A spatial analysis of green teams: A tactical response to marijuana production in British Columbia

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Abstract Over a period of 4 years (1997–2000), British Columbia (BC) experienced tremendous growth in the illicit production and distribution of domestically grown marijuana. By the close of 2000, each policing jurisdiction in BC had adopted a particular policy in response to grow operation proliferation. In summary, four policy responses were noted. First, some maintained the status quo wherein enforcement of police initiated investigations and citizens' tips continued, but with no additional resources specifically dedicated to grow operations. Second, some jurisdictions suspended the majority of investigation and enforcement of grow operations. Third, some agencies implemented or reinforced existing resource intensive drug squads, which focused on trafficking, sales and production of all types of drugs. Finally, some of the jurisdictions formed specialized tactical units known as "green teams" that focused solely on the enforcement of marijuana production. In this paper, we evaluate the effectiveness of green teams using a Geographic Information System (GIS) and difference-in-difference estimates. The results indicate that green teams decrease grow operations within their target area without significant displacement to surrounding areas.

Introduction

In evaluating policies that target the behaviors of particular groups (e.g., local welfare policy) or within specific geographic areas (e.g., economic development or

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tax policies), it is not enough to focus on the impacts solely within the targeted population/area. Instead, one must be cognizant of behavioral changes occurring on the periphery of the targeted group/area. That is, targeted policies may yield unexpected externalities (either positive or negative) that impact the behavior of non-targeted groups or in non-targeted areas. Consequently, when considering the costs and benefits of different policies it is important to consider the net impacts of a scheme, taking account of any potential spillover or displacement. When local jurisdictions are free to exercise discretion in choosing particular policy interventions, the success or failure of the policy is likely to be dependent upon the choices made in neighboring areas.

There are many different types of policies where displacement effects are central. For instance, local efforts to legalize gambling or build professional sporting arenas often rest upon the promise of generating increased consumer spending and tax revenue within the targeted development areas. However, research has demonstrated that even when casinos and stadiums do increase consumer spending locally, these monies are often diverted from entertainment alternatives in surrounding areas (Coates & Humphries, 1999; Eadington, 1995; Siegel & Anders, 1999). The evaluation literature on local excise taxes levied on such goods as gasoline, cigarettes, and liquor demonstrates that another type of displacement can occur when differentials in tax levels induce ''boundary crossing'' behaviors on the part of consumers seeking cheaper goods (Beard, Grant, & Saba, 1995; Coats, 1997; Saba, Beard, Ekelund, & Ressler, 1995). Thus, the decision to adopt an increase in local excise taxes is often jointly considered along with tax policy in geographically proximate areas (Nelson, 2002).

Geographically targeted criminal justice policies represent another context where displacement effects need to be considered. At a broad level, rational choice theorists believe that increasing severity of punishment in one jurisdiction will lead offenders to commit crimes in areas with more lenient sentencing (see Bailey & Peterson, 1999). At a more local level, local governments rarely have the resources needed to combat major problems (drugs, gangs, prostitution) across all locations simultaneously. Driven by political pressures, community demands, and economic constraints, it is often necessary to geographically target interventions within specific neighborhoods or communities. This is especially true when the intervention takes the form of a ''crackdown'' against a particular behavior. This has the potential to displace crime.

Police crackdowns are defined as ''sudden and dramatic increases in police officer presence, sanctions, and threats of apprehension either for specific offenses or for all offenses in specific places'' (Scott, 2003). Crackdown efforts are appealing to the public, policy makers and the police because they offer quick, immediate action in response to crimes that seem to be rapidly increasing and threatening public order and safety (Scott, 2003). Many such efforts have been shown to be effective in reducing specific crimes in specific locations (Braga, 2001; McGarrell, Chermak, Weiss, & Wilson, 2001; Weisburd & Green, 1995). There is also evidence that geographically targeted crackdowns have led to instances of positive externalities or a ''diffusion of benefits'' where the positive treatment effects are seen outside of the target area (Braga, 2001; Grogger, 2002). However, targeted crackdowns can also have negative consequences. First off, the effects of crackdowns appear to be short-lived. Even when it can be demonstrated that they did reduce crime, once the resources are removed or the operation ends, there often is little or no lasting

Fig. 1 Grow operations 1997–2003
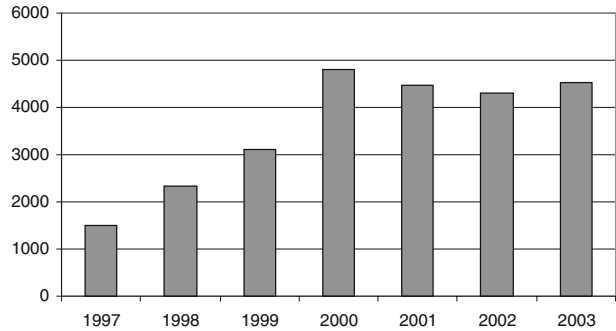
deterrent effect (Cohen & Ludwig, 2003; Sherman & Rogan, 1995; Tita et al., 2003). Crackdowns also have been shown to have a negative impact on police-community relations (Maher & Dixon, 2001; Sherman, 1997), increase the potential for abuse by police (Davis & Lurigio, 1996), and divert funds from other areas of policing (Davis & Lurigio, 1996; Green, 1996). The most common criticism of geographically targeted crackdowns, however, centers on the issue of displacement (Davis & Lurigio, 1996; Kennedy, 1993; Wood et al., 2004). That is, opponents of these efforts argue that they do little to reduce overall levels of crime. Instead, they contend that crime is simply pushed out into the areas surrounding the targeted area. We address the displacement criticism by examining the adoption of drug enforcement policies aimed at curbing marijuana production in British Columbia (BC) and explore whether crackdowns were successful in reducing production, or whether the interventions simply displaced the production to neighboring areas.

Over a period of 4 years (1997–2000), BC experienced tremendous growth (over 300%) in the reporting of illicit production facilities. Following 2000, there has been a basic leveling off of the problem (see Fig. 1).

While the increase began in the heavily populated regions close to the United States border, similar increases were observed in virtually every police jurisdiction in the province. Police managers and local politicians were eager to react to the increase in grow operations due to the perceived involvement of organized crime and the hazards[1] associated with this form of illicit drug production. Around the end of 2000, most of the policing jurisdictions had adopted a particular policy in response to the proliferation of grow operations.

Jurisdictions chose one of four options. Only one of these options was a targeted crime reduction effort specifically aimed at reducing marijuana grow operations. The majority chose to simply maintain the status quo wherein enforcement of police initiated investigations and citizens' tips continued in the same manner before, and during, the increase in grow operations. Others became disenchanted with the cost-benefit of investigating and prosecuting operations and actually suspended the majority of investigation and enforcement activities concerning grow operations. The remaining jurisdictions took a more aggressive stance toward marijuana production. Some agencies implemented or reinforced existing resource intensive drug squads, which focused on all aspects of trafficking, sales and production of all types of drugs. Finally, the remaining jurisdictions formed specialized integrated tactical

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[1] Approximately 30% of indoor grow operations have at least one hazard (i.e., weapons, fire, other drugs, electricity by-passes, presence of mold, and home invasion).

units that focused solely on the enforcement of legislation directed toward the reduction of marijuana production.

In the next section, we provide some background on the policing jurisdictions that comprise BC and discuss the various policy responses. Our focus is primarily on the adoption of "green teams" and the ways in which we expect them to be successful in reducing production. We also consider the crime reductive mechanisms of policy to clearly articulate a rationale for why we might expect the adoption of such crackdowns to lead to displacement. After discussing our data, we outline our analytical plan in more detail. We compare the results observed in the reduction of marijuana production by adopters of green teams versus other policy regimes. We pay special attention to how production faired in those jurisdictions neighboring the adopting jurisdictions. The paper concludes with a discussion of our findings.

**Police response to marijuana grow operations in BC**

The structure of policing in BC consists of autonomous municipal departments and Royal Canadian Mounted Police (RCMP) detachments. Each municipal department or RCMP detachment is essentially independent with limited sharing of information and services across jurisdictions. While the RCMP is a national policing agency, it is often contracted by provincial and/or municipal governments to deliver police services, and as such, individual RCMP detachments and municipal departments are responsible for introducing their own policies in response to issues of crime within their community. Specific to marijuana grow operations, during the study period (1997–2003) there was no provincial or national level drug control policy that imposed a specific response to marijuana cultivation. In other words, local police jurisdictions had discretion to use any of the four strategies mentioned above.

Figure 2 illustrates the policing jurisdictions in BC and the policies adopted in response to marijuana grow operations within each area at the end of 2000.

The majority of jurisdictions (74%) chose to continue investigating tips and enforcing grow operations as they had been over the previous 3 years. No additional resources were specifically dedicated to counter grow operations and the departments/detachments were able to maintain a relatively constant rate of grow operation investigation. These "status quo" jurisdictions tended to be in smaller, more rural settings or in urban settings with a smaller increase in marijuana cultivation relative to other areas.

A small number of jurisdictions (4%) dramatically reduced the level of investigation and enforcement of grow operations files. The decision to decrease investigations appears to be based on a mixture of fiscal constraints and disillusionment with the lenient treatment of convicted marijuana producers by the Canadian courts. These "no action" jurisdictions were all urban centers that had seen a sharp rise in grow operations from 1997 through 2000.

Some agencies (7%) implemented or reinforced existing drug squads, which focused on all aspects of trafficking, sales and production of all types of drugs. Given the resource intensive nature of this dedicated "drug squad" policy, it is not surprising that those departments choosing to maintain a drug squad come from either larger, more urban centers, or groups of smaller, more rural departments that combine resources to share costs and services. Finally, some of the jurisdictions
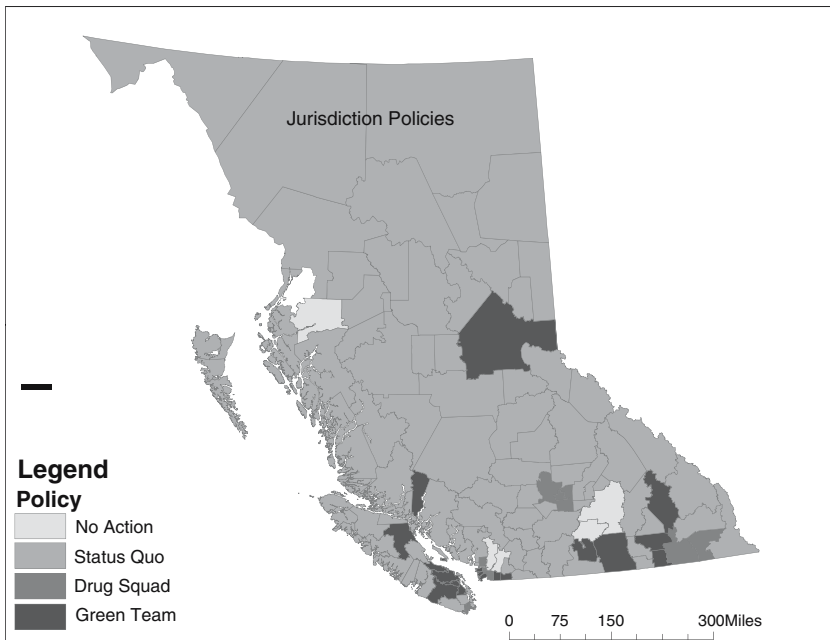
Fig. 2 Jurisdiction policies

(14%) formed specialized integrated tactical units that focused solely on the enforcement of marijuana production.

To understand how these tactical units may reduce grow operations, and potentially lead to displacement, some background on the teams is helpful. Whether known by colorful names such as ''green team'', ''grow busters'', ''bud busters'' or more formally ''marijuana enforcement team'', these units have the specific purpose of policing marijuana growing operations across their entire police jurisdiction. While increasing police presence and the threat of grow operation detection is part of their mandate, they have no ability to impact on the range of typical sentences received for successful convictions. This is partly due to the inability of the criminal justice system to deal with the scope of the problem, and partly because of the gray area surrounding marijuana policy in Canada. The question of whether marijuana use should be legalized or decriminalized has been argued by policy makers for the past 30 years. While no formal changes in marijuana policy have occurred during this time, the Canadian criminal justice system has changed the way it deals with drug possession, distribution, and production through charging and sentencing practices. These changes reflect the Canadian public's relaxed views on drug use, specifically marijuana. However, while the criminal justice system is dramatically lessening the clearance rate and sentences for marijuana possession, instances of marijuana cultivation and distribution are increasing dramatically.

The green teams investigate all of the grow operation files for the department. The process begins with public tips pertaining to marijuana production being forwarded to the unit. The integrated unit, made up of staff from police, community services, fire services and electricity providers, then investigate the tips. The use of a partnership approach is built upon the premise that a dedicated, multi-agent team

will better facilitate sharing of information and allow for more successful investigations. The teams also run publicity campaigns that educate citizens on the function of the green team, how to ''spot a grow operation'', and the hazards associated with this form of drug production. It is the multi-agent integration that serves as the primary difference between green teams and intensive drug squads. Drug squads are primarily policing ventures.

In this paper, we evaluate the impact on marijuana production of the green teams, and contrast this with the effects of the other three policy options outlined above. By using a Geographic Information System (GIS) to identify where the policy was implemented, we explore issues of effectiveness and displacement. That is, does an effective detachment reduce marijuana production within the jurisdiction, and does it do so at the cost of displacing the problem to nearby areas? Or, as the crime displacement literature often supports, does the benefit of having a green team in a neighboring jurisdictions diffuse into surrounding areas?

The use of GIS in policing and crime reduction has increased dramatically over the past decade. GIS is used to support policing by serving as a tactical tool that aids in the design and implementation of specific policing strategies and investigations. GIS is also used as a strategic instrument that supports the evaluation/assessment of decision-making within the department. More specifically, GIS and crime mapping is used to map the coverage of police activity and crime reduction projects, identify crime hotspots for targeting, to inform the deployment and allocation of police and other crime reductive tactics, to enable the visual communication of crime patterns and statistics to the public, and to assist in the assessment of crime reduction policy initiatives (Chainey & Ratcliffe, 2005). It is in the latter capacity that GIS is employed in this research. Before describing the data used in this study, we review the displacement literature, with specific focus on police crackdown efforts.

Displacement literature

The issue of displacement is a primary concern to police managers and crime prevention policy planners and practitioners. The question of whether tactical, operational, and/or crime prevention responses actually reduce criminal activity or whether the initiatives simply displace crimes spatially and temporally is vital in policy evaluation. While there is rich literature on displacement theory (Brantingham & Brantingham, 2003b; Eck, 1993), there has not been extensive research on the incidence of displacement or on advancing measurement techniques. This aside, the available research indicates that spatial displacement does exist, but it is not serious enough to hinder crime prevention policies (Brantingham & Brantingham, 2003a). Studies show that situational crime prevention techniques, which often include tactical and operational interventions, repeatedly result in a reduction of crime in the target area without significant displacement to other areas (Braga et al., 1999; Brantingham & Brantingham, 2003a; Clarke, 1997; Eck, 1993; Hesseling, 1994; Knutsson, 1998; McGarrell et al., 2001; Novak, Hartman, Holsinger, & Turner, 1995; Smith, 2001). In fact, crime prevention initiatives occasionally result in a diffusion of benefits where crime incidents are reduced in the target area and surrounding areas (Clarke & Weisburd, 1994; Repetto, 1974). However, there are criminal activities, such as open drug markets, where partial displacement is evident

(Greene-Mazerolle, Price, & Roehl, 2000; Maher & Dixon, 1999). As Bowers and Johnson (2003) demonstrate, by altering the geographic scale of the potential displacement areas, it is possible to uncover evidence in support of crime displacement and a displacement of benefits.

While open air drug markets are clearly a different crime phenomenon than illicit drug production, there are similarities that make research on spatial diffusion in this area relevant to this paper. Both drug production and drug markets are based on an underground economy that depends on connections between agents for information and product flow. For instance, in an open air drug market, traffickers rely on connections between suppliers and buyers to sustain their business. Drug producers rely on similar connections to market their product. Space is important in both situations because individuals make their connections in an activity space influenced by where they live, work, and play (Brantingham & Brantingham, 1984). Not only are connections made and sustained in space, but individuals also depend on their knowledge of an area to determine the cost of doing business. If a neighborhood has characteristics (i.e., low social control) that lower the costs of doing business, then the individual is motivated to stay in that area unless the costs go up (i.e., police crackdown efforts). Despite the similarities, it is important to recognize that drug production would be more susceptible to spatial displacement than open air drug markets. Drug markets rely on a physical or geographic area for their customer base, therefore the cost of moving to a different area becomes higher for someone selling drugs in an open market than for someone producing drugs in a covert location.

The research in the area of open air drug markets and drug houses presents mixed results. Weisburd and Green (1995) looked at the effect of police enforcement of drug crimes and license regulation of business owners on drug hotspots in Jersey City, New Jersey. They found strong evidence for reduction of disorder-related calls with no evidence of displacement and some diffusion of benefits. Smith (2001) evaluated a crime control initiative in Richmond, VA, where patrols in the drug market were supplemented by specialized tactical teams and clean-up and repairs to buildings and landscaping. There was a significant treatment effect with no evidence of spatial displacement of crimes and once again a diffusion of benefits. Some studies on open drug markets have found significant treatment effects with displacement to indoor locations (Kennedy, 1993; Maher & Dixon, 2001). Other evaluation research concerned with crime prevention in open drug markets has found evidence of expansion diffusion. Expansion diffusion occurs when there is an increase in crime in areas adjacent to the treatment area while crime levels within the core region remain high. Wood et al. (2004) evaluated a police crackdown in Canada's largest heroin market in Vancouver, BC. The results, primarily on needle disposal data, indicate expansion diffusion, with no significant reduction in drug use in the core area based on needle exchange indicators, but significant displacement of drug use outside of the treatment area. The literature presented above illustrates a partial displacement in open drug markets after policies similar to the green teams under study are implemented. Our question here is, should one expect a similar displacement or diffusion of benefits in drug production sites?

Marijuana production is especially susceptible to spatial displacement due to the suspected involvement of organized crime. By definition, individuals involved in organized criminal networks communicate with one another for the purpose of information sharing (Williams, 2001). It follows that people involved in illicit marijuana production would share information about high-risk jurisdictions, where a

grow operation would be more likely to be discovered by law enforcement. Unlike open drug markets, where a significant amount of business is gained by maintaining a stable location, there is little tying grow operations to a particular jurisdiction. One might also expect a diffusion of benefits outside of the police jurisdiction due to a perception that increased police activity mobilizes community action and results in more public tips, resulting in a regional displacement where growers move outside of a region rather than just to a neighboring jurisdiction. While the literature on the policing of marijuana production is not well developed, a study by Potter, Gaines, and Holbrook (1992) evaluating a marijuana eradication effort in Kentucky supports the above statements. The authors found no significant reduction in outdoor marijuana production and an increase in smaller scale production that ultimately dispersed over a larger area following the crackdown. Other negative consequences of the eradication include increased public support for the marijuana industry, an increase in the quality of marijuana, and an increase in the sophistication of the operation.

Another reason to expect displacement involves the purely economic factors that drive any market, including illegal ones. If the police are successful in increasing the costs of crime by increasing the likelihood of apprehension (certainty), then we should expect actors in the market to react rationally. That is, operators will shut down their business if the costs of doing business outweigh the benefits. When enough operators in a jurisdiction are arrested, have their grow operation dismantled, or otherwise driven out of the market, supply of marijuana will decrease. So long as demand is left unchecked, the supply shortage will lead to a noticeable increase in price, especially within the local market. The increase in price will, in turn, entice new entrepreneurs to enter the market in those jurisdictions where local policies have not succeeded in raising the costs of crime. Therefore, even if the operators themselves (organized or individual) are not "displaced" to surrounding jurisdictions, new operators in jurisdictions where the costs of production are not so high will enter the market to exploit the established niche. Thus, one might expect jurisdictions that border on places where green teams were adopted to experience the greatest increase in growth.

Suspects are also more likely to relocate grow operations to adjacent jurisdictions based on the environmental psychology principle of "least effort", that is when multiple destinations of equal desirability are available, all else being equal, the closest one will be chosen. If a grow operation is "busted" or otherwise compromised, those involved with its management are likely, according to routine activities and pattern theories, to find the next similar opportunity—one that is known to the suspects. Suspect awareness space provides the simplest solution: offenders 'know' of a good place, they have personal connections to the owner/occupants, and have a feel for the neighborhood, and whether or not it would be a risky or safe place from which to conduct business. The alternate scenario would have the intending grow operators set out to break new ground, as it were, to discover new opportunities. The latter is not likely to be the most efficient way of operating. If one accepts that, over the long run, nearer opportunities are better than those farther away, then proximal locations/opportunities should win out. Obviously there are exceptions; some motivated individuals are likely to innovate, or break new ground and seek to exploit new opportunities. Brantingham and Brantingham (1984) describe this process as "distance decay". With all else being equal, proximate opportunities are more attractive than those that are distal.

Data

To determine whether green teams affect reported grow operations, we assembled data on marijuana production files from 1997 to 2003 from every law enforcement jurisdiction in BC. This data were collected as part of a larger study that examined the scope of grow operations and the criminal justice response (Plecas, Malm, & Kinney, 2005). We also collected data pertaining to the type of policy adopted in each jurisdiction, the date of implementation, and for the few cases where the effort was abandoned, the end date.

Displacement studies of crime within the criminological literature often utilize point pattern analysis of incident data displayed at the individual address level. By observing changes in the spatial pattern of incidents in both the treatment area and neighboring control regions, conclusions are drawn as to whether the intervention results in absolute reductions in crime or simply displaces it. The current research is not amenable to point pattern analysis because the implementation of the policy occurred throughout the entire policing jurisdiction and not specific neighborhoods. Therefore, by definition, displacement can only occur when grow operations move across jurisdictions. Unlike most interventions that target small sub-city level units that tend to be relatively homogenous such as neighborhoods or parts of a community, policing jurisdictions are large and heterogeneous.

In addition to the intra-jurisdictional heterogeneity, policing areas in BC vary greatly in population and geographic area. In order to compare events at this level of analysis, it was necessary to aggregate individual events into yearly counts. The implication of using this aggregate level of analysis is that if the policy was enforced differently throughout a jurisdiction, there may be instances of true crime displacement that we are unable to capture. For instance, if grow operations close to the jurisdiction's borders were enforced less rigorously than operations deeper within the jurisdiction, displacement may occur intra-jurisdictionally rather than inter-jurisdictionally. Under such conditions, even if we are able to demonstrate a program effect, we are biased against detecting a displacement effect. Nevertheless, the net impact of the scheme, positive or otherwise, would still be revealed.

The relatively large unit of analysis and unequal distribution of population presents an additional challenge. Our original goal was to employ a quasi-experimental design involving propensity score techniques (see Rosenbaum & Rubin, 1983, 1984), to create a control group of observations that closely resemble the jurisdictions that adopted green teams. This technique is becoming increasingly popular in the evaluation of criminal justice/drug policy (McCaffrey, Ridgeway, & Morral, 2004; Ridgeway, 2006; Tita et al., 2003) as well as measuring the costs of crime (Greenbaum & Tita, 2004). Because the population of BC is so highly skewed, we were unable to create comparison areas that were statistically similar to the treatment areas in terms of population size and composition, measures of income, police expenditures, and size of police force.[2]

Given that it is not possible to formally control for changes in the independent variable (rates of grow operations within a jurisdiction), one can provide for analytic control in its place. Conceptually, such a strategy seeks to understand the relative changes in those variables that one would normally strive to hold constant. For this

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[2] Most of the jurisdictions that adopted green teams were in the heavily populated lower mainland region, and most of the jurisdictions in this area adopted.

paper, it is not possible to cease the influx of new grow operations in either the study area or its immediate neighbors. If this were possible, our crime event problem would appear to be solved. But the spirit of holding variables controlled, as in the classic experiment, can still guide the research design. Instead, as with many quasi-experimental designs, strict controls must give way to analytic controls.

Displacement cannot always be measured, so one cannot say with certainty that increases in one jurisdiction are directly related to displacement. However, the main issue at stake is to develop an analytical strategy to understand why the relative distributions of grows in jurisdictions within the province are not similar. Given that the Canadian Criminal Code is the same across the country, the expected differentiation is very likely to be the regional variation of 'handling' grow operations. This would include how vigorous law enforcement activity is in particular regions or jurisdictions relative to others, at each level of the criminal justice system. If opportunities are ubiquitous, and the risks involved are constant (i.e., ''no real risk'') then offending rates (per capita, or per household) should occur uniformly across jurisdictions. Additionally, the large majority of production cases take place within indoor facilities, so geographic situations are also not likely to be significant factors (i.e., natural, or outdoor, soil and light quality). Yet we observe real jurisdictional variation for the study period.

Analysis

Table 1 shows the annual counts of reported grow operations for the years 1997–2003. The first row reports the counts for all adopting jurisdictions while the second and third rows report the numbers for neighboring non-adopting jurisdictions and the total of all jurisdictions respectively. The difference in scale between areas is attributable to the fact that green teams tend to be applied in jurisdictions with the highest annual grow operation counts. We employ counts because several jurisdictions have very low population, but relatively high numbers of grow operations. Standardizing by population resulted in the creation of several extreme outliers in the overall distribution and thus we settled upon counts. By graphing these numbers (see Fig. 3), it is clear that the post-adoption slopes between adopters and non-adopting neighbors differ significantly. Though the pre-adoption levels were highest among adopting jurisdictions, the neighboring areas were higher than the levels in the remainder of BC. The growth in production (the slope) between the adopters and their neighbors were also similar prior to adoption. Taken together, this evidence does suggest that there was an effect in the adopting areas and that this was

Table 1 Mean annual grow operations 1997–2003, by area type

Area	1997	1998	1999	2000	2001	2002	2003
Adopting areas	29.8 (31.9)	44.4 (43.0)	70.3 (75.4)	115.8 (156.7)	82.3 (97.3)	80.2 (101.6)	67.1 (71.9)
Neighboring non-adopting areas	13.9 (21.1)	23.1 (41.1)	28.5 (50.6)	45.5 (94.6)	47.9 (86.3)	49.4 (88.5)	51.8 (92.5)
Total	11.6 (20.1)	18.2 (33.4)	24.6 (47.3)	38.0 (90.0)	35.0 (69.7)	34.8 (71.5)	33.9 (67.3)

Note: Values in parentheses are standard deviations
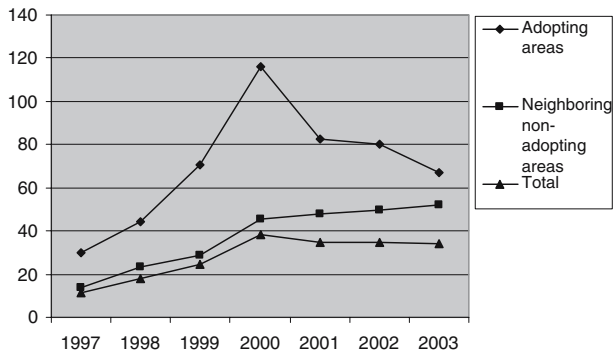
Fig. 3 Mean annual grow operations 1997–2003, by area type

not simply regression to the mean. However, it would be premature to conclude that the effect on grow operations is truly the effect of adopting grow teams. Many other factors could be influencing local changes in production that have little to do with the particular policy. For instance, it is plausible that areas that adopted green teams experienced unobservable shifts in local demand for marijuana. Alternatively, perhaps education programs reduced the number of people consuming marijuana.

As noted above, we were unable to construct a suitable counterfactual test using statistical matches (i.e., "propensity scores") that would have helped us rule out whether the treatment effect was real, or simply the result of other place-specific characteristics (e.g., population, policing size, wealth). Creating a comparison group based upon simple contiguity aids us in overcoming this potential problem. As Grogger (2002) argues, places that are closer together are more likely to be more homogeneous in terms of demographic and economic factors that might influence levels of criminal activity.

We also examined the spatial distribution of annual counts of grow operations by jurisdictions. Global measures of spatial dependence look for spatial associations in the distribution of some phenomenon. Positive associations exist when neighboring locations share similar levels of a variable, for example, clusters of high (or low) values in geographically proximate locations. The association is negative when neighboring locations are dissimilar, with high-level locations adjacent to low-level neighbors. One of the most commonly used measures of global spatial association is Moran's I, a statistic that measures the extent of similarity or dissimilarity in a variable across neighboring spatial units. As demonstrated in Fig. 4, the global Moran's $I = .62$ ($p \leq .001$ in two-tailed test) for the total count of grow operations in 2000. A positive Moran's I indicates that jurisdictions with similar numbers of operations are reasonably spatially clustered across BC. This is important because we want levels of activity to be similar across both the treatment and control areas.

Estimating the impact of grow teams on grow operations

We use difference-in-difference estimates to compare changes in the level of reported grow operations before and after the adoption of specific policies in jurisdictions that initiated green teams (treatment) with neighboring jurisdictions that chose another policy (controls). Figure 5 maps the change in grow operation
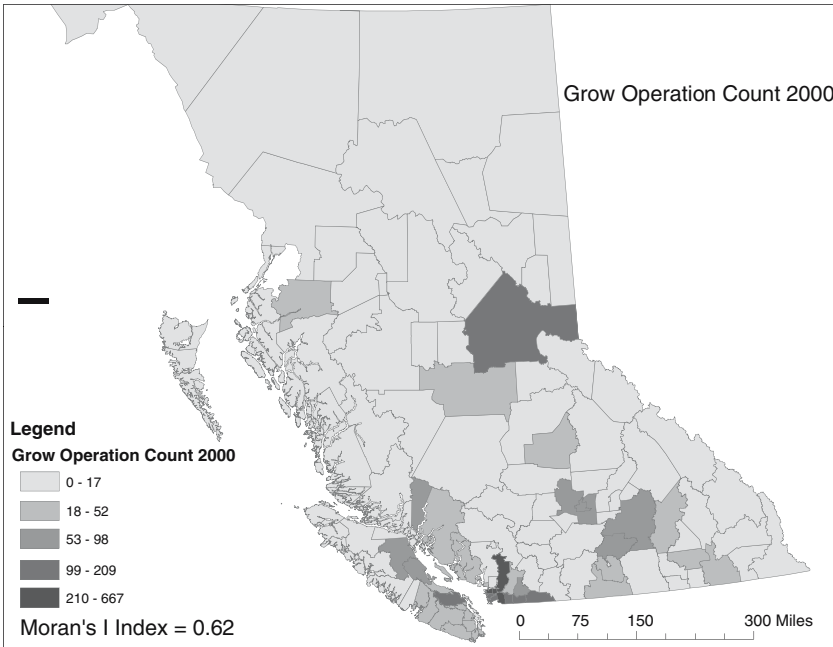
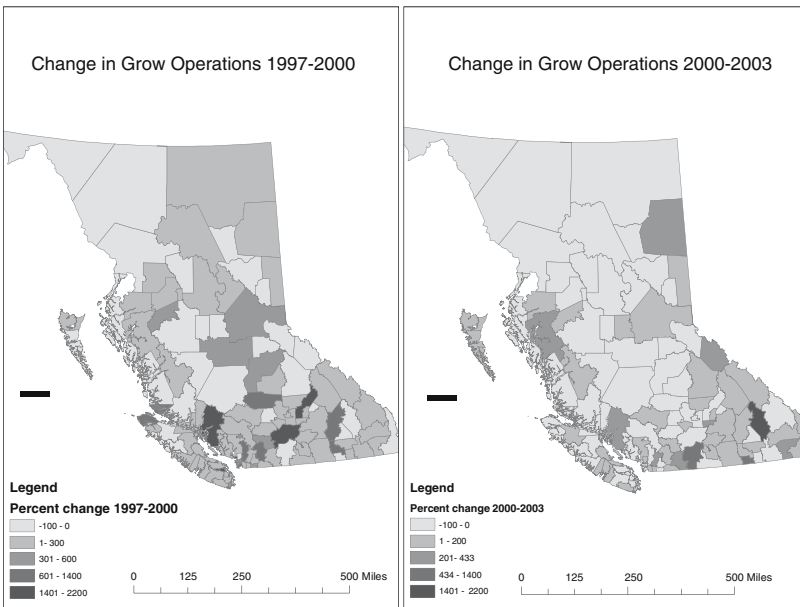**Fig. 4** Spatial distribution of grow operations 2000

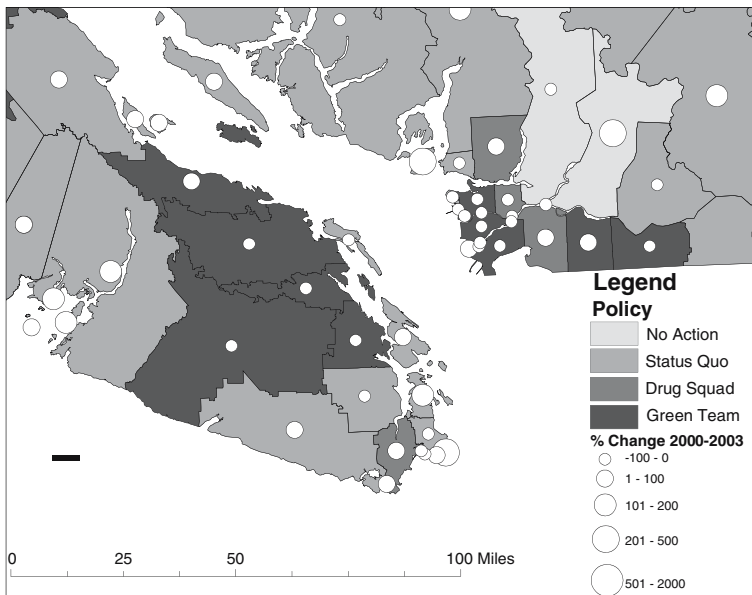**Fig. 5** % Change in grow operations

pre- and post-treatment, and Fig. 6 maps the % change in grow operations post-treatment in relation to policies adopted in the high population area of the province.

An OLS regression of the change in average growth rate regressed on a set of dummy variables can be used to determine whether any of the pre- to post-adoption differences between the treatment and control jurisdictions are significant. The following model is estimated for the entire sample of adopting jurisdictions ($n = 18$) and the non-adopting neighboring jurisdictions ($n = 47$):

$$\Delta G_i = \delta_0 + \delta_1 \text{NONGREEN\_POST}_{it} + \delta_2 \text{GREEN\_PRE}_{it} + \delta_3 \text{GREEN\_POST}_{it} + \varepsilon_{it} \tag{1}$$

where, ΔG_{it} is the change in the average growth rate of marijuana production in jurisdiction i for the ''pre'' (1997–2000) and ''post'' (2001–2003) policy adoption time frame. By definition, the control jurisdictions do not adopt green teams. The dummy variable NONGREEN_POST captures the growth rate for the control jurisdictions and is coded 1 for 2001 (the year after all places adopted a particular policy) and the remaining years. GREEN_PRE captures changes in the treatment areas and is a dummy variable equal to 1 for the years 1997–2000 and 0 otherwise, and GREEN_POST is a dummy variable equal to 1 for the treatment jurisdictions in the years 2001–2003. ε_{it} is the random error term.

Control jurisdictions prior for the years 1997–2000 are the omitted category in the estimation of Eq. 1. Therefore, the coefficient on NONGREEN_POST, δ_1, represents the pre- to post-adoption change in the growth rates of marijuana production for the control jurisdictions. The change in growth rates of treatment jurisdictions is calculated as $(\delta_3 – \delta_2)$. The difference in these two changes, $(\delta_3 – \delta_2) – \delta_1$, is the difference-in-difference estimate (See Cohen & Ludwig, 2003; Greenbaum & Tita, 2004; Meyer, 1995).

Fig. 6 % Change in grow operations 2000–2003 and jurisdiction policies in the high population area of BC

Results

The difference-in-difference analysis compares the difference between the change (difference) in pre-adoption to post-adoption growth rates in marijuana production in treatment jurisdictions to the same changes in the control areas. For example, the growth rate of the number of grow operations was 0.26 (26%) for the treatment jurisdictions prior to the policy adoption. After the implementation of the teams, the growth rate reversed and declined at a rate of –0.56. Therefore, the difference in pre- to post-adoption growth rates for the grow team areas was –0.82. For the neighboring control areas, the growth rate fell from a pre-adoption rate of 0.40 to a post-adoption rate of 0.07, for a difference of –0.33. As expected, the drop in growth rates was larger in the jurisdictions that adopted green teams. The difference-in-difference estimate, therefore, is –0.82–(–0.33) = –0.49.

To determine whether this difference in the growth rate differences is statistically significant, an OLS regression of Eq. 4 is estimated. The difference-in-difference estimate is the combination of coefficients $(\hat{\delta}_3 - \hat{\delta}_2) - \hat{\delta}_1$. To test whether our difference-in-difference estimate was significant, we conduct a Wald test. Formally, we test whether $(\hat{\delta}_3 - \hat{\delta}_2) - \hat{\delta}_1 = 0$. With a p-value of 0.017, the result of the Wald test indicates that the difference in growth rates between the adopting jurisdictions and neighboring jurisdictions is indeed statistically significant.

Discussion

Based on 7 years of marijuana production data from every police jurisdiction in BC, the estimates presented above indicate that tactical units, such as green teams, decrease grow operations within their target area. Compared to the rate of increase in the period preceding green team implementation, the treatment jurisdictions experienced an 82% decline in marijuana cultivation. This decrease begins within the first year of their introduction. Neighboring control areas experienced a seven percent increase in grow operations post-treatment.

Though the results are consistent with a theory in which more effective grow team investigation is leading to displacement into neighboring jurisdictions, we cannot say that this is occurring with any certainty. This research reaffirms previous research that suggests displacement seldom occurs at 100%. The problem usually decreases even as it shifts (Scott, 2003). Though marijuana grow operations continued to increase among the neighbors, the rate of increase at least slowed compared to the pre-treatment rate (33% decline in growth rate pre- to post-treatment). Similarly, without access to more micro-level data on the decision making processes of grow operators, we have no way of knowing whether the slowing of growth represents a positive externality by way of the diffusion of the benefit of grow team adoption in adjoining areas. Clearly, however, the payoff of adopting a targeted intervention in the face of unchecked growth of grow operations far outweighs the benefits of doing nothing.

We also repeated the analysis above excluding from the control group those neighboring jurisdictions that had a ''drug squad'' policy. Not surprisingly, we found that the impact of green teams was even greater (diff-n-diff = –0.56, Wald test = 0.036) when neighboring jurisdictions that took some form of a punitive,

aggressive stance against drugs, in general, were excluded from the analysis. This suggests that drug squads were also effective against marijuana grow operations, and supports a clear finding that when faced with growing levels of marijuana production, ''doing something'' clearly outweighs the option of doing nothing and maintaining the status quo. Similarly, adopting policies aimed at disrupting local grow operations reduced the operation levels in comparison to activity levels within jurisdictions that chose to reduce the level of enforcement/prosecution.

Our research provides another example that outlines the important reasons for considering displacement effects in the evaluation of locally targeted policy interventions, particularly crime prevention policy. In order to counteract displacement, it is critical to understand why displacement might occur and develop measures to track whether or not the problem is moving. Geographic information systems are a key tool in identifying displacement and the effectiveness of crime prevention policies. By using GIS to identify treatment areas and their neighbors, we were able to show that green teams are an effective place-based intervention that appears to reduce the level of marijuana production in the target jurisdictions without displacing activities to neighboring jurisdictions.

References

Bailey, W. C., & Peterson, R. D. (1999). Capital punishment, homicide and deterrence. In M. A. Zahn, & M. D. Smith (Eds.), *Homicide: A Sourcebook of social research*. Thousand Oaks, CA: Sage Publications.

Beard, T. R., Grant P., & Saba, R. (1995). Border-crossing sales, tax avoidance and state tax policies: An application to alcohol. *Southern Economic Journal*, *64*, 293–306.

Bowers, K. J., & Johnson, S. D. (2003). Measuring the geographical displacement of crime. *Journal of Quantitative Criminology*, *19*(3), 275–301.

Braga, A. (2001). The effects of hot-spots policing on crime. *Annals of the American Academy of Political and Social Science*. *578*, 104–125.

Braga, A. A., Weisburd, D. L., Waring, E. L., Greene-Mazerolle, L., Spelman, W., & Gajewski, F. (1999). Problem-oriented policing in violent places: A randomized controlled experiment, *Criminology*, *37*, 541–580.

Brantingham, P. J., & Brantingham, P. L. (1984). *Microspatial analysis of crime, in patterns in crime*. New York: Macmillan Publishing Company.

Brantingham, P. L., & Brantingham, P. J. (2003a). Crime prevention and the problem of crime displacement: estimating quantum of displacement using a cohort component approach. In H. Kury, & J. Obergfell-Fuchs (Eds.), *Crime prevention: New approaches mainz*. Germany: Weisser Ring, Gemeinnützige Verlags-GmbH.

Brantingham, P. L., & Brantingham, P. J. (2003b). Anticipating the displacement of crime using the principles of environmental criminology. *Crime Prevention Studies*, *16*, 119–148.

Chainey, S., & Ratcliffe, J. (2005). *GIS and crime mapping*. West Sussex: Wiley.

Clarke, R. V. (1997). *Situational crime prevention*. New York: Harrow and Heston.

Clarke, R. V., & Weisburd, D. L. (1994). Diffusion of crime control benefits: Observations on the reverse of displacement. In R. V. Clarke (Ed.), *Crime prevention studies. Monsey*. NY: Willow Tree Press.

Coates, D., & Humphries, B. (1999). The growth effects of sports Franchises, Stadia and Arenas, *Journal of Policy Studies and Management*, *18*, 601–624.

Coats , R. M. (1997). A note on estimating cross-border effects of cigarette taxes. *National Tax Journal*, *573*, 84.

Cohen, J., & Ludwig, J. (2003). Policing crime guns. In J. Ludwig, & P. Cook (Eds.), *Evaluating gun violence: Effects on crime and violence*. Washington, D.C.: Brookings Institution Press.

Davis, R., & A. Lurigio (1996). *Fighting back: Neighborhood Antidrug Strategies*. Thousand Oaks, CA: Sage.

Eadington , W. (1995). Economic development and the introduction of Casinos: Myths and realities. *Economic Development Review*, *13*, 51–54.

Eck, J. (1993). The threat of crime displacement. *Criminal Justice Abstracts*, *25*, 527–546.

Green, L. (1996). *Policing places with drug problems*. Thousand Oaks, CA: Sage.

Greenbaum , R., & Tita G. E. (2004). The impact of violence surges on neighborhood business activity. *Urban Studies*, *41*, 2495–2514.

Greene-Mazerolle, L., Price, J. F., & Roehl, J. (2000). Civil remedies and drug control: A randomized field trial in Oakland, CA. *Evaluation Review*, *24*, 212–241.

Grogger, J. (2002). The effects of civil gang injunctions on reported violent crime: Evidence from Los Angeles County. *Journal of Law and Economics*, *XLV*, 69–90.

Hesseling, R. (1994). Displacement: A review of the empirical literature. *Crime Prevention Studies*, *3*, 197–230.

Kennedy, D. M. (1993). *Closing the market: Controlling the drug trade in Tampa, Florida*. Washington, D.C.: U.S. Department of Justice, National Institute of Justice.

Knutsson, J. (1998). The Swedish experience of situational crime prevention. *Studies on Crime and Crime Prevention*, *7*, 189–212.

Maher , L., & Dixon D. (1999). Policing and public health: Law enforcement and harm minimization in a street level drug market. *British Journal of Criminology*, *39*, 488–512.

Maher , L., & Dixon, D. (2001). The cost of crackdowns: Policing Cabramatta's Heroin Market. *Current Issues in Criminal Justice*, *13*, 5–22.

McCaffrey D., Ridgeway G., & Morral A. (2004). Propensity score estimation with boosted regression for evaluating adolescent substance abuse treatment. *Psychological Methods*, *9*, 403–425.

McGarrell, E. F., Chermak, S., Weiss, A., & Wilson, J. (2001). Reducing firearms through directed police patrol. *Crime and Public Policy*, *1*, 119–148.

Meyer, B. (1995). Lessons from the U.S. unemployment insurance experiments. *Journal of Economic Literature*, *33*, 91–131.

Nelson, M. (2002). Using excise taxes to finance state government. Do neighboring state taxation policy and cross-border markets matter? *Journal of Regional Science*, *42*, 731–752.

Novak, K. J., Hartman, J. L., Holsinger, A. M., & Turner, M. G. (1995). The effects of aggressive policing of disorder on serious crime. *Policing—An International Journal of Police Strategies and Management*, *22*, 171–190.

Plecas, D., Malm A., & Kinney B (2005). *Marihuana growing operations in British Columbia Revisited 1997–2003*. Abbotsford: International Centre for Urban Research Studies (ICURS).

Potter, G., Gaines, L., & Holbrook, B. (1992). Blowing smoke: An evaluation of marijuana eradication in Kentucky. *American Journal of Police*, *9*, 97–116.

Repetto, T. A. (1974). *Residential crime*. Cambridge, MA: Ballinger.

Ridgeway, G. (2006). Assessing the effect of race bias in post-traffic stop outcomes using propensity scores. *Journal of Quantitative Criminology*, *22*, 1–29.

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, *70*, 41–55.

Rosenbaum, P. & Rubin, D. B. (1984). Reducing the bias in observational studies using subclassifaction on the propensity score. *Journal of American Statistical Association*, *79*, 516–524.

Saba, R., Beard, T. R., Ekelund, Jr. R., & Ressler, R. (1995). The demand for cigarette smuggling. *Economic Inquiry*, *33*, 189–202.

Scott, M. S. (2003). The benefits and consequences of police crackdowns. *Problem-oriented guides for police. Response Guides Series*. U.S. Department of Justice: Community Oriented Policing Services.

Sherman, L. (1997). Policing for crime prevention, In L. Sherman, D. Gottfredson, D. MacKenzie, J. Eck, P. Reuter, & S. Bushway (Eds.), *Preventing CRime: What Works, What Doesn't, What's Promising*. Washington, D.C.: U.S. Department of Justice, Office of Justice Programs.

Sherman, L., & Rogan, D. (1995). Deterrent effects of police raids on crack houses: A randomized, controlled experiment. *Justice Quarterly*, *12*, 755–781.

Siegel, D., & Anders, G. (1999). Public policy and the displacement effects of casinos: A case study of riverboat gambling in Missouri. *Journal of Gambling Studies*, *15*, 105–121.

Smith, M. R. (2001). Police-led crackdowns and cleanups: An evaluation of a crime control initiative in richmond. *British Journal of Criminology*, *38*, 61–77.

Tita, G., Riley, K. J., Ridgeway, G., Grammich, C. A., Abrahamse, A., & P. W. Greenwood. (2003). *Reducing gun violence: Results from an intervention in East Los Angeles*. Santa Monica, CA: RAND.

Weisburd, D. L., & Green, L. (1995). Measuring immediate spatial displacement: methodological issues and problems. In J. Eck, & D. L. Weisburd (Eds.), *Crime and Place. Monsey*, NY: Criminal Justice Press.

Williams, P. (2001). Transnational criminal networks. In J. Arquilla, & D. Ronfeldt (Eds.), *Networks and netwars: The future of terror, crime, and militancy*. Santa Monica, CA: RAND.

Wood, E., Spittal, P. M., Small, W., Kerr, T., Li, K., Hogg, R. S., Tyndall, M. W., Montaner, J. S. G., & Schechter, M. T. (2004). Displacement of Canada's largest public illicit drug market in response to a police crackdown. *Canadian Medical Association Journal*, *170*, 1551–1557.