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# Marijuana Growth in British Columbia

*by Stephen T. Easton*

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Editor & Designer: *Kristin McCahon*

For media information, please contact Suzanne Walters, Director of Communications,
(604) 688-0221, ext. 582, or from Toronto: (416) 363-6575, ext. 582.

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## Executive Summary

The cultivation and production of marijuana in British Columbia highlights the problems inherent in the enforcement of laws that are generally ignored by broad sectors of the populace. Some 7.5 percent of all Canadians report they use marijuana currently, and over their lifetimes, 23 percent report themselves as having used marijuana at least once.

This paper raises several issues that have the cumulative effect of suggesting that in the long term, the prohibition on marijuana cannot be sustained with the present technology of production and enforcement. To anyone with even a passing acquaintance with modern history, it is apparent that we are reliving the experience of alcohol prohibition of the early years of the last century.

In Canada, and more specifically British Columbia today, as with alcohol nearly a century ago, marijuana is too easily produced and exported to be controlled with the tools available to law enforcement in a free society. The return on investment is sufficiently great so that for each marijuana growing operation demolished, another takes its place.

For a modest marijuana growing operation of 100 plants, harvest revenue is from 13 kilograms of marijuana sold in pound blocks out the back door valued at $2,600 per pound. This amounts to slightly less than $20,000 per harvest. With four harvests per year, gross revenue is nearly $80,000. A conservatively high estimate of production cost is about $25,000. The return on invested money is potentially high: around 55 percent.

The underlying characterization of the marijuana grow operation is that it functions as a profit-maximizing activity in which the values of output and costs yield a market equilibrium rate of return. Such an assumption permits an estimate of the total number of grow-ops. The range of estimates depends upon the value of the crop, the costs of production, the risk-adjusted rate of return to other small businesses, and the likelihood of discovery by the police. For the year 2000, the estimated number of "grow-ops" in British Columbia may be as high as 17,500. Combined with domestic consumption, numbers of this magnitude suggest that exports from British Columbia are worth nearly $2 billion.

Why is it that indoor marijuana cultivation and consumption appear to take place more openly in BC than elsewhere in Canada? The most striking difference between BC and the rest of Canada lies in the rate at which offences are settled by charging the offender (or "cleared"). Only 13 percent of possession offences in BC are cleared by charge. Elsewhere in Canada over 60 percent of possession offences are cleared by charge. In addition, the penalties for conviction appear to be low.

In a sample of Vancouver marijuana growing operations "busted" by the police, most of those who were convicted received no jail time: 55 percent. Five more percent were sentenced to a single day or less and another 8 percent received sentences of between one day and 31 days, while still another 8 percent received 60 days. Some 11 percent were sentenced to 90 days. Of those who are repeat offenders, half are reconvicted within the year. Of the 35 percent who were fined, the average fine amounted to less than $1,200: a small amount considering the size of most marijuana operations. While police resources are spent to destroy nearly 3,000 marijuana growing operations a year, the consequences are relatively small for those convicted.

Current public policy proposals emphasize decriminalization. Suppose, however, that marijuana were treated like any other product and were to be sold at retail cigarette value rather than in bulk. At current prices, a marijuana cigarette costs about $1.50 to produce, and sells for around $8.60. Since the consumer currently is willing to pay $8.60, imagine a tax on marijuana cigarettes equal to the difference between the local production cost and the street price. This would transfer the revenue from the current producers and middlemen, many of whom are associated with organized crime, to the government. Crudely, government would have revenue of about $7 per cigarette. Using conservative assumptions about Canadian consumption, this comes to revenue of over $2 billion, and should marijuana be taxed on the same basis for export (leaving aside obvious problems of international diplomacy with the United States), additional revenue could be generated. Further, policing assets currently involved in enforcing marijuana-related statutes could be deployed elsewhere.

What the analysis reveals is how widespread marijuana use is in Canada and how extensive production is in British Columbia. As a consequence, the broader social question becomes less about whether we approve or disapprove of local production, but rather who shall enjoy the spoils. As it stands now, growers and distributors pay some of the costs and reap all of the benefits of the multi-billion dollar marijuana industry, while the non- marijuana-smoking taxpayer sees only costs.

# Marijuana Growth in British Columbia

The cultivation and production of marijuana in British Columbia highlights the problems inherent in the enforcement of laws that are generally ignored by broad sectors of the populace.[1] Some 7.5 percent of all Canadians report they use marijuana currently (or at least have done so during the past year). Of those aged 15 years and older, about 23 percent of the Canadian population report that they have used marijuana at least once in their life.[2] By province there are variations in recent marijuana use with British Columbia the highest at 11 percent, and Newfoundland and Ontario the lowest at 3.8 percent and 5.1 percent respectively. There is variation in use by age and sex, with younger people more likely to have used the drug than older people[3] with males using at twice the rate of females.

This paper raises several issues that have the cumulative effect of suggesting that in the long term, the prohibition of marijuana cannot be sustained with the present technology of production and enforcement. To anyone with even a passing acquaintance with modern history, it is apparent that we are reliving the experience of alcohol prohibition of the early years of the last century.[4] In that sorry episode, on both sides of the Canada-US border the widespread demand for prohibited alcohol led to the rapid growth of criminal enterprises that expanded to produce the product that the general population desired.[5] As a testament to the enduring significance of the period, recall that even today we cheer for Eliot Ness as he smashes the alcohol making stills of organized crime in endless television reruns of *The Untouchables*. Ironically, we may now sip a cocktail as we do so.

In Canada, and more specifically in British Columbia today, as with alcohol nearly a century ago, marijuana is too easily produced and exported to be controlled with the tools available to law enforcement in a free society. The return on investment is sufficiently great that for each marijuana growing operation demolished, another will take its place.

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1 I am indebted to several people who have read, commented, and offered insight about drafts this paper. Jason Clemens, Herbert Grubel, David Easton, Malcolm Easton, Kash Heed, Fred McMahon, Robert A. Jones, Niels Veldhuis, and Michael Walker each offered valuable insights but are not responsible for the content. Liv Fredrickson helped with data input as well as advice. Obviously I am responsible for errors.

2 (Single *et al*., 1999.) Contrast these figures with lifetime use of 8.1 percent for cocaine and 10.4 percent for LSD, speed, or heroin. On the legal side, 72 percent of the Canadian population has used alcohol in the past year, and 27 percent identify themselves currently as tobacco smokers.

3 Among those 15 to 19 years old, about 25 percent have used in the past year (Single *et al*., table 5.3). Although it is not in the survey data, it may very well be that the younger set—aged 9 and up, should actually be queried as well. Data from grade schools suggest that use of marijuana in the past year in grade 7 is typically around 10 percent or below. The percentage swells to around 30 percent or higher by grade 9 (*New Brunswick Student Drug Use Survey 2002 Highlights Report*; *Nova Scotia Student Drug Use 2002 Highlights Report*; *Prince Edward Island Student Drug Survey 2002 Highlights Report*). Data from other provinces are consistent with these figures.

4 See, for example, Mark Thornton (1991), "Alcohol Prohibition was a Failure," *Cato Policy Analysis* No. 157 (January).

5 See, for example, Warburton (1932, chapter IX) or Thornton.

Although there are a host of important criminological, social, psychological, and economic issues associated with marijuana, this paper is primarily a framework that develops a series of "facts" and characterizations of the marijuana industry in British Columbia that can be revisited, revised, and challenged to make a sensible policy debate possible.[6] The first two sections of the paper organize the discussion using the economist's model of demand and supply with an emphasis on the latter. Subsequent sections include a methodology and estimate of the number of marijuana growing operations ("grow-ops" as they are popularly known) in British Columbia, some discussion of why British Columbia appears to be a significant location for marijuana production, and some thoughts about the transformation of currently illegal returns into tax revenue were marijuana to be made legal.

## Canadian Marijuana Consumption

Marijuana consumption is difficult to measure. Although there are plenty of data about marijuana *use* in Canada, very little is quantitatively oriented. To say that someone "uses" once or twice a week is not very specific about the *quantities* they are likely to use. Reuter suggests that a "very heavy user of marijuana consumes about 3 marijuana cigarettes per day" (1996, p. 7).[7] In Australia, usage has been measured in the Australian Institute for Health and Welfare *1998 National Drug Strategy Household Survey*.[8] More Australians appeared to have tried marijuana (39 percent compared to 23 percent of Canadians), and more Australians have used marijuana "recently" (18 percent compared to 7.5 percent in Canada).

The average marijuana cigarette is 0.4 to 1.0 grams in weight (Adams and Martin, 1597). [9]For those who still think in Imperial units, there are about 28.35 grams in an ounce or about 453.6 grams in a pound. There are, of course, 1,000 grams in a kilogram. Consequently, even if marijuana use is measured in number of cigarettes, quantity is still difficult to assess. Loosely, 15 grams of marijuana generates between 15 and 30 cigarettes according to taste. I have found no correction for the strength of the active ingredients

6 I do not discuss the Canadian federal government initiatives to decriminalize small amounts of marijuana. Such a proposal deserves a separate and specific response.

7 On the other hand, asking around locally suggests that this is high for British Columbia leaf. Anecdotally, a heavy user is said to use one cigarette per day.

8 Digital document available at *http://www.aihw.gov.au/publications/health/ndshs98d/*. Although these data have more information about frequency of consumption, quantity must still be imputed.

9 Others find slightly lower values at roughly 0.39 grams per cigarette (W. Rhodes *et al*., 1995, *What America's Users Spend on Illegal Drugs*, 1988-93, Washington, D.C.: Office of National Drug Control Policy, p. 20, cited in Reuter, 1996.) In contrast, commercial cigarettes weigh-in at 0.77 grams, a weight that appears to have stabilized since 1988. Prior to 1988, the weight of a cigarette had fallen from over 1.6 grams in the early 1950s to about 0.77 today (*http://www.ncth.ca/NCTHweb.nsf/0/ac40b01bdef1ff99852569d60063e43b/$FILE/gdb6a-weight.pdf*).

on the "weight" of the cigarette. Some people report that they consume as many as 60 cigarettes per day, but they are obviously exceptional.

## Some limits on the size of the *internal* market for marijuana

If roughly 7.4 percent of the Canadian population currently uses marijuana, then with 25 million Canadians aged 15 or over this implies about 1.87 million users. Table 1 puts this consumption into some kind of numerical perspective.[10] The first column identifies the number of users based on estimates of usage described in Single *et al*. (1999, Table 5.1) The second column gives an estimate in metric tons of internal Canadian marijuana consumption. The third column multiplies this by price to illustrate the size of the Canadian (consumption) market. This of course does not include exports. The final column details the expenditure by Canadians on (legal) tobacco for the past few years to illustrate the scale of the internal market.

How large is the industry? Expenditures on illegal marijuana in Canada are roughly the same order of magnitude as those on legal tobacco products. Substantial though these numbers may be, however, they are not the central issue. Even as the Government of Canada apparently plans to reduce the penalty for consumption, most attention focuses on production for which the external market in the United States is simultaneously an economic goldmine and a political landmine. As the evidence will show, it is obvious that much of the British Columbia marijuana crop is grown for export.

**Table 1: Estimates of the Internal Canadian Market for Marijuana, 1988-2000**

| Year | Current users (millions) | Total internal consumption* (thousands of kilograms) | Annual expenditure on marijuana* (billions of dollars) | Annual expenditure on tobacco (billions of dollars) |
|---|---|---|---|---|
| 1988 | 1.38 | 111.0 | 1.4 | |
| 1990 | 1.10 | 92.1 | 1.5 | |
| 1991 | 1.11 | 87.9 | 1.5 | |
| 1992 | 1.13 | 92.2 | 1.6 | |
| 1993 | 0.96 | 81.1 | 1.2 | |
| 1994 | 1.71 | 152.1 | 2.0 | |
| 1995 | 1.73 | 154.1 | 1.7 | |
| 1996 | 1.75 | 156.1 | 1.7 | |
| 1997 | 1.78 | 158.2 | 1.7 | 2.5 |
| 1998 | 1.80 | 160.1 | 1.9 | 2.5 |
| 1999 | 1.82 | 162.0 | 1.7 | 2.4 |
| 2000 | 1.84 | 164.1 | 1.8 | 2.3 |

*Table 1A provides upper and lower estimates.
Sources: See Appendix Table 1A.

10 This table is derived from Appendix table 1A, which details the sources and methods of construction. Table 1 uses the "low" estimates from table 1A.

## Producing Marijuana in British Columbia

There is very little hard information about the actual number of marijuana growing operations ("grow-ops") in British Columbia. From the pattern of police enforcement we believe that the numbers have been increasing, but the actual scale of marijuana growing is difficult to know with assurance—for obvious reasons. From 1997 to 2000, Plecas *et al.* report that the number of grow-ops discovered and dismantled, or "busted" in the usual terminology, more than doubled: from 1,251 to 2,808. This issue is addressed below in the section titled "How Many Grow-ops are Out There?"

There are several ways to produce marijuana. I will discuss the outcomes of indoor supply, which is the most relevant to an urban setting and the current data set. Nearly 80 percent of all grow-ops discovered by police are indoor operations, although this reflects policing costs as well as the true distribution of grow-ops. Further, there are likely to be plenty of individual marijuana grow operations of a few plants that are not likely candidates to be busted and are consequently are not included in the statistics. Before turning to the production side of the marijuana industry, however, there is the matter of price that permeates any discussion of the business. The next section develops a characterization of the relationship between price and quantity that is used throughout the rest of the analysis. This is important because evaluating marijuana quantities sold at per pound prices of production may lead to different interpretations of size and significance of the industry than by evaluating marijuana sales at the more expensive "per cigarette" level of consumption.

### The price of the product

To give some idea of the value of marijuana (Appendix A discusses the estimates in detail), table 2 uses estimated values computed from cross-Canada data gathered by the RCMP from 1995 to 1999. Aggregating these data and estimating a relationship for British Columbia gives a sense of the values appropriate for different quantities of the drug.[11]

**Table 2: Retail Purchase Prices by Quantity of Purchase**

| Unit in which purchased | Year 2000 Canadian $ unit price | Gram weight of purchase | Price per gram of the purchase |
|---|---|---|---|
| 0.5 gram | 8.6 | 0.50 | 17.16 |
| 1 gram | 15.3 | 1.00 | 15.33 |
| 1 ounce | 254.5 | 28.35 | 8.98 |
| 1 pound | 2,613.0 | 453.60 | 5.76 |
| 1 kilogram | 5,077.0 | 1000.00 | 5.08 |

The underlying estimation appears as equation 2 in Appendix A.

11 Not all units were actually purchased or reported in the raw data. For example, the kilogram price is an extrapolation of the estimated power function that relates price to quantity. All the other quantities were part of the data set.

The table's first column reports the unit of purchase. The second column reports the average price of the purchase of that unit. The third column indicates the number of grams in the purchase bundle in order to put the purchases into a common unit. The final column reports the implicit price per gram at the different quantities. As is expected, larger quantities are cheaper on a per gram basis.[12]

## Growth cycle and "bud" size

Outdoor crops mature once a year. Each indoor crop takes between 6 weeks and 4 months to mature.[13] To err on the side of caution, we will use a period that gives four harvests per year.

At harvest each plant produces one "bud" which is the structure that produces about 100 grams of usable marijuana. This, in turn, yields a dry weight of roughly 33 grams.[14] Although they may not be a representative sample, data from Vancouver police drug busts suggest that in 1998 a bud weighed about 3.3 ounces (100 grams). In 1999 the average bud had increased to 4.3 ounces (122 grams). Most estimates (Plecas *et al.*, for example) take 100 grams as the relevant average. This assumption will also be made in what follows.

## Potency

One frequently uttered sentiment is that British Columbia grown marijuana is on the stronger end of the spectrum. This may be true, but it is tricky to document systematically. Data collected by the RCMP tend to suggest that the potency, the THC content, has remained roughly constant over the 1995 to 1999 period. Nationally, there was no obvious increase in the measured quality of marijuana acquired by the police from various activities: busts, buys, and the like. Within British Columbia, although the mean THC content has increased over the same period, that increase is not statistically significant.[15] Consequently, although it is possible that there has been an increase in the THC content (if popular reports are to be believed), it remains to be observed systematically, though the raw numbers are not inconsistent with an increase in the late 1990s.

## The house

The marijuana producer needs an establishment to house a grow-op. Typically, grow-ops have been found in rented houses. A house typically rents for about $18,000 a year, though there is evidence that increasing the scale of production demands alternatives.[16] Grow-ops arise (in part) because they have a very quick time to market compared to natural marijuana crops that have an annual cycle.[17]

The equipment necessary to run a grow-op includes supplies, lights, fans, seeds, and miscellaneous other materials. For a 100-plant operation,

12 For example, Caulkins (1994) finds a similar relationship for cocaine prices and quantities in the United States.

13 A relatively new phenomenon is that grow-ops are being found with "continuous cycle" harvesting. That is, there is a "circle" of plants with one at each stage in the productions process. Such a model takes more hands-on work, since one task or another has to be performed more frequently, but if the grow-op is busted by competitors, then there is much less market-ready product available. A clear trade-off is being made.

14 In addition, there are often several smaller buds, but I have not seen estimates of how many or how large they are.

15 Based on 2,089 BC observations, the THC (delta-9-tetrahydrocannabinol) content from 1995-1999 was 6.5, 6.9, 6.6, 7.1 and 7.4 percent (Ladds, 1999).

this amounts to about $10,000.[18] The electricity costs about $2,500 per year. Many growers gladly pay for it. Others fear that the hydro company will notice the extensive residential use of electricity and might investigate.[19] Still others simply steal the electricity.

Similarly, the grower cannot set up a generator in the back yard or on a balcony. It will make a conspicuous noise and will alert thieves who would help themselves to the maturing buds, an activity known as "grow-rips." Obviously, there is no public recourse if you, as a grower, are burglarized. Nor can you carry theft insurance for the valuable crop. This may also help to explain the boom in "guard" dogs in some parts of British Columbia's Lower Mainland as well as protection provided by organized crime for selected operations (Howell, 2002).

Ignoring electricity costs, table 3 reports that the total material cost of the operation is about $28,000. Obviously what is missing is the labour cost. At a minimum wage of $8 per hour over a 24-hour day to provide for constant security, the cost of labour could add another $70,000 to expenses. On the one hand, unlike the standard minimum wage paid and received, this is tax "free," and even the most intensively farmed grow-op does not really need 24 hour care all the time. Consequently, this is a *very* high estimate of labour costs, and means that we will tend to understate the profitability of grow-ops. On the other hand, there is always the possibility of violence associated with grow-ops, which adds a premium to the usual market wage. For obvious reasons it is difficult to document labour usage and remuneration patterns systematically.[20]

## How much does such an operation produce?

Although most estimates of production are speculative or designed to serve a particular purpose, Plecas *et al*. (p. 35) find that the average number of plants discovered in all marijuana grow-op busts around the province has been on the increase. Across British Columbia from 1997 to 2000 the average number of plants seized rose from 140 to

16 Recent busts reported in Vancouver newspapers suggest that new houses worth $300,000 to $400,000 are being purchased and used for a year or so for such purposes. Large-scale production at greenhouse operations in more rural settings has also been found recently. This suggests that the scale of grow-ops is increasing and is not inconsistent with observations by Plecas *et al*.

17 A quick introduction to marijuana grow operations is available to anyone who wishes to peruse the Internet. The detail and apparent sophistication of the technology is voluminous. The police have provided tips for spotting grow operations: *http://www.city.richmond.bc.ca/emergency/police/grow_operations.htm*. There is information on the types of lights and programs necessary to maximize indoor yield by following the links at sites such as: *http://www.cannabislink.ca*; or *http://www.cannabisnews.com*. Easier yet, try typing something like "marijuana growing" into a search engine.

18 This is typical in the sense that even though the average size is higher than 100 plants per grow-op, most operations still remain small, and the high average is due to some really large and spectacular busts of thousands of plants. There are relatively few of these in the data. As a result, although I call this typical, it is a statement about most likely to be observed rather than mean number of plants. The average number of plants found in grow-ops is rising.

19 Interestingly, there is irritation among some in law enforcement that the electricity supplier is not active in identifying likely grow-ops unless they fail to pay their bills. If they fail to pay, or are found bypassing the meter, then the electricity company expects prompt action by the police since it is a theft in progress.

20 Sharecropping (in which the financer and the grower split the crop) also is known. Some informal reports to the author suggest a 50-50 split is common.

**Table 3: A Calculation of Vancouver Grow-ops**

| Revenue | Numbers | Comment |
|---|---|---|
| Number of plants | 100 | Near both mean and median in 161 busts VPD* busts from 1994-1999 |
| Number of seasons | 4 | From 6 to 12 weeks |
| Total number of buds produced during one year | 4 x 100 = 400 | Each bud is roughly 100 grams |
| Total weight in kilograms | 13.3 | (400 x 100) x ⅓ to account for dry weight |
| Price per pound (bulk) | $2,600 | See table 2 (2.2 pounds per kilo) |
| **Annual value of sales** | $76,000 | This is bulk (rounded) |
| **Costs** | **Numbers** | **Comment** |
| House rent | $18,000 | Assumes full year occupancy |
| Supplies | $4,000 | Fans, lights, containers, seeds, etc. |
| Wages (implicit or explicit) | $2,000 | Care and clipping of plants |
| Electricity** | $2,500 | Could be less if operator steals power |
| Operating Cost | $24,500 | ($1,500 per pound) |
| **Share to operator** | $38,000 | 50% of final product |
| **Net revenue** to investor* | $13,600 | 50% of revenue less operating cost |
| **Return on a dollar of cost** | 55% | (All figures rounded) |

*Source: Wicksteed (2002) provides data about the size distribution of busts and the cost of supplies. House rents are a casual average from local newspapers. Plecas *et al.* provide estimates of the size of buds.
**Electricity at 0.57 cents per kWh implies an annual cost of $2,500 for lighting this operation. More generally this amounts to roughly $8.50 per plant.

180. There are apparently more operations, and an apparent increase in size of these operations.

## A rough calculation of a marijuana grow operation

To get a sense of the numbers for a typical operation, assume a grow-op has 100 plants. This puts it in the "modest size for commercial use" category. Harvest revenue comes from 13.3 kilograms of marijuana sold in pound blocks out the back door at $2,600 per pound.[21] This amounts to slightly more than $19,000 per harvest. Since there are four harvests per year (on the conservative side), gross revenue is about $76,000. Even if costs are about $24,500, and the final sales are split equally with the operator, the net rate of return on invested money is potentially very high. The 100-plant grow-op makes around 55 percent return for a year's worth of activity using the most conservative assumptions.

But the rate of return is not *really* 55 percent. There is the chance that you will be busted–either by your colleagues on the wrong side of the law, or by the police. If 10 percent of grow operations were busted by police, competitors, or thieves, then the expected annual rate of return is about 40 percent.[22] This is still a fine rate of return if you can get it, but there are clearly risks in the busi-

21 This may be a little high currently, but see table 2. In discussing this figure with British Columbians who claim to know, they suggested that they were not able to get more than $1,900 per pound. This is casual empiricism and serves to alert the reader to the gross uncertainties of any estimates. Consequently, in estimating the number of marijuana grow operations (below), it is appropriate to use a wide range of assumptions.

ness that are not about business. Interestingly, the observation that there are additional risks and our knowledge of the returns to the marijuana grow-op business provide a mechanism for determining the number of marijuana grow-operations. This is discussed in the next section.

## How Many Grow-Ops Are Out There?

One of the enduring problems facing anyone interested in the illegal, or "black," or even gray economy, is to derive an estimate of the underlying level of total activity from the sample of those that are detected. There are problems in doing this. A few might be catalogued under some broad headings:

- sample selection—only the unlucky or the least capable are caught;
- varying intensity of effort on the part of the authorities—more police "fishing" means a higher catch, at least initially; and
- an uncertain feel for what the alternatives are facing the agents who are thinking of going into illegal production—can they find a remunerative line of work in the legal sector, or are their alternatives really all about illegal alternatives to, say, marijuana production?[23]

This section proposes one calculation method to infer the number of grow-ops in British Columbia. More generally, it is a technique that could be used in a number of situations both current and historical. Although one may disagree in detail with *every* aspect of the analysis, it also provides a target to classify the underlying variables that may be important to any analysis of uncounted activities.

### The approach

The underlying characterization is of the grow-op as a profit maximizing activity in which the value of output less costs, relative to the value of assets, yields the rate of return to assets. For each crop of a grow-op, all costs are fundamentally variable, so that we can write the rate of return as relative to costs.[24]

If the industry is in equilibrium, then the return on capital (or costs) is equated to the rate of return

22 That is, with only a 90 percent chance of realizing your sales, the expected rate of return becomes: ((0.9 x (½ x $76,000) - 24,500)/24,500).

23 There is still plenty of disagreement about the number of marijuana grow operations in British Columbia. Mark Hume of *The Globe and Mail* of January 12, 2004 reports: "Police estimate 2,000 to 3,000 grow-ops are producing BC bud in Greater Vancouver" (p. A2). On January 31, 2002, however, the *Vancouver Sun*'s Scott Simpson reports that the head of the Vancouver drug squad, Inspector Kash Heed, "could not estimate the number of growing operations in Vancouver, but said the number for the Lower Mainland has been pegged as high as 15,000" (*http://www.mapinc.org/mjcn.htm*). Interestingly, on a different page of the January 12, 2004 *Globe and Mail,* Peter Cheney reports police estimates that there are now 15,000 marijuana grow operations in Ontario (p. A6).

24 The alternative is to assume that the capital is used for a number of crop cycles. This would have the effect of increasing the value of output relative to the asset base. Consequently, this assumption biases the return to growing marijuana downward. The "true" returns on invested capital are likely to be higher.

in other industries or activities on the margin. This is the key observation underlying the estimation of the total number of illegal activities. It is what links the unobserved illegal activity to the known, legal world.

More formally, we write the value of output, PQ (price times quantity) less cost, C, relative to the value of capital, or in this case, cost. This gives a rate of return to investment (cost) in a particular year.

Thus R is a return over costs and looks like:

1. $R = [PQ-C]/C$

The value of output less cost is net income, PQ-C, during the year, and the return over costs is akin to the usual calculation of the rate of return to capital. If we believe that the industry is in equilibrium, about which more will be said later, then the return on capital (or costs) is equated to the rate of return in other industries or activities on the margin. Thus $R = R^*$, where $R^*$ is the market rate of return.

Unlike the market, however, a grow-op includes ingredients of extraordinary risk not captured by legal market entities. Let us add a probability of getting caught[25] in a grow-op and consequently the risk of losing the entire crop. If the probability of getting caught is $\pi$, then the harvester has a $(1-\pi)$ probability of being able to sell quantity Q at price P. Compared to a riskless sale, this lowers the return to any given investment.[26]

2. $[(1-\pi)PQ-C]/C = R^*$

The left-hand side tells us that the harvester has a $(1-\pi)$ probability of being able to sell quantity Q at price P. Compared to a legal sale, this lowers the return to any given investment. The investor is assumed to lose the costs, C, whether the crop can be sold or not.

The expected return is equated to the return that the investor can get in any other sector of the economy, $R^*$. In effect, we assume that the potential investor in the marijuana business is faced with two options: Our potential producer can invest in those activities that are legal and receive a normal rate of return of $R^*$; or our potential producer can invest in a grow-op that includes an extraordinary risk of crop loss.

### *A refinement*

The market rate of return, $R^*$, constrains the amount of investment in marijuana grow operations. If more and more people get into the business, eventually it will drive the return below that which could be made in other business activities. This limits the size of the sector. Symmetrically, if the return to marijuana grow-operations is higher than the return in other activities, this leads to more investment going to the marijuana industry, eventually driving the return toward the market average. This basic framework may not fully capture the essential constraints on an illegal activity. Do potential growers of marijuana view the market return on funds as relevant in assessing their alternatives? If one were loaning funds to a grow-op producer, the lender may insist on a risk premium associated with the loan so that the constraint associated with an equilibrium in the

25 In this context, "getting caught" includes being shopped by unscrupulous competitors, as well as having your crops catch fire, or simply be stolen by thieves. A tip apparently led to the discovery of a "massive" hydroponic operation in Barrie, Ontario, in the old Molson brewery—a site in plain view of Highway 400 (*The Globe and Mail*, January 12, 2004, p. A1, A6.) In Vancouver, police speculate that a marijuana grow-operation is invaded each day by competitors.

26 The investor is assumed to lose the costs, C, whether the crop can be sold or not.

marijuana growing business is not the market return, R*, but a return that is risk-adjusted above those associated with legal investments. As a result, the cost of funds that this group faces carries a risk premium relative to that of legal investments.[27]

This suggests an expression like 3 is relevant to the basic equilibrium:

3. $[(1-\pi)PQ-C]/C=R^*+\pi$

which equates the expected return on the left-hand-side to a higher-than-legal-market return by an amount of the risk, $\pi$. Although the risk may not simply be additive, Appendix B derives a form that is consistent with 3.

## Calculating the number of grow-ops

How does all this help with a calculation of the number of grow-ops in British Columbia?

We need to assume something about $\pi$. We assume that it is the risk of being busted by the police.[28] If we assume that only the police bust grow-ops, then we can develop a measure of the total number of grow-ops in the province.

To see this, recall what we "know" in this context:[29]

- We know the price of the product (see appendix B)
- We know the quantity of product for each operation—or at least we know the average output of those that are busted.
- We know the cost of the operation, although there are a few nagging issues that make this a more speculative calculation than the other data.
- We know the market return on legal enterprises—although this can be argued, the range of variation is likely not to matter much as will become apparent in the calculation.
- Finally, we also have a measure of the number of operations that have been busted around the province.[30]

These data are sufficient to calculate the number of grow-ops. To see this, first consider the variable, $\pi$. Since $\pi$ is the probability of being busted, we can think of $\pi$ as being the ratio of busts relative to the total, T, the (unknown) number of grow-ops:

4. $\pi=B/T$

27 Note that this is not the same as another experiment: should a person participate in the legal or illegal market? In this case, clearly the decision is based on R*.

28 It also should include any other risk associated with being illegal rather than legal, e.g., lack of resources for redress of theft, extras security, and the like. Underestimating the risk will underestimate the number of grow-ops.

29 In this context, "know" is speculative under the best of circumstances.

30 This, of course, is police busts. It should also include "busts," or thefts, or any other event that reduces the ability to sell the final product on the left-hand side of the equation. As discussed earlier, some reports have marijuana "rips" at one a day in the Vancouver area alone. Consequently, these calculations that use only police data to estimate the number of marijuana grow operations are very conservative.

**Table 4: The Effect of Different Assumptions for Estimating the Number of Grow-Ops in BC**

| Actual Police Grow-op Busts | Assumed Return to Legal Activities | Assumed Ratio of Value to Cost | Market Return is R* | | When the Return is risk Adjusted, R*+ π | |
|---|---|---|---|---|---|---|
| | | | Implied Total Number of Grow-ops | Implied Probability of being Busted | Implied Total Number of Grow-ops | Implied Probability of being Busted |
| B | R* | PQ/C | T | π | T | π |
| 2,800 | 10% | 5.0 | 3,590 | 0.78 | 4,308 | 0.65 |
| | | 4.5 | 3,706 | 0.76 | 4,529 | 0.62 |
| | | 4.0 | 3,862 | 0.73 | 4,828 | 0.58 |
| | | 3.5 | 4,083 | 0.69 | 5,250 | 0.53 |
| | | 3.0 | 4,421 | 0.63 | 5,895 | 0.48 |
| | | 2.5 | 5,000 | 0.56 | 7,000 | 0.40 |
| | | 2.0 | 6,222 | 0.45 | 9,333 | 0.30 |
| | | 1.9 | 6,650 | 0.42 | 10,150 | 0.28 |
| | | 1.8 | 7,200 | 0.39 | 11,200 | 0.25 |
| | | 1.7 | 7,933 | 0.35 | 12,600 | 0.22 |
| | | 1.6 | 8,960 | 0.31 | 14,560 | 0.19 |
| | | 1.5 | 10,500 | 0.27 | 17,500 | 0.16 |
| | | 1.4 | 13,067 | 0.21 | 22,400 | 0.13 |
| | | 1.3 | 18,200 | 0.15 | 32,200 | 0.09 |
| | | 1.2 | 33,600 | 0.08 | 61,600 | 0.05 |

Since we know the number of operations that have been busted by the police, B, everything is "known" (however imperfectly) except for T, the total number of grow-ops at risk. That is, we know P, price, Q, quantity and R*, the rate of return on legal economic activity.

Some manipulation gives us the following expression:

$$5. \qquad \pi = B/T = \{[(PQ/C)-(1+R^*)]/[1+(PQ/C)]\}$$

or, finally, an expression for the total number of grow-ops:

$$6. \qquad T = B.\,[1+(PQ/C)]/[(PQ/C)-(1+R^*)]$$

So what do the numbers look like? To illustrate: Let B = 2,800[31]; let R* = 10%; let (PQ/C) = 5

$$7. \qquad T = 2{,}800.[(1+5)]/[(5-(1.10)] = 2{,}800.[6/(3.9)] = 4{,}308$$

Table 4 reports what the theory implies for the number of grow-ops in British Columbia using various assumptions about the ratio of the value of output to costs. From the estimates in table 3, the number of grow-ops would be between 10,500 and 17,500 depending on the approach to risk. In later sections I use the 17,500 figure as I believe it best characterizes conditions in BC.

31 This is the number of "founded" cases in 2000 in all of British Columbia (Plecas *et al.*, 2002, p. 27.)

One point needs reinforcing. These are estimates for the numbers of "bustable" grow-ops. By that I mean that the small operations of a few plants that are for personal use generally are not "busted." The Vancouver Police busted 30 grow-ops with fewer than 50 plants over a period of several years. The average was 117 plants, with a median of 95 plants. The fewest seized in a grow-op bust were 25 plants, and the most seized were over 1,100 plants (Wickstead, 2000a). A reasonable interpretation of the data in the table is that for grow-ops over 25 plants, these are the total number of "bustable" operations implied.[32]

How reasonable are these estimates? If the reader wants a general rule for thinking about this, consider: what fraction of grow-ops is likely to be discovered and busted by the police? Suppose the police are able to bust one-half of all grow-ops. With 2,800 grow-op busts in the year 2000, it means that there were 5,600 grow-ops initially. If the police bust only 10 percent of grow-ops, then we can infer that initially there were 28,000 grow-ops. Although certainly not definitive nor a substitute for analysis, readers should use their "ingenuity guided by experience" to form their own tentative estimate.

## Some of the limitations of this calculation

There are a number of limitations inherent in this calculation. First, the number of busts known is not the same as the number of actual busts as seen from the producers. We use known police busts. Clearly, if there are grow-rips by competitors or "colleagues," then the effect is to underestimate the riskiness of the enterprise.[33] Thus, the numbers in the table will underestimate the number of grow-ops. This is because the total number of grow-ops is, by formula, proportional to the number of busts as seen by the growers.

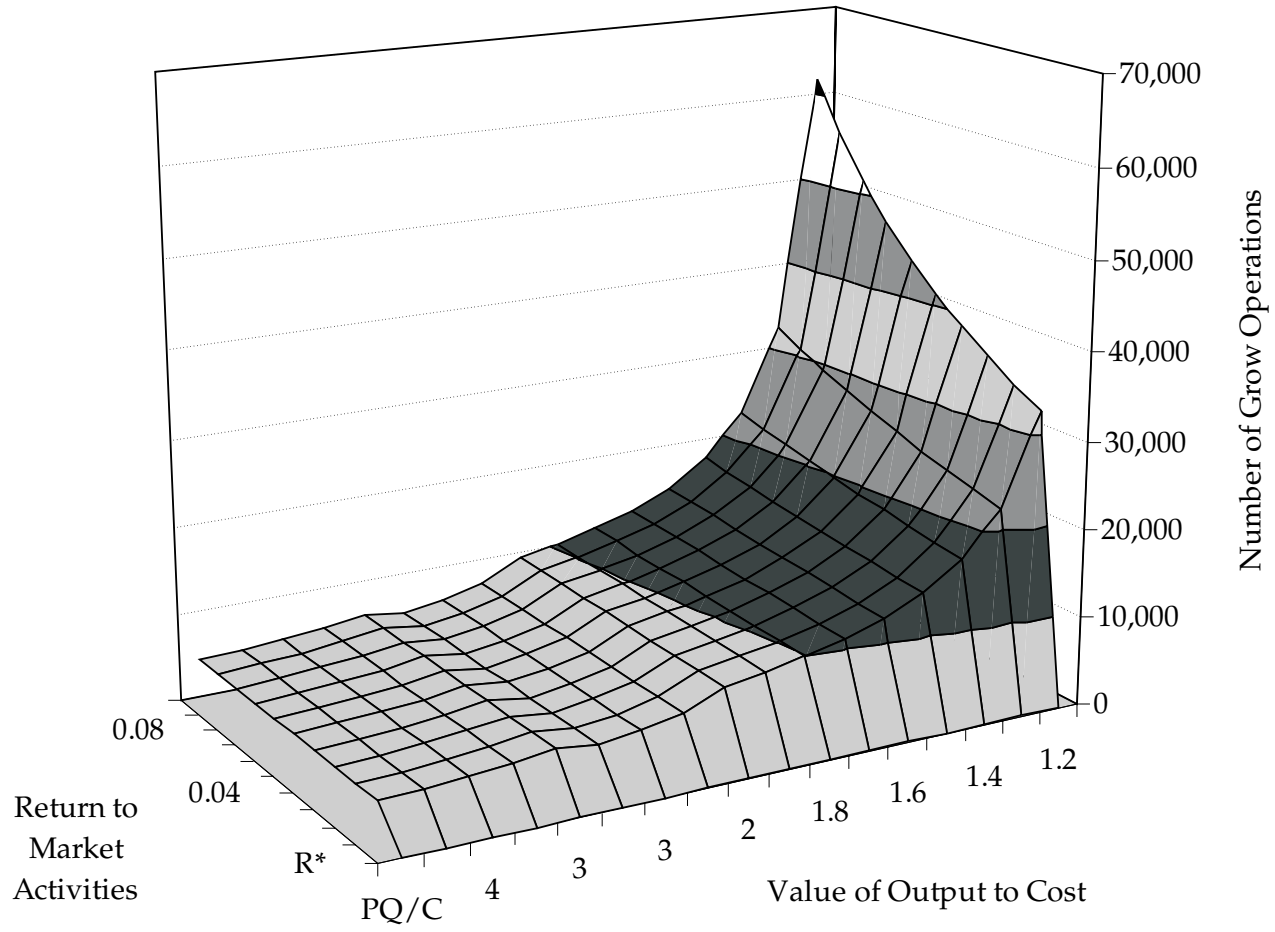
Second, increased enforcement implies increased numbers. Again, this is a consequence of the formula that requires the number of grow-ops to be proportional to the number of busts. The reason that the enforcement "doesn't matter" in the calculation is that the only thing assumed to be important to the producer is the actual number of busts relative to the total that gives rise to the risk. Yet most of us would be concerned that the calculated number of grow-ops should not increase merely with increased enforcement. This is a limitation of the model in the text that must be addressed. The standard way to solve the problem (that is akin to simultaneity in enforcement and production) is discussed below in appendix C, "A Richer Model."

Because of the many uncertainties associated with every ingredient of the formula, we want to look at a wide range of assumptions including different assumed rates of return available on outside investment. Figure 1 displays the patterns associated with a range of values relative to costs and rates of return. The ratio of value of sales to cost, PQ/C, is plotted on the "x"-axis; the measure of "R*", the market return on investment outside the industry (assuming additional risk at-

32 However, Plecas *et al*. report that in province wide data, there is at least one case in which a single plant was seized! For 1997-2000 they report the average number of plants seized increasing from 141 to 180 during the period.

33 According to Plecas *et al*., 2002, table 2.6, about 57 percent of all files being opened for grow-ops comes from Crimestoppers or anonymous tips. These leave plenty of room for competitors as well as offended members of the general public to identify grow-ops. "Grow-rips" as they are known, appear to be increasing. The police are responding to more calls for break-ins that are for the purpose of stealing marijuana, but the thieves have, by mistake, targeted non-marijuana growing houses (O'Brian, 2004; *Vancouver Sun*, Jan. 20, 2004).

**Figure 1: Number of Marijuana Grow Operations as a Function of the Value of Output and Rate of Market Return**




tached) is plotted on the "y"-axis; and the "Number of Grow-ops" is along the vertical axis. Although not plotted, the value of π, the probability of being busted, like T, is a calculated value.

## Estimates of the total number of grow-ops applied to the regions of British Columbia

The most recent characterization of the number of grow-ops in British Columbia is to be found in Plecas *et al.,* 2002. For the year 2000 they suggest a figure of 2,808 incidents of busted grow-ops in British Columbia.

We can see the implications of the model by region if we are willing to go with a particular value of the rate of return and the value of output relative to costs. Table 5 takes model 2 in which the rate of return includes an explicit risk premium, and uses the value 1.5 for the ratio of the value of output relative to costs.

Although interesting, because they indicate the likely scope of the marijuana industry geographically, yearly variations in table 5 are

## Table 5: Implied Number of Grow-ops by Region

| District | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|
| **Greater Vancouver** | 2,975 | 4,188 | 5,625 | 8,394 |
| Fraser Valley | 775 | 1,025 | 1,394 | 1,756 |
| Squamish-Lillooet | 81 | 106 | 106 | 206 |
| **Mainland/Southwest** | 3,831 | 5,319 | 7,125 | 10,356 |
| Nanaimo | 613 | 725 | 731 | 913 |
| Comox-Strathcona | 456 | 563 | 731 | 888 |
| Capital | 563 | 450 | 738 | 619 |
| Cowichan Valley | 275 | 519 | 581 | 406 |
| Sunshine Coast | 50 | 219 | 213 | 156 |
| Alberni-Clayoquot | 88 | 113 | 119 | 113 |
| Powell River | — | 100 | 94 | 119 |
| Mount Waddington | 38 | 63 | 75 | 56 |
| **Vancouver Island/ Coast** | 2,081 | 2,750 | 3,281 | 3,269 |
| Thompson-Nicola | 294 | 575 | 519 | 506 |
| Central Okanagan | 238 | 350 | 506 | 519 |
| Northern Okanagan | 169 | 313 | 294 | 500 |
| Okanagan-Similkameen | 175 | 231 | 269 | 344 |
| Columbia-Shuswap | 156 | 156 | 206 | 225 |
| **Thompson/Okanagan** | 1,031 | 1,625 | 1,794 | 2,094 |
| Fraser-Fort George | 144 | 175 | 269 | 406 |
| Cariboo | 144 | 181 | 163 | 381 |
| Cariboo Overall | 288 | 419 | 431 | 788 |
| Central Kootenay | 200 | 281 | 475 | 388 |
| Kootenay Boundary | 81 | 238 | 244 | 131 |
| East Kootenay | 88 | 125 | 138 | 181 |
| Kootenay Overall | 369 | 644 | 856 | 700 |
| Kitimat-Stikine | 63 | 75 | 75 | 156 |
| Skeena-Queen Charlottes | 44 | 38 | 31 | 13 |
| Central Coast | 6 | — | — | 6 |
| North Coast Overall | 113 | 113 | 106 | 175 |
| Bulkley-Nechako | 81 | 44 | 50 | 119 |
| Stikine (region) | — | 6 | 13 | — |
| Nechako Overall | 81 | 50 | 63 | 119 |
| Peace River | 25 | 31 | 69 | 44 |
| Northern Rockies | — | 6 | 13 | 6 |
| Northeast Overall | 25 | 38 | 81 | 50 |
| **Province Overall** | 7,819 | 10,956 | 13,738 | 17,550 |

Assumptions: Ratio of Sales to Costs (PQ/C) = 1.5
The Rate of Return to Enterprise: R* = 10%
$\pi$, the Probability of being Busted, is 16%
The Opportunity Cost for the grower is (R*+$\pi$)

**Table 6: The Export Consequences of Different Estimates of the Number of Grow-Ops**

| Value of Output to Cost Ratio* PQ/C | Number of Grow-Ops* | Marijuana Production in British Columbia (metric tons)** | Marijuana Exports*** from British Columbia (metric tons) | Retail Bulk Value of Exports**** (Billions of dollars) |
|---|---|---|---|---|
| 5.0 | 4,308 | 102 | 72 | 0.36 |
| 4.5 | 4,529 | 108 | 77 | 0.39 |
| 4.0 | 4,828 | 115 | 84 | 0.42 |
| 3.5 | 5,250 | 125 | 94 | 0.47 |
| 3.0 | 5,895 | 140 | 109 | 0.55 |
| 2.5 | 7,000 | 166 | 136 | 0.68 |
| 2.0 | 9,333 | 222 | 191 | 0.96 |
| 1.9 | 10,150 | 241 | 211 | 1.05 |
| 1.8 | 11,200 | 266 | 236 | 1.18 |
| 1.7 | 12,600 | 299 | 269 | 1.34 |
| 1.6 | 14,560 | 346 | 315 | 1.58 |
| 1.5 | 17,500 | 416 | 385 | 1.93 |
| 1.4 | 22,400 | 532 | 502 | 2.51 |
| 1.3 | 32,200 | 765 | 735 | 3.67 |
| 1.2 | 61,600 | 1,464 | 1,433 | 7.17 |

*See table 4 for the basis of the estimates.
**Assume 33.3 grams per plant and 180 plants per grow-op (Plecas *et al*.), and 4 crops per year.
***British Columbia exports are BC production less BC consumption. National consumption from table 1. BC consumption is 13 percent of the national total, adjusted for consumption per user or 30,600 kg.
****Assumed price of $5,000 per kg. (see table 2).

driven entirely by the number of busts in each region. Increased enforcement arising from local conditions are much more likely to have an impact in a region than they are in the overall scheme of things.

## Potential British Columbia marijuana exports

Using the estimate of the number of grow-ops from table 4 will also allow an estimate of the total quantity of marijuana grown in British Columbia. Contrasted with the implicit demand of table 1, it gives a rough and ready sense of the level of exports by the industry. In table 6 the first column reports different possible output to cost ratios that are reasonable in assessing the British Columbia marijuana industry. Each of these numbers gives rise to an estimate of the number of grow-ops in the second column. The third column derives the implied quantity of production (measured in metric tons) associated with each of the estimates of the number of grow-ops. Since exports from British Columbia are the quantity of production less the amount absorbed domestically within the province, the estimate of the quantity of exports is generated by using the production figure of column four with the consumption from table 1 adjusted for the size of the province of British Columbia.

The value of exports is measured at an assumed price of $5,000 (Canadian) per kilogram. This is a bulk value since it is purchased and shipped in quantity rather than cigarette by cigarette. Of course the value of the exports at final sale will

**Table 7: The Value of Grow-op Marijuana Relative to GDP in British Columbia**

| | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|
| BC's Gross Domestic Product (GDP) (billions of dollars) | 114.4 | 115.6 | 120.6 | 130.8 |
| Grow-op Sales as a Percentage of BC GDP | 1.1% | 1.6% | 2.4% | 2.8% |

depend upon the prices in the US and will be substantially greater.

A reasonable supposition, given that British Columbia absorbs slightly more than its 13 percent of Canada's population, is that British Columbia's consumption is roughly between 21 and 54 metric tons (from table 1). The quantity of output is vastly greater: between 100 and 1,460 metric tons.[34] It is reasonable to conclude that most of the British Columbia crop is exported to the United States or in some measure to the rest of Canada. The estimate that appears to me to be the most reasonable (albeit tentative) generates exports of nearly $2 billion in year 2000.

## The size of the British Columbia marijuana industry

To put this into some kind of perspective, table 7 measures the value of production of marijuana from grow-ops at between 1 percent and 2.8 percent of British Columbia's Gross Domestic Product (GDP) that was roughly $130 billion in 2000.[35] However useful this is insofar as it scales the cost of domestic production by comparing the wholesale value of BC's marijuana crop to GDP, the ratio is inflated since we are using final sales and not the value-added of the marijuana grow industry.[36]

To measure the value of the marijuana crop at final sale prices properly, we need to use the prices associated with the quantities that are sold on the retail market: the gram, ounce, pound, kilo etc., amounts since prices per unit vary by quantity. Similarly, prices vary by region and by type of product. Using a statistical analysis of price per gram as a function of quantity sold, region, urban-rural, and other variables, we can construct a retail price model for sales. If we were to assume that marijuana were sold by the pound, then in British Columbia in the year 2000, the retail price is about $2,600 in urban British Columbia. If we were to assume that marijuana was sold by the ounce, then it would be worth about $4,100 per pound on average. By the cigarette, a pound would sell for $7,800.

34 That is, with 7,000 to 17,500 grow-ops each producing about 13.3 kilograms annually, the total harvest is between 168 and 420 metric tons. Specifically, 33.3 grams per plant x 180 plants x 4 crops per year = 24 kilograms per year per grow-op.

35 Sales to the general public are assumed to be in the ounce range. In any case, table 2 permits the reader to calculate his or her own valuation.

36 Since GDP measures value added rather than final sales, the size of the marijuana industry appears too large relative to other industries. Rather than try to "guild the bud" by further refinements of the value added of the marijuana grow operations, the comparisons should be taken for what they are: an effort to get some sense of the overall scale of economic activity in the marijuana industry in BC. Obviously we can construct a value-added measure consistent with our representative grow-op of table 2, but this is placing a great deal of weight on a rather speculative calculation.

**Table 8: The Value* of the BC Marijuana Harvest by Region Measured at "per Cigarette" Values (in millions of dollars)**

| District | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|
| Greater Vancouver | 950 | 1,328 | 2,319 | 3,422 |
| Mainland/Southwest | 1,224 | 1,687 | 2,937 | 4,222 |
| Vancouver Island/Coast | 665 | 872 | 1,353 | 1,333 |
| Thompson/Okanagan | 329 | 515 | 740 | 854 |
| Provincial Total | 2,497 | 3,474 | 5,664 | 7,156 |

***The assumptions underlying quantities for this table are the same as those for table 5.**

So what are the bounds to a measure of retail value of sales? To answer this we need a measure of the price of what is sold. Significantly, the unit in which the marijuana is sold is an important consideration. From our estimates in table 2 and the supporting discussion in appendix A, we know the relationship between price per gram and quantities sold—be it a fraction of a gram, or by the kilo, and various quantities in between.

To carry this to the extreme, suppose that the British Columbia producers' crop was to be valued at the per cigarette street cost: the smallest and most expensive retail unit. Table 8 gives a sense of the values.

Table 8 reflects the retail value of the product from each of British Columbia's regions. The producers do not, of course, receive these amounts. Like many agricultural products, the "middle-man" receives much of the difference between the final sale price and the original producer. Transportation, packaging, marketing, and risk of confiscation by various competitors and law enforcement are all part of the difference.

Although the values do not reflect the actual receipts by the growers in each region, the numbers do reflect an estimate of the contribution to ultimate street sales made by each region should the final product be sold at British Columbia retail prices in British Columbia. Estimating the "true" street value of the actual product would necessitate knowing exactly where final consumption took place: both at home and in the United States.[37]

Although many underground activities have consequences for society ranging from alcohol prohibition of the 1920s to drug prohibitions today, economists have had a difficult time in describing the extent of production. The British Columbia marijuana industry is a good place to begin to study this problem. While decentralized, the characteristics of the grow-ops are relatively well known, and there is a considerable volume of product, much of which heads to the US.

37 There is a substantial marijuana trade with the US.

## Why Does it Happen in British Columbia?

Although current federal initiatives to decriminalize the possession of small quantities of marijuana may change the traditional location of marijuana production, one of the enduring, frequently-asked questions is why it is that marijuana cultivation and consumption have traditionally taken place more openly in BC than elsewhere in Canada. Is it British Columbia's *indoor* climate? What is different on the Coast?[38]

Although there is no simple answer to such a question, several statistical observations may bear on the issue. One outstanding statistic is that possession incidents are not "cleared by charge" as frequently in British Columbia as they are in Canada's other provinces.[39] Although there are differences between BC and the rest of Canada for charges with respect to other drugs, the difference is greatest with respect to marijuana. Second, a look at the pattern of arrests and penalties facing marijuana growers in Vancouver also gives a sense of the consequences for (some) marijuana growers.

Table 9 reports drug incidents and charges for 2001. Only 13 percent of possession offences in BC are cleared by charge. Elsewhere in Canada over 60 percent of possession offences are cleared by charge. Even though BC has nearly twice as many offences relative to population as the rest of Canada, clearing by charge is one-fifth of that elsewhere in Canada. The reasons for such a pattern may depend upon the courts, the prosecutors, or the police, but it is surely indicative of a difference in perspective at some level in the enforcement of the law.[40]

Is clearing by charge the relevant data for explaining the size of the British Columbia marijuana industry? Are fines lower here than elsewhere? Probably not, but why this industry has been so successful in British Columbia and less so elsewhere remains a topic of serious interest. In that spirit, the next section considers the effect of being caught ("busted") in a marijuana grow-operation. Although I do not have comparative data on those caught for growing marijuana elsewhere in Canada, the kinds of punishments in British Columbia are consistent with a marginal level of deterrence.

### What happens to marijuana growers?

Local conditions in British Columbia obviously play a role in the production of marijuana. If British Columbians really are producing the massive quantities of the drug that I have suggested, is-

38 Recent high-profile police busts in Ontario and Quebec make it clear that marijuana growing is no longer unique to British Columbia.

39 Actually, BC is far less likely to clear offences by charge than the rest of Canada for almost any drug possession offence. "Clearing by charge" means that a file is sent to Crown prosecutors for action on a criminal charge. Files can be closed in other ways if, for example, the person the police believe committed the crime has died or is being charged with a more serious offence on another charge.

40 The observation that BC does not often charge for marijuana possession (nor, for that matter, other drug possession), and yet the province has a particularly potent marijuana crop is a puzzle. Theory would suggest that if enforcement is very enthusiastic, then the crops would be small and of high potency. A less strict criminal enforcement environment would be expected to produce crops that are less strong and less intensively cultivated. BC appears to be the opposite.

**Table 9: Drug Crimes and Drug Charges in Canada and British Columbia, 2001**

| Incidents Known to the Police | Actual Number in Canada | Actual Number in BC | BC as a Share of Canada | Incidents Cleared by Charge in BC | Incidents Cleared by Charge in Canada Net of BC |
|---|---|---|---|---|---|
| Heroin—Possession | 504 | 367 | 73% | **37%** | **80%** |
| Trafficking | 403 | 258 | 64% | 74% | 86% |
| Importation | 58 | 13 | 22% | 23% | 22% |
| *Heroin—Total* | 965 | 638 | 66% | 51% | 75% |
| Cocaine—Possession | 5,478 | 1,744 | 32% | **38%** | **82%** |
| Trafficking | 6,265 | 1,876 | 30% | 70% | 81% |
| Importation | 490 | 53 | 11% | 28% | 36% |
| *Cocaine—Total* | 12,233 | 3,673 | 30% | 54% | 79% |
| Other Drugs—Possession | 3,982 | 675 | 17% | **25%** | **59%** |
| Trafficking | 2,472 | 329 | 13% | 43% | 76% |
| Importation | 1,302 | 231 | 18% | 17% | 14% |
| *Other Drugs—Total* | 7,756 | 1,235 | 16% | 28% | 57% |
| Cannabis— Possession | 49,639 | 11,757 | 24% | **13%** | **62%** |
| Trafficking | 11,124 | 2,098 | 19% | 62% | 73% |
| Importation | 739 | 203 | 27% | 4% | 21% |
| Cultivation | 9,122 | 3,477 | 38% | 27% | 37% |
| *Cannabis—Total* | 70,624 | 17,535 | 25% | 22% | 61% |

Note: 2001 population: CANADA: 31,081,887; BC: 4,095,934. BC's population is 13% of Canada's.
Sources: Statistics Canada, *Canadian Crime Statistics 2001*, cat. no. 85-205 XIE, pp. 17 and 37.

sues of local law enforcement are clearly part of the cost of doing business. This section explores some of the consequences from fragmentary data arising from charges and convictions when grow-operation busts take place. Although the discussion is entirely in the context of Vancouver data, since Vancouver is an important source of British Columbia marijuana it is clearly a significant environment. The first subsection looks at the consequences for being caught by the Vancouver police in a marijuana grow-operation over the 1996-1999 period.[41] A second subsection characterizes those who are caught to see whether the punishments meted out give any hint about their effectiveness in deterring illegal marijuana grow operations. There are obviously many other important questions to be answered, such as connections with organized crime, and the financing and money laundering and trading for other illegal drugs, but the data are not able inform us on these issues.

## Sentencing those found guilty

Table 10 details the outcomes for those who were sentenced after being convicted of offences associated with the busting of marijuana grow-ops in Vancouver. The first column indicates the num-

41 The raw data for this section relies on Wickstead, "Who Wants to be a Millionaire?" It relates to Vancouver between 1996 and 1999.

ber of days of the sentence. The second column gives the percentage of all those convicted (for whom we have relevant data, as some were still awaiting sentencing), and the third column reports the cumulative percentage of those sentenced, up to and including the number of days indicated.

Most who were charged and convicted received no jail time. In table 10, the first row indicates that 55 percent of convictions received zero days' jail time. Five percent of those convicted received a single day in jail. Another 8 percent received sentences between 1 day and 31 days, and still another 8 percent received 60 days. Some 11 percent were sentenced to 90 days. Sentences for the remaining 11 percent were spread out from 120 days to 540 days.

**Table 10: Sentenced Jail Time for Those Convicted in Marijuana Grow-Operations**

| Days | Percent Sentenced | Cumulative Percent |
|---|---|---|
| 0 | 55.3 | 55.3 |
| 1 | 4.4 | 59.6 |
| 30-46 | 7.9 | 67.5 |
| 60-61 | 7.9 | 75.4 |
| 90 | 11.4 | 86.8 |
| 120 | 1.8 | 88.6 |
| 150 | 0.9 | 89.5 |
| 180 | 6.1 | 95.6 |
| 240 | 0.9 | 96.5 |
| 270 | 0.9 | 97.4 |
| 540 | 2.6 | 100.0 |
| Total | 100.0 | 100.0 |

Note: 114 observations.
Source: Wickstead, 2000a.

A number of ingredients go into sentencing. For the data available, the number of prior convictions (of any type) and the size of the operation in which the convicted person was caught appear to be positively associated with the length of the sentence, although it is clear that much more than those factors must influence sentencing.

Statistical analysis reveals that an additional prior conviction will increase the length of the sentence by on average, a little over three and one-half days.[42] Similarly, the value of the grow-operation affects sentencing. A $100,000 increase in the imputed value of the grow-op tends to add over 16 days to sentencing. However, what is equally interesting is that these two variables—prior convictions and the value of the operation—account for only about 16 percent of the explanation of the length of sentence. "Other factors" explain the length of sentences associated with marijuana grow-op busts. Whether this has to do with the judge in whose court the case is heard, the prosecutor who works the case, the defense counsel who defends, or specific details of the case not captured by our data, clearly more research has to be done to reach an understanding of the reasons for the observed durations of sentences.

As might be expected, cultivation and drug trafficking were the majority of offences for which there were convictions. Table 11 indicates the range of days for those convicted of cultivation. One half, 50 percent, received no jail time. Two received 540 days. All but a handful received 90 days or fewer as a sentence. Of course not all these days are actually spent in jail since after one-sixth of a sentence, roughly, a convicted person is eligible for parole, and days in jail before conviction count for two days served after conviction.

42 See appendix E for the statistical details of the analysis.

**Table 11: Days Sentenced for Cultivation Offence**

| Days of Sentence | Percent | Cumulative Percent |
|---|---|---|
| 0 | 50.0 | 50.0 |
| 1 | 6.0 | 56.0 |
| 30-59 | 8.4 | 64.3 |
| 60-61 | 9.5 | 73.8 |
| 90 | 13.1 | 86.9 |
| 120 | 2.4 | 89.3 |
| 150 | 1.2 | 90.5 |
| 180 | 6.0 | 96.4 |
| 240 | 1.2 | 97.6 |
| 540 | 2.4 | 100.0 |
| Total | 100.0 | 100.0 |

Note: 84 observations.
Source: Wickstead, 2000a.

Outside of the loss of your equipment and product, how important are the personal costs for having been convicted in a marijuana grow operation dismantled by the Vancouver Police Department? Who are some of the people who are growing marijuana and are they deterred from returning to the business? To explore this issue we can look at some of the current producers' past run-ins with the law. What do their criminal records reveal?

## Time between convictions

Although charges are not the same as convictions, past convictions and current charges provide their own feel for the drumbeat of suspect economic activity in the marijuana trade. Figure 2 plots the histogram of the days between charges for those apprehended in current grow-ops. Prior charges were varied, although many relate to marijuana.

The distribution in figure 2 (reported in the legend) shows that the average time between convicted offences is about 14 months. In the figure, the horizontal axis shows the number of days between convictions. The vertical axis shows the frequency with which each number of days between charges is observed. The median is 11 months (328 days). This means that as many are charged in under 11 months as after 11 months. So among those with more than a single arrest, if charges are leveled this frequently, it is reasonable to suggest that whatever it is that many of these people are doing, they are continuing to do it![43] From the point of view of an ongoing business, court time, or a charge, are simply part of the costs of doing business.

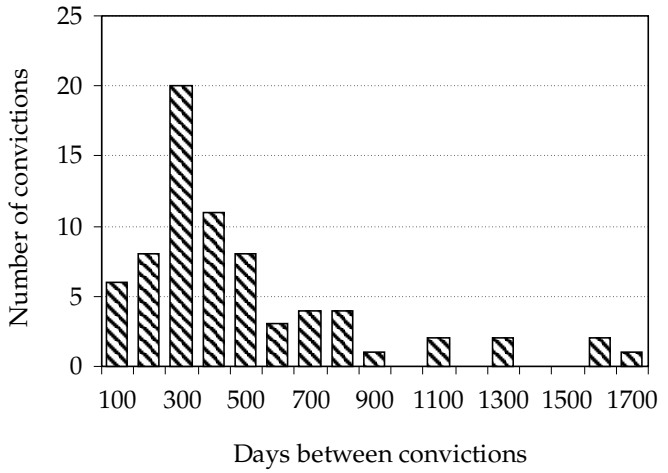
This sense is heightened by the data in table 12 that reports the outcome of all the charges for which data are available about those who were charged in the Vancouver police busts, many who have had multiple incidents in the past.

The first column of table 12 reports the number and proportion of all those who are currently charged with running a grow-op (or who face other charges arising from the arrest) and who have been convicted in the past. Of those now charged, about 70 percent were convicted and only 3 percent acquitted. Twenty-two percent had charges stayed with four percent discharged or dismissed.

Among the 670 convictions, there were 237 fines imposed (a little over a third of those convicted.) These fines averaged $1,167. To put this into per-

43 Two observations were excluded as the time between charges was 4,500 and 5,000 days. These were well above any other observations. The data in the text use a cutoff of 2,000 days. The mean for the whole sample, including the two very high observations, was 551 days.

**Figure 2: Days Between Convictions**




spective, with only 100 plants, we saw about $170,000 per operation in sales. The effective fine is far less important than having to set up all over again in another house. Recall that the equipment costs over $10,000 and that with the bust, the producer lost the last crop, seed, and house lease.[44]

Restitution is theoretically a tool that can be used to undo the damage of the grow-op. Destruction of a house, damage to power connections, and miscellaneous damage to other facilities are all the types of things eligible for restitution. What is the record? Of the 167 cultivation cases, 11 involved restitution. These had a mean of about $3,500. Of the 167 cases, 45 paid fines for which the average $2,550. Only two fines were over $6,500. Compared to the rewards of growing marijuana, these are not substantial amounts.

## In summary

Marijuana production in British Columbia is substantial. Based on Vancouver data, a third of those who are caught are repeat offenders while two-thirds are first-time offenders. The penalties for being caught growing marijuana do not appear to be particularly stringent, and repeat offenders appear to average being caught marginally less than once a year. Fines appear to be modest and not sufficient to deter the behaviour. It is difficult to evaluate a policy that induces police to assign resources to catch nearly 3,000 grow operations a year, yet treats offenders to what must be seen as relatively minor punishment. These punishments do not seem to prevent recidivism. As argued in earlier sections, it is too profitable to prevent new people moving into production and to prevent old producers from rebuilding.

# Legalization in Canada: Suppose We Tax it Like Other Sins?

What kind of money are we talking about if we try to reduce the crime and punishment associated with marijuana? Although there are many issues associated with the full or even partial legalization of marijuana, one of the most important is how much the demand for marijuana changes when the price changes. Measuring the demand for legal products is hard task, but it is doable, and forms core employment for legions of economists. For marijuana, an illegal product, it is a more difficult job and impossible to do directly.[45] Fortunately, some issues can be ad-

44 In a case I recently observed, the convicted grower asked the judge in all innocence, "Do you want that in cash?" causing all in the courtroom to shake their heads.

**Table 12: The Result of Past Charges of those Currently Charged in Busts of Grow-ops**

| | Convicted | Stayed | Acquitted | Discharged | Dismissed | Fines |
|---|---|---|---|---|---|---|
| Number | 670 | 212 | 26 | 21 | 23 | 237 |
| Percent of charged | **0.70** | 0.22 | **0.03** | 0.02 | 0.02 | |
| Percent of convicted | | | | | | 35 |
| Average fine of those fined | | | | | | $1,167 |

Source: Wickstead, 2000a.

dressed without detailed knowledge of the elasticity of demand.

## Crude estimates in a revenue "switching" regime

Based on the grow-op data, for an investor we have assumed relatively high costs of around $62,600 to produce, conservatively, 400 plants per year. That works out to $156 per plant, and a plant produces 33.3 grams for a production cost of $4.70 per gram.[46] A gram makes anywhere from one to three cigarettes. So today, *with the substance illegal*, we are looking at a per-cigarette wholesale price of $1.60 to $4.70 as opposed to the current "retail" price of $8.60 per half gram.[47] This is still more expensive than tobacco, but then the tobacco industry has had a head start on mass production techniques, and by including very expensive labour costs, these are extreme assumptions about the production costs of marijuana.[48]

What about tax revenue? If we substitute a tax on marijuana cigarettes equal to the difference between the local production cost and the street price that people currently pay—that is, transfer the revenue from the current producers and marketers (many of whom work with organized crime) to the government, leaving all other marketing and transportation issues aside we would have revenue of (say) $7 per cigarette. If you could collect on every cigarette and ignore transportation, marketing, and advertising costs, this comes to over $2 billion on Canadian sales[49] and substantially more from an export tax, and you forego the costs of enforcement and deploy your policing assets elsewhere.[50]

Notice that we have merely substituted government taxation for the premium on illegality. We

45 Appendix F reviews some approaches to an estimate of the demand for marijuana.

46 To make the point that these "estimates" are fraught with uncertainty, I will round the numbers ruthlessly.

47 Contrast this with the current price of tobacco cigarettes that sell for about 24 cents of which 9 cents is production and distribution. Tax makes up the difference.

48 In the long run, the cost of producing both tobacco and field marijuana is likely to be similar since both are weeds amenable to cultivation. A pound of tobacco wholesales for about $3 Canadian a pound (between $1.75 and 2.00 per pound US depending on the grade. See *http://www.ers.usda.gov/ publications/ agoutlook/Jan1999/ao258b.pdf*).

49 That is, from appendix table 1A, year 2000 low weight is 160,000 kg, or 160,000,000 grams. Assume .5 grams per cigarette or 320 million cigarettes. At a cost of approximately $1.60 per cigarette, available revenue (plus transport and marketing that are assumed to be negligible) is 320 million cigarettes x ($8.60 - $1.60) = $2.24 billion.

have not changed anything else. We have kept the price the consumer pays the same, and we have not altered the structure of production. We would still grow marijuana in "flower pots" except now it would be in the open and taxed like any other commodity at the retail level.

Importantly, this approach has the effect of transferring to the government revenue currently received by illegal producers as reward for their cost of production and risk.[51] Unless we wish to continue to transfer these billions from this lucrative endeavor to organized crime, this policy should be considered. Not only would we deprive some very unsavory groups of a profound source of easy money, but also resources currently spent on marijuana enforcement would be available for other activities.

## Advanced production techniques

If we were to assume that the wholesale price of marijuana would fall if it were legalized, since it would become cheaper to produce with proper mass production techniques—remember the difference between gin produced in hidden stills during Prohibition and modern distilleries—then both the cost and retail prices would most certainly fall. If we assume that the elasticity of demand is 0.6—a common estimate for tobacco and alcohol demand (see appendix F)—at the current price, then dropping the price from $8.60 to $0.10 per cigarette would increase the quantity consumed by nearly 60 percent, but less than in proportion to the fall in price. However, by increasing taxes, the $8.60 per cigarette retail price can be maintained with an increase in government revenue of another few billion dollars. The simplest taxation arithmetic is basic. The government can transfer revenue from organized crime and other small producers to itself by taxing a legal product to the level consumers have already revealed they are willing to pay. There are questions about how we collect taxes on exports, and what would happen should the US retaliate against our legalization, but the basic argument would be the same: we affect no change in price, we only transfer the revenue from current producers.

As for those current producers who argue for legalization, recall the old proverb, "Be careful what you wish for; your wish may be granted." Many of those who advocate legalization for pecuniary reasons are perhaps thinking primarily of the increase in demand associated with legalization.[52] However, as with the transition from prohibition to legalization of liquor early in the last century, we may note that very few of the "ma and pa" stills are currently in operation. Although there is always room for home and boutique production, large, sophisticated industries would quickly supplant local suppliers of marijuana with a corresponding decrease in costs.

50 Of course marijuana enforcement is only one aspect of drug enforcement and only one aspect of overall enforcement. There are economies of scope and scale that may well make this issue more complicated. Further, since we believe a lot of the product is sold in the US, it is unlikely that Canada would be able to collect much of this revenue.

51 In a wild flight of fancy, the government could even choose not to tax, but current policy obviously emphasizes taxes on "sin," and in this, marijuana is no different than tobacco, alcohol, and gambling, and no doubt would be taxed accordingly.

52 The current Canadian proposal to decriminalize up to 15 grams of marijuana possession is an interesting exercise. It has the potential to increase demand without legalizing supply. If prices rise at all, it is likely that they will rise in the short run. In all probability, the supply response will be sufficiently great to keep the price stable in the medium and long term. Higher prices in the short run will only reward current producers—including organized crime. I hope these are merely unintended consequences of an inadequately thought out policy shift.

## Conclusion

Marijuana is grown all over the world. In British Columbia (as in other provinces, notably Quebec and Ontario), it is a significant crop that fuels organized crime. Marijuana production appears to have been growing robustly during the past decade. Like many illegal products and services, it is difficult to measure the level of marijuana production. This is particularly the case when it is cheap to set up a grow operation and the market is substantial. In this paper I have reported a methodology for estimating the output of illegal production. Using estimates of marijuana growing in British Columbia based on this methodology, I have developed an estimate about the overall size of the local market and the implied level of exports.

The analysis reveals how widespread is the use of marijuana in Canada and how extensively it is produced in British Columbia. Consequently, the broader social question becomes less whether or not we approve or disapprove of local production, but rather who shall enjoy the spoils. As it stands now, growers and distributors pay some of the costs and reap all of the benefits of the multi-billion dollar marijuana industry while the non-marijuana-smoking taxpayer sees only costs. Alcohol prohibition in the US expanded organized crime in North America. Removing alcohol prohibition generated many problems, but none like those afflicting society in the days of Al Capone and his ilk. Removing the prohibition on marijuana production would permit society to replace today's gift of revenue to organized crime with (at the very least) an additional source of revenue for government coffers.

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# Appendices

## Appendix Table 1A

Table 1A puts Canadian marijuana consumption into some kind of numerical perspective that is commensurate with the degree of uncertainty associated with it. Row 1 identifies the number of users based on estimates of usage described in Single *et al.* (1999, table 5.1). User numbers are imputed (using rates of change from Rhodes *et al.*) for years not sampled. Row 2 gives the actual surveyed percentage of Canadians over the age of 15 who are users. Row 3 assumes per-user consumption of marijuana cigarettes (based on US data.) Rows 4 and 5 use two estimates for the size of

**Table 1A: Estimates of the Internal Canadian Market for Marijuana, 1988-2000**

| | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Millions of Current Users in Canada[a] | 1.38 | 1.41 | 1.10 | 1.11 | 1.13 | 0.96 | 1.71 | 1.73 | 1.75 | 1.78 | 1.80 | 1.82 | 1.84 |
| 2. Actual surveyed users as a % of the population 15 or older* | | 6.5 | 5.0 | | | 4.2 | 7.4 | | | | , | | |
| 3. Number of cigarettes used per month** | 16.9 | 17.3 | 17.6 | 16.6 | 17.2 | 17.8 | 18.7 | 18.7 | 18.7 | 18.7 | 18.7 | 18.7 | 18.7 |
| Weight of one cigarette | | | | | | | | | | | | | |
| 4. Low (grams)*** | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| 5. High (grams) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Implied Average Annual Marijuana Consumption per user (grams): | | | | | | | | | | | | | |
| 6. Low weight estimate | 77.0 | 79.5 | 82.0 | 76.2 | 78.4 | 82.4 | 86.5 | 86.5 | 86.5 | 86.5 | 86.5 | 86.5 | 86.5 |
| 7. High weight estimate | 202.8 | 207.6 | 211.2 | 199.2 | 206.4 | 213.6 | 224.4 | 224.4 | 224.4 | 224.4 | 224.4 | 224.4 | 224.4 |
| 8. Price per ounce (in year 2000 $C)**** | 370.3 | 377.6 | 476.1 | 474.0 | 482.3 | 418.0 | 382.7 | 321.5 | 303.9 | 308.1 | 331.9 | 303.9 | 303.9 |
| 9. Price per gram $C | 13.0 | 13.3 | 16.8 | 16.7 | 17.0 | 14.7 | 13.5 | 11.3 | 10.7 | 10.8 | 11.7 | 10.7 | 10.7 |
| Total Canadian Internal Consumption (in thousands of kgs—metric tons) | | | | | | | | | | | | | |
| 10. Low weight average | 106.3 | 111.7 | 90.1 | 84.8 | 88.2 | 78.8 | 147.7 | 149.7 | 151.6 | 153.7 | 155.5 | 157.4 | 159.4 |
| 11. High weight average | 279.8 | 291.9 | 232.0 | 221.5 | 232.3 | 204.3 | 383.2 | 388.2 | 393.2 | 398.6 | 403.3 | 408.2 | 413.4 |
| Total Canadian Internal Consumption Annual Expenditure (in billions of dollars) | | | | | | | | | | | | | |
| 12. Low weight average | 1.4 | 1.5 | 1.5 | 1.5 | 1.6 | 1.2 | 2.0 | 1.7 | 1.7 | 1.7 | 1.9 | 1.7 | 1.8 |
| 13. High weight average | 3.6 | 3.9 | 3.9 | 3.7 | 3.9 | 3.0 | 5.2 | 4.4 | 4.2 | 4.3 | 4.7 | 4.4 | 4.4 |
| 14. Amount Canadians Spend on Tobacco | | | | | | | | | | 2.5 | 2.5 | 2.4 | 2.3 |

Notes: All figures are in 2000 Canadian dollars.
[a]Data from surveys reported by Single (1999) interpolated with rates of growth of US use reported in Rhodes *et al*. (2000)
*Single (1999).
** US data (Rhodes *et al*.)
***US data (Rhodes *et al*.) converted from ounces to grams.
****Author's calculation using Canada-wide data for 1998-2001 and US data to track relative price movement. See the section below on pricing marijuana in Canada. Rhodes *et al*. use ⅓ ounce as a purchase unit. This accounts for the difference between the prices in rows 8 and 9 and those of table 2 in the text. All are derived from the pricing formula of appendix A.

each marijuana cigarette. These are reasonable low and high values. The price estimates are developed (Appendix A) and are adjusted by an available US price series for marijuana to account for relative price movements.[53] The next two rows refer to the high and low estimates of metric tons of internal Canadian marijuana consumption. The final rows multiply this by price to illustrate the size of the Canadian (consumption) market. Of course this does not include exports.

The final rows of table 1A indicate that the bounds on Canadian domestic consumption of marijuana bracket substantial differences. Appropriate interpretation of such uncertainty is that we need to know more about the true quantitative measures of consumption to understand how much of the crop is used locally and how much is exported. How large is the industry? To illustrate the internal market, the final row of table 1 lists Canadian expenditures on legal tobacco. Notice that the value of legal tobacco expenditures lies roughly in the middle of the two estimates of the value of Canadian consumed marijuana.

## Appendix A: Pricing Marijuana in British Columbia and Canada

What prices are used to evaluate the quantities of marijuana sold? This is an interesting question that has been explored in the context of gram quantities of heroin and cocaine as distinct from pound or kilogram quantities. Using gram prices leads to a higher evaluation of the amount of a drug than using the bulk quantity value. If there is a systematic relationship between them, then it is less important since one or the other form of pricing may be relevant to a particular problem, but one can go either forward or backward to generate the price relevant to the question being asked, and with knowledge about quantities sold, an average price can be generated.

Locally, Plecas *et al*. suggest:

> Current estimates of the average wholesale market value of a kilogram of dry local marijuana in British Columbia, sold in large quantities of a kilogram or more, vary from $3,500 to $7,500 per kilogram. Estimates of the retail value of a kilogram of dry local marijuana in British Columbia, sold by the pound or by the ounce, vary between $3,500 and $9,000 per kilogram. One can reasonably assume that the average market price in British Columbia during the period [1997-2000] considered was probably somewhere between $5,000 and $7,000 per kilogram. (p. 37)

Caulkins (1994) considers the problem of quantity discounts in the following way. Let P(x) be the market price of x grams (note this is *not the price per gram of x grams sold* but the price of x grams sold). If f(x) is the distribution of retail sales – the frequency with which each gram quantity x is sold, then the total amount paid is $\int P(x)f(x)dx$ and the total quantity purchased is $\int xf(x)dx$. The average price paid for the total consumption of marijuana is then

$$1. \qquad \overline{P} = \frac{\int P(x)f(x)dx}{\int xf(x)dx}.$$

To know the value of final sales of the total amount sold, multiply $\overline{P}$ by total quantity sold.

53 All prices, however, are in 2002 Canadian dollars.

While this formula is undoubtedly correct, we do not have good information about the true distribution of quantities sold, f(x). Further, we need to assume something about the relationship between price and quantity sold. What is assumed is that $P(x) = ax$ in which the power reflects the quantity discount. If $\beta = 1$, then price is proportional to quantity. If $\beta < 1$, then there are quantity discounts and the price per gram is falling with increasing quantities. How fast it falls depends on $\beta$.

In general, if P(1) is the price of one gram, then $P(1) = \alpha$, and $P(x) = P(1)x^{\beta}$ so that increases in price are relative to the gram price.[54]

To understand marijuana pricing in British Columbia we have the RCMP data from 1995-1999.

The relevant approach is to estimate the relationship $\ln(P) = \alpha+\beta\ln(Q)$ where price is the price per unit for the chosen quantity and the term "LN" refers to the natural logarithm. For example, based on the data available we find the equation for table 2 in the text:

2. $LN(P) = 2.73 + 0.84*LN(Q)$
(31.31) (39.3)
$R^2 = 0.95$
$N = 86$

In comparison, Caulkins (1994) finds that $\beta = 0.80$ for heroin based on the US Drug Enforcement Administration's STRIDE data with some 301 observations. I find the similarity between the two estimates striking in light of the different product and location. Taken at face value, it suggests that the cost of the cutting, repackaging, and retailing are adding to cost in a similar way in both disparate data sets.

But there is clearly more to the price than simply a power function of the observed relationship between quantity and price. There are other dimensions to the pricing function for which this literature does not usually control.

Fortunately, the price data come with some additional information attached as to the location of purchases and the type of marijuana purchased. In British Columbia, for example, I find that equation 3 in the table below best characterizes the relationship between price per gram and independent attributes such as weight in which the marijuana is sold, urban or rural, home grown or commercial, and whether or not the crop was grown hydroponically. Also included in this national data set are provincial dummies and whether the purchase was of imported marijuana or not.

In Equation 3, where PPG is the price per gram, WEIGHT is the actual weight sold, CITY is a dummy variable for urban or rural; HG refers to home grown (as distinct from "commercial"); HYDRO refers to hydroponically grown.[55] There are also a series of dummy variables for provinces. The regression suggests that there is, for example, a 1.7 percent increase in the price per gram for a 10 percent increase in the quantity unit sold. The data also suggest that there is a discount on home-grown marijuana and a premium for hydroponic marijuana. Similarly, marijuana sold in the city is cheaper than that sold in rural areas.

54 That is $d\ln[p(x)/p(1)] = \beta.d\ln(x)$ so that $\beta$ is the percentage increase in price with respect to a percentage increase in quantity. A value of $\beta < 1$ means that when quantity purchased increases by 10 percent, the price increases by less than 10 percent.

55 The form of this equation is similar to that of 2 except that we are looking at price per gram on the left hand side. The coefficient on the natural logarithm of weight is consequently $\beta$-1 which implies that a point estimate of $\beta = 0.83$.

**Equation 3—Full**

Dependent Variable: LOG(PPG)

Price per gram of marijuana

Included observations: 86

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| LN(WEIGHT) | -0.2 | 0.0 | -9.3 | 6.9E-14 |
| CITY | -0.33 | 0.14 | -2.38 | 0.02 |
| HG | -0.59 | 0.25 | -2.40 | 0.02 |
| HYDRO | 0.36 | 0.14 | 2.59 | 0.01 |
| IMPTD | 0.10 | 0.18 | 0.52 | 0.60 |
| ALTA | 0.06 | 0.20 | 0.31 | 0.76 |
| SAS | 0.16 | 0.16 | 0.98 | 0.33 |
| MAN | 0.26 | 0.20 | 1.30 | 0.20 |
| ONT | 0.12 | 0.16 | 0.76 | 0.45 |
| QUE | 0.21 | 0.25 | 0.82 | 0.41 |
| NUN | 1.1 | 0.2 | 5.8 | 1.E-07 |
| NWT | 0.53 | 0.25 | 2.12 | 0.04 |
| NS | 0.49 | 0.18 | 2.67 | 0.01 |
| C | 2.6 | 0.1 | 29. | 3.3E-41 |
| R-squared | 0.66 | Mean dependent var | | 2.25 |
| Adjusted R-squared | 0.60 | S.D. dependent var | | 0.64 |
| S.E. of regression | 0.41 | Akaike info criterion | | 1.18 |
| Sum squared resid | 11.9 | Schwarz criterion | | 1.58 |
| Log likelihood | -36.9 | F-statistic | | 10.9 |
| Durbin-Watson stat | 1.33 | Prob(F-statistic) | | 2.4E-12 |

The variable IMPTD refers to whether the product was imported or local. Among the provincial dummies, British Columbia is the home province and consequently does not appear on the list. The provincial dummies are self-explanatory. Other than British Columbia, those that do not appear were excluded because of problems with a small number of observations.

The points of interest in the provincial dummies is that there is a substantial increase in price associated, not surprisingly, with Nunavut and the Northwest Territories, and a premium for Nova Scotia. The rest of the provinces have prices not distinguishable from those in British Columbia. Overall, about 60 percent of the price variance is explained, and of that, about 50 percent is explained without provincial dummies.

## Appendix B: Risk and the Alternatives

Suppose that an investor has a bond that pays $1 per year in perpetuity. The formula relating the price of the $1 per year and the rate at which the future is discounted to the present at the interest rate, r, is:

4. $P_b=(1/r)$.

If we have an investment that is likely to be destroyed in any period at a rate of $(1-\pi)$, then the price of the $1 per year is now:[56]

5. $P_b= (1-\pi)/(r+\pi)$.

Since $P_b$ and the rate of discount are inverses, the discount of the future is:

6. $(1/P_b) = (r+\pi)/(1-\pi)$

The text assumes for analytic simplicity that this is approximated[57] by $(r+\pi)$ and that in turn, this is represented by, $R^*+\pi$: the alternative return available to our grow-op operator. It is an alternative at the same risk as would be found in the grow-op business, which is what puts all legal investments at risk.

## Appendix C: A Richer Model Police Enforcement Enthusiasm

The primary problem with the model thus far is that it does not take into account different conditions that affect the number of busts carried out by the police (or for that matter by others who want to rip off grow-ops.)

### *Grow-op busts as a function of resources spent*

To see how this affects the framework developed above, assume that the number of busts, B, is a product of the number of grow-ops, T; the number of police assigned to the "grow-busters," N; the amount of security installed by the grow-ops themselves, S; and other stuff, x. This leads to an expression:

7. $B = \exp(b_0).T^{b_1}N^{b_2}S^{b_3}x^{b_4}$

that can be rewritten in log-linear form as:

8. $\ln(B)=b_0+b_1\ln(T)+b_2\ln(N)+b_3\ln(S)+b_4\ln(x)$.

Since we know that the number of busts is related to the total number of grow-ops as:

9. $$T = B.\left(\frac{1}{1-\left(\frac{C.(1+R^*)}{P.}\right)}\right)$$

or, for simplicity write as:

10. $T=B.v$

where the expression in equation 9 in large brackets is **v**.[58]

Now take the natural log of both sides of 10 and substitute from 8 so that we have:

56 That is, $P_b = \sum_{t=0}^{\infty}\left(\frac{1-\pi}{1+r}\right)^t - 1$

57 Clearly this is a better approximation, the smaller is $\pi$.

$\ln(T) =$
$b_0+b_1\ln(T) + b_2\ln(N) + b_3\ln(S) + b_4\ln(x) + \ln(v).$

This leads to a reduced form for the total number of grow-ops, T*, as:

$$\ln(T^*) = \left(\frac{1}{1-b_1}\right)[(b_0 + b_2\ln(N) + b_3\ln(S) + b_4\ln(x)) + \ln(v)]$$

Without further identification of the coefficients, little can be said. However, if we assume that all except $b_3$ are positive, and that only a fraction of grow-ops are busted so that $0<b_1<1$, then the number of grow-ops will be greater than those developed by our formula by an amount, proportional to **v** raised to the power $[1/(1-b_1)]$ for given values of the other variables.

Since $b_1$ is such an important number, we may want to know something about it. It is the scale effect of grow-ops on the number of busts. It is not obvious that it is a large number. Suppose that there was plenty of "space" and an additional grow-op faced no constraints that were different than those that had gone before. Holding everything else constant, the coefficient is the change in the number of busts because of a change in the number of grow-ops. This is likely to be a small number. Unless there is crowding or congestion—as has been alleged in some locales—the change in the number of busts because of an additional grow-op is likely to be small.

Suppose, for example, that $b_1 = 0.01$. That is, an increase of 100 grow-ops increased the likelihood that 1 additional bust would take place. In this case, the estimates in the table would have to be increased as a function of **v** raised to the power $[1/(1-b_1)]$. If v is 5, then the estimate is increased by 1.6 percent. If $b_1 = 0.1$, then the estimates would increase substantially. If the value of $b_1$ is not too large, it is not likely to impart much of a downward bias to the estimates.

Notice that we can, in fact, estimate a relationship that calculates $b_1$ in principle. Writing the equation for the number of busts, B, which is at least partially observable, as a reduced form, that is as a function of T*, the equilibrium number of grow-ops, we have an estimating equation:

$$\ln B = \ln T^* - \ln(v)$$

that reduces to the measurable:

$$\ln B = \left(\frac{1}{1-b_1}\right)\left(b_0 + b_2\ln(N) + b_3\ln(S) + b_4\ln(x) + \ln(v)\right) - \ln(v)$$

or,

$$\ln B = \left(\frac{b_0}{1-b_1}\right) + \left(\frac{b_2}{1-b_1}\right)\ln(N) + \left(\frac{b_3}{1-b_1}\right)\ln(S) + \left(\frac{b_4}{1-b_1}\right)\ln(x) + \left(\frac{b_1}{1-b_1}\right)\ln(v)$$

that permits identification of the coefficients and a reduced form estimate of the impact of the different variables on the number of busts.

Since we can know at least the number of police, N, tasked to finding grow-ops, and we have our estimates for v, subject to the vagaries of S and x, we can estimate $b_1$. A first step in this analysis is in Appendix D below.

58 Note that the value of **v** is likely to lie somewhere between 1.2 and 3 and depends entirely on the cost of production, revenue, and yield on alternative opportunities.

## Appendix D: Delay Times and the Number of Grow-Ops

To get an estimate of the delay times we use data from Plecas *et al.* for 32 regions. In the regression we have the log of the time to bust, D, regressed against the log of the number of busts, B. The panel data are based on eight regions and four years of data using a fixed effect model since the regions do not change and may have individual characteristics. The coefficient on D tells us the effect of delay on the number of busts. In this case, a 10 percent increase in the time of delay results in a 1.4 percent decrease in the number of busts. In terms of the model, it suggests that the effect of the number of grow ops measured is affected by the number of grow ops. With more delay, fewer grow-ops are discovered. Although there may be many reasons for this, the subtleties of the model in appendix C are clearly an issue that should be investigated.

**Dependent Variable: LOG(B?)**

Method: GLS (Cross Section Weights)

Sample: 1997 2000

Included observations: 4

Number of cross-sections used: 8

Total panel (unbalanced) observations: 31

One-step weighting matrix

White Heteroskedasticity-Consistent Standard Errors & Covariance

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| LOG(D?) | -0.14 | 0.017 | -8.48 | 0.0000 |
| YEAR | 0.22 | 0.013 | 16.7 | 0.0000 |
| Fixed Effects | | | | |
| C—C | | | | 4.14 |
| K—C | | | | 4.44 |
| M—C | | | | 6.80 |
| NC—C | | | | 2.70 |
| T—C | | | | 5.40 |
| V—C | | | | 5.95 |
| NE—C | | | | 1.86 |
| NK—C | | | | 2.28 |
| Weighted Statistics | | | | |
| R-squared | 0.998 | Mean dependent var | | 6.73 |
| Adjusted R-squared | 0.997 | S.D. dependent var | | 4.33 |
| S.E. of regression | 0.216 | Sum squared resid | | 0.98 |
| F-statistic | 12060 | Durbin-Watson stat | | 2.49 |
| Prob(F-statistic) | | | | 0.00 |
| Unweighted Statistics | | | | |
| R-squared | 0.988 | Mean dependent var. | | 4.45 |
| Adjusted R-squared | 0.98 | S.D. dependent var. | | 1.66 |
| S.E. of regression | 0.218 | Sum squared resid. | | 0.996 |
| Durbin-Watson stat. | 2.81 | | | |

# Appendix E

The regression underlies the remarks in the text. It is a regression of sentenced days in jail on prior offences and the value of the grow-op as estimated by the police. The coefficient on PRIORS tells us the effect of a change in the number of prior offences on the length of sentence. On average, an additional prior offence adds about 3.58 days to the sentence. The number of priors runs from 0 to 25 so in the extreme, priors may add 90 days to a sentence. Looking at the coefficient on the value of grow-ops (measured in units of $100,000 as reported by police), an increase of $100,000 implies an increase of about 16 days in sentenced jail time. Since the estimated value of the marijuana grow operations runs between $75,000 and $3.6 million, the effect on sentencing can be substantial. At the extreme, the value can add 540 days to the jail sentence.

Also of interest is the adjusted $R^2$ that indicates that about 16 percent of the variance of days sentenced can be explained by the two variables in the regression. This is the basis for the remarks in the text suggesting that there is much left to explain: 84 percent, to be precise.

**Dependent Variable: SENDAYS**

Included observations: 111

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -8.85 | 15.8 | -0.56 | 0.58 |
| PRIORS | 3.58 | 1.79 | 1.99 | 0.05 |
| VALUE/100000 | 16.2 | 4.09 | 3.97 | 0.00 |
| R-squared | 0.17 | Mean dependent var | | 52.1 |
| Adjusted R-squared | 0.16 | S.D. dependent var | | 101. |
| S.E. of regression | 93.1 | F-statistic | | 11.2 |
| Log likelihood | -659. | Prob(F-statistic) | | 0.00 |

## Appendix F: The Demand for Marijuana

Although not used in this analysis, a critical value for many problems with respect to marijuana is the elasticity of demand. The elasticity of demand measures the percentage change in the quantity consumed associated with some percentage change in price. Although conventionally expressed as numbers like 0.5 or 1 or 1.5, elasticities are negative since an increase in price reduces the quantity demanded. An elasticity of 1 implies that a 10 percent fall in price is associated with a 10 percent increase in quantity. An elasticity of less than one means that a fall in price of say, 10 percent, engenders an increase in the quantity consumed of less than 10 percent.

One approach to finding a value for the elasticity of demand for the consumption of marijuana is to use an analogy. We can measure the demand for other addictive substances that are legal and commonly used, such as tobacco, for which the elasticity of demand is about 0.5; and for alcohol, another addictive substance, for which the measured elasticity is between 0.18 and 0.86 in the short run.

Estimates for marijuana use span values between 1.4 and 0.1. However, it is important to recall that these estimates are not of the usual kind. They estimate some form of usage rather than quantity. The fact that you smoke once a month is recorded rather than the quantity of marijuana that you purchase. Survey data suggest a very inelastic demand for marijuana (0.2), while purchase-related data tend to find elasticities around 1.0 (Nisbet and Vakil,1972) although Clements and Daryal (1998) and Daryal (2002) find elasticities between 0.5 and 0.1. Saffer and Chaloupka (1999) estimate an elasticity for marijuana use of 0.28 and 0.44.

## About the Author

**Stephen T. Easton** is a professor of Economics at Simon Fraser University and a Senior Scholar at The Fraser Institute. He received his A.B. from Oberlin College and his Ph.D. from the University of Chicago. Recent works published by The Fraser Institute include *Privatizing Prisons* (editor, 1998), *The Costs of Crime: Who Pays and How Much? 1998 Update* (with Paul Brantingham, 1998), and *Rating Global Economic Freedom* (editor, 1992). He was also co-author of *A Secondary Schools Report Card for British Columbia* (1998), *The 1999 Report Card on British Columbia's Secondary Schools*, *Boys, Girls, and Grades: Academic Gender Balance in British Columbia's Secondary Schools* (1999), and *The 1999 Report Card on Alberta's High Schools*. Other publications about education include "Do We Have a Problem Yet? Women and Men in Higher Education," in David Laidler (ed.), *Renovating the Ivory Tower: Canadian Universities and the Knowledge Economy* (Toronto: C.D. Howe Institute 2002), pages 60–79; "Plus ça change, plus c'est la même chose" in Stephen B. Lawton, Rodney Reed, and Fons van Wieringen, *Restructuring Public Schooling* (Berlin: Springer-Verlag, 1997) and *Education in Canada: An Analysis of Elementary, Secondary and Vocational Schooling* (Vancouver: The Fraser Institute, 1988). His editorials have been carried by the *Vancouver Sun*, the *Globe and Mail*, the *Financial Post*, the *Ottawa Citizen*, the Stirling chain and many other newspapers around the country. Professor Easton continues his work as co-author of the Institute's *Report Cards* on schools in Alberta and British Columbia.