?

Although police technologies can be evaluated in many ways, action research is most useful and valid when the strongest methods of evaluation are used to test the most optimal deployment of that technology. Concerning methods, testing LPR on comparable places with and without the intervention is needed in order to ensure that results are believable (and not due to chance, selection bias, or other coincidences). With regard to optimal deployment, we should test the effects of LPR in places with high probability of crime in ways that reflect the most likely user and that use the most effective tactics. Further, researchers also have to consider the resources available for evaluation; using those resources wisely is important in the researcher-practitioner relationship.

At the same time, there is a lack of an evidence base for LPR technology that presents guidance on what is the most effective deployment of LPR units as we discussed in Chapter 1. In the absence of such information, the next-best option is to look at the evidence base of police practices more generally. This evidence base may provide clues to the best possible approach for deployment that will likely lead to the most positive results *based on scientific research and evidence* as opposed to best guesses, hunches, or hopes (Lum, 2009; Sherman, 1998). An evidence-based approach is an alternative to a "best practices" one,

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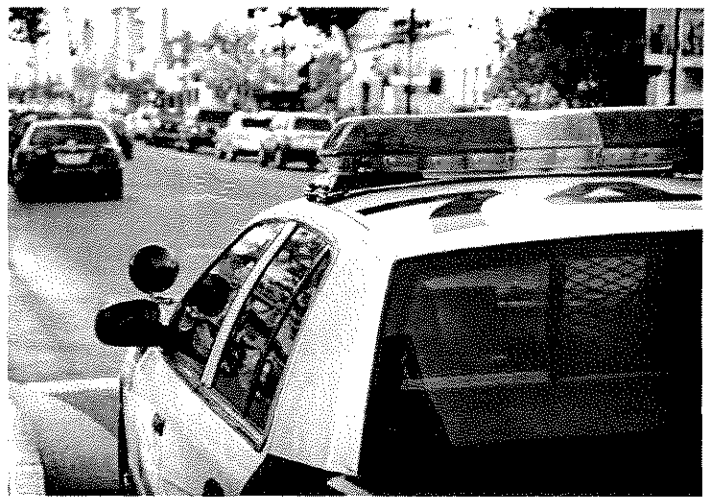
[11] In the PERF experiments, officers stayed in hot spots for about 1 hour.

[12] See http://gemini.gmu.edu/cebcp/LPR/index.html

which is based on an experience or consensus rather than on evaluation and systematically collected and analyzed information.

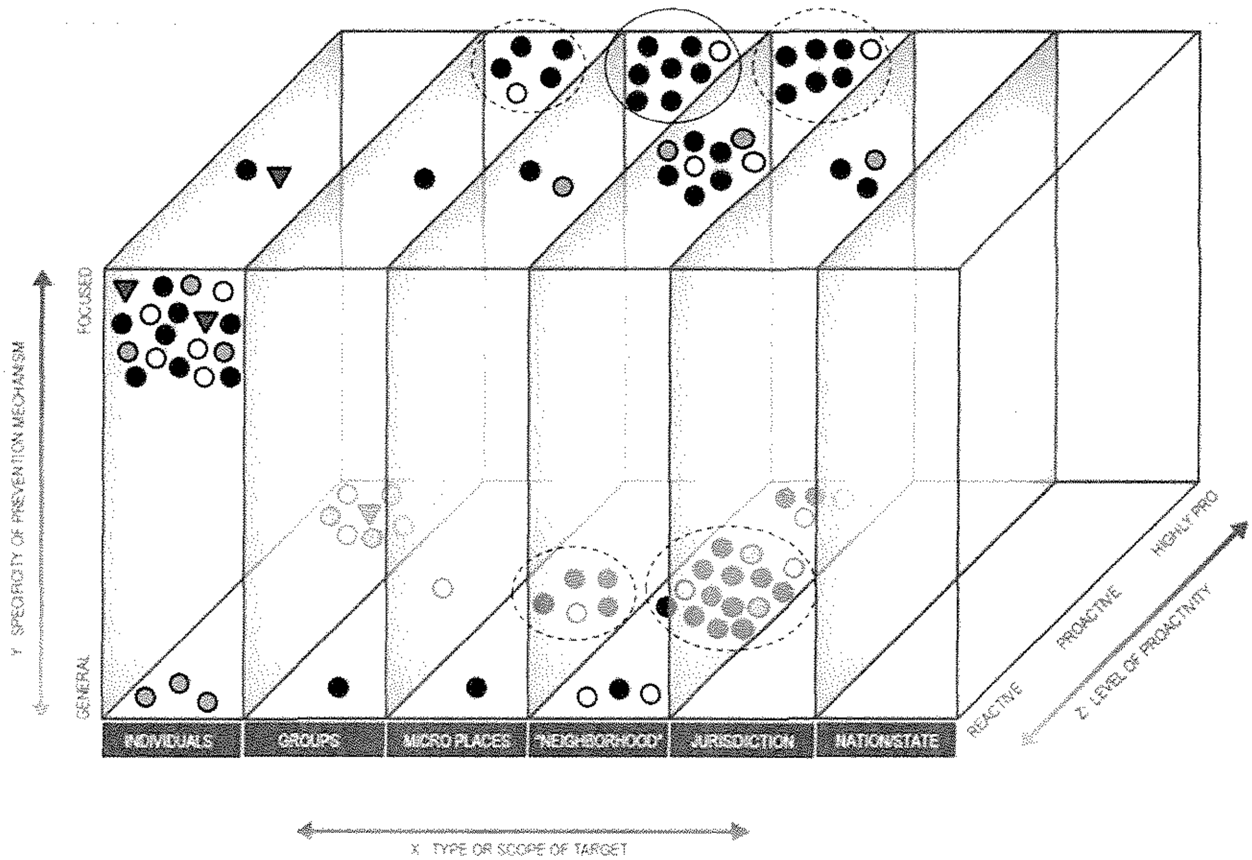
Fortunately, there is existing evidence concerning many police tactics and strategies (see reviews of this research by the National Research Council, 2004; Sherman et al., 1997; Sherman et al., 2002; Weisburd and Eck, 2004). Further, there have also been a number of Campbell systematic reviews and meta-analyses[13] of law enforcement strategies and tactics that guide police agencies on what works to reduce crime. These have included hot-spot policing, neighborhood patrol, second-responder policing, policing guns, counterterrorism, drug enforcement, and problem-oriented policing (see Bennett et al. 2008; Braga 2007; Davis et al. 2008; Koper and Mayo-Wilson 2006; Lum et al. 2006; Mazerolle et al. 2007; Weisburd et al. 2008).



Recently, Lum, Koper, and Telep (2009; ONLINE FIRST, 2010) have developed a translation tool for this entire field of rigorous police research. It is known as the ***Evidence-Based Policing Matrix*** shown in Figure 3.1 and is available online.[14] As defined by its creators, the Matrix "is a research-to-practice translation tool that categorizes and visualizes all experimental and quasi-experimental research on police and crime reduction according to three common dimensions of crime prevention—the nature of the target, the extent to which the strategy is proactive or reactive, and the specificity or generality of the strategy. This categorization and visualization of policing evaluation studies reveals three-dimensional clusters of effective studies, which we refer to as 'realms of effectiveness.' These realms of effectiveness provide insights into the nature and commonalities of effective police strategies and can be used by police agencies to guide various aspects of their operations." The Matrix currently houses all rigorous to highly rigorous police research through December 31, 2009, and is updated biannually.

[13] See http://www.campbellcollaboration.org/crime_and_justice/
[14] The Matrix is available for free at http://gemini.gmu.edu/cebcp/matrix.html

Figure 3.1: The Evidence-Based Policing Matrix (Lum, Koper, and Telep, 2009)



How is the Matrix applicable to designing LPR deployment? When police agencies deploy a new technology in patrol, they want to optimize the potential that technology will have by using it in the manner most likely to reduce crime. The Matrix shows clustering of effective studies, or "realms of effectiveness," at the intersection of three types of tactical approaches that show positive effects:

(1) tactics that target places, specifically, small areas of high concentrations of crime or "hot spots";

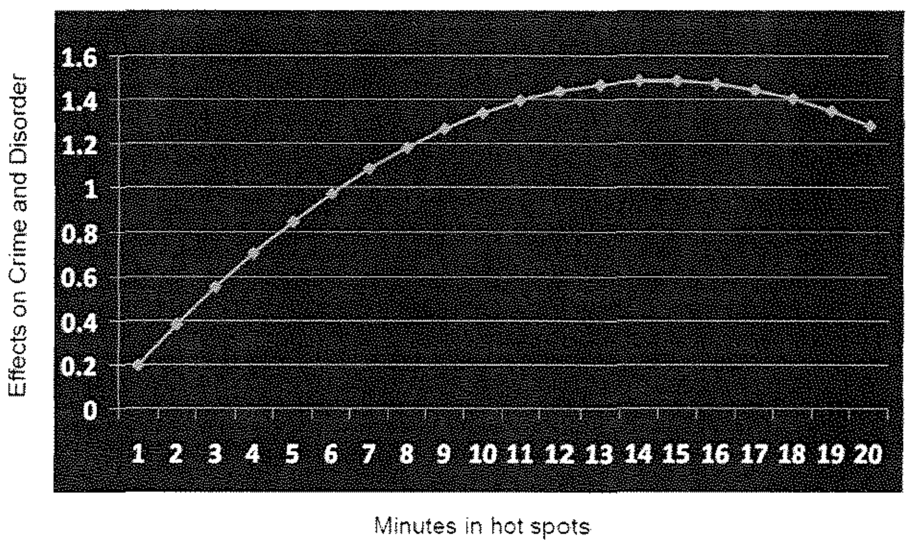
(2) tactics that are more proactive in nature, which use data and information to develop strategies to anticipate and prevent future crimes, or to address underlying causes of crime; and

(3) tactics that are more specific in their prevention mechanisms or more tailored to the problem at hand.

Thus, for LPR deployment, the current evidence in the Matrix suggests that the most optimal use of this technology would be to deploy it in small and clearly delineated crime hot spots, to use crime analysis and crime data to develop those hot spots, and to tailor a proactive approach (and also clearly articulate and supervise that approach) within these hot spots for the task at hand.

Existing research also provides clues on the ideal duration and extent of these deployment activities. The Koper Curve Principle as illustrated in Figure 3.2 (see Koper, 1995) states that the deterrent effect of hot spots policing is maximized when officers do not stay in hot spots for long periods of time. Not only can officers become bored and unmotivated by staying in a small hot spot for hours, but as Koper's research illustrates, there are diminishing marginal deterrence effects for each minute that an officer lingers in a hot spot after 12–15 minutes. In other words, to maximize the effectiveness of a hot-spot policing approach, officers should not stay in hot spots all day but rather move from hot spot to hot spot in a completely random fashion, staying for only a very short period of time.

Figure 3.2: The Koper Curve



The existing evidence also provides guidance about the type of tactics and strategies that might lead to greater crime prevention effects. For example, positive evaluations in the Matrix indicate that tailored, focused, and analytical approaches seem to have a greater effect on crime reduction and prevention than vague, general approaches (Weisburd and Eck, 2004). This could suggest that officers respond better to clear directives or tactics that are supported by tangible analysis.[15] With LPR, we hypothesized this type of tailored

[15] This stands in contrast to an intuitive approach to policing that is reliant on hunches and experience (see Bittner and Bayley, 1984; Sherman, 1984). These and other scholars, notably Goldstein (1979), advocate for more information and analysis to support officer discretion.

approach would be to "sweep" the small hot spot at least once for parked and moving vehicles that may create an alert and then, depending on the place, allow for an officer to exercise discretion to do what he or she felt worked best for that location. This approach was also used in the PERF experiment. In our study, this often meant strategically positioning officers' vehicles in certain locations in which the probability of a stolen vehicle passing by would be greatest (such as a busy intersection or a frequently used car park). We often called this combined approach a "sweep and sit" scheme, which is contrasted from just a "fixed location" use of LPR or a completely mobile use of LPR.

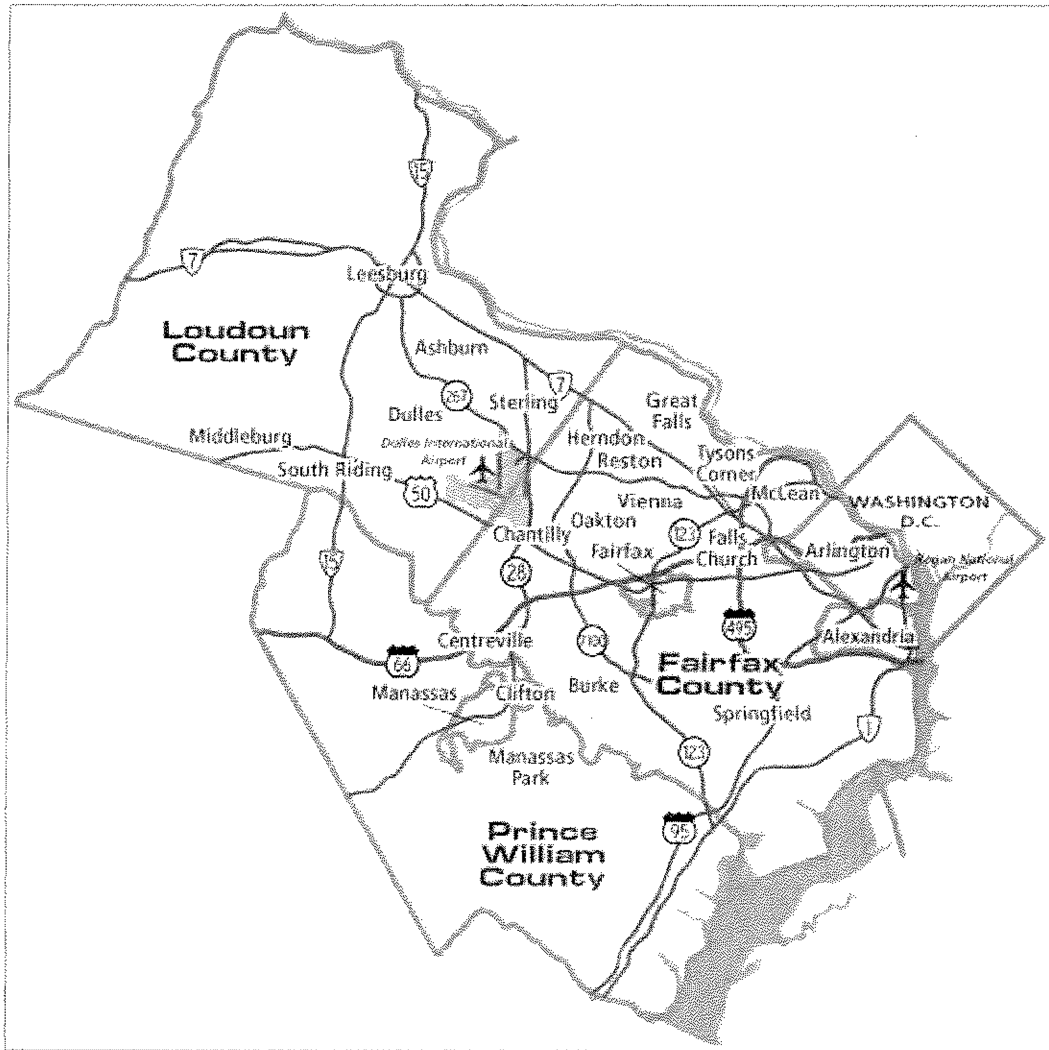
Thus, to test the effectiveness of LPR on crime, we created an intervention for our experimental hot spots that best reflected the existing evidence. *Specifically, we randomly assigned dedicated officers to experimental hot spots to conduct the sweep-and-discretion LPR intervention described above. During each shift, officers were also assigned multiple hot spots using a random allocation scheme. They were required to leave the hot spot after 30 minutes had elapsed and to move on to the next randomly allocated hot spot.*

Identifying Hot Spots for the Experiment

The adjacent jurisdictions used for this evaluation were Alexandria City and Fairfax County, Virginia. Fairfax County is one of the larger Northern Virginia suburban counties outside of Washington, D.C., where many individuals who work in the metropolitan D.C. area reside. According to the U.S. Census, it has a population of approximately 969,600 persons; approximately 59% are Caucasian, 10% are African American, 15% are Hispanic, and 17% are Asian. The County spans almost 400 square miles, with a population density of about 2,450 persons per square mile. The police department consists of approximately 1,370 sworn officers serving a well-educated community (over 50% of residents have a college education) with high home ownership rate (70%).

Alexandria City is a denser city immediately adjacent to the Washington, D.C.'s Southwest border. According to the U.S. Census, it has a population of approximately 150,000; approximately 56% are Caucasian, 22% are African American, 14% are Hispanic, and 5% are Asian. The City covers about 15 square miles, with a population density of about 8,552 persons per square mile. The police department consists of about 320 sworn officers serving a community that is very well educated (54% have a bachelor's degree or higher).

Figure 3.3: Northern Virginia Map



We used a two-step process to derive the hot spots used to test the effectiveness of LPR. These steps reflect both principles and theories of crime at places as well as practical crime prevention concerns. With regard to criminological theory, we wanted to create **hot spots that were small in size.** A number of place-based criminologists—notably, Sherman et al. (1989), Sherman and Weisburd (1995), Weisburd (2002; 2008), and Weisburd, Bernasco, & Bruinsma (2009)—have argued that the size of hot spots matter for both theory and practice. Specifically, there can be discernible patterns of crime – as well as areas without crime – within neighborhoods believed to be "dangerous". Patrolling larger geographic areas may actually be less efficacious in accurately targeting crime hot spots. Further, Weisburd, Bushway, Lum and Yang (2004) found that crime trends at very small and specific places are stable and often drive an entire city's crime rates. These findings have been supplemented by empirical evidence, which has strongly supported that when police direct their patrol to small, "micro" places of crime, they can have a significant crime prevention effect (Weisburd and Eck, 2004).

From a more practical, crime prevention standpoint (and in addition to empirical findings on hot spot policing), we also wanted to derive **hot spots which were environmentally meaningful.** It is not enough to rely only on geographic information systems to create hot spots based on crime data, even if we generate small hot spots. Once concentrations of crime are mapped, hot spots need to be individually inspected to reflect the goals of our intervention and the realities of policing. If computer-generated hot spots are too large, for example, a sweep-and-sit, Koper curve method may not be accomplished in 30 minutes or less. If computer-generated hot spot boundaries are not clearly delineated, officers may not know the exact location in which to patrol. Finally, computer-generated hot spots may not make environmental sense. Hot spots may be cut by rivers or train tracks or be blocked by geographic attributes that would make patrolling such an area difficult.

Below, we detail how we created our final hot spots for testing in this field experiment. By using GIS and statistical analysis to develop the hot spots, and then working with officers to refine the boundaries of the hot spots, we were better able to ensure the feasibility and meaningfulness of the intervention to officers and researchers.

STEP I: USING GIS TO IDENTIFY CRIME CONCENTRATIONS

To identify concentrations of crime to create our hot spots, we used ArcGIS,[16] a geographic information systems software, to map automobile theft data from both jurisdictions. ArcGIS uses a process called "geocoding" to convert the address field of each crime database into numerical latitude ("x") and longitude ("y") coordinates. Because crime data has many entry errors, such as spelling, spacing, or format, we used an interactive and recursive process of database cleaning and computerized mapping, so as to maximize the ability of ArcGIS to geocode as much of the crime data as possible. Each of the agencies involved had crime analysis units that assisted with the initial downloading and preliminary cleaning of this data. The final geocoding match rate of crime data addresses to x-y coordinates was 91.6% for FCPD and 99.5% for APD.[17]

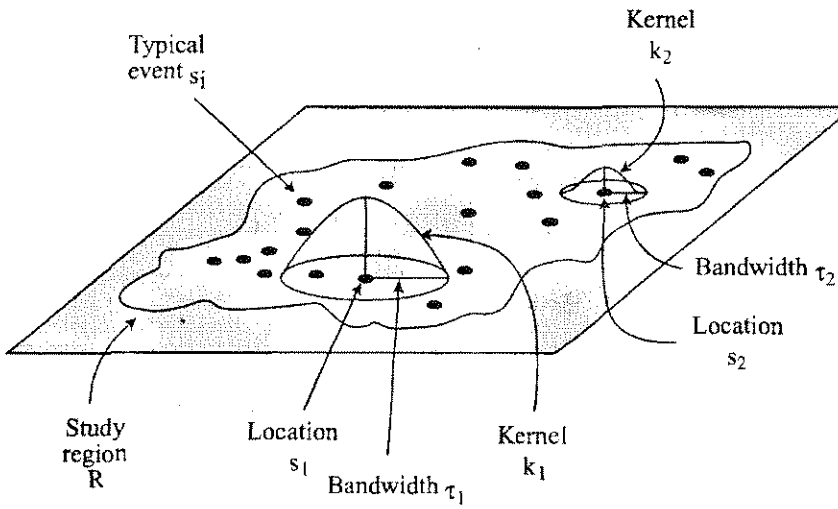
Once crimes were geocoded, exploratory spatial analysis was then run to develop hot spots. Exploratory spatial data analysis uses numerical coordinates to generate and analyze distributions of distances between crimes in a defined space. It includes point pattern analysis, such as kernel density analysis, and spatial statistical approaches such as nearest-neighbor analysis (Anselin et al., 2000). To develop our initial hot spots, we used kernel-density analysis, which creates both visualizations and associated descriptives about the crime density surrounding a point. Figure 3.4 shows a kernel density illustration

[16] ArcGIS is a product of the ESRI Corporation (see www.esri.com).

[17] The lower match rate for FCPD could reflect a number of factors, although we suspect it is due to FCPD's relative newness to crime analysis, mapping, and a new records management system. It may also be due to the varied and expanded geographic terrain of Fairfax County compared with Alexandria City.

(Bailey & Gatrell, 1995). Such visualizations are essentially statistical distributions of the concentration of points within the area starting from a point on a map to a distance or radius. These radii are called "bandwidths" and can be determined by ArcGIS default or manually adjusted by the analyst.

Figure 3.4: Kernel Density Illustration (from Bailey and Gatrell, 1995)



Source: Adapted from Bailey and Gatrell (1995).

To confirm hot spot diagnosis via Kernel Density results, we also created STAC hot spots through CrimeStat.[18] STAC hot spots were created for all crimes, auto thefts and theft from auto for both Alexandria City and Fairfax County. STAC analysis was run with settings of three, five, and 10 incidents per ¼, ½, and 1 mile. Thus, nine different STAC simulations were run for each study site in order to get the best picture of hot-spot distributions.

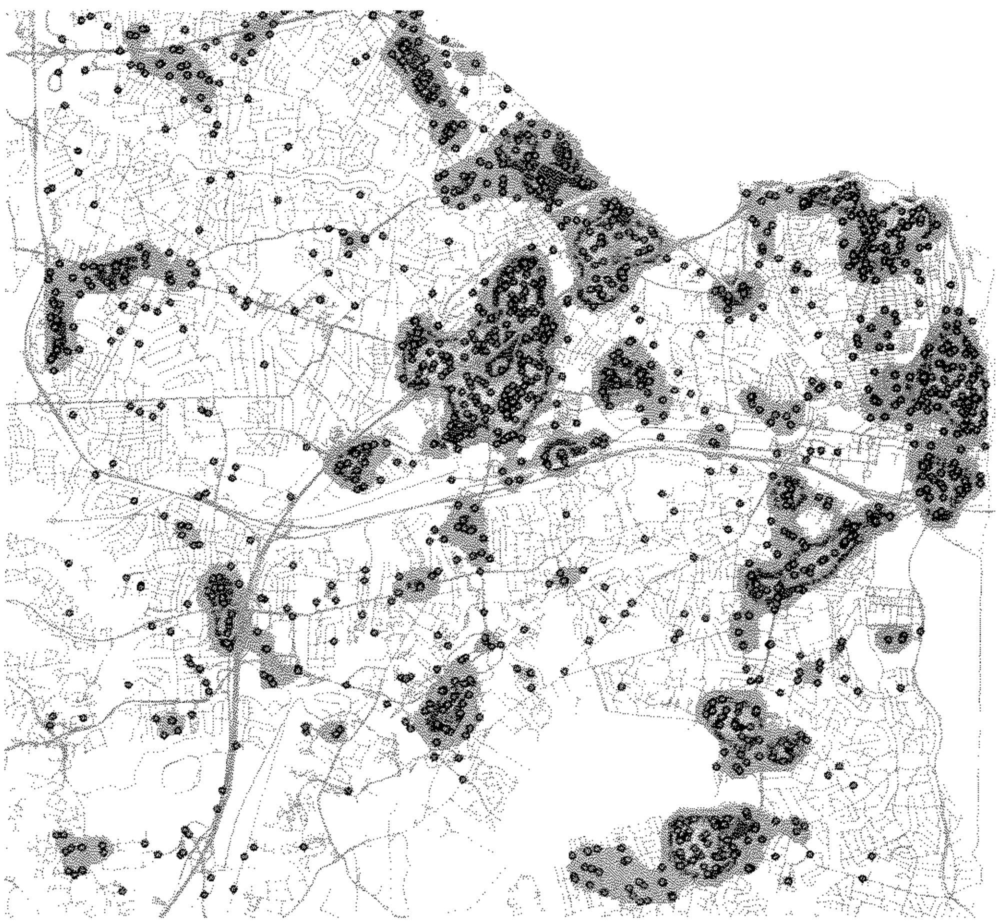
At this point, we then decided to narrow our study area to include all of Alexandria City and only the eastern portion of Fairfax County for several reasons. First, the auto theft and theft from auto incidents had high densities and clustering at the border areas of the two jurisdictions. Additionally, most of the auto-related incidents in Fairfax County fall within the Eastern half of the county, close to its border with Alexandria City. Last, by narrowing the focus of our study area, we were able to fine-tune our STAC and kernel density settings and analysis to better identify smaller, more micro-level auto-incident-

[18] CrimeStat is a free spatial analysis program available through the National Institute of Justice and the Inter-university Consortium for Political and Social Research (ICPSR). See http://www.icpsr.umich.edu/icpsrweb/CRIMESTAT/ for details on the program.

related hot spots for our experiment. We also decided to use only auto theft to identify the hot spots for LPR deployment in our final maps.[19]

After deciding on the new study area and types of crime to map, we merged the two jurisdictions into a single geographic database that represented our new dual-jurisdiction area. We then reran the kernel-density simulations using a search radius of 251.91 feet, and the STAC simulations (at ¼, ½, and 1 mile distances). Overall, reducing the total search area for hot spots resulted in much better representations of hot spots. What emerged is shown in Figure 3.5. The area delineated with the yellow border in the northeast corner of this map is Alexandria City, which is bordered to the west and south by Fairfax County.

Figure 3.5: Kernel Density Analysis of Auto Theft for January 1, 2008 Through September 15, 2009



[19] We did not include auto theft recovery data for either location, given that this information was not readily available for one of the two jurisdictions.

STEP 2: HOT-SPOT ADJUSTMENT WITH OFFICERS

Even with accurate mapping of clusters of crime using GIS, the problems with relying on these initial maps to deploy officers for hot-spot policing are many. First, the boundaries of hot spots are still vague, no matter what software (ArcGIS or STAC) is used. Spots may make statistical sense, such that number of crimes or the density of population within each area chosen are similar, but the hot spots may not make operational or environmental sense. For example, a hot spot can be divided by an environmental barrier (e.g., river, park, railway, business area) that is difficult to cross by either offenders or officers. Second, the hot spots have to be small enough for our intervention to be administered within 30 minutes, following the Koper Curve Principle.

More practically, if police delineate large areas that encompass both hot and cold areas, this could lead to not only an unnecessary spreading out of scarce resources but also a watering down of the effects in these areas. On the other hand, if departments are too specific in their hot spot identification, resources may also be used inefficiently, and officers can get bored with a hot-spot approach, especially if they are driving around the same small place. Hot-spot policing that is operationally meaningful must therefore be informed by not only place-based theories and spatial analysis but also environmental considerations and operational meaningfulness.

To strike this balance, we met with officers and supervisors from each agency who were familiar with these areas and readjusted each of the 40 identified hot spot by hand on paper maps. Once new boundaries were demarcated, they were digitally transferred back to ArcGIS so that the deployment and outcome measures within them could be detailed. The readjustment was based on three criteria:

1. hot spots had to be clearly delineated;
2. hot spots had to be small enough so that the sweep-and-sit approach could occur within 30 minutes; and
3. hot spots had to be environmentally "friendly," meaning that they could be crossed easily without major barriers that would obstruct officer movement and tactics.

Take, for example, Figures 3.6a and b. Figure 3.6a reflects an early hot spot that researchers identified from the GIS analysis. Boundaries were vague, cutting across streets and large intersections. While the spot seemed small and manageable, when we presented this hot spot to officers familiar with this area, this was believed not to be the case. Because of environmental barriers and density of cars in this area, the readjustment by officers, according to our deployment criteria, became two smaller and more specifically defined areas, shown in Figure 3.6b.

Figure 3.6a: Initial Hot Spot

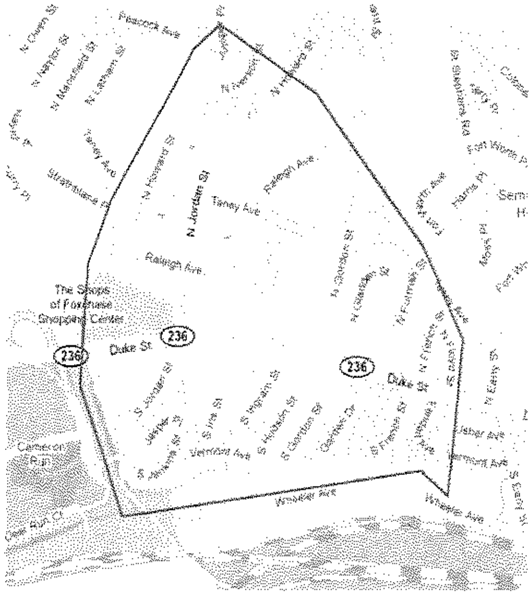
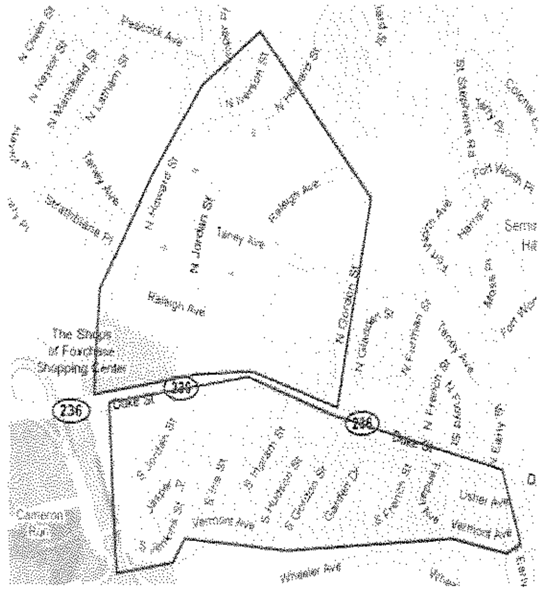
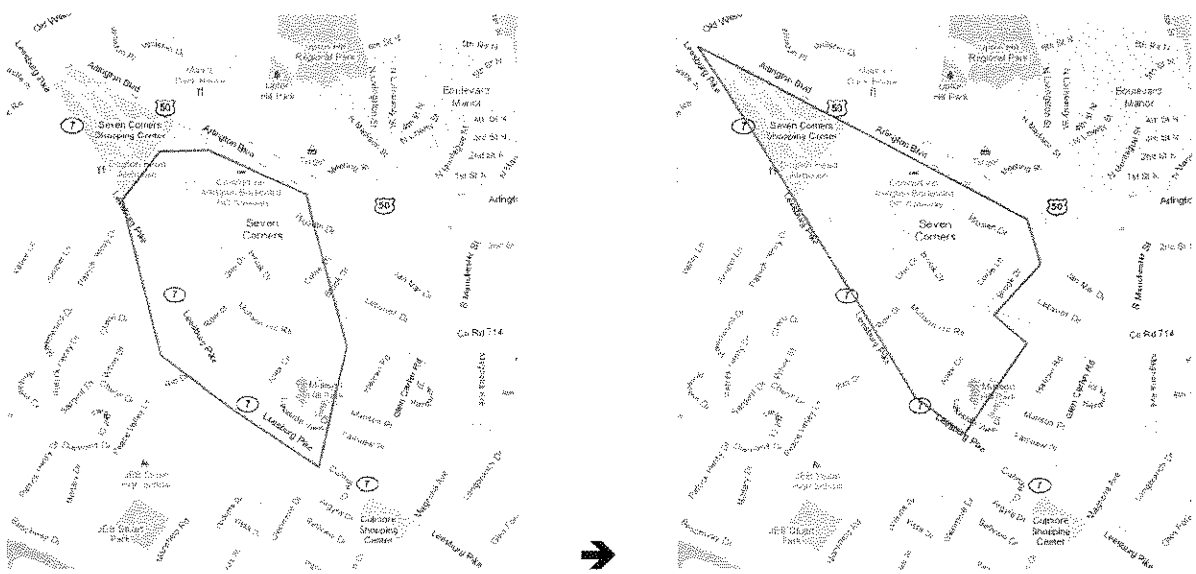


Figure 3.6b: The New Hot Spots



Officers argued that by splitting the hot spot in this way, they could carry out a "sweep-and-sit" technique within the 30 minutes allotted. The amount of sweeping and sitting time could vary at hot spots, and the GMU team did not set rigid requirements given the diversity of the hot spots developed. Another adjustment example can be seen in Figure 3.7.

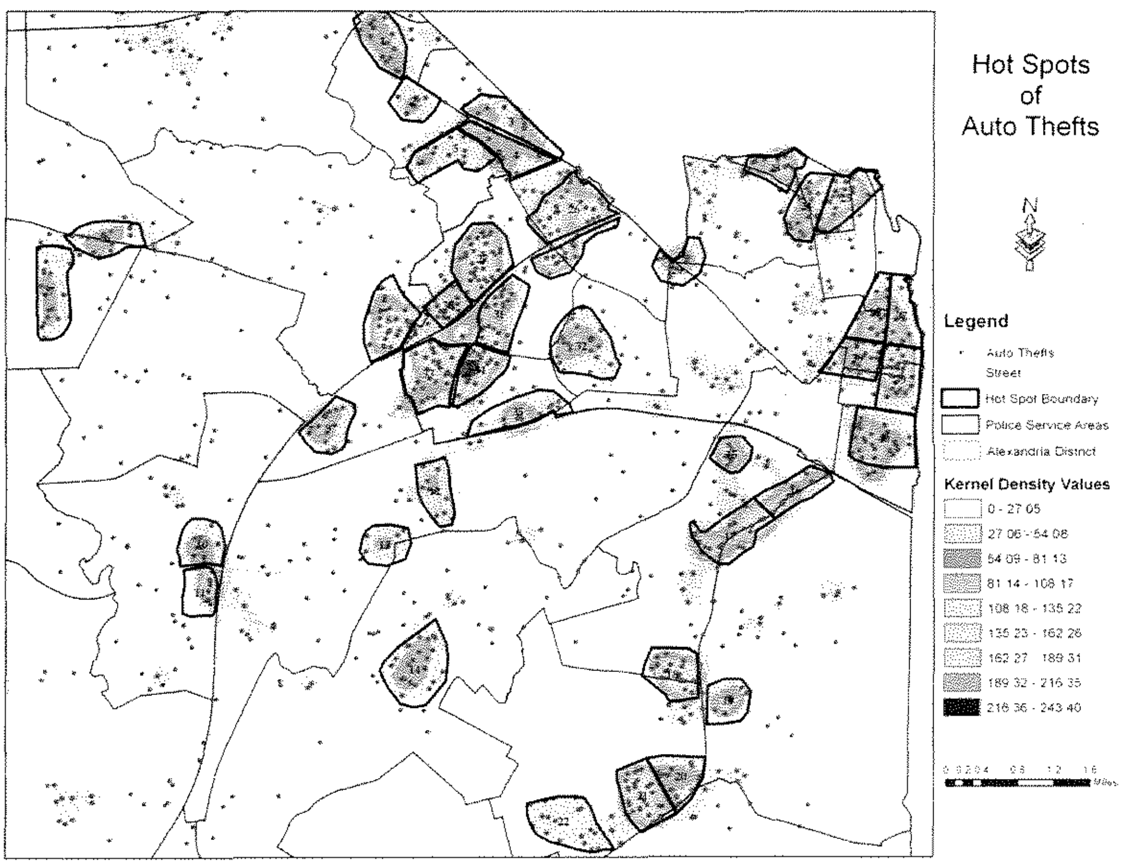
Figure 3.7: Another Readjustment Example



This mixed method of combining statistical approaches with officer adjustments became very important to the research team, because it meant that it combined a statistical analytic exercise—the generation of hot spots—with the realities of the operational units in order to come up with hot spots that were generated from a combination of research and experience. This type of interaction between the research team and operational units not only brings operational meaning to the implementation of research studies but better builds collaboration and understanding between researchers and agencies.

Thus, our initial 40 hot spots became 45 hot spots. One further adjustment was also made. Because the human resources available for this project from each agency was minimal (two officers from each agency were dedicated to this project), it would be impossible, given the time period allotted for these four officers, within the confines of their shift work and other responsibilities, to cover all hot spots in the areas we initially defined. To alleviate this issue, we removed the easternmost sector of the Alexandria Police Department from this project, as well as some western and southernmost hot spots from the Fairfax County police agency. Thus, in the end, we reduced our field of hot spots to 30 for this experiment, which are delineated by black borders in Figure 3.8.

Figure 3.8: Final Hot Spots for the GMU Experiment



The average number of auto thefts in these hot spots varied from five to 41 incidents (as calculated from the data we had available from January 2008 through September 2009), with an average in each hot spot of 20.23 incidents and a standard deviation of 9.412. The average area of the hot spots selected for this study varied in size from 0.06 square miles to 0.5 square miles, with an average of 0.238 square miles and standard deviation of 0.105 square miles. Some hot spots were on or close to the border between Alexandria City and Fairfax County, while others were not, creating an excellent and unique opportunity for a multi-jurisdiction study.

Randomization and Experimental Design

Field experiments establish validity through randomization in order to isolate the effects of treatment from other factors that may contribute to group differences. Randomized controlled trials are considered the "gold standard" in evaluation research and help to ensure that there is no systematic bias that divides subjects into experimental and control groups (Campbell and Stanley, 1963; Farrington and Petrosino, 2001; Weisburd, 2003). Specifically, random allocation provides an appropriate counterfactual in the control group, indicating what would happen had treatment not been administered (Cook, 2003). We use a place-based randomized control design in this study, as it is regarded as highly effective in contributing to believable results when examining the effectiveness of patrol crime prevention strategies (Boruch et al., 2000; Cook, 2003; Weisburd 2000).

Of the 30 hot spots, 15 were randomly assigned to receive the LPR deployment intervention as described previously, while the other 15 received "business as usual" policing (no change in the existing police activities in that area). The assignment was not revealed to the officers involved. To randomize hot spots, each was numbered 1–30 from the northernmost to the southernmost hot spot. To select approximately equal number of hot spots from each jurisdiction (13 of the hot spots fell in APD's jurisdiction and 17 in FCPD's jurisdiction), we block-randomized by jurisdiction, randomly selecting seven from Alexandria City and eight from Fairfax County.

"Of the 30 hot spots, 15 were randomly assigned to receive the LPR deployment intervention, while the other 15 were not. The assignment was not revealed to the officers involved."

The experiment was designed to last 30 officer working days for each officer (recall, there were two officers assigned within each jurisdiction for this experiment). For each working day for each officer, we also randomly selected five of the experimental hot spots per officer per day so that multiple hot spots per shift could be visited for 30-minute periods. Thus, there was a chance that officers would sometimes visit similar hot spots in consecutive working days. Each of the five randomly selected experimental hot spots were printed onto a hot spot assignment sheet (see Appendix C), and placed into a sealed envelope with an instruction sheet (see Appendix B). The instructions sheet repeated the training that each officer received prior to the start of the experiment, which we describe below. We provided 30 sealed envelopes to the supervisors of each officer, for a total of 60 envelopes per police agency. These were given one by one to the officers for the 30 consecutive working days that the officers were available for the experiment.[20]

On each of the hot spot assignment sheets we provided an area where officers would record the number of reads, hits, and strategy used each time they went into and out of a designated hot spot. They also recorded the time that they entered and exited the hot spot so that the research team could measure how well the officers adhered to the 30 minute rule. Research team cell phone numbers were also provided on each map so that any questions from officers could be fielded at any time throughout the duration of the experiment. Once officers were done with their shifts, they would place their five maps, with recorded information, back into the envelop, seal and sign the envelop and return the packet to their supervisor.

Implementing the Experiment

TRAINING: Two officers in the Fairfax County Police Department (FCPD) and two officers from the Alexandria Police Department (APD) were dedicated to participate in the experiment and were not required to answer calls for service (unless in emergency or back-up situations). In order to insure the experiment was implemented well, we trained each officer with his or her supervisor on the entire experiment and gave each of them specific instructions about what to do with the daily envelopes. We include the transcripts of training materials in Appendix D, which provides a useful summary to agencies and researchers interested in replicating this experiment.

ASSIGNMENTS AND SUPERVISION: After training each officer and supervisor, we implemented the experiment on February 22, 2010, for each police department.[21] The FCPD ended its experiment on April 20, 2010, while the APD ended its experiment on June 1, 2010. In the Fairfax County Police Department (FCPD), the experiment was implemented by a marked auto theft specialized unit, consisting of one detective from that unit and one patrol officer on detail assigned to this project. Each officer had his own LPR vehicle and was assigned to work during the day. Hence, it could have been possible that

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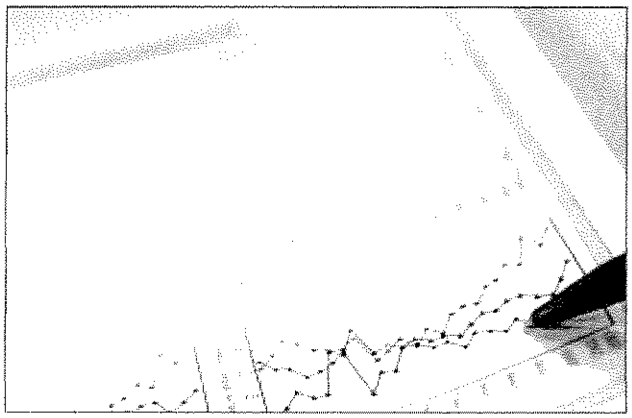
[20] There were days during the experimental period in which officers were not available, which extended both experiments in each jurisdiction further than anticipated.

[21] The start date of the experiment was delayed due to the historic 2010 Washington D.C. area snowstorm. Although most of the snow and ice had been cleared from the roads before the evaluation started, road salt and debris did affect the effectiveness of the plate readers, and snow banks blocked officer access to some parts of hot spots during the first few days of the evaluation. Another factor in the delay was the transition to a new records management system in one of agencies.

both officers worked on the same day and times. Limited resources and shift constraints did not allow the researchers to determine exactly when officers would patrol, although they generally did so during the daylight hours.

The implementation in the Alexandria Police Department (APD) was conducted by two patrol officers in District 3, or the Western half of the city. Because of resource scarcity, only one officer at a time could be allocated to the LPR unit per shift, so a system of two officers, switching off daily, was used. Additionally, APD officers are assigned to 11.5-hour shifts, which meant that they only work 3–4 days per week. This led to the APD experiment taking longer. For the vast majority of the experiment, the officers were able to maintain the experiment and its instructions, including following directions if they were unable to complete their daily assignments. In only one case, due to an unavoidable personal situation, did one officer not complete his 30-day assignment. It should be noted that this officer could have completed this assignment, but due to the time restrictions of this project, the GMU team decided to stop the experiment on this officer's 26th experimental day.



To ensure that the experiment was implemented correctly, supervisors were assigned by each agency command to oversee these officers. The research team also visited each agency after approximately 7 working days of the start of the experiment and then subsequently every 10 days or so to pick up folders and make sure the experiment was going as planned. The fidelity of the experiment was greatly increased by initial training, supervision, and detailed instructions included in each daily assignment packet.

IMPLEMENTATION FIDELITY: The daily logs for each patrol sheet indicate that the experiment was implemented fairly well and that the 30-minute rule was strictly followed. In the Fairfax County Police Department, of the 300 patrols assigned (five hot spots per day for 30 days for two officers), officers were unable to complete only 20 assignments. Of those 280 assignments completed, almost all (272) stayed 20–40 minutes within a hot spot, with 237 very close to exactly following the 30-minute rule. In APD, officers were also assigned to 300 total patrols and did not complete 44, since the experiment was ended earlier for one of the two officers. Of these 256 completed assignments, officers spent 20–40 minutes in 248 of them and followed the 30-minute time-in-hot-spot rule strictly in 236 hot spot assignments.

Responding to crimes, traffic stops, and family emergencies accounted for many of the missed assignments. Although officers were instructed to stay within the hot spot and to regard scanning vehicles with the LPR system as their priority during patrol, it was well understood that backup calls, crime occurring within the hotspot, and similar events would be a higher priority for officers than experiment implementation.

PLATE SCANNING: The data within the LPR units consisted of downloaded stolen automobiles and license plates from the Virginia State Police, as well as any additional license plates entered into the LPR system manually by officers. This data was then compared to scanned plates. The average number of plate scans within hot spots per 30-minute visit in Fairfax County was 450. The mean number of plates scanned during a full patrol period ranged from a low of 324 to a high of 601. In Alexandria, the average number of plates scanned within hot spots was 689, ranging from 87 to 1068.[22] The variation between the number of plate scans can be explained in part by the characteristics of different hotspots—the presence of a busy street near or in the hot spot, the number of cars that are routinely parked in the area, and so on. The difference in the mean number of plate scans in hot spots was not statistically significant.

In total, there were 19 "accepted" hits in Fairfax during the experiment. Of these, there were three stolen vehicles found, one lost vehicle, and one set of stolen plates recovered in the hot spots during the experiment. The remaining hits were from terrorist/gang (13)[23], or sex offender watch lists (1). In Alexandria, there were 14 "accepted" hits, four of which were for stolen vehicles, and two of which were stolen tags. The remaining hits were from terrorist watch lists (4) or a mistaken or already recovered vehicle in the database (4).

From these data, it is difficult to draw any strong conclusions about the relationship between the number of plates scanned and the number of auto theft recoveries, which were both infrequent. However, the reader should recall that this experiment focuses on measuring the impact on LPR's ability to deter crime, not only the number of hits received by the LPR units.

The Outcomes Measured

In our experiment, we measure both the specific and general deterrent effect of LPR deployment (see Nagin, 1998; Sherman 1990). We define a general deterrent effect of LPR on crimes as measured by examining the trends of many different categories of crime and disorder in hot spots. The reason for measuring a general deterrent effect is that even if autothefts are not reduced, having a marked patrol unit in these locations may deter other crimes, as evidenced in previous hot spot patrol studies. In our study, we measured general deterrence using counts of reports of crimes and disorders, including crimes

[22] One of the two LPR officers in Alexandria failed to stop the LPR in-between hot spots and reported plate read numbers that were unusually high. Although we had the start and end number for reads for the day, we could not be sure that the LPR was not used outside of the hot spots (i.e., plates read in between hot spots). Thus, the average for the number of plates scanned in Alexandria was calculated using only one officer's reported numbers.

[23] Officers did not distinguish between terrorist and gang watch lists in accepted hits.

against persons and property (which included auto related crimes), weapon-related crimes, disorders, and drug activity. To give the reader a sense of the distributions of these crimes, we present Table 3.1. Table 3.1 provides the counts, for the entire Fairfax County and Alexandria City during the period we implemented the experiment for each jurisdiction, respectively.

Table 3.1. General Crime Distributions for the Two Jurisdictions

Crime Type	FCPD	% of Total Crimes	APD	% of Total Crimes
Person	1225	11.7%	508	15.9%
Property	4503	43.0%	1761	55.0%
Disorder	3959	37.8%	742	23.2%
Drugs and Vice	667	6.4%	173	5.4%
Weapons	99	1.0%	19	0.6%
TOTAL CRIMES	10453	100.0%	3203	100.0%

We also measured the deterrent effect of LPR on auto theft/theft from auto, as well as auto related crimes (auto theft, theft from auto, and other auto-related offenses such as driving under the influence and reckless driving). We chose these types of crimes, given that the types of data entered into the LPR units in these agencies primarily reflect these crime categories. While we use these measures for a "specific" deterrent effect, we note that a specific deterrent effect of LPR does not have to be measured with auto-related crimes. Whatever the specific type of crime(s) targeted with the devices would be this measure. Further, the term "specific deterrent effect" might also point to the effect of and LPR arrest on an individual's offending and recidivism. This is not measured in this study, but are important considerations nonetheless. Table 3.2 shows these distributions.

Table 3.2. Auto-Related Crime Distributions for the Two Jurisdictions

Crime Type	FCPD	% of Total Crimes	APD	% of Total Crimes
All Auto Related	2250	21.5%	655	20.4%
Auto Theft and Theft from Auto	1018	9.7%	437	13.6%

Percentages shown are of total crimes per jurisdiction.

Thus, we collected three measures for each of our hot spots: all crimes (persons, property, disorder, drugs and vice, and weapons), auto-related crimes (auto theft, theft from auto, and other auto-related offenses), and just auto theft/theft from auto. These counts were collected for five periods:

- **PRE-INTERVENTION PERIOD:** The period of days, equivalent to the intervention period, before the start date (February 22). For the Alexandria Police Department, this period included November 15, 2009, through February 21, 2010—for a total of 99 days. For the Fairfax City Police Department, we recorded crime information from December 26, 2009, through February 21, 2010, matching the 58 intervention period days for FCPD.

- **INTERVENTION PERIOD**: The time period during the intervention. For the Alexandria Police Department, the intervention lasted from February 22 through May 31, 2010—a total of 99 days. For the Fairfax County Police Department, the intervention lasted from February 22 through April 20, 2010—a total of 58 days.

- **POST-INTERVENTION PERIOD**: We also collected crime data for 30 days after the intervention stopped for each jurisdiction. For the APD, this time period went from June 1 through June 30, 2010, and for the FCPD, this time period went from April 21 through May 20, 2010.

- **SEASONAL LAG OF INTERVENTION PERIOD**: To capture a seasonal effect of the intervention period, we recorded crime counts in the same time period of the intervention in the previous year. For the Alexandria Police Department, this was from February 22 through May 31, 2009, and for the Fairfax County Police Department, from February 22 through April 20, 2009.

- **SEASONAL POST-INTERVENTION PERIOD**: To capture a seasonal control for the post-intervention period, we recorded crime for the same 30-day period of the post-intervention period, but for the previous year. For the APD, this time period went from June 1 through June 30, 2009, and for the FCPD, this time period went from April 21 through May 20, 2009.

Statistical Approach and Models

Using a randomized controlled experiment, we applied the LPR patrols to our 15 experimental hot spots. Each of our three crime categories – all crimes, auto-related crimes, and auto thefts/theft from auto, were then recorded for each of the five periods above for each of the 30 hot spots. Of interest were differences between treatment and control hot spots for two dependent variables: crimes during the intervention period and in the post-30-day period immediately following the intervention. The control hot spots reflect the most appropriate counterfactual to the experimental units in a randomized controlled experiment. This makes the comparison of crime counts for each an adequate analytic approach. However, to better specify our model, we also incorporated three further controls: the pre-intervention levels of crime and the levels of crime in the same during- and after (3)-treatment periods the year prior.

Choosing the most appropriate statistical model to examine the effects of the intervention depends on the distribution of the dependent variables. While the distribution of all crimes during the intervention period appears normal, the distributions of auto-related crimes and auto theft/theft from auto were not, as Figure 3.9 (a – c) indicates. In particular, auto crimes were skewed to zero or one crime per hot spot. This suggested that linear regression would not be an appropriate statistical approach for each of these models, but that perhaps a generalized linear model (Poisson or negative binomial) would be more useful, especially to model specific deterrence.

Figure 3.9a. Distribution of All Crimes Within Hot Spots During the Intervention Period

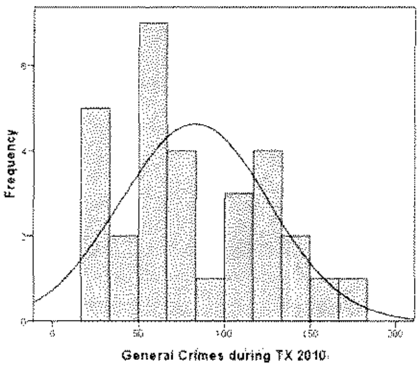


Figure 3.9b. Distribution of Auto Thefts and Thefts from Auto Within Hot Spots During the Intervention Period

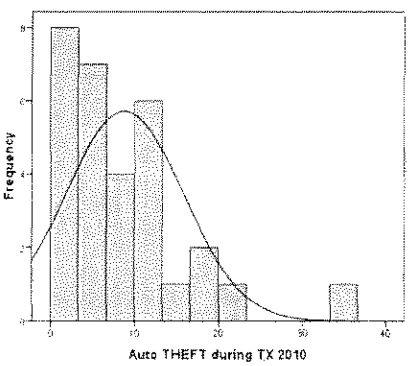
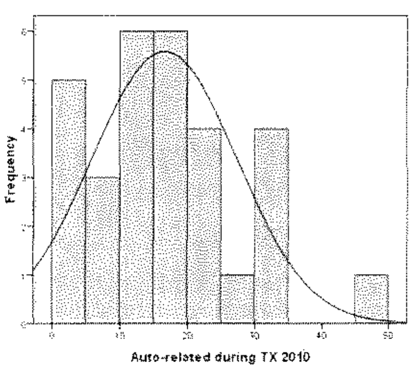


Figure 3.9c. Distribution of Auto-Related Crimes Within Hot Spots During the Intervention Period



Because there was evidence of over-dispersion in these low crime counts for auto-related crimes, the negative binomial generalized linear model was preferred over the Poisson distribution model for auto-related and autotheft/theft from auto categories (although we did conduct Poisson and found similar findings). We ran two models: First, we modeled the counts of these different categories of crime in the intervention period compared to the pre-intervention period. Second, we modeled the counts of these different categories of crime in the post-intervention period compared to the pre-intervention period. The models specified were:[24]

ALL CRIMES:

Model 1: Modeling the Intervention Period

$$Y(Tx) = \beta_0 + \beta_1\left(x^{tx}\right) + \beta_2\left(x^{pre}\right) + \beta_3\left(x^{seasonTx}\right) + \beta_4\left(x^{ju}\right) + \beta_5\left(x^{juINT}\right)$$

Model 2: Modeling the Post-Intervention Period

$$Y(POST) = \beta_0 + \beta_1\left(x^{tx}\right) + \beta_2\left(x^{pre}\right) + \beta_3\left(x^{seasonPOST}\right) + \beta_4\left(x^{ju}\right) + \beta_5\left(x^{juINT}\right)$$

where: β_0 = Intercept

x^{Tx} = Intervention (experiment = 1, control = 0)

x^{pre} = Crime levels during pre-intervention period

$x^{seasonTx}$ or $x^{seasonPOST}$ = Seasonal covariate; indicates crime levels in the same period of dependent variable, but one year prior. The addition of "*Tx*" or "*POST*" matches the dependent variable being measured.

x^{ju} = A dummy variable for the jurisdiction (APD = 1, FCPD = 0)

x^{juINT} = A variable representing the possible interaction effect between location of the hot spot (Alexandria or Fairfax) and whether or not the hot spot was an experimental or control unit (Experiment x Jurisdiction)

In addition, for auto-related and autotheft/theft from auto crimes, the variable names remain the same as above. Here we also included in the model the natural log of an "offset" or exposure variable, ln(*offset*). The offset variable indicates the number of days (99 or 58) that a hot spot was exposed to the intervention:

AUTO-RELATED AND AUTO THEFT/THEFT FROM AUTO ONLY:

Model 1: Modeling the Intervention Period

$$Y(Tx) = \exp\left[\beta_0 + \beta_1\left(x^{Tx}\right) + \beta_2\left(x^{pre}\right) + \beta_3\left(x^{seasonTx}\right) + \beta_4\left(x^{ju}\right) + \beta_5\left(x^{juINT}\right)\right] + \ln(offset)$$

Model 2: Modeling the Post-Intervention Period

$$Y(POST) = \exp\left[\beta_0 + \beta_1\left(x^{Tx}\right) + \beta_2\left(x^{pre}\right) + \beta_3\left(x^{POST}\right) + \beta_4\left(x^{ju}\right) + \beta_5\left(x^{juINT}\right)\right] + \ln(offset)$$

[24] These models were developed in consultation with Dr. Christopher Koper of the Police Executive Research Forum, and reflect Taylor et al. (2010).

Experimental Results

MEAN COUNTS OF CRIME

Table 3.3 shows the counts for the hot spots per jurisdiction for each crime categorization and for each time period measured.

Table 3.3. Mean Counts of Crimes for Hot Spots by Jurisdiction and Measure

	Mean	Std. Deviation	Mean	Std. Deviation
	FCPD (17 hot spots)		APD (13 hot spots)	
ALL CRIMES				
Pre-Intervention	52.24	24.004	71.31	45.644
During Intervention	86.41	41.384	77.77	46.494
Post-Intervention	41.12	20.068	17.85	12.233
Seasonal Intervention (2009)	82.65	43.190	66.00	37.076
Seasonal Post-Intervention (2009)	44.53	24.567	25.38	15.570
AUTO RELATED*				
Pre-Intervention	12.82	6.635	17.00	13.916
During Intervention	16.71	9.835	16.54	12.190
Post-Intervention	6.88	3.295	3.77	3.059
Seasonal Intervention (2009)	9.06	5.309	13.15	7.679
Seasonal Post-Intervention (2009)	7.94	4.981	6.69	5.407
AUTO THEFT/THEFT FROM AUTO				
Pre-Intervention	7.12	3.407	14.62	13.035
During Intervention	6.24	3.882	12.23	8.691
Post-Intervention	2.76	2.223	2.69	2.689
Seasonal Intervention (2009)	4.94	2.817	9.77	6.698
Seasonal Post-Intervention (2009)	2.71	1.312	4.62	2.755

* Recall, "auto-related" means auto theft, theft from auto, and other auto-related offenses such as driving under the influence and reckless driving.

Table 3.4 then displays the mean values across the 30 hot spots of the experiments in the pre-, during, and post-intervention periods.

Table 3.4 Mean Counts of Crime in the Control and Experimental Group Combined by Time Period Measured

	Control or Experiment	Mean	Std. Dev.	Std. Error	Min	Max
ALL CRIMES						
Pre-Intervention	Control	60.87	39.379	10.168	15	149
	Experiment	60.13	32.935	8.504	12	151
	Total	60.50	35.671	6.513	12	151
During Intervention	Control	79.67	48.153	12.433	19	164
	Experiment	85.67	38.878	10.038	28	170
	Total	82.67	43.109	7.871	19	170
Post-Intervention	Control	32.40	23.591	6.091	3	91
	Experiment	29.67	17.690	4.568	5	60
	Total	31.03	20.535	3.749	3	91
AUTO-RELATED CRIMES						
Pre-Intervention	Control	13.80	8.402	2.169	3	28
	Experiment	15.47	12.386	3.198	4	54
	Total	14.63	10.434	1.905	3	54
During Intervention	Control	15.33	9.788	2.527	3	32
	Experiment	17.93	11.768	3.039	4	49
	Total	16.63	10.717	1.957	3	49
Post-Intervention	Control	5.47	3.758	.970	0	12
	Experiment	5.60	3.376	.872	0	12
	Total	5.53	3.511	.641	0	12
AUTO THEFT/THEFT FROM AUTO						
Pre-Intervention	Control	9.60	6.833	1.764	3	23
	Experiment	11.13	11.855	3.061	2	50
	Total	10.37	9.539	1.742	2	50
During Intervention	Control	8.07	5.298	1.368	3	20
	Experiment	9.60	8.458	2.184	2	35
	Total	8.83	6.978	1.274	2	35
Post-Intervention	Control	2.47	2.642	.682	0	8
	Experiment	3.00	2.171	.561	0	8
	Total	2.73	2.392	.437	0	8

GENERAL DETERRENCE OF ALL CRIMES

In applying the models when examining the general deterrent effect of LPR patrol, there appeared to be no discernible difference in the levels of crime during or after the intervention period between experimental and control hot spots (Table 3.5). We discuss shortly why this may have occurred, from weakness of intensity of intervention to the possibility of a real lack of effect of LPR.

Table 3.5 Linear Regression Results for General Deterrent Effect of LPR

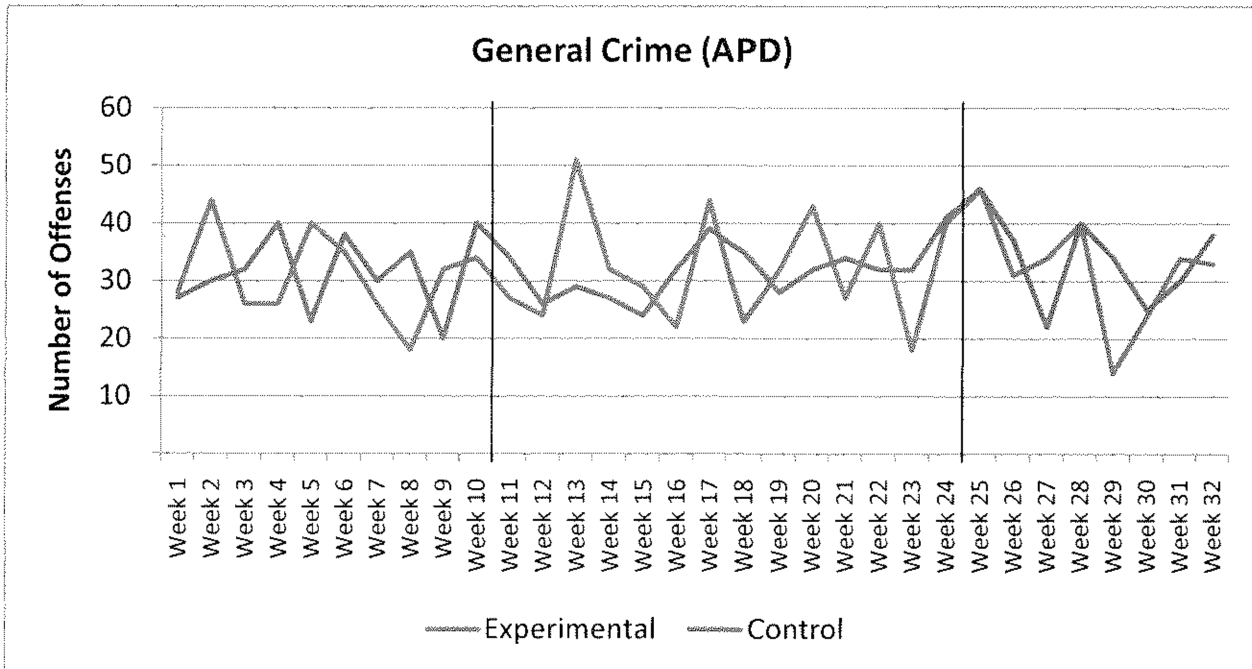
	MODEL 1 Y(Crime Levels During Tx)	MODEL 2 Y(Crime POST Intervention)
Constant	8.46 (7.600)	10.19 * (4.730)
Intervention Effect (Experiment=1)	10.19 (7.998)	-.26 (4.486)
Pre-Intervention Crime Levels	.71 *** (.152)	.06 (.073)
Seasonal Effect (either Tx or POST in 2009)	.44 ** (.132)	.62 *** (.121)
Jurisdiction Effect	-8.33 (9.174)	-12.803* (5.772)
Interaction Effect (Intervention x Jurisdiction)	-13.28 (11.866)	.44 (6.861)
Adjusted R^2	.87 (15.722)	.62 (12.713)

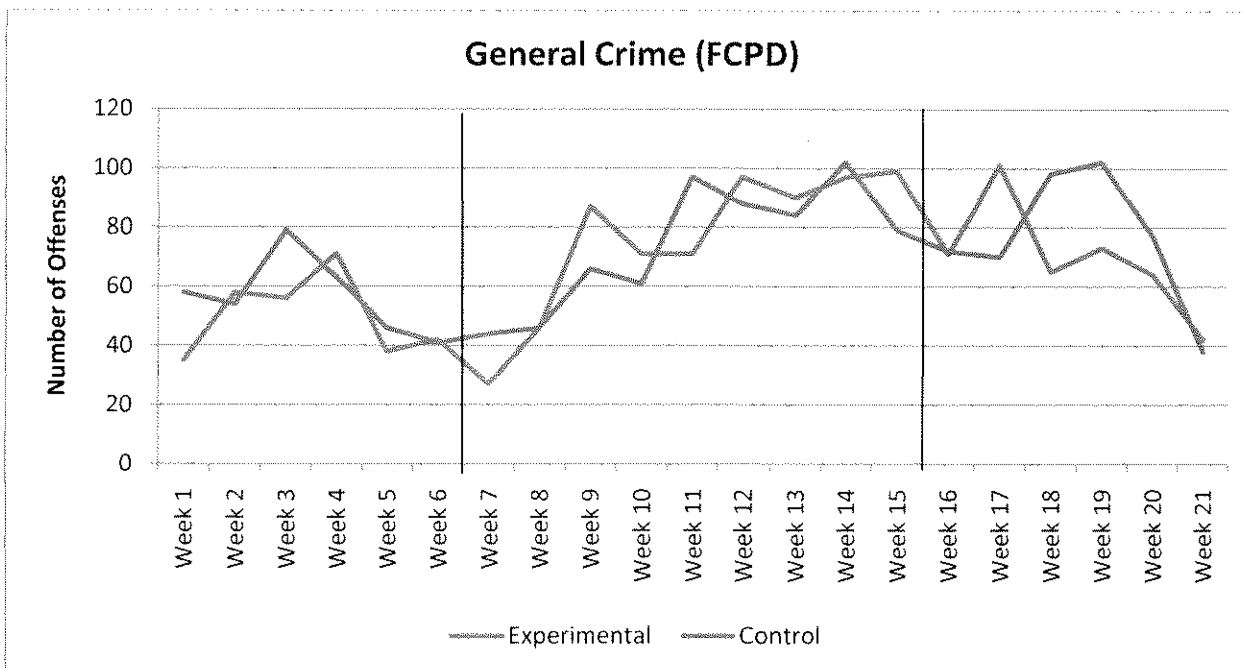
Unstandardized β coefficients reported, with standard errors in parentheses.
* $p<.05$, ** $p<.01$, *** $p<.001$

It appears that crime levels during the treatment period were best predicted by crime levels in the same time period before treatment and during the same time period a year prior (the "seasonal effect"). Although crime levels in the post-intervention period were not significantly influenced by crime levels prior to treatment, a seasonal effect was also found. It appears that hot spots in Alexandria city had significantly less crimes compared to Fairfax County in the post treatment period, although this was found in both treatment and control groups. The interaction effect indicates that the effects of the intervention did not differ across the two jurisdictions.

Figure 3.10 shows the weekly counts of all crimes for Alexandria Police Department (APD) and Fairfax County Police Department (FCPD) during the pre-intervention, intervention, and post-intervention periods. The experimental period is delineated by the vertical lines for each jurisdiction respectively.[25] No clear pattern emerges from these visualizations between control and experimental groups.

Figure 3.10. Weekly trends of all crimes for Alexandria City and Fairfax County





[25] Weekly trends of all crimes for Alexandria from the week of November 15, 2009 ("Week 1") through the week of June 30, 2010 ("Week 32") and for Fairfax County from the week of December 26, 2009 ("Week 1") through the week of May 20, 2010 ("Week 21").

SPECIFIC DETERRENCE OF AUTO THEFT AND AUTO-RELATED CRIMES

Similarly, we did not discover a statistically significant specific deterrence effect of LPR deployment in hot spots on auto theft or auto-related crimes (Table 3.6). And, as with all crimes above, the effects of the intervention did not differ across the two jurisdictions.

Table 3.6. Negative Binomial Results for Specific Deterrent Effect of LPR

	Auto-Related Model 1 Y(Tx)	Auto-Related Model 2 Y(POST)	Auto-THEFT Model 1 Y(Tx)	Auto-THEFT Model 2 Y(POST)
Intercept	-2.39 *** (.544)	-3.03 *** (.556)	-2.76 *** (.448)	-3.90 *** (.561)
Intervention Effect (Experiment=1)	.37 (.532)	.32 (.557)	.03 (.525)	.60 (.577)
Pre-Intervention Crime Levels	.04 (.023)	.03 (.030)	.04 (.022)	.04 (.030)
Seasonal Effect (either Tx or POST in 2009)	.04 (.041)	.04 (.053)	.05 (.045)	.08 (.120)
Jurisdiction Effect	-.70 (.550)	-1.03 (.641)	-.52 (.615)	-.70 (.689)
Interaction Effect (Intervention x Jurisdiction)	-.49 (.817)	-.50 (.852)	-.07 (.796)	-.96 (.894)
Chi-Squared (df=24)	4.031	7.495	6.108	12.715
Log-Likelihood	-111.145	-80.677	-93.096	-62.902

Unstandardized β coefficients reported, with standard errors in parentheses
* p<.05, ** p<.01, *** p<.001

Figure 3.11 shows the weekly counts of auto-related crimes and auto theft/theft from auto for Alexandria Police Department (APD) and Fairfax County Police Department (FCPD) during the pre-intervention, intervention, and post-intervention periods for each jurisdiction respectively.[26] No clear pattern emerges from these visualizations between control and experimental groups.

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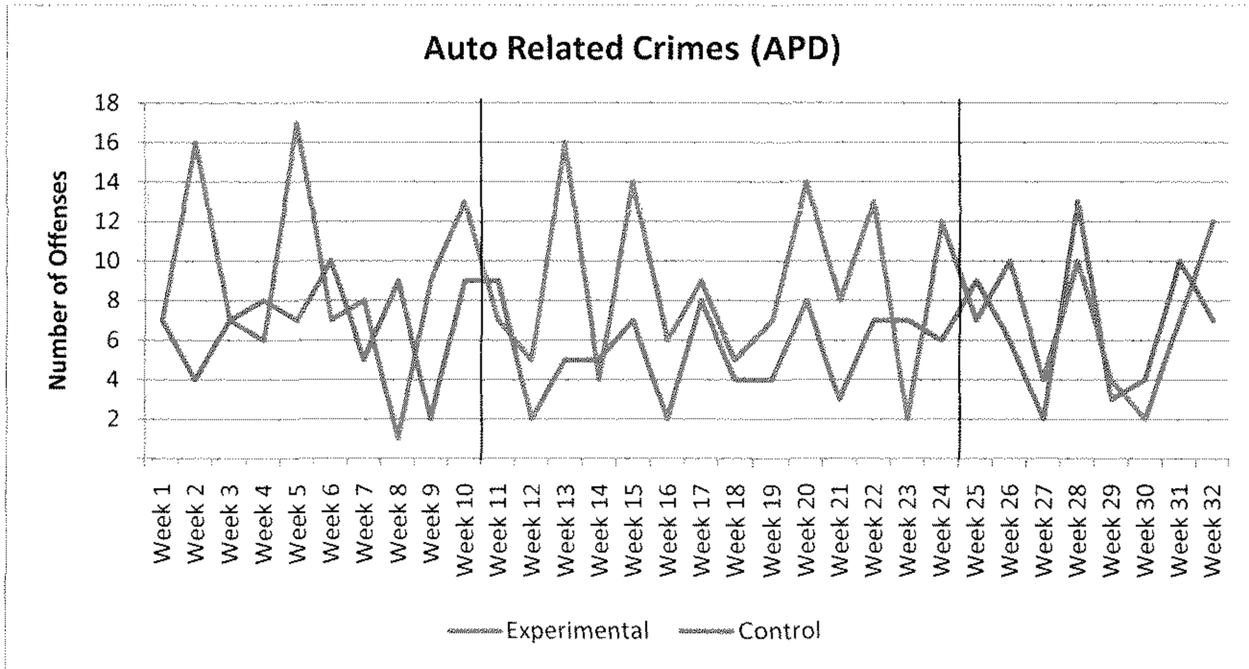
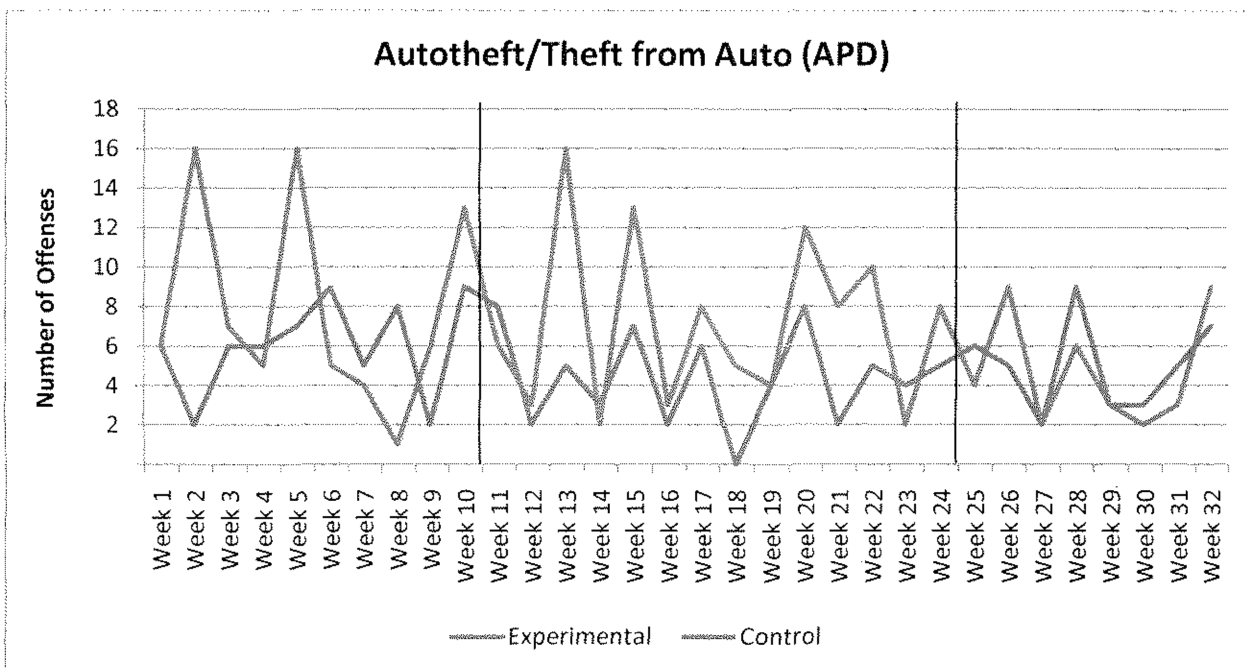
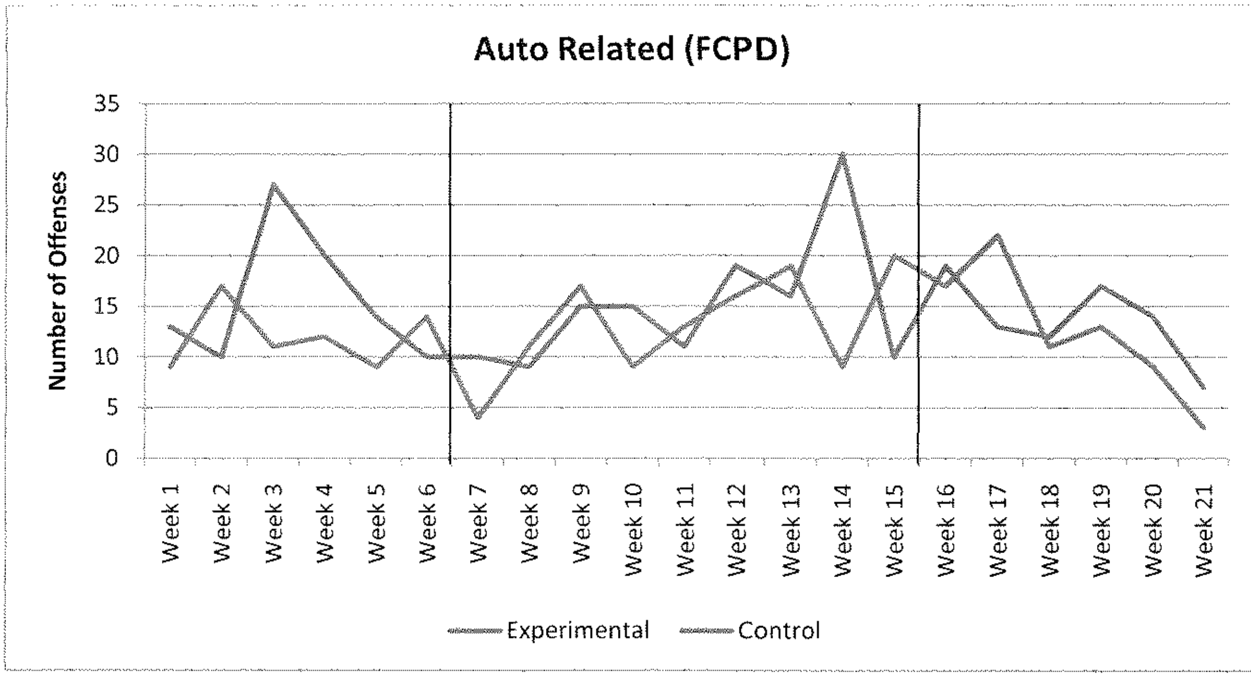
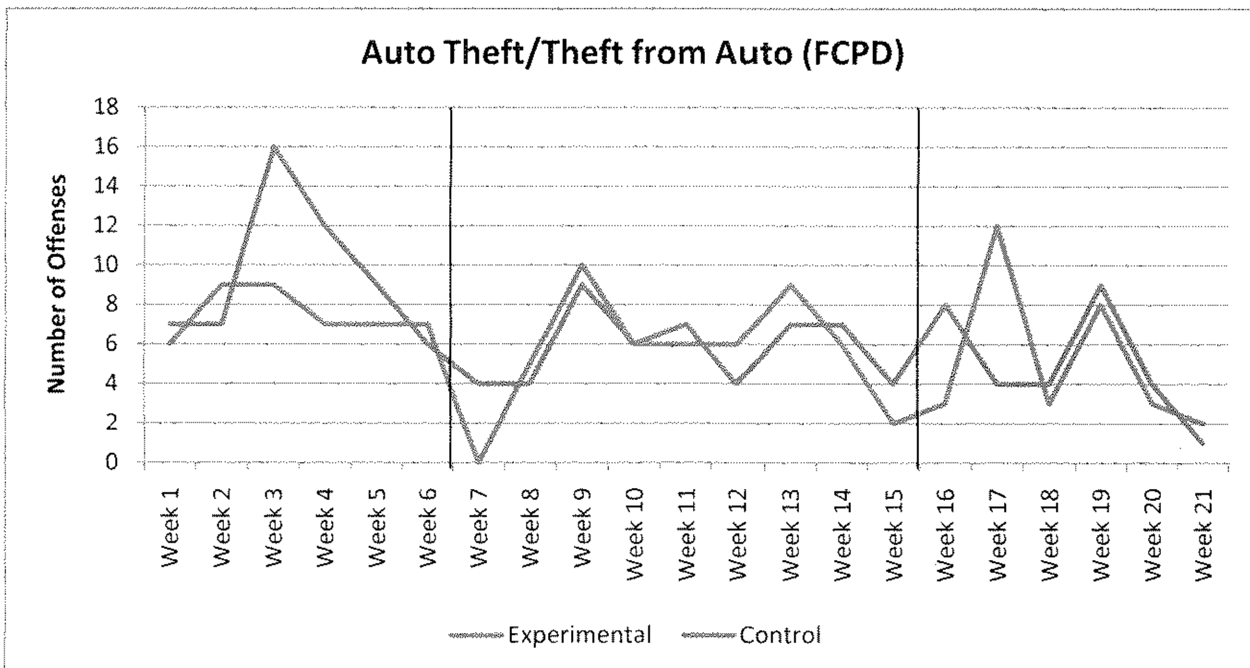
[26] Again, weekly trends of all crimes for Alexandria are from the week of November 15, 2009 ("Week 1") through the week of June 30, 2010 ("Week 32") and for Fairfax County from the week of December 26, 2009 ("Week 1") through the week of May 20, 2010 ("Week 21").

Figure 3.11. Weekly trends of auto-related crimes and auto thefts/thefts for Alexandria City and Fairfax County









A NOTE ON SENSITIVITY TESTS FOR DISPLACEMENT AND DIFFUSION

This study was not designed to specifically measure displacement of crime and diffusion of benefits (see Clarke and Weisburd, 1994; Weisburd et al., 2006), primarily because of the small number of hot spots and adjacency between some hot spots. Although the individual re-mapping of hot-spot boundaries helped to define areas that were more environmentally distinct, there may be the possibility of displacement of crime and diffusion of benefits to adjacent control hot spots from experimental ones. The limitation on the number of hot spots in these two jurisdictions did not allow for the creation of clearly distinct and separated hot spot locations with non-overlapping buffer zones to measure displacement.

However, to consider the possibility of displacement and diffusion, we ran sensitivity tests for each of our models, controlling for possible effects of the intervention from experimental to control hot spots. To do this, we created a dummy variable to control for the presence of an adjacent experimental hot spot to a control area. This allowed us to detect whether any differences created by the intervention in an experimental hot spot was the result of displacement or diffusion. The inclusion of this factor in each of the models described above did not significantly affect any of the effects shown.

Possible Explanations for Non-Significant Findings

The findings may simply indicate that LPR patrols, even when used in ways that reflect the evidence, do not have a general or specific deterrent effect on crimes as measured by crime levels during and after the intervention. Indeed, the PERF findings (Taylor et al., 2010) were similar. That research team also found that hot spots in which LPR was used did not see the same significant reductions in crime compared to hot spots in which an autotheft specialized unit did manual-checking (although the LPR patrols had more detections of stolen automobiles). From these findings, any blanket-statement supporting agency purchase or government funding of LPR devices should be viewed cautiously.

There are two important caveats to the meaning of both the GMU and PERF findings. First, as we learned in Chapter 2, LPR is rapidly diffusing into American law enforcement, especially among agencies with 100 or more sworn officers. This rapid technological diffusion is occurring with or without the evidence about the effectiveness or effects of LPR. Secondly, accepting these findings assumes that the intervention within the experiment reflects the correct way to deploy LPR units.

> *"From these findings, any blanket-statement supporting agency purchase or government funding of LPR devices should be viewed cautiously."*

The first caveat has important implications for the second. No matter the evidence, police agencies and federal and state governments have already invested in LPR technology. Finding the way to get the most out of LPR units already in use will be the next stage of evaluation. We suggest that three factors should be considered in improving the effects that LPR might have on crime generally or on auto theft (or other crimes) more specifically. These factors are:

1. **Intensity and frequency of deployment:** One possible reason for the lack of significant difference between treatment and control hot spots in this experiment is the weakness in the intensity of the intervention in our experiment. Because of very limited resources in both APD and FCPD, there was likely only a single vehicle involved in an experiment hot spot at any given time. This intensity differs drastically from other hot spot experiments conducted by Sherman, Weisburd, and Mazerolle, in which saturation of patrol and an "all-hands-on-deck" approach is employed.

   On the other hand, this limited resource availability of LPR is likely to reflect the normal situation in many agencies that use LPR. One or a few units might be available for even larger agencies, as our national survey found. Given the PERF findings, we suggest that a combination of LPR units and manual auto-theft tactical approaches (running tags on mobile terminals or through dispatch) in hot spots may be more useful in a situation of limited resources. We also hypothesize (although further testing is needed) that a Koper Curve approach in hot spots is more economical in terms of hot-spot coverage.

2. **Limited database of LPR units:** Discussed extensively in Chapter 4, this is the notion of improving the base of data imported into LPR units. As emphasized in Chapter 1, LPR is an information technology system and therefore relies on the availability of data from which the system can compare scanned tags. If data is outdated, limited in size or scope, or not connected to other pieces of data, this will limit the abilities of LPR. These are limits reflected in this experiment. However, expanding the source and connectivity of data that LPR units access as well as the analysis conducted on data that LPR units collect can have consequences on citizen privacy and also police agency legitimacy.

3. **The use of LPR may reduce the deterrent effect of patrol:** It may be the case that LPR use alone by uniformed vehicle patrol reduces the deterrent effect of that patrol unit. For example, if an officer is sitting in a fixed location scanning cars passing by, he or she may provide less general coverage of a hot spot, even within 30 minutes, than a roaming car might provide. Or, an officer focusing on LPR "hits" and positioning his or her vehicle to scan cars may miss seeing disorders and crimes because of the distraction. On the other hand, LPR frees the officer from constantly running tags on his or her mobile unit. One option that officers might consider is to view LPR as a background-scanning device but focus on activities that evidence indicates are effective (problem solving and proactive patrol in very small hot spots).

Should we just focus on arrest as our outcome measure?

During one presentation of these findings, an individual suggested that the non-significant findings simply reinforced the notion that the performance measure used for LPR should not be crime rates but rather arrests and license plates scanned. We disagree. Police scholarship has made significant inroads into moving police away from only considering reactive, police-initiated performance measures such as numbers of arrest. Indeed, arrest rates can increase with no effect on crime or calls for service. Rates of crime or calls for service could even increase during periods of more arrests.

Further, one would be hard-pressed to justify a $20,000 purchase of an LPR unit with an increase in one, five, or even 10 arrests without a decrease in crime (unless, perhaps those arrests could show a decrease in crime over the long term). We also disagree with regard to the "number of scans" or "number of positive hits" benchmark for successful deployment. Most obviously, an officer can obtain the same number of scans in one area compared to another, but with different positive hit rates. With regard to hit rates, the argument about arrests, above, is similarly applied.

What needs to be more generally emphasized is that technology will ultimately always lead to faster processing. But as Lum (2010) emphasizes, efficiency does not equal effectiveness, especially in policing. Technologies are not used in a vacuum but are filtered through the organizational, strategic, and tactical cultures of police agencies. Such cultural filtering may lead to accepting a technology, because it seems obviously

"Technologies are not used in a vacuum but are filtered through the organizational, strategic, and tactical cultures of police agencies. Such cultural filtering may lead to accepting a technology, because it seems obviously efficient given past practices, or makes sense given the current mentality of the police. Both of these are predicated on the belief that past and current practices, traditions, and cultures, as well as organizational structures are the most optimal for police decision making."