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Review of the world cannabis situation

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PREFACE

The *Bulletin on Narcotics* is a United Nations journal that has been in continuous publication since 1949. It is printed in all six official languages of the United Nations: Arabic, Chinese, English, French, Russian and Spanish.

The *Bulletin* provides information on developments in drug control at the local, national, regional and international levels that can be of benefit to the international community.

In 1999, the United Nations Office on Drugs and Crime (UNODC) (then the United Nations International Drug Control Programme) issued a special double issue on cannabis. The issue, volumes XLIX and L, 1997/1998, contained articles covering recent developments in research into the drug. Almost 10 years later, it is clear that the cannabis market, the largest of the illicit drug markets, remains little understood and under documented. Unlike the other plant-based illicit drugs, the surveying of all suspected cannabis cultivation has thus far proved to be impractical. Similarly, the abuse of cannabis is so pervasive that, despite some impressive efforts at the national and international levels, it is also very difficult to assess. Given these facts, relying only on official or scientific literature to assess this market would convey only a limited picture. Cannabis, however, is a drug that is consumed within a specific cultural and social context. This culture has spawned an enormous amount of "grey" literature which, when used to complement the scientific literature, can help us to develop a more comprehensive assessment of the world cannabis situation. Therefore, while grey literature is not part of a conventional scientific review, it does help to fill an undeniable knowledge gap that hampers our understanding of the cannabis market.

A shorter version of this comprehensive article was published in the *World Drug Report 2006.** Some of the research that informs the present review was undertaken in response to and in accordance with General Assembly resolution 59/160 of 20 December 2004, in which the Assembly requested UNODC to prepare a global market survey on cannabis.

UNODC wishes to thank Ted Leggett of the Research and Analysis Section for conducting extensive research on the topic. For comments on the article, special thanks go also to Wayne Hall, Professorial Research Fellow at the University of Queensland, Australia; Harold Kalant, Professor Emeritus, Department of Pharmacology, University of Toronto, and Research Director Emeritus, Centre for Addiction and Mental Health, Toronto, Canada; and Kálmán Szendrei, Professor Emeritus, Department of Pharmacognosy, Faculty of Pharmacy, University of Szeged, Hungary. Research for the section of this review on the health effects of cannabis was conducted by Alexey Kutakov.

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EDITORIAL POLICY AND GUIDELINES FOR PUBLICATION

Individuals and organizations are invited by the Editor to contribute articles to the *Bulletin on Narcotics* dealing with policies, approaches, measures and developments (theoretical and/or practical) relating to various aspects of the drug control effort. Of particular interest are the results of research, studies and practical experience that would provide useful information for policymakers, practitioners and experts, as well as the public at large.

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The preferred mode of transmission of manuscripts is Word format. Each manuscript submitted should consist of an original hard copy and an electronic version (in Word for the text and in Excel for the tables and figures), in any of the six official languages of the United Nations (Arabic, Chinese, English, French, Russian and Spanish). The manuscript should be accompanied by an abstract of approximately 200 words, a complete set of references numbered in the order of their appearance in the text and a list of key words. The manuscript should be between 10 and 20 double-spaced typewritten pages, including tables, figures and references. Tables should be self-explanatory and should supplement, not duplicate, information provided in the text.

Manuscripts, together with brief curricula vitae of their authors, should be addressed to the Editor, *Bulletin on Narcotics,* United Nations Office on Drugs and Crime, Vienna International Centre, P.O. Box 500, 1400 Vienna, Austria. A transmittal letter should designate one author as correspondent and include his or her complete address, telephone number, facsimile number and electronic mail (e-mail) address. Unpublished manuscripts will be returned to the authors; however, the United Nations cannot be held responsible for loss.

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A review of the world cannabis situation

T. Leggett

ABSTRACT

Cannabis is the world's most widely cultivated and consumed illicit drug, but there remain major gaps in our understanding of global cannabis markets. For example, it appears that premium sinsemilla cannabis, often produced indoors in consumer countries, has become more potent in recent years and that its market share is also growing in some areas. This may be leading to greater localization of cannabis markets. It may also be responsible for the increase in the proportion of cannabis users in treatment populations at the international level. Assessing the extent and impact of this trend, however, is hampered both by a lack of international standards on issues such as terminology and by unanswered research questions. In order to arrive at accurate global estimates of the extent of production, there is a need for more scientific data on cannabis yields. On the demand side, more information is required on the question of cannabis dosage and volumes used by both occasional and regular users. Cannabis is not a uniform drug: the impact of using cannabis of differing potencies and chemical compositions needs to be researched. While issues concerning cannabis have been evaluated many times in the past, it remains a highly adaptable plant and, consequently, a dynamic drug, requiring constant reassessment.

Keywords: cannabis; cannabis abuse; cannabis production; cannabis trafficking; global.

Introduction

The present review was prepared pursuant to General Assembly resolution 59/160 of 20 December 2004, which requested the United Nations Office on Drugs and Crime (UNODC) to prepare a global market survey of cannabis. Remarkably, in the 80 years that cannabis has been under international control, during which it has remained the most commonly used illicit drug, the international community has never conducted a comprehensive study of the market for this drug. There are at least two factors that have led to this state of neglect.

- International law treats cannabis as it does other illicit drugs; but in practice, several States have reduced the priority afforded to enforcement of laws on cannabis relative to other drug issues. Signatories to a range

of international drug control treaties have agreed that cannabis should be deemed an illicit drug. Despite these agreements, many States have, in various ways, relaxed their controls over cannabis. Even where these changes do not amount to a breach of the treaties, there appears to be a divergence in spirit between international agreements and individual State action. This discontinuity has not been addressed at an international level and thus international efforts to address cannabis have also fallen by the wayside.

- The sheer scope of cannabis production and consumption is daunting. While an estimated 95 per cent of the world's illicit heroin supply comes from opium produced in just one country (Afghanistan) and almost all of the world's cocaine comes from three countries (Bolivia, Colombia and Peru), cannabis is cultivated in virtually every country in the world. It is grown both indoors and outdoors, often in small amounts by the users themselves. It is frequently traded informally, or shared freely, by people not involved in other criminal activity. Consequently, it is extremely difficult to estimate the amount of cannabis produced, trafficked and consumed—measures that form the traditional pillars of a market analysis.

In essence, it is very difficult to monitor an activity that people in virtually every country in the world conduct quietly in their own homes and about which the international community appears ambivalent. While there has been extensive research on the health effects of cannabis, including a growing literature examining its potential therapeutic use, there has been little academic study of the ways the drug is cultivated, dealt and smoked. Thus, many basic questions remain largely unanswered in the scientific and published literature, including the following:

- How much of a cannabis plant is presently used as a drug?
- How much marketable cannabis can be produced from a given expanse of land?
- How much of the plant material bought is actually smoked by the consumer and how much is discarded as waste?
- How much cannabis by weight do users consume in a given session of use?

In order to begin to answer some of these questions, the present review has had to resort to the so-called "grey literature", including documents produced by those who cultivate and use cannabis themselves. The reliability of many of these publications is dubious and they are at times contradictory, but until actual scientific investigation takes place on these issues, there is no alternative to their use.

In the end, the present review delivers no startling new statistics and exposes no heretofore concealed trends. Rather, it looks at some of the questions that have been asked above and makes a modest attempt to answer them using a range of

sources. The result does contain some surprises, but asks more questions than it answers, and cannot avoid becoming a request for further research. A lot more information is needed about the way cannabis is procured and consumed for evidence-based policy recommendations to be made.

The first part of this review looks at the technical aspects of cannabis production, in particular the modern innovations in indoor cultivation. The question of cannabis yields is explored. The second part looks at cannabis consumption, including the questions of how the drug is procured, the size of cannabis cigarettes, dosage and patterns of use. An attempt is then made to reconcile supply-side and demand-side estimates.

The third part of the review looks at what is known about cannabis markets in regions around the world, highlighting the universality of the problem. This is followed by a look at the impact of cannabis, focusing on two areas of primary concern: the recent increases in sinsemilla potency and their possible impact on treatment demand; and the recent findings of the scientific literature on the health effects of cannabis consumption.

I. HOW CANNABIS IS PRODUCED

Cannabis the plant

Cannabis is a unique plant. It has been cultivated by mankind for centuries, although it is only fairly recently that its use as a drug has outpaced its other applications. As evidenced by its geographic range, the plant is exceedingly hardy and adaptable, leading to the oft-repeated quip "cannabis can grow anywhere". However, it can only reach its full potential, and thus be of practical use, under certain conditions.

The cannabis plant prefers temperatures of 14°-27° Celsius, but can withstand freezing temperatures for brief periods of time. While it can grow in difficult soil types, such as sand, it prefers loams rich in nitrogen. It has been dubbed a "camp follower", owing to its ability to flourish in human waste dumps and manure, and this may be one reason for its early cultivation [1]. Despite some claims to the contrary [1], the hemp industry literature indicates that the cannabis plant is a "heavy feeder", drawing lots of nutrients (especially nitrogen) from the soil, and that feeding is most intense immediately before and during flowering ([2], p. 72; [3]). It prefers direct sunlight, as much as it can get. After the first six weeks, it can grow with little water, as it possesses a powerful taproot, but it only flourishes with regular moisture.* For drug purposes, however, arid climates seem to favour the production of resin and reduce the risk of fungus and moulds. In addition, the cannabis plant requires well-drained soil or its roots will rot, so it does not grow well in clay.** It can be grown in slightly alkaline soil, but prefers a fairly neutral pH of between 6 and 7.*** It is resistant to many predatory insects and has even been used as a hedge to protect other crops from insects, but it is vulnerable to spider mites, aphids and other pests.

In short, while its feral range is wide, the cannabis plant is like any other crop: its productivity is linked to the amount of care and support it is given. When

*On the other hand, since it appears that one of the functions of cannabis resin is to protect the plant from water loss and that some of the best known strains of cannabis come from arid climates, it has been hypothesized that aridity has a positive effect on the drug potential of the plant.

In an interesting study, Haney and Bazzaz [4] observed the proliferation of cannabis in the United States of America. Aside from noting its extreme adaptability and aggressive nature, the authors point out the areas where cannabis has **not successfully spread. Looking at the state of Illinois, which at that time was considered to be a state in the heart of the "cannabis belt" in the United States, Haney and Bazzaz show that the plant is non-existent in the south-eastern part of the state. This area is characterized by tight soil that is low in nitrogen and high in clay. Of these two factors, the authors reckon that clay is the most important inhibiting factor, as cannabis has been found growing in very sandy soil with low nitrogen content.

***Industrial hemp can be grown in a pH of up to 7.8, according to Cloud ([5], p. 3).

intentionally cultivated, however, it can be grown in most inhabited areas of the world.

Is the cannabis plant one species or several?

The cannabis plant's unique properties have led to much debate concerning the taxonomic classification of cannabis and it was reclassified several times before being given its own family, the *cannabaceae*, shared only with the hops plant. Its wide geographic distribution and extremely adaptive morphology have further confused matters, as plants bred under different conditions can bear little resemblance to one another. Some argue that there are two or three species: "sativa", "indica" and, sometimes, "ruderalis". This breakdown is very popular in the grey literature on cannabis plant cultivation. Even today, there is disagreement about whether *Cannabis* is a genus with only one species or several.*

What is the life cycle of the cannabis plant?

The cannabis plant is an annual, completing its life cycle in a single season and dying after reproduction. When cultivated outdoors in the temperate climates of the northern hemisphere, seeds are traditionally planted between March and May and the plant flowers between September and November, representing about a six-month growth cycle, with only one crop possible.** Closer to the equator, however, it is possible to manage two annual crops from the same plot [8] and it has been claimed that some tropical varieties will experience up to four growth seasons a year ([9], p. 114). Plants harvested for drug use are generally completely destroyed and they would normally die soon after harvest time in any case.***

The cannabis plant is unusual in being "dioecious", which means (with the exception of an odd hermaphrodite)**** each individual plant is either male or female. Males fertilize females by means of wind-borne pollen.

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*See, for example, the ruminations of Richard Evan Schultes [1], in which he illustrates the difficulties in distinguishing whether cannabis is a genus with one, highly varied and adaptable species or several distinct species, before conceding that most botanists feel that cannabis is a monotypic species. Ironically, later in life Schultes served as an expert witness to argue for the defence in cannabis cases on the basis that laws prohibiting the use of specified strains of cannabis species might not apply to others. For a discussion of this debate, which also concludes that cannabis has only one species, see Small [6]. Small notes the argument in support of the position that cannabis is monospecific made by hemp specialist Dewey, who claimed that cannabis seeds planted in a region different from their origin appeared to take on the characteristics of the cannabis native to their new home within a few generations.

**Frank and Roseland, cited in Mignoni ([7], p. 42).

***Indoors, cannabis plants can be kept alive indefinitely, even after harvesting, by reverting back to a vegetative photoperiod, but this practice is rare, as it generally involves more time and effort than starting again from clones.

****Monoecious (hermaphroditic) varieties have been bred for industrial hemp production, as this allows more uniform crops. Hermaphroditism in dioecious plants is often a reaction to stress, as a way of ensuring pollination despite adverse conditions.

The cannabis plant flowers over time or when it detects the coming of autumn, as evidenced in the shortening of days. This allows plants that germinated late to complete their life cycle in an accelerated manner. The exact photoperiod required to induce flowering varies by variety: plants from temperate climates, in their home environment, tend to flower later in the season, whereas plants coming from harsher climes necessarily have to reproduce in a tighter timeframe. A 12-hour night period is enough to induce flowering in most, if not all, varieties.

All of these unusual characteristics (variability, adaptability, dioeciousness, wind-borne pollination and photoperiod-linked fertility) have implications for illicit cannabis production. The genetic diversity of the cannabis plant and the fact that individual plants tend to manifest only one sex makes it well suited for selective breeding to enhance desired qualities. Strains that have evolved under difficult climatic conditions can be bred with those that produce the best quality drug, for example. Plants can be designed to make them more concealable, resilient, productive or potent.

It just so happens that female plants, when unfertilized, produce the best quality drugs and cultivators must work around this fact if they want to aim for the high end of the market. As will be discussed below, this is one of the factors that pushed the production of premium cannabis indoors, in order to avoid undesired pollination. The indoor environment also allows manipulation of the light cycle. Plants can be fooled into thinking that the season has changed and their maturation accelerated as a result. This allows growers to decide when and for how long a plant will be allowed to flower. These matters are discussed further below.

Cannabis the drug

Several drug products can be produced from the cannabis plant, falling into three main categories:

- "Herbal cannabis": the leaves and flowers of the plant
- "Cannabis resin": the pressed secretions of the plant, commonly referred to as "hashish" in the West or "charas" in India
- "Cannabis oil"

For reasons that will be discussed, herbal cannabis is the most popular form in North America and most of the rest of the world, while cannabis resin is the most popular form in much of Europe and in a few regions that traditionally have produced cannabis resin.

Within these categories, a number of different grades and strains are also available in most major market areas. In any large market there are generally cheap and expensive alternatives. In the United States, for example, a distinction is commonly made between "schwag" or "commercial" grade cannabis (typically

field-grown in Mexico or domestically) and higher-grade herbal products, often referred to by the brand name of the cultivar. In France, New Zealand and the United Kingdom of Great Britain and Northern Ireland, especially potent cannabis is often referred to as "skunk", a reference to the result of an important early crossing of plants from different sources, which was perceived as being particularly smelly by users. The variety of cannabis strengths and products in the market may be likened to the range of cigarette or alcohol products and brands. Preferences are influenced by culture, but individual tastes vary.

While there are shadings, the primary product division on the herbal side is between high-grade cannabis produced without seeds and the more mundane product. Known as sinsemilla (from the Spanish *sin semilla*: without seeds), this product is composed entirely of the unfertilized flowers of the female plant and is far more potent than other forms of cannabis herb.

The terminology in this area can become confusing:

- Since most sinsemilla consists of only the flowering tops of the plant, it is sometimes referred to as "buds", but seeded buds are also marketed, of course.
- Today, most sinsemilla is produced indoors, and nearly all cannabis produced indoors on any scale is sinsemilla, so there is a tendency to equate the two, while this may not always be accurate.
- Indoor sinsemilla is often grown using hydroponic (non-soil, discussed below) techniques and nearly all hydroponic cannabis grown is sinsemilla, but many indoor producers favour soil-based (often referred to as "organic") production, so the terms are by no means equivalent.
- Outside the United States, most sinsemilla is produced in the country where it is consumed and in some (particularly European) countries the opportunities for outdoor cultivation may be limited, so some commentators equate "sinsemilla" with "domestically grown", but this may also be inaccurate.

While the term "hashish" has been historically used to describe all sorts of cannabis concoctions, today the word is primarily used to refer to cannabis resin. As the plant flowers, glands called "trichomes" produce a sappy, resinous substance in which much of the cannabinoid content of the plant is concentrated. The purpose of this resin is unclear, but it has been hypothesized that it plays a role in protecting the buds from harsh environmental conditions (for example, ultraviolet light, insect pests and water loss due to wind) or as a means of collecting windborne pollen, as it is in the unfertilized female flowers that the resin is most plentiful and most potent.

The resin is collected wet or after it has dried. Dried resin must be heated or pressed to make it malleable. Sale-ready cannabis resin differs in colour from sandy

to reddish to black. It differs in consistency from putty-like to brittle and dusty. These differences may be attributed to:

- The type of cannabis plant used and the way it was cultivated and cured
- The presence of non-resinous plant matter
- The extent to which the resin has been pressed, heated or otherwise handled
- Age
- Adulterants introduced by manufacturers

Darkening may be due to a kind of oxidation, as resin that has been roughly handled (such as Indian hand rubbed) or left to age (such as traditional Afghan) may appear darker. A green colour may be indicative of unwanted plant material rather than pure resin, but experienced users agree that colour is not a reliable gauge of potency.

Any place that produces cannabis could produce cannabis resin ("hashish"), although in practice only a few do. Today, for example, the single largest producer of "hashish" is the Ketama region of Morocco. While Morocco has a long-standing cannabis ("kif") culture, it is only since around 1970 that the country began producing "hashish", a practice allegedly introduced by foreigners. Historically, there have been two means of collecting cannabis resin: hand-rubbing and sieving.

In hand-rubbing, workers remove the gummy resin from the living plants by running their hands over the flowering tops. The resin adheres to the skin and has to be removed by forcefully peeling it away and rubbing it into little balls, which are combined and moulded into shapes for marketing. Hand-rubbed cannabis resin may have been the first way cannabis was consumed and it represents a rather inefficient and labour-intensive means of gathering the drug. Hand-rubbing today is concentrated in India and Nepal.*

*India has traditionally produced at least three standard cannabis products: "bhang", which is chopped cannabis leaves, usually consumed as a drink, often with other psychoactive ingredients added; "ganja", which is herbal cannabis; and "charas", which is hand-rubbed cannabis resin. "Charas" is generally dark and somewhat pliable when heated. Indian "charas" was rediscovered by the West when hippies in the 1960s made pilgrimages to India in search of enlightenment and started what is known as the "hashish trail". Exporting hand-rubbed cannabis resin is problematic, as the rough handling causes the product to age quickly: tetrahydrocannabinol (THC) degrades into other cannabinoids and the drug then produces a less desirable mental state. Moisture is often captured in the mix during manual handling and this can lead to moulding. If stored on site, however, it can last for years and local users tend to age their "charas" for a year before smoking it. This, as well as the time-consuming labour required to gather the drug, has limited its presence in international trafficking and most "charas" is consumed domestically. "Charas" from Nepal is considered to be of an even higher quality than "charas" from India, although lower grades are also produced. It is often smoothed into balls ("temple balls") or "fingers" and may have a shiny or waxy appearance. There are persistent claims that temple balls are treated with opium or some by-product of the opium refining process ("first water") but these claims are difficult to substantiate.

Hand-rubbing is not to be confused with hand-pressing. The dust-like product produced by sieving becomes malleable when heat and pressure are applied and this can be done by hand or by machine in order to prepare it for storage and shipping.

Sieving requires the plants to be dried first, which means an arid climate is essential. The resin and trichomes become powdery and brittle and can be removed from the bulk of the plant matter by use of a screen and some percussive force. Traditionally, fabric is used as a screen and a basin or pot as a collection device. Light tapping produces the purest cannabis resin, but greater quantities (including quite a lot of relatively inert plant matter) can be gathered by the application of more force. The powdery resin that is produced is either gently heated or manually or mechanically pressed to make it malleable. Lower grades may be adulterated with a range of oils and inert or active bulking agents.

As with cannabis herb, there are grades to cannabis resin, which vary depending on the country of origin. Much like olive oil, cannabis resin made from the first sifting is rated highest, as it contains the maximal amount of resin with minimal impurities. Producing 10 grams of top grade cannabis resin (such as the Moroccan "zero-zero") requires about 1 kilogram of plant material (i.e. a 1 per cent, or 100 to 1, extraction ratio) and some premium varieties have even lower ratios. Often, the residue is used to produce additional resin of a lower quality. Lower quality cannabis resin may be produced at ratios of up to 50 grams per kg or more.

Manual preparation processes are highly labour intensive and somewhat wasteful, so it is not surprising that modern consumers of cannabis resin have devised more efficient technologies. Many of these were piloted in the Netherlands. The potency of the cannabis resin they produce (*nederhasj*) is much higher than the resin produced through traditional methods, although the yield is not as great. Sinsemilla cannabis plants are generally used for *nederhasj*, further enhancing potency.

A third sort of cannabis resin ("jelly hash") has also emerged in recent years. This appears to be a combination of *nederhasj* and cannabis oil, with a soft consistency and very high THC levels. Cannabis oil itself may be making a comeback, as new processes are developed that reduce the risk of solvent impurities. There have also been other cannabinoid concentrates developed, such as the Vancouver product known as "budder". The proponents of these products argue that they will be easier for medical cannabis patients to consume, without the necessity of smoking plant matter.

Despite these technological developments, there are many people in Europe who prefer traditionally made cannabis resin. They face problems of quality in their supply, however. Morocco dominates the European market and all but the highest grades of its output of cannabis resin appear to have declined in quality in recent years. Particularly worrying are the adulterants said to be used to bulk up lower grades, producing products such as "soap bar" in the United Kingdom and "Chernobyl" in France. These have been persistently alleged to contain all sorts of additives over the years, including the highly unlikely claim that they are made with an unspecified, addictive animal tranquillizer. Despite these claims, in its review of

cannabis potency, the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) asserts that, in Europe, "resin is rarely adulterated" ([10], p. 40).

Cannabis resin is smoked like cannabis herb, but can also be used in cooking and eaten. It can be vaporized or smoked in a range of ways, which include pressing a small amount between two hot knives and inhaling the fumes. It is often added to a medium such as tobacco before consumption.

What are the psychoactive components of cannabis?

Cannabis contains over 400 chemicals, of which more than 60 are chemically unique and are collectively referred to as cannabinoids. Delta-9 THC is believed to be responsible for most of the psychoactive effects of cannabis, although related chemicals are believed also to play a role. The precise way in which the various components of cannabis interact and influence the physiological and subjective effects of cannabis is a topic of ongoing research.

Much of the THC in a plant is in acid form or in a less potent variant and the application of heat is essential to make all of the THC accessible. Chemically synthesized delta-9 THC is known as dronabinol (marketed as Marinol).

One of the most important secondary chemicals is cannabidiol (CBD), the biosynthetic precursor of THC, which converts to THC as the plant matures. It has been argued, particularly by users, that this chemical alters the subjective perception of the effects of THC, enhancing the sedative effect. This claim is the subject of ongoing research [11]. At least one study has concluded, on the contrary, that the psychoactive effects of cannabis are mainly due to THC [12]. Some research exists on the independent muscle relaxant and anti-psychotic properties of CBD [11]. If these investigations are borne out, they may challenge the notion that the quality of cannabis can be reduced to its THC content. Numerous forensic studies have found that different varieties of cannabis contain different ratios of cannabinoids. For example, some South African varieties have been found with virtually no CBD [13, 14]. Most plants used to make cannabis resin have a high CBD content, although whether this is a result of historic accident or more deeply related to the nature of the drug remains unclear [15]. These variations could possibly provide some explanation for the different subjective effects of different cultivars, a topic widely discussed by cannabis users.*

*Users say that "sativa" varieties produce more of a "cerebral high", while "indicas" produce more of a "body stone". The grey literature often argues that "sativas" have large amounts of THC compared to CBD, while "indicas" are relatively CBD-rich. Smokers of high THC "sativas" say they become more energetic and creative, while those who consume varieties where CBD is relatively high talk about falling into a physically relaxed "couch lock". For a discussion of the different subjective effects of different cultivars of cannabis, see, for example, Drake ([16], p. 25). One of the challenges breeders pose for themselves is capturing the preferred qualities of each strain. There is also variation in the proportions of other cannabinoids in local cannabis products, such as cannabinol and tetrahydrocannabivarin, and the processing and age of the sample can have an effect on cannabinoid content. Finally, different methods of ingestion result in different levels and combinations of cannabinoids being absorbed. Heat is required to decarboxylate THC acid to THC, and this affects the potency of cannabis when it is eaten.

THC is found in most parts of the plant aside from the stems and seeds, but is most plentiful in the flowers and small leaves surrounding them. This is where the glandular trichomes (the tiny, mushroom-shaped glands that produce resin) are most prominent. A positive correlation has been found between the number of stalked capitate glandular trichomes and THC content [17]. Some commentators dispute that either trichome numbers or resin quantity are reliable indicators of potency. The quality (THC level) rather than the quantity of resin is emphasized [18].

Other cannabinoids are of use to forensic researchers. For example, cannabinol (CBN) is a mildly psychoactive product of THC degradation and is not found in the fresh plant. The ratio of THC to CBN can thus be an indicator of the age of a sample of cannabis [19].

Cannabis resin is a concentrated product and it is therefore remarkable that, in major markets such as Germany and the United Kingdom, the cannabis herb available locally is actually more potent than the cannabis resin that is consumed. In 2002, low average resin potency levels were found in countries as diverse as Norway (5 per cent), Latvia (4.5 per cent), Portugal (2.6 per cent) and Hungary (2 per cent) ([7], p. 31). Some of this may be because of the presence of low quality Albanian cannabis resin in the market. For countries whose cannabis comes from Morocco, the differences could be due to divergence in sampling and testing, or they could be due to lower quality or diluted products being shipped to certain markets.

The potency of sinsemilla is much higher than that of the seeded product, with a 2004 average of about 10.5 per cent in the United States (as compared with 2.5 per cent for low-grade cannabis herb)* and close to 18 per cent in the Netherlands [20] (as compared with about 6 per cent for imported cannabis) [10]. Individual samples have exhibited THC levels in excess of 30 per cent, although this is extremely rare. As will be discussed further below, sinsemilla is distinct enough in appearance and potency to be considered a separate drug product, like "hashish". There has even been discussion of scheduling sinsemilla as a "hard drug" in countries that have liberalized their cannabis policies.** Making the distinction between sinsemilla and other herbal cannabis products in the official statistics is important for public education, trend monitoring and market valuation.

While the cannabinoid profile of sinsemilla is partly determined by its genetics, sinsemilla samples tend to be very high in THC and very low in CBD ([22], p. 10). As suggested above and discussed below, this means that the difference between smoking sinsemilla and other forms of cannabis is more than just how quickly the user gets intoxicated: it may be a qualitatively different experience.

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*Data from the University of Mississippi Cannabis Potency Monitoring Project.

**For example, the Home Secretary of the United Kingdom, Charles Clarke, recently asked the Advisory Council on Misuse of Drugs to consider whether "skunk" should be excepted from the downgrading of cannabis from a class B to a class C drug. See Travis [21].

Cultivation techniques

The cannabis market today is quite different from that of just 40 years ago. First, the market definition of the drug itself has changed. After the massive growth of the Western market in the 1960s and 1970s, users' tastes have grown increasingly sophisticated. The market for high quality cannabis has expanded and many users today insist on smoking only the unfertilized buds of the female plant,* as opposed to the mixed matter that was considered standard in the past. Even low-grade cannabis today is likely to contain more flowers than during the early years of the modern cannabis boom.

Secondly, the plant has been improved. Since the early 1970s, cannabis production has been revolutionized by breeders and cultivators working in Canada, the Netherlands and the United States. Selective breeding has resulted in plants that are more potent, faster maturing, hardier and more productive.** Cultivation techniques have been refined to increase yields dramatically. Using the best plants and the best technology, growers can now harvest up to six crops a year indoors, producing far more cannabis in a smaller space than ever before. Even casual outdoor cultivation has benefited from a growing base of knowledge on how to produce the best cannabis.

In the past decade, the spread of new cannabis technology has been facilitated by the information revolution and its impact on globalization. Technical know-how is now disseminated through a large number of websites and chat groups where growers exchange experiences and tips. Seed "banks" are some of the prime sources of this information and their sales though the Internet allow growers worldwide to access the best new strains.

Technologically sophisticated operations are aptly referred to as "cannabis factories". In many ways, cultivation of cannabis in some countries is becoming more like the production of synthetic drugs than the production of other plant-based drugs. While cannabis produced in less sophisticated ways continues to maintain market share, law enforcement pressure may have the unintended side effect of driving production indoors, promoting higher potency products and increasing the share of production occurring in the consumer countries.

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*For example, one survey of regular users in New South Wales, Australia, found that 60 per cent only smoked cannabis buds and that nearly all only smoked cannabis leaf when buds were not available or when they could not afford pure bud cannabis. See Didcott and others ([23], p. 26).

**As will be discussed below, there are methodological problems in respect of time series THC-level data and it is still debated whether global THC levels have increased overall, but there is no doubt that strains available today, cultivated using cutting-edge technology, are more potent than in the past. In addition, as will be demonstrated in the following discussion, yield per unit area per year is about 16 times greater in modern indoor cultivation than in a traditional outdoor farm.

How has cannabis changed in recent years?

As market logic would dictate, the revolution in cannabis production described above was preceded by a revolution in demand. Looking at the largest consumer country, the United States, this history is clear. While cannabis has been consumed throughout the past century (especially after the wave of emigration following the Mexican Revolution of 1910), the drug-fuelled social movements of the 1960s generated an unprecedented proliferation of use. This expanding trend continued to escalate through the 1970s.

After a decline in the 1980s and early 1990s (to a low of about 22 per cent annual use among students in the twelfth grade in 1992), the drug came back into fashion in the United States in the mid-1990s and seems to have reached a plateau of about 35 per cent of students in the twelfth grade in the late 1990s and the early years of the new millennium. This means that there are some lifetime cannabis smokers in the United States who have been consuming the drug for over 40 years, as well as young initiates who continue to try it for the first time every year in large numbers. The presence of long-term users in the market may be fuelling demand for higher potency products. For example, only 3 per cent of all users in Ireland polled in 2002/2003 who had used cannabis in the previous month said they used "skunk" most frequently, rather than more mundane products, but 10 per cent of older adult users (35-64 years of age) did so [24].

The social movements of the 1960s contributed to the cannabis revolution in other ways as well. "Hippies" roaming the globe came into contact with traditional cannabis cultures and brought this knowledge back home with them. Sometimes, they also brought seeds and, working at home, they started breeding North American cannabis. In the early years, "home-grown" was hardly a selling point, as much superior product could be imported from Mexico. Law enforcement crackdowns, including the use of the herbicide "paraquat" in Mexico, however, led to a decline in import quantity and quality in the mid-1970s. While supplies from Colombia eventually filled this void, users were aware of supply vulnerability and many began serious cultivation efforts at home.

Most of the cannabis herb smoked in the 1960s would be maligned as "schwag" today, as it was seeded. In addition to seeds, it included a great deal of leaves, twigs and other material that would be regarded as waste today. Sinsemilla only entered the market some years later. This is not to say that the sinsemilla technique was recently invented. It is said to be traditional in parts of India, where "paddars" ("ganja doctors") were hired to remove male plants from cultivation areas [25]. It has also been present for some time in the Americas. In 1933 in Panama, United States military officers familiar with this practice noted that local cultivators, while aware that male plants were weaker, did not bother weeding them [26]. It would appear that sinsemilla cultivation was far less common in the Americas in the early years of the present boom and a look at early cultivation manuals shows how the

market slowly developed an understanding of the potency of sinsemilla.* Most commentators place the emergence of sinsemilla in the United States around the early to mid-1970s ([28], p. 9) and in Europe at about 1980 [29].

Law enforcement action in the second half of the 1970s to the early 1980s appears to have pushed some domestic production indoors,** and caused growers to focus on producing greater quality rather than quantity in order to evade detection. Producing sinsemilla outdoors can be difficult to do in areas of dense cultivation, because a single male can pollinate downwind females over a very wide radius.*** This reduces local illicit outdoor production to the lowest common denominator and thus sinsemilla can only be grown either in isolated areas or where there are strict cultural controls over how cannabis is grown (something that is difficult to maintain in an illicit market). Outdoor sinsemilla cultivation is impossible in an area where industrial hemp is grown or where wild hemp proliferates. The move towards more indoor cultivation has thus supported the expansion of sinsemilla production.

Weeding the males, aside from being a labour-intensive process if production is done on any scale, means pulling up half the saleable crop**** and interferes with optimal spacing of the plants (since there is no way of predicting which plants will be thinned). In addition, seeds add a lot of weight to the final product, so the price of sinsemilla must outweigh this loss in order for the market to become viable. The move towards starting with cloned plants supported sinsemilla production, as it eliminated the need for weeding males whether the crop was grown indoors or outdoors.

Cloning simply means taking a cutting from a successful mother plant, a technique frequently used in propagating houseplants. This cutting is left to develop roots and then planted. It is a genetic duplicate of its mother and can be used to generate still more cuttings. Eventually, a grower can work with entire crops of genetically identical plants. A square metre of mother plants is said to be capable of producing 100 clones a week [29].

There are several advantages to working with clones. First, the cuttings are guaranteed to be exclusively females. Second, they will be duplicates of a mother proven to be a successful producer and whose life cycle and weaknesses are known. Finally, the clone assumes the stage of the life cycle of the mother and so needs less time to reach flowering than would a similarly sized plant grown from seed.

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*The *Cannabis Underground Library: Seven Rare Classics* [27] includes seven early texts on cannabis growing from the 1970s and 1980s, which illustrate the evolution in understanding over time.

**Bergman, as cited in Jansen [30].

***Cannabis pollen has been found to comprise up to 36 per cent of the total pollen during the peak of cannabis pollination in mid- to late-August in areas where cannabis plants are common [31].

****Despite disinformation to the contrary, male plants have similar levels of THC as female plants [32].

Used in combination with the forced flowering technique described below, clones dramatically accelerate the rate of cannabis production.

How were the modern strains of the cannabis plant developed?

Until the mid-1970s, nearly all the cannabis consumed in North America was a landrace strain of the sativa variety. Landrace strains are those native to a particular geographic region and the early varieties usually contained a geographic designation, for example "Acapulco gold".

A key turning point was reached when plants gathered from different parts of the world were bred. According to the users, this specifically involved the breeding of tropical "sativa" plants and highland "indica" plants. In the user's typology, pure sativas are considered to have good psychoactive effects but are believed to be both late maturing (making them difficult to grow in northerly latitudes) and very tall (making them difficult to conceal outside and problematic to grow inside). They say it was not until seeds from Central Asia and the Middle East were introduced—seeds of plants traditionally used in making cannabis resin—that these problems were overcome. These "indica" genes were said to accelerate the life cycle, boost yields, be more cold resistant, generate a different sort of high and produce more manageably sized (and thus concealable) plants. But some argue that random cross-breeding resulted in the manifestation of some of the less desirable characteristics of "indicas" and that "serious breeders of the 1980s began to view indica with more scepticism" ([28], p. 9).

One of the beneficiaries of seed gathering by "hippies" was a semi-legendary American breeder known as the "Skunkman". The Skunkman is said to be the father of "skunk"—a smelly hybrid of three distinct and previously uncrossed cannabis genetic lines: Colombian, Mexican and Afghan. This hybrid was said to be 75 per cent "sativa" and 25 per cent "indica" and was supposedly among the first to capture the THC "high" of the "sativas" with the rapid growth cycle and yield of the "indicas" ([33], p. 154). It remains one of the cornerstone cultivars used in breeding today and high quality cannabis herb is still referred to as "skunk" in various parts of the world.

Around 1985, during the era when then President Ronald Reagan began a crackdown on illegal drugs in the United States, the Skunkman brought the best in American cannabis breeding to a location where he could experiment with his plants a little more openly: Amsterdam, the Netherlands. At the time, indoor cultivation of cannabis was just starting to take off in the Netherlands, [29, 30] so he joined up with a number of local cannabis experts and the "breeding revolution" in Amsterdam began [33]. Today, there are many cannabis seed companies in the Netherlands, with a growing number of rivals in Canada and other countries around the world.

The creation of premium strains of cannabis has changed the nature of consumer demand. Today's cannabis is clearly graded, with large price differences between "schwag" and name-brand product. Today's premium buyers can read about how their selected strains fared in various international competitions and "harvest festivals" on the Internet or in seed bank promotional materials. They can also learn about the lineage of the plant and perhaps its THC levels and can hear subjective accounts of its taste and effects. This has introduced pretensions to connoisseurship among some cannabis users, with product descriptions involving terminology more commonly associated with wine tasting.

How is the growing cycle accelerated?

In addition to selective breeding for fast maturity, the rate at which cannabis plants come to flower can be increased by manipulation of the light cycle. Outdoors, the success of cannabis plants grown for drug purposes is highly dependent on latitude. This is because most types of cannabis plant only flower when the days grow shorter. At northerly latitudes, this happens before the plant has had a chance to develop fully, or coincides with lethal frosts. This makes outdoor cultivation of drug-quality cannabis plants in much of Europe, for example, very difficult, especially for plants that evolved at lower latitudes. Indoors, these restrictions clearly do not apply and, in addition, the photoperiod (the amount of light received by the plants during the day) can be manipulated to "force" flowering whenever it suits the grower. During the vegetative phase, when the plant is maturing, it is generally exposed to either continuous light, or 18 hours of "daylight" to six hours of darkness.* When the grower is ready for the plants to flower, they are switched to a 12/12 day/night cycle and this is sufficient to induce flowering in most varieties.

In the wild, cannabis plants would normally have several months of vegetative growth before the days grow shorter, but growers may have a different agenda. Some vegetative growth is necessary, obviously, for the plant to produce good flowers, but indoor cultivators often force flowering with only a few weeks of growth, particularly when working from clones.

Forced flowering results in smaller yields per plant than if each plant had been allowed to mature further, but this is more than offset by the faster overall production time and in the greater number of small plants that can be fitted into a given growth area. Whereas traditional outdoor growers are limited to one (in higher latitudes) or perhaps two (nearer the equator) harvests a year, new technology growers can stagger production to produce almost continual harvests. The turnaround time from clone to harvest is generally in the order of 8-10 weeks, allowing between 4 and 6 harvests off the same square metre of floor space. The best-known

*The 18/6 photoperiod appears to be returning to vogue because, while continual light can increase yields, this advantage is offset by the expense of additional lighting.

example of this is the "Sea of Green" technique from the Netherlands, which is discussed below.

Clearly, high-technology indoor cultivation is only one cultivation strategy and it is only available to relatively well-resourced growers, largely in developed countries. Its advantages, including the fact that the drug can be produced in the most profitable consumer countries, might lead one to believe that it will eventually supplant more traditional approaches. But the cannabis market, like the alcohol and cigarette markets, addresses a wide range of consumer tastes and budgets, so it is likely that cheap, lower-potency cannabis will continue to find buyers. Consumer trends are also influenced by product availability, so law enforcement plays a role in the types of cannabis consumed.

What are the main cultivation strategies today?

At present, then, we have a global market with diverse cannabis products on offer. These different cannabis products originate from different cultivation sources and these sources operate differently. Understanding the dynamics behind cannabis production means understanding these different cultivation strategies. While any typology of such a widespread phenomenon as cannabis growing is doomed to overgeneralization, the following are proposed as working categories:

- Feral and semi-cultivated. Some cannabis is gathered from the wild, or seeds are quickly sown and results harvested with very little work invested in between.
- Traditional field cultivation. While this category covers a wide range of practices, it is intended to include all those who farm cannabis as a full-time job, at least seasonally.
- Modern outdoor cultivation. This is field growing utilizing the latest know-how, wherever performed, including "guerrilla" cultivation, that is, when cannabis is grown on land not owned by the cultivator.
- Modern indoor cultivation. Both in soil and hydroponic cultivation, this is the height of high-technology cannabis production.

Each of these production strategies will be discussed in turn.

Feral and semi-cultivated cannabis plant

Since the cannabis plant grows well on its own in some parts of the world, "cultivators" may do little more than drop seeds and harvest whatever comes up, or collect the produce of feral plants. This allows a cash crop to be harvested with little investment, a practice that is very difficult to deter with crop-directed efforts. Indeed, enforcement pressures may make these loose markets more competitive, forcing cultivators to become more efficient. A similar strategy may be employed by

informal growers in developed countries, who plant small patches in vacant or public land on the off chance that they will be able to harvest something with very little risk or effort.

The best known expanses of feral cannabis are in Central Asia, a region that could probably satisfy world cannabis demand if the drug was widely cultivated. But in many parts of the world, including much of Africa, subsistence farmers may keep a small patch of cannabis plants as a source of income for the family. In some instances, these outputs are consolidated by wholesalers for transport to urban areas or even export.

Traditional field cultivation

Table 1 shows the yields of outdoor cannabis cultivation in various parts of the world. Irrigated crops in Morocco provide one example of traditional field production. Cannabis has been grown for some time in Morocco for use in "kif", the local mixture of cannabis and tobacco. Only since the 1960s has cannabis been cultivated to supply the cannabis resin market of Europe, with most of the production occurring in the traditional cannabis-producing region of Ketama, an area where little else grows well.

Cannabis in the Ketama region of Morocco is planted extremely densely in irrigated areas, with 30 or more plants per square metre. This creates a large number of small, unbranched plants, each producing around 4 grams of cannabis resin, which is usually later processed into about 0.04 grams of "hashish". Non-irrigated plots in Morocco perform no better than semi-cultivated areas, such as in Kazakhstan.

Plants in other traditional areas, such as Mexico and South Africa, are not planted as densely and crops are generally smaller and more dispersed, as both countries have active eradication programmes and evasion of law enforcement is an issue.

Table 1. International outdoor yields

Country	*Plant type and cultivation style*	*Yield (grams per square metre)*
Kyrgyzstan (1999)	Outdoor feral	47
Kazakhstan (1999)	Outdoor feral	74
Morocco	Outdoor rain fed	76
Morocco	Outdoor irrigated	127
Mexico	Outdoor mixed; multi-season	180
South Africa	Outdoor mixed	116

Sources: UNODC, except for Mexico, for which information was obtained from the United States Drug Enforcement Administration.

Traditionally, field-grown cannabis is rarely sinsemilla for one obvious reason: it is almost impossible to ensure that male plants do not fertilize crops in areas of intense cultivation. The development of the sinsemilla technique in India may have been the result of the isolated and mountainous areas where the drug was grown. In modern Morocco, in contrast, the male pollen is so thick that clouds of it are said to be visible in Southern Europe [34].

Modern indoor cultivation

Aside from input costs, which, depending on the size of the operation can be substantial, there appears to be little reason for the modern cannabis cultivator to deal with the unpredictability of nature. Climatic problems, plant and animal predators, insect pests and fungi, the non-productive (from a photosynthetic point of view) hours lost to the night and certain aspects of the security risk can be minimized by operating entirely indoors. In addition, growing conditions can be enhanced to a level that cannot be achieved under the best outdoor conditions. For example, carbon dioxide levels can be boosted to a level last encountered on earth in the early years of the planet, but which plant life still "remembers" how to utilize.*

Indoor growing is done on a massive scale both by organized criminal groups and by many cannabis consumers themselves in developed countries. For example, a survey of regular cannabis users in the United Kingdom found that most of the respondents (63 per cent) had tried growing their own cannabis plants. Of these, 34 per cent grew plants from pedigreed seeds exclusively and 43 per cent used pedigreed seeds as at least one of their sources of growing stock. Another 13 per cent used cuttings exclusively and 20 per cent used cuttings as at least one of their sources of growing stock. Only 18 per cent grew outdoors exclusively, compared with 54 per cent who grew indoors exclusively. Just under 10 per cent used hydroponics as one of their cultivation techniques ([35], p. 17).

Of course, not all growers make use of the full range of technologies available to them and some indoor cultivation operations have little to recommend them over the windowsill cultivation of earlier decades. Depending on the segment of the market for which they are growing, some growers may make use of suboptimal technologies in order to keep overheads low. The size of these operations also varies tremendously, from self-contained single-plant units, to closet or bedroom cultivation, to full-scale warehouse-sized operations. In Canada, entire railway cars and shipping containers have been kitted out for indoor production and buried to evade detection. Some cultivation combines indoor and outdoor cultivation at different stages of the life cycle, including the use of greenhouses, thus cutting down on input costs.

*Discussions with cultivators in Amsterdam, the Netherlands, suggest that use of CO^2, while once in vogue, is presently in decline. In order to retain CO^2, grow rooms must be sealed. This produces problems with heat and humidity and additional air conditioners and dehumidifiers are needed. In the end, the increased yields do not seem to justify the expense. Most large-scale growers today emphasize air circulation, rather than adding CO^2.

The cannabis plant requires different conditions, including different nutrient and light conditions, at the various stages of its life cycle. By demarcating separate areas for each stage, crops can be cultivated simultaneously at each point in the growth process. This allows staggered cultivation and, under the Sea of Green method, a harvest every two weeks. The Sea of Green technique involves cultivating a large amount of plants in a given area for a short period of time before flowering. This results in a smaller yield per plant but more plants in a harvest and shorter cultivation periods, which allows for more harvests per year. Different parts of the growing area are used for plants in different stages of their life cycle, staggering production.

The first stage could be loosely termed "germination" and can include sprouting and planting of seeds or the rooting of new cuttings (clones). Here, continuous light is desirable, with no break or night-time cycles, as cannabis grows best when it is allowed to photosynthesize without interruption. Metal halide bulbs are preferred for this stage, but cheaper lights (using fluorescent bulbs) are often substituted. Plants can be placed closely, at four plants per square foot (about 36 per square metre). Germination of seeds or cuttings to viability generally takes two to three weeks.

The second stage is vegetative growth, in which the plant achieves the size and maturity it needs to allow it to flower successfully. Here again, the plants are exposed to continuous light. Plants require more space at this stage, but can still be spaced at one plant per square foot (about nine per square metre). It is in the vegetative stage that methods like Sea of Green cut down on production time—Sea of Green plants may be vegetated for as little as two weeks. Of course, a longer vegetative period has a positive effect on yield per plant, but plants can grow quite large and space considerations may be as much of an issue as individual plant yield.

As the first and second stages require much the same conditions, they may be combined in the same location with the seedlings occupying a shelf above the vegetative growing area. Or, if the vegetative growing area will also be used for flowering, then a curtain is required to shield the mature plants from the light needed by the seedlings.

The flowering stage requires manipulation of the light cycle, so plants in this stage cannot be housed in the same lighting area with seedlings and vegetative plants. High-pressure sodium lights are preferred for this stage, which are also energy efficient in terms of light output. Flowering takes some time and this is often the cultivation time quoted by seed banks: usually about one and a half to three months.

The final stage is harvesting and curing. This takes at least two weeks. The total process, from seeds to sale, can take about 16-18 weeks.

In order to avoid detection through excessive electricity bills, many indoor growers around the world steal their electricity. For example, in a Canadian police

operation conducted in January 2002 ("Operation Green Sweep I") electrical theft was found in 99 of 189 indoor cultivation operations searched [36].

Indoor operations can be massive. In Canada, every year two or three indoor plots with between 10,000 and 20,000 plants are found [36]. At 100 grams per plant and four harvests a year, such an operation can produce up to eight tons of cannabis annually. In 1999, Canadian authorities unearthed eight railway cars that had been buried to create an underground cannabis factory. On certain streets, half the houses have been found to grow cannabis plant [36].

Modern outdoor cultivation

While indoor cultivation seems to be gaining an increasing share of overall cultivation, there has also been a reaction in the opposite direction, perhaps due to enforcement efforts that include asset forfeiture. Since the mid-1980s in the United States, "guerrilla" cultivation, in which cannabis plants are grown on land not owned by the cultivator, has constituted an increasing share of total outdoor domestic cultivation. This can include private property, but has increasingly included public lands, such as the parks in the states of California and Kentucky. In Daniel Boone National Park in Kentucky alone, over 200,000 plants were eradicated in 2003, and more than twice that many are destroyed in the parks of California each year [37]. Many of the Californian operations are controlled by Mexican organized criminal groups [37].

Cultivation on public lands is not limited to the United States, but has been found in Canada and Colombia and in other parts of the world. While some "guerrilla" growers select sites they can access from their homes, some spend the entire growing season camped out by their plot for security reasons.

Yield

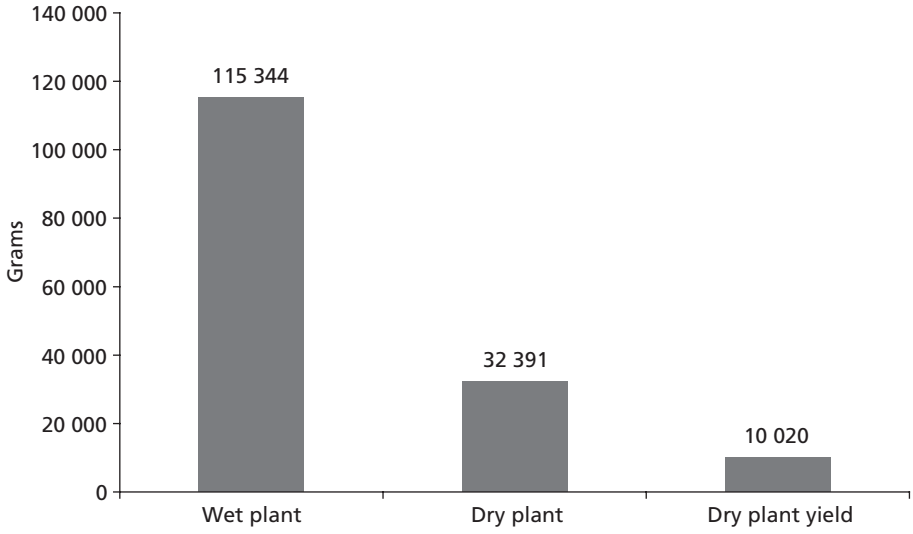
Coming to grips with the scale and variety of cannabis production operations around the globe requires some discussion of yield. Given the variability of the plant and the range of cultivation techniques employed, coming up with precise figures such as yield to plot area ratios can be difficult. Poorly cultivated or feral plants may produce small buds, while those with the benefit of the best genetics and the latest growing technology can produce massive ones.

Clearly, from a consumption perspective, plant yields are tied to the type of drug product desired. Low-grade herbal cannabis contains seeds and large leaves, whereas sinsemilla consists entirely of the buds and small leaves surrounding them. On the other hand, sinsemilla is often grown indoors using forced flowering techniques, which can result in an exaggerated flower to plant ratio. According to the United States Drug Enforcement Administration, 34 per cent of a non-sinsemilla cannabis plant contains useable material (the leaf and bud components) and 58 per

cent of a sinsemilla plant contains useable material (as it contains no seeds) [38]. It would appear that no sinsemilla plants were examined for that determination, however, and that the seeds were simply removed from field-grown plants to create different ratios. This does not mean that sinsemilla plants produce more saleable crop than non-sinsemilla plants, because the seeds (which constitute 23 per cent of the weight of the entire plant) ([39], p. 5) are included in the commercial product. "Useable" does not mean "saleable" in this context: low-grade cannabis is sold with seeds and other unusable plant matter.

The United States Drug Enforcement Administration reports that a cannabis plant loses two thirds of its weight in water during the drying process and the wet plant to dry product ratio is said to be 14 per cent ([39], p. 4). With regard to the latter assertion, at least one cultivation expert agrees: "[Dried] [l]eaves and flowers constitute from ten to twenty per cent of the harvested [wet] weight of the [outdoor] crop" ([16], p. 52).

Figure I. Ratio of wet plant to dry plant to yield



Source: Data supplied by the Office of Medical Cannabis, the Netherlands.

Empirically based figures for sinsemilla can be drawn from the medical cannabis industry, where a scientific approach is taken in order to produce maximal yields of good potency under controlled indoor conditions with minimized input costs. The Office of Medical Cannabis (Bureau voor Medicinale Cannabis) in the Netherlands is one such facility. A recent harvest of 115,344 grams of wet plant was dried to 10 per cent moisture content to produce about 32,391 grams of dried plant, a ratio of about 28 per cent, or between one quarter and one third. From this, a net yield of 10,020 grams was achieved after the bulk quantity was cleaned of twigs, stems and seeds (a process known as "manicuring"), with 21,219 grams of waste and

1,048 grams of spillage. This would suggest that saleable material represents about 30 per cent of dried plant weight and about 8 per cent-10 per cent of wet plant weight. This is easily summarized in the ratio 10-3-1 and is on the low end of the figures cited above [40]. One analyst notes: "About 75 per cent of the fresh weight is moisture that is lost in the drying process. Almost half of the dried plant matter is stem; only about a quarter (18 per cent-28 per cent) remains after the herb is cured and manicured into medical-grade bud" ([41], p. 3). This would correspond to a ratio of 10-2.5-0.7, a slightly lower yield ratio.

Given the expertise of the medical producers, these figures should thus be regarded as optimal (high end) sinsemilla yields. In contrast, street product will usually contain more plant bulk; this is obvious in the case of non-sinsemilla products, because seeds are the densest part of the plant. Medical cannabis producers, concerned about fungal and mould growth, also tend to dry their product more than illicit producers, typically to about 10 per cent moisture content. Street samples generally contain more moisture (giving more bulk for sales purposes), ranging from 12 per cent to 16 per cent, but the impact on total bulk is minimal: 100 kilograms dried to 7 per cent moisture content yields about 27.5 kilograms dried plant, whereas the same material dried to 15 per cent yields about 29.55 kilograms ([41], p. 3). In the end, the 10-3-1 ratio (wet weight of plant—dry weight of plant—dry weight of product) is probably a good average of reasonable values for sinsemilla.

For low-grade cannabis, most of the seeds (and perhaps more stems and leaves) are included. One recipient of medical grade cannabis in the United States reported cleaning even this product to the extent that 25 per cent of the material was lost ([42], p. 20). Seeds make up 23 per cent of the dry weight of the entire plant and stems 43 per cent ([39], p. 5). Most of the stem weight is not included in the street product, but most of the seeds are. Even if all of the stem were removed, seeds would still make up about 40 per cent of the dry product by weight. Allowing for some stem, it can be concluded that about half of the weight of low-grade cannabis is unusable. The ratio between leaf, bud and stem in sinsemilla and non-sinsemilla plants is about the same, so the product outputs (though not the useable amounts) should be about the same.

As discussed above, some cultivation styles emphasize dense plantings, while others focus on a smaller number of highly productive plants. It has been argued that, for the average home garden plot, cultivating a large number of small plants or a small number of large plants results in roughly the same yield ([43], p. 5). Many indoor growers discuss their yields in terms of wattage: one pound for each 600-watt high-pressure sodium bulb being a common rule of thumb. But this is not much help in comparing indoor and outdoor yields. The following discussion concludes that yields should be expressed per unit area (square metre or hectare) rather than per plant.

For example, the United States Drug Enforcement Administration, in cooperation with the National Center for Natural Products Research at the School of

Pharmacy of the University of Mississippi, undertook a study of outdoor cannabis yields in 1990 and 1991 using different (mainly "sativa") seed stocks and planting at different densities [39]. Plants grown at "dense" spacings (between 0.91 and 1.28 metres between plants) produced between 215 and 274 grams per plant, while plants given more room (up to 2.74 metres between plants) produced higher yields, including one plant that produced 2.3 kilograms of cannabis. The study concluded that "a very significant factor affecting yield was planting density". Indeed, squaring the space per plant resulted in per plant yields increasing as much as fourfold. However, this increase does not represent the most efficient use of land area, as the yield per unit area, calculated from the various plantings by the United States Drug Enforcement Administration, shows (see table 2). On average, the densest plantings were more than twice as productive per unit area as the most widely spaced.

Table 2. Cannabis yields at various planting densities

Density (number of plants per square foot)	*Yield (grams)*	*Yield per square foot (grams)*
9	222	25
9	274	30
9	215	24
18	233	13
36	860	24
72	1 015	14
81	777	10
81	640	8
81	936	12
Average yield per square foot for densest plantings		26
Average yield per square foot for most widely spaced plantings		10
Average yield per square foot		14
Average yield per square metre		150

Source: United States Drug Enforcement Administration, 1992.

While individual plants may be spaced three metres apart in some "guerrilla" cultivations, most clandestine growers do not have the luxury of such space* and the size of the resulting plants (some over three metres tall in the University of Mississippi study) would make them difficult to conceal. Furthermore, as table 2 shows, low planting densities quickly reach the point of diminishing returns for growers. All this suggests that using average, low-density, per-plant yields as a rule of thumb is likely to produce inflated estimates and that laws that seek to regulate the number of plants grown, rather than the land area under cultivation, may be misguided.

In practice, traditional growers use much greater planting densities. In Morocco, to cite an extreme case, about 30 plants are cultivated per square metre in irrigated areas, not one [8]. Similar densities are used in Sea of Green indoor operations, where

*For example, the National Organization for the Reform of Marijuana Laws in the United States argues, "... most US marijuana is grown densely in gardens of nine square feet or less" [44].

per-plant yields are in the neighbourhood of 10 grams apiece, [45] far from the "pound a plant" rule formerly used by the United States Drug Enforcement Administration.*

In addition to plant density, cultivation style is clearly relevant in determining yield. Dense, indoor, high-technology plantings are more productive than dense, outdoor, traditional ones. Looking at some 35 yield estimates given by a wide range of different sources, a degree of consensus is discernable on the yields per square metre of the various cultivation strategies [47]. Table 3 shows figures derived from a wide range of sources of varying reliability. Still, a considerable amount of consistency can be discerned, with the exception of a few outliers.

Looking first at the outdoor situation, yields vary from as low as 47 grams per square metre for feral or semi-cultivated varieties grown without irrigation in difficult climates, to as high as 500 grams per square metre in well-tended gardens. A modal value of around 75 grams per square metre could be hypothesized for low-end operations, with quite a bit more variation on the upper end of the scale. An average of about 200 grams per square metre outdoors has been said to be consistent with figures gathered in court cases in the United States ([41], p. 2). Throughout the present review, a figure of 100 grams per square metre (or one ton per hectare) will be used for outdoor crops when cultivation style is unspecified.

All this highlights that cannabis is an extremely productive drug crop. One square metre of outdoor cultivation space is sufficient to supply a user with one 0.27 gram cannabis cigarette a day (a reasonable size for a European user) for a year. A hectare could produce enough cannabis to supply 10,000 light daily users. If all 162 million annual users smoked this amount (which is clearly not the case), global demand could be met by a production area of 162 square kilometres (about 100 square miles), an area about the size of Liechtenstein. Of course, this area is presently spread all over the Earth.

There is one important complicating factor, however. In some parts of the world, multiple cannabis seasons are claimed and there is considerable confusion about this matter.** Yields in off-seasons may be considerably less. Weather is also an extremely important factor for rain-fed crops.

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*The Drug Enforcement Administration's figure also conflicts with the 100 grams a plant later affirmed by the United States Sentencing Commission as appropriate when looking at mixed gender crops. "The one plant = 100 grams of marihuana equivalency used by the Commission for offences involving fewer than 50 marihuana plants was selected as a reasonable approximation of the actual yield of marihuana plants taking into account *(a)* studies reporting the actual yield of marihuana plants . . . ; *(b)* that all plants regardless of size are counted for guideline purposes while, in actuality, not all plants will produce useable marihuana . . . ; and *(c)* that male plants, which are counted for guideline purposes, are frequently culled because they do not produce the same quality of marihuana as do female plants". *Federal Register* 60 (10 May 1995): 25078, as quoted by the National Organization for the Reform of Marijuana Laws [44]. This figure was extended to all crops, including those involving more than 50 plants. See also the 1995 annual report of the United States Sentencing Commission ([46], p. 148).

**In Lesotho, for example, it has traditionally been said that there are two harvests, but the first one appears to be simply the culling of male plants to make the inferior *majat* grade cannabis herb, used primarily in combination with methaqualone. More recent reports suggest three harvests are made, with substantial variability in yield between each.

Table 3. Cannabis yields as reported by various sources

Source	*Plant and cultivation style*	*Output per plant (grams)*	*Plants per square metre*	*Weight per square metre (grams)*	*Seasons per year*	*Output per square metre per year (grams)*	*Cost per square metre per year at $400 per ounce (US dollars)*
United States Drug Enforcement	Sinsemilla outdoor	560	. .	. .	. .	. .	. .
UNODC (1999) Kyrgyzstan	Outdoor feral	. .	. .	47	1	47	671
UNODC (1999) Kazakhstan	Outdoor feral	. .	. .	74	1	74	1 056
UNODC Morocco	Outdoor rain-fed	76	1	76	2	152	2 171
UNODC Morocco	Outdoor irrigated	4	30	127	2	254	3 629
Government of Mexico (as cited by the United States Department of Homeland Security)	. .	. .	. .	. .	. .	180	. .
Government of Trinidad and Tobago (UNODC annual reports questionnaire)	Outdoor	100	. .	. .	. .	. .	. .
Government of Colombia (UNODC 2004 annual reports questionnaire)	. .	. .	. .	100	1	. .	. .
Government of South Africa	. .	. .	. .	. .	. .	212	. .
R. Clarke (1998) ([47], p. 189)	Outdoor	. .	. .	100-200 (flowers only 15-30)	. .	. .	. .
M. Starks (1990) [48]	Unspecified outdoor	227-454	Less than 4 ft apart (0.66)	152-304	1	152-304	2 171-4 344
J. Gettman and P. Armentano (1998) [44], citing Urbanek	Outdoor	412	. .	. .	. .	. .	. .
British Columbia Compassion Club Society	Outdoor	250	. .	. .	. .	. .	. .

Table 3 *(continued)*

Source	*Plant and cultivation style*	*Output per plant (grams)*	*Plants per square metre*	*Weight per square metre (grams)*	*Seasons per year*	*Output per square metre per year (grams)*	*Cost per square metre per year at $400 per ounce (US dollars)*
United States Drug Enforcement Administration [38]	Non-sinsemilla outdoor	336 (0.75 lb)	. .	. .	. .	. .	. .
United States Drug Enforcement Administration [38]	Sinsemilla outdoor	560 (1.25 lb)	. .	. .	. .	. .	. .
M. Thomas (2002) [45]	Outdoor	About 500 (1.1 lb)	1	500	1	500	6 400
B. Drake (1986) [16]	Outdoor	. .	1-2 (60-80 cm apart)	. .	. .	. .	. .
W. Scholten [40]	Indoor scientific	100	4-6	400-600	4	1 600-2 400	23 000-34 000
British Columbia Compassion Club Society	Indoor	. .	. .	180-700	. .	. .	. .
R. Clarke (2002) ([47] p. 9)	Indica/sativa 1 m indoor	100	Assume 4	400	3-4	1 200-1 600	17.000-23 000
R. Clarke (1998) ([47], p. 189)	Indoor (“Skunk #1”)	. .	. .	150-300 (flowers only)	3	. .	. .
M. Thomas (2002) [45]	Indoor Sea of Green	9-14 (0.5 oz)	36 (2 per sq ft)	324-504	4	1 296-2 016	18 514-28 800
M. Thomas (2002) [45]	Indoor Screen of Green	84 (3 oz)	9	756	3	2 268	32 400
G. Green (2003) [49]	Indoor Screen of Green	56 (2 oz)	9	504	3	1 512	21 600
J. Gettman and P. Armentano (1998) [44]	All	280	. .	. .	. .	. .	. .

United States Sentencing Commission [46]	Unspecified	100 (37.5-412)	. .	. .	. .	. .	. .
Onlinepot.org website	Unspecified indoor	170	16 plants per 1 000 watts, 2 ft plants: assume 4	680	4-52 (with CO^2)	720-3 400	39 000-49 000
A. C. M. Jansen (2002) [30]	. .	. .	. .	. .	. .	1 000	14 285
Overgrow.com website	Indoor soil	57	. .	. .	4	. .	. .
Overgrow.com website	Indoor hydroponics	99	. .	. .	4	. .	. .
J. Gettman and P. Armentano (1998) [44], citing Urbanek.	Indoor	177	. .	. .	. .	. .	. .
High Times.com website, "Max Yields"	Indoor		. .	126 (0.5 oz sq ft)	. .	. .	. .
High Times.com website, "Max Yields"	Indoor	. .	. .	1 008 (0.25 lb sq ft)	. .	. .	. .
Nirvana Seeds [50]	Indoor Sea of Green	. .	9	. .	3	. .	. .
J. Cervantes (1993) [51]	Indoor hydroponics	7	4	28	4	112	1 600
Cannabis-seedbank.nl website	Outdoor	10-200 g per plant	40 x 10 g	300-600	. .	. .	. .
Cannabis-seedbank.nl website	Greenhouse	. .	1-10	50-250	2-3	100-750	. .
Cannabis-seedbank.nl website	Indoors	. .	. .	300-600	3-6	. .	. .

Note: Two dots (. .) indicate that data are not available or are not separately reported.

Indoors, yields vary from a low of just over 300 grams per square metre to a high of just under 800 grams per square metre. These yields are produced by a number of different strategies, with considerable debate as to which is the most productive. Individual plants can be freakishly productive and this can be perpetuated, to some extent, by cloning. Overall, an average of about 500 grams per square metre seems to be confirmed by several sources. Of course, the real productivity of indoor plots is determined by the number of harvests that can be produced in a year. As discussed above, a four-stage cultivation system allows three to six harvests per unit of floor area per year. Thus, indoor crops are between 15 and 30 times as productive per square metre of cultivation space as are outdoor crops.

Why make cannabis resin?

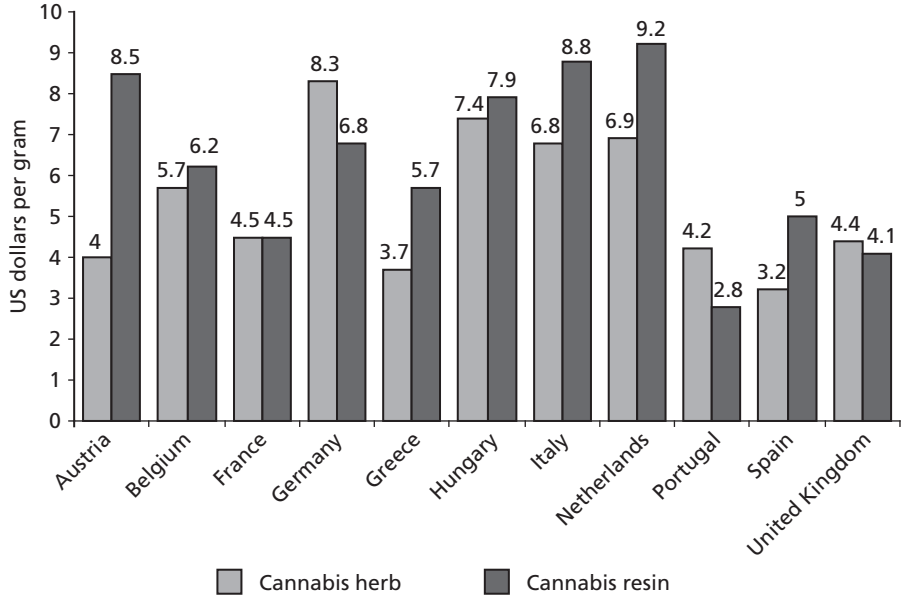
The production of cannabis resin requires considerable additional processing of a plant that is, essentially, ready to use. Yields are only about 4 per cent of herbal yields and prices per gram are nowhere near 25 times higher. Indeed, while cannabis resin is more potent than the herbal product from which it is made, it is not 25 times more potent; thus, making cannabis resin results in a net loss of consumable THC. A pertinent question is: why make cannabis resin?

There are several possible historical explanations for why production of cannabis resin emerged over the years and has retained some popularity, most of which relate to the commercialization of the plant. Cannabis resin is much less bulky than cannabis herb, lacks the overwhelming odour of the herbal plant and is highly malleable. This makes it easier to transport. This may be one reason why cannabis resin is popular where consumer markets are in different countries from production sites, as is the case in Europe, but is less common in areas where cannabis is grown locally, such as North America.

Sieved cannabis resin also stores better than herbal cannabis [52]. While the outside layer of a piece of cannabis resin loses potency through exposure to light and air, the inside can retain its quality over extended periods, especially if stored carefully [53]. Storage is particularly important in the arid areas where much cannabis resin has traditionally been produced, as it ensures a supply even during periods of drought.

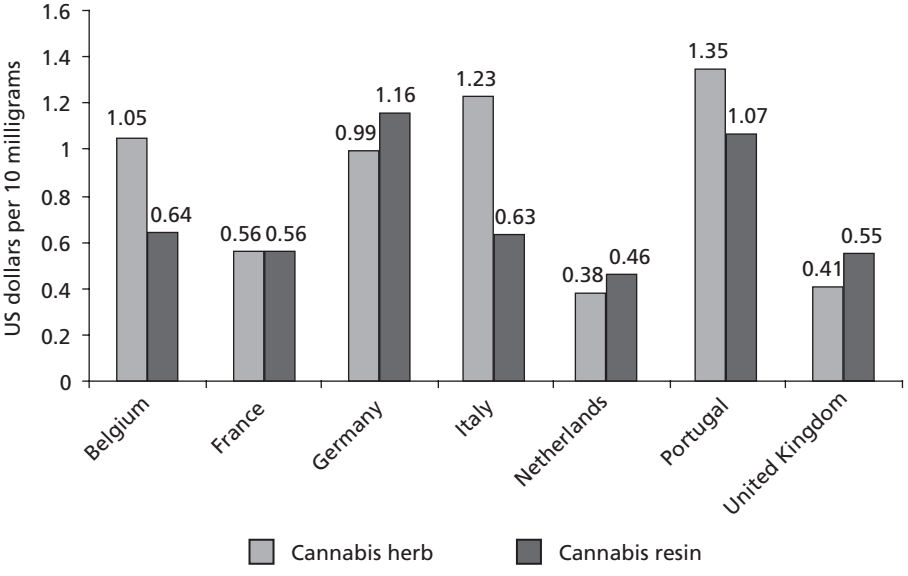
But these factors alone cannot override the fact that, per unit of land and per worker hour, cannabis resin is a lot less profitable than cannabis herb. In some European countries, cannabis resin is more expensive than cannabis herb, but this is not always the case (see figure II). In Belgium, for example, the typical cost of cannabis herb and cannabis resin are nearly the same: $5.70 a gram for cannabis herb and only $6.20 a gram for cannabis resin. Of course, this is a reflection of the fact that most of the cannabis resin in Belgium comes from Morocco and most of the cannabis herb is produced locally or in the Netherlands, with high input costs.

Figure II. Relative prices of cannabis herb and cannabis resin in markets in Europe



Source: United Nations Office on Drugs and Crime, annual reports questionnaire.

Figure III. International price per milligram of tetrahydrocannabinol

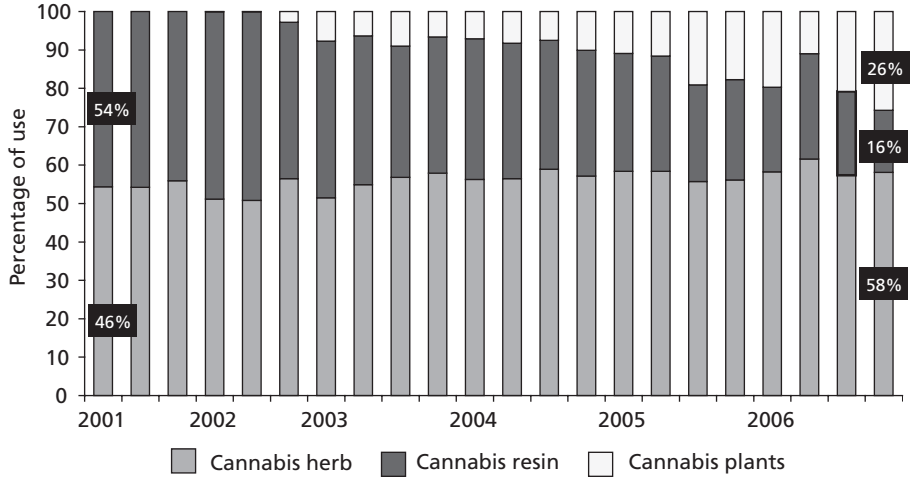


Source: European Monitoring Centre on Drugs and Drug Addiction.

Still, from the perspective of the producer of cannabis resin in Morocco, the amount of land area dedicated to producing one gram of "hashish" is at least 25 times greater than that needed to produce one gram of cannabis herb outdoors, and the increase in potency is not commensurably large: typically, herbal cannabis from Morocco contains about 2 per cent THC and cannabis resin from Morocco contains about 8 per cent THC, when tested on site [54]. If, as EMCDDA has suggested, prices vary linearly with potency in Europe [10], this represents a lot of additional work for relatively little additional profit.

Of course, the price per unit of THC is not always consistent, either within countries or between them. Figure III shows the price in United States dollars per 10 milligrams (mg) of THC in cannabis herb and cannabis resin for various markets in Europe. In Belgium, cannabis resin remains a good deal from the perspective of psychoactive content: potencies are 6 per cent for cannabis herb and 10 per cent for cannabis resin, while the price is essentially the same. In markets where herbal cannabis is a cheaper source of THC (Germany, the Netherlands and the United Kingdom) there are indications that resin is losing market share, being displaced by domestic or imported sinsemilla. For example, in the United Kingdom the share of all cannabis seizures that were resin seizures has declined significantly, from 46 per cent in the first quarter of 2001 to only 16 per cent in the second quarter of 2006. The greater share of herbal cannabis seizures includes a growing number of whole plant seizures, indicating increasing local production. If domestic production expands in other European countries, Moroccan suppliers may face the loss of a major export market.

Figure IV Breakdown of cannabis seizures in the United Kingdom by quarter, 2001-2006



Source: United Kingdom, Forensic Science Service [55].

In the end, the persistence of use of cannabis resin in Europe may be related to the facts of the local market. The cannabis that is grown in Morocco is of a low quality and therefore not competitive as a herbal product. Europeans consume cannabis with tobacco and cannabis resin is well suited to that combination. Moreover, Europe has a long-standing tradition of consumption of cannabis resin and such traditions die hard. As a result, the suppliers in Morocco are bound to continue to produce cannabis resin, despite its lower profitability.

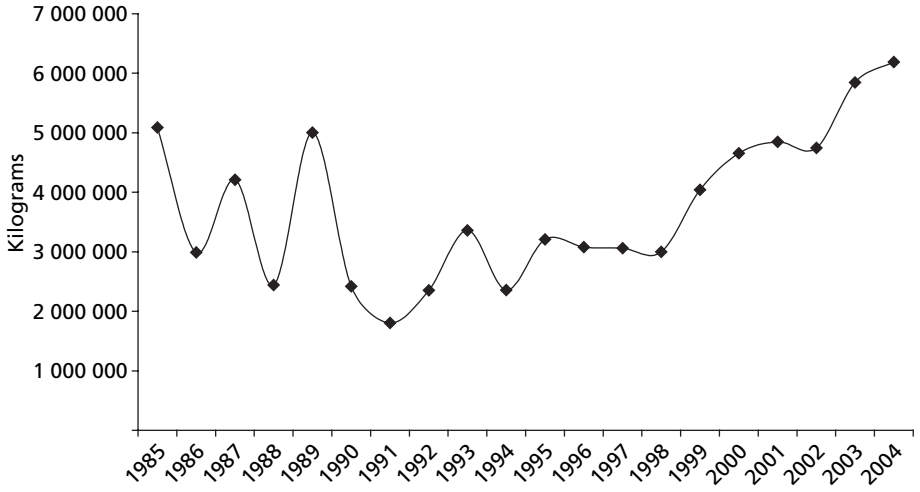
Supply-side global estimates

There are two primary ways to estimate the amount of cannabis produced and consumed in the world based on supply-side information:

- Total global reported seizures and eradication figures can be multiplied by an estimated rate of interdiction.
- An estimate of the total number of hectares under cultivation can be multiplied by an estimate of yield per hectare.

Both approaches have specific problems. Interdiction multipliers are most appropriate with drugs that have clear production sites and transport corridors and that face steady enforcement pressures. Cannabis has none of these characteristics. Global cannabis seizures show high rates of variability with little connection to what is known about global use patterns. While the trend has been upwards since 1998, consistent with the expanding cannabis market indicated by other data

Figure V. Global cannabis herb seizures, 1985-2004



Source: United Nations Office on Drugs and Crime, Database for Estimates and Long-term Trend Analysis (DELTA).

sources, seizures more than doubled between 1998 and 2004 and there is no indication that global use levels doubled during that time. It is far more likely that the rate of interdiction has increased dramatically, but this variability itself calls into question the validity of any proposed multiplier.

Furthermore, this aggregated trend masks tremendous local variability. It is not unusual for developed countries, where interdiction pressures should be fairly consistent, to experience year-on-year variations in annual cannabis seizures of 100 per cent or more. It is unlikely that cannabis production or consumption varies commensurably.

On the other hand, per hectare estimates suffer from the following deficiencies:

- There is no direct way to determine the number of hectares under cultivation and, as has been demonstrated above, crop yields would have to be tied to the cultivation technique used.
- Outdoor per-hectare productivity would be subject to the impact of local weather patterns (especially precipitation for rain-fed crops) and pest problems.
- Areas under cultivation are likely to vary substantially in places where active eradication programmes are in effect.

Conducting an empirical survey of global cannabis production would be nigh on impossible. Cannabis can be grown indoors or outdoors, in small plots or on large plantations and in most inhabited areas of the world. Over the period 1994-2004, 82 countries provided UNODC with cannabis production estimates. In comparison, only six provided estimates for coca leaf production. But the fact that a country did not provide an estimate does not mean that no cultivation exists, as some countries simply lack the capacity to come up with accurate estimates. Fortunately, there are other ways of identifying countries where cannabis is produced.

Member States were also asked to identify the national source of the cannabis consumed in their country. On that basis, a second list of 142 producer countries can be identified. A third list of producer countries can be generated by singling out those countries which report the seizure of whole cannabis plants. It is extremely inefficient to transport whole plants internationally, as only certain parts are useable as a drug. Thus, when a whole plant is seized, it is very likely that it was locally grown. Seizures of whole cannabis plants were reported in 141 countries during the period 1994-2004.

Combining these three lists results in the identification of some 176 countries and territories where cannabis is produced, out of 195 Member States reporting to UNODC (representing a response rate of 90 per cent).

Thus, conducting a comprehensive empirical survey would require observation in at least 176 countries and territories around the world. This is clearly infeasible. Even with a sampling approach, the costs of such an undertaking would be prohibitive.

The UNODC annual reports questionnaire* asks Member States to estimate the number of hectares under cannabis cultivation in their respective countries, but most respondents do not fill out this section. In fairness, most States would have little knowledge of how to make such an estimate. Given that most consumption is domestic and many societies do not regard cannabis as particularly problematic, most would have little incentive to invest much time in making such a calculation.

Table 4. Cannabis production estimates for major countries of production, 2003

Country	*Area under cultivation (hectares)*	*Area eradicated (hectares)*	*Estimated production in herbal equivalent[a] (tons)*	*Total seizures in herbal equivalent[a] (tons)[b]*
Morocco	134 000	. .	98 000	21 000[c]
Afghanistan	52 000	. .	(50 000)	6 432[d]
Mexico	29 500	22 000	10 400	2 160
Paraguay	5 500	753[e]	(15 000)	257[f]
Colombia	5 000	—	4 000	134
United States	(4 500)	365[g]	4 455	1 224
Total	**231 000**	**23 118**	**181 885**	**31 207**

Notes:

Figures in parenthesis are estimates based on data from other sources.

Cannabis resin data are converted into "herbal equivalent" by multiplying by 25.

Two dots (. .) indicate that data are not available or are not separately reported.

A dash (—) indicates that the amount is nil.

Some of the information on production reflected in this table was derived from sources other than the respective Governments and should therefore be treated with caution. For example, the Government of Brazil maintains that Paraguay is the source of most of the cannabis seized in Brazil but there is evidence of substantial cultivation of cannabis plant within Brazil.

[a]The "herbal equivalent" figure is used because seizures of cannabis resin actually represent at least 25 times the land area needed to produce the same weight of cannabis herb.

[b]Assuming a 4 per cent yield.

[c]Assuming that 80 per cent of the cannabis resin seized in Belgium, Denmark, France, Germany, Ireland, Italy, Norway, Portugal, Spain, Sweden and the United Kingdom emanated from Morocco.

[d]Assuming that 100 per cent of the cannabis resin seized in Pakistan (based on that country's response to the annual reports questionnaire) and the Islamic Republic of Iran emanated from Afghanistan; the supply of cannabis resin from Afghanistan to Europe is not included.

[e]Data from 2004.

[f]Assuming that 80 per cent of the cannabis herb seized in Argentina and Brazil (based on those countries' responses to the annual reports questionnaire) emanated from Paraguay.

[g]Total plants converted to 1 plant per square metre outdoor equivalents.

*The UNODC annual reports questionnaire is the mechanism through which Member States report to the United Nations on the drug control situation in their respective countries. The questionnaire is an integral part of UNODC's data collection activities. It is completed annually by Member States and consists of three parts: Legislative and administrative measures (part I); Extent, patterns and trends of drug abuse (part II); and Illicit supply of drugs (part III).

However, it is possible to combine the information available about the biggest markets and seizure data to come up with some idea of the number of hectares under cannabis plant cultivation, at least for those markets for which reliable estimates exist. Table 4 sets out the main producing countries about which information is available. Together, these countries are the source of at least 78 per cent of global cannabis seizures. The largest missing piece of the puzzle is Africa where, for reasons discussed below, data on production and seizures are difficult to reconcile with other available information.

All this suggests that the bulk of global cannabis production occurs in an area of about 231,000 hectares, of which more than half are in Morocco. This is a small area, about the size of the Comoros Islands. The estimated seizure rate for these main producing countries shown in table 4 is about 17 per cent. In other words, after eradication, four fifths of the cannabis produced in the six main producing countries gets past law enforcement.

This rate of interdiction refers to some of the most developed markets for cannabis in the world and it is likely that the corresponding figure in places like Africa is probably much lower. The application of this rate should therefore be considered as a low-end estimate. Global cannabis seizures in 2003 amounted to 5,845 tons of cannabis herb and 1,361 tons of cannabis resin (about 34,000 tons of herbal equivalent) for just under 40,000 tons of global cannabis production seized. If this is about a fifth of true production, about 200,000 tons were produced in 2003. However, most of this (85 per cent) was reduced to cannabis resin. Total cannabis product output should be about 30,000 tons of cannabis herb and just under 7,000 tons of cannabis resin.

II. HOW IS CANNABIS CONSUMED?

How is cannabis procured?

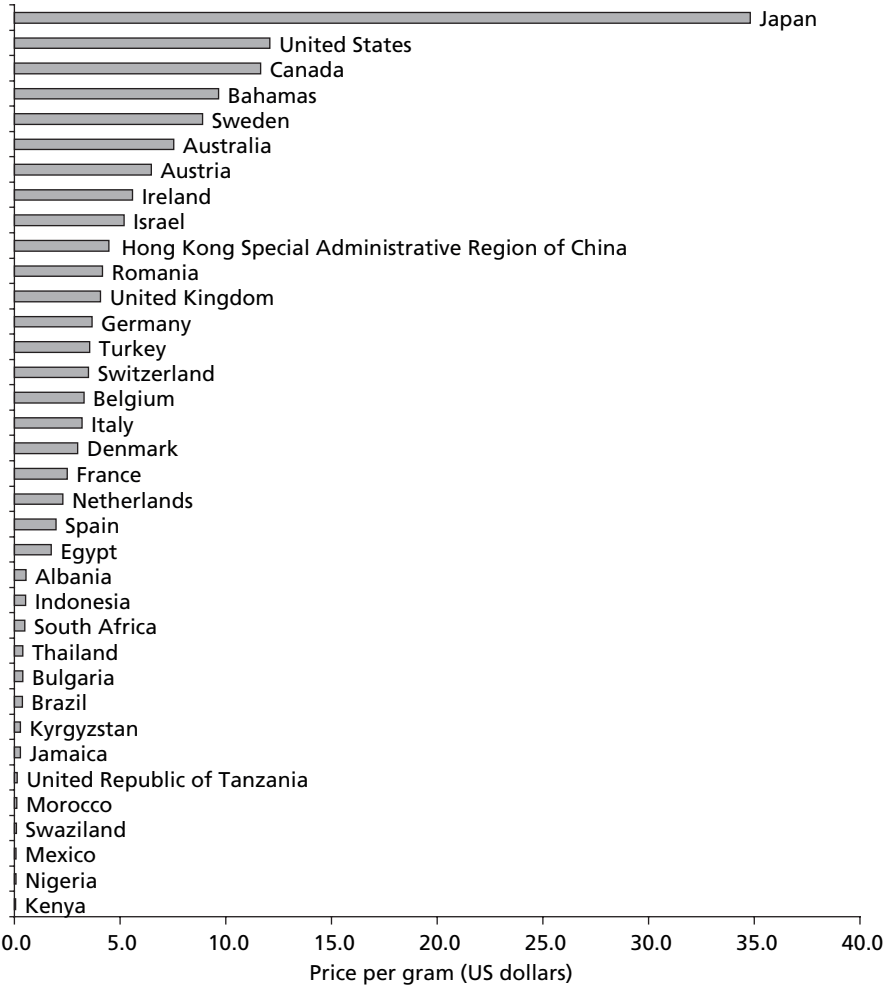
While substantial seizures prove that large quantities of both cannabis herb and cannabis resin are trafficked internationally, it is far from clear what share of the overall market this represents. Given the wide range of locations in which the cannabis plant can be grown and its low volume-to-value ratio relative to other drugs, it appears that the movement of cannabis between continents is declining in favour of greater domestic production. According to survey data, a sizable share of cannabis users either grow their own cannabis or acquire it through local social networks, rather than through impersonal vendors tied to international syndicates. With the possible exception of some amphetamine-type stimulants, cannabis is the only drug where the entire market chain, from production to consumption, can be contained in a single individual.

Unlike many other drugs, the price of cannabis remains very low in most countries. In producer countries in the developing world, it is sometimes cheaper to get "high" on cannabis than it is to get drunk on beer. In South Africa, for example, the price of a matchbox full of cannabis buds has been about 4 rand for years (just over 50 United States cents), less than a bottle of beer in a bar [56]. In Singapore, cannabis has, in the past, been used by worker communities as an inexpensive substitute for alcohol [57]. Even in developed countries, the price of a dose of cannabis remains low. As might be expected, prices are lowest in various poor countries where cannabis is produced (such as Colombia, India, the Lao People's Democratic Republic and various African countries) and highest in the developed countries, especially where law enforcement is strong (such as Japan, Sweden and the United States). The United States is one of the more expensive places in the world to buy cannabis; an average price in the United States of $300 an ounce sounds substantial, until it is pointed out that a dose sufficient to get a casual user "high" costs less than $5.

Continuing with the example of the United States, the price of cannabis in the United States has been relatively stable, between $10 and $20 per gram for small buyers throughout most of the 1980s and 1990s.

As a result, users can afford to be generous. Cannabis is usually consumed communally, with a single cannabis cigarette being passed around. In France, 82 per cent of occasional users (between one and nine incidents of use in the survey year) never consume the drug alone. Even among regular users (between 10 and 19 incidents of use per month), 20 per cent never consume alone and only 20 per

Figure VI. Price of herbal cannabis in selected countries and areas

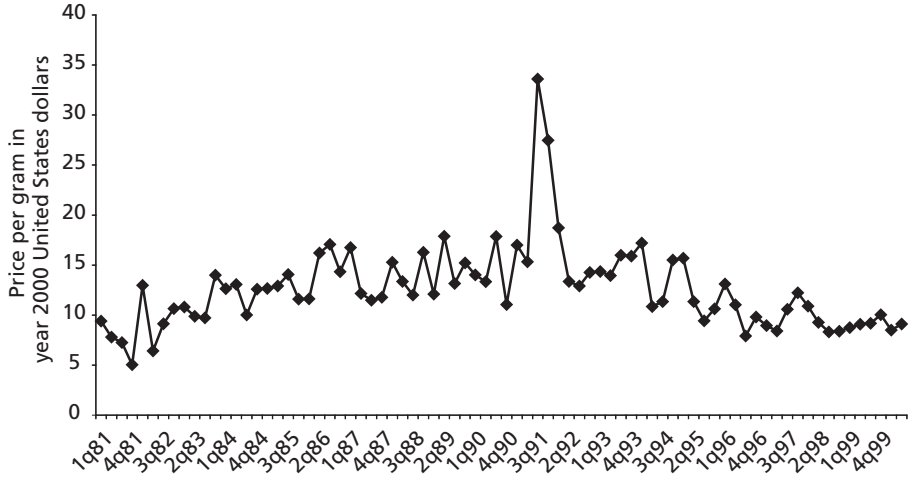


Source: UNODC annual reports questionnaire.

cent report they "often" do so [59]. In New Zealand in 2001, only 4 per cent of users surveyed said they smoked alone during a "typical" consumption session ([60], p. 36). Moreover, this phenomenon is not unique to casual users: surveys among regular users in the United Kingdom show almost all of them (96 per cent) share cannabis cigarettes at least some of the time ([61], p. 16).

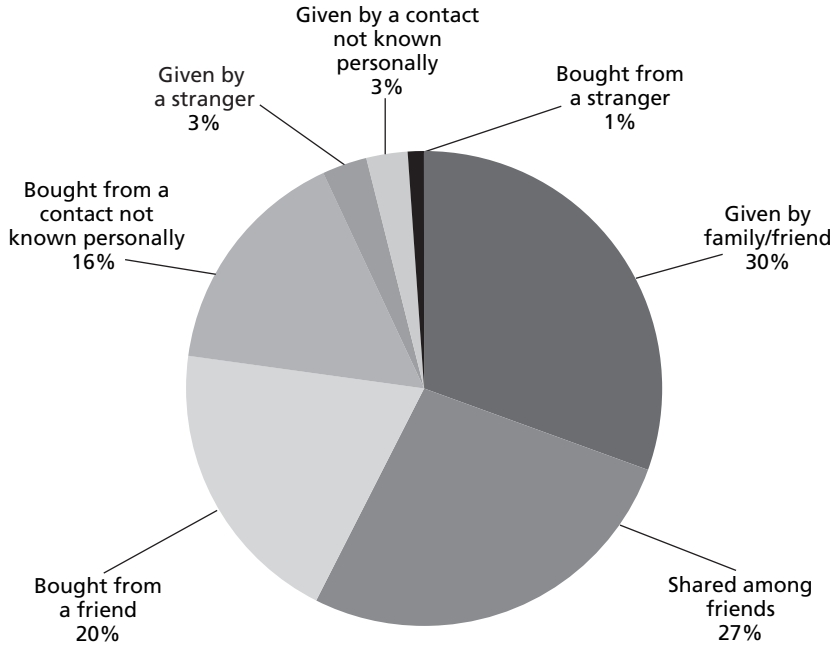
Since the drug is shared, users do not always pay for the portion they consume. According to household survey data taken in the United States, a majority (57 per cent) of users said they obtained the cannabis they had used most recently for free or that they had shared someone else's cannabis ([62], p. 22). In Ireland, the figure is 64 per cent (see figure VIII) [24]. In New Zealand, 84 per cent of annual cannabis

Figure VII. Price in the United States of a gram of cannabis for a small buyer (less than 10 grams) in year 2000 dollars, 1981-1999



Source: United States, Office of National Drug Control Policy [58].
Note: The letter "q" stands for "quarter". Thus, "1q81" means the first quarter of 1981.

Figure VIII. Source of cannabis on most recent occasion of use among survey respondents in Ireland



Source: Ireland, National Advisory Committee on Drugs and Drug and Alcohol Information and Research Unit [24].

users received at least some of their cannabis for free, with 20 per cent receiving "most" and 1 per cent "all" of their cannabis for free ([63], p. 229).

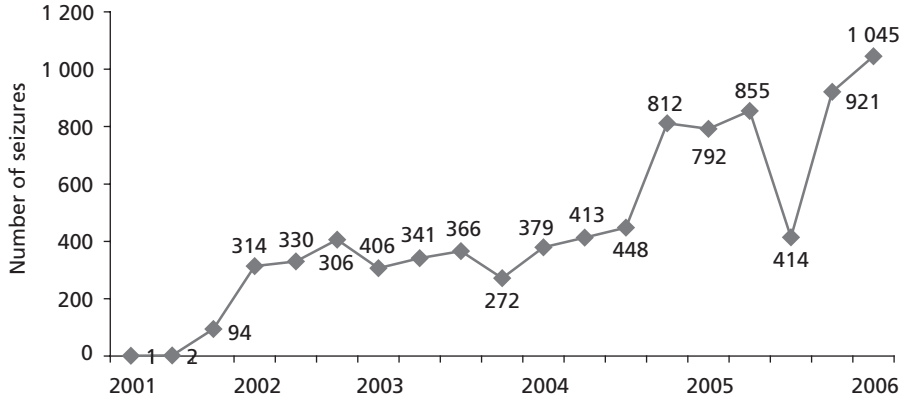
A detailed analysis of data from a survey conducted in 2001 in the United States found that 43 per cent of users had bought none of the cannabis they had used in the previous year, despite using the drug an average of 30 days during that time. This analysis argues that "most marijuana users are 'distributors', [but] most do not report selling marijuana" ([64], p. 173).

Another reason users can be relatively free with their drugs is that many people produce the drug for personal use or for their social circle. In New Zealand, a household survey found that 10 per cent of all current users had grown at least some of their own supply ([60], p. 36). According to the response of Belgium to the UNODC annual reports questionnaire in 2003, production for personal consumption was on the increase in Belgium and some 70 per cent of the cultivation operations detected (totalling 258 in 2003) involved less than six plants. The proportion of people cultivating cannabis plant for personal use is much higher among those who use the drug frequently. A survey of regular users in Australia found that two thirds of respondents grew some cannabis plant for their own use and nearly half grew all or most of the cannabis they used ([23], p. 54). This tendency is not limited to areas with good conditions for growing cannabis plant, such as Australia. Atha and others in the United Kingdom found that 63 per cent of a sample of regular users reported having grown the drug at some point in their lives, growing an average of 24 plants. The authors note that "most home-grown [cannabis] is not sold". They estimate that 30 per cent of the cannabis used by regular users in the United Kingdom was home-grown in 1997 ([35], p. 16). A total of 66 per cent of cannabis was estimated to have been home-grown in 2005 [65]. If this is correct, a significant share of the cannabis used in the United Kingdom is produced and distributed free within the country. A second study concurs: "domestic production is on the increase and as much as half of the cannabis consumed in England and Wales may be grown here. Some cultivation is on a commercial basis, but much is on a small scale, for personal use or use by friends" ([66], p. 1). As this second study suggests, what these small growers do not use or give away, they often sell within their social circle. According to household survey data in the United States, most (78 per cent) of those who say they bought cannabis in the past year say they bought it from "a friend". Similar figures were found in an international comparative study of cannabis users in Bremen, Germany (80 per cent), and San Francisco, United States (95 per cent) ([67], p. 395).* As figure VIII shows, only 1 per cent of annual users surveyed bought cannabis from a stranger in Ireland [24]. Distribution among social groups mitigates many of the negative effects associated with drug markets dominated by organized criminal groups. It also suggests that law enforcement efforts typically used in combating other drug markets are unlikely to show much success in the case of cannabis.

*The study also included users in Amsterdam, the Netherlands, most of whom bought their cannabis from a "coffee shop".

Even outside networks of friends, it is unclear how much cannabis is trafficked in the sense of being smuggled across borders from production to consumer sites. While substantial international trafficking in cannabis does occur, it also appears that consumers in several countries are coming to rely more and more on domestically produced cannabis. In the United States, for example, the estimated share of cannabis derived from domestic cultivation has increased dramatically in recent years. In 1986, it was estimated that one sixth of the cannabis consumed in the United States was produced within the country [68], but there are strong indications that this share has increased, including an increase in indoor production and "guerrilla" cultivation operations on public lands ([37], p. 43). Similarly, in Canada in 1985, only 10 per cent of the cannabis consumed was produced domestically [69], but by 2002, it was estimated that "well over half" was grown in Canada [36]. In the United Kingdom, as noted above, an estimated 30 per cent of the cannabis used by regular users was home-grown in 1997, ([35], p. 16) increasing to 66 per cent in 2005, and supplies from India, Morocco and the Netherlands appear to have decreased [65]. This is also confirmed by an increase in the number of all cannabis seizures that involved whole plants, from one in the second quarter of 2001 to 921 in the third quarter of 2005 (see figure IX), nearly as many as the number of cannabis resin seizures (of which there were 968) [55]. In the Netherlands, the trend has been moving away from imported cannabis resin and towards domestically produced sinsemilla and cannabis resin. Other countries have always been fairly self-reliant in terms of cannabis supply. Almost all the cannabis consumed in Australia and New Zealand is domestically produced for example [70]. Even imports from nearby developing countries appear to have waned in Australia, as they have been replaced by locally grown, high potency strains ([71], p. 62).

Figure IX. Seizures of cannabis plants in the United Kingdom by quarter, 2001-2006



Source: United Kingdom, Forensic Science Service [55].

How is cannabis consumed?

Most cannabis herb is smoked, but there are many ways of doing this and each culture where the drug is used seems to produce its own various methods. Perhaps the most popular technique is to make a kind of cigarette (known as a "joint") using specialty rolling paper or other material (such as scrap paper or the leaves of local plants). In Ireland, for example, 98 per cent of people surveyed who had used cannabis (herbal or resin) in the past month said smoking cannabis cigarettes ("joints") was one of the ways they consumed cannabis, with the second most popular response being pipes (7 per cent) [24]. In Europe, a filter is often used, sometimes taken from a tobacco cigarette. Cannabis herb is generally smoked with tobacco in Europe, parts of Asia, North Africa, Australia and New Zealand, but not in most of sub-Saharan Africa,* the United States or Canada.**

Other popular cannabis smoking techniques include:

- Pipes, including both specially made and tobacco pipes, often with a foil screen.
- Water pipes, hookahs, "hubble bubbles" or bongs, in which the smoke is cooled by passing through a water chamber.
- Cigars that have been emptied of their tobacco contents and refilled with cannabis (referred to as "blunts" in the United States after Philly Blunts, a popular cigar brand).
- Vaporizers, modern machines that heat, but do not burn, the cannabis, releasing the THC into a plastic bag for inhalation.
- Makeshift devices, such as hollowed out apples, beer-can bongs, etc.
- More exotic techniques, such as the "chillum" (a large, horn-like, clay pipe used in India and Jamaica), and others.

Cannabis (typically the resin) can also be eaten. THC is fat-soluble and so cannabis can be included in a range of food products and is typically consumed in baked goods. The subjective effects of eating cannabis are different from the experience of smoking, due to different metabolic processes involved in absorbing the drug. It is clear that the onset is slower and the duration longer when cannabis is eaten.

The amount consumed is related to the method of consumption. Vaporization is said to require twice as much cannabis and eating four times as much to produce the same effect [41]. Although there is considerable variation, the typical bowl on a bong is large enough to accommodate about one twentieth of a gram of cannabis, but most bong smokers will reload the bowl several times in a session. Pipes made

*One exception is the mixture of "majat" (low-grade cannabis treated with a solvent) and tobacco used to smoke methaqualone (the so-called "white pipe" mixture).

**For example, one study of regular users in New South Wales, Australia, found 79 per cent of users mixed their cannabis with tobacco ([23], p. 25).

specifically for smoking cannabis tend to have much smaller bowls than tobacco pipes. A good example is the "sebsi" used in Morocco to smoke "kif", a mixture of cannabis and tobacco. The bowl of a "sebsi" is typically very small. In contrast, the "chillum" used in India and Jamaica can hold vast amounts of cannabis, but these are commonly used by people who consume the drug for religious purposes, not casual users.

The amount of cannabis found in a cannabis cigarette depends on whether tobacco is included (see table 5),* whether single or multiple rolling papers are used and the strength of the cannabis. Studies of cannabis cigarette size in the United Kingdom in the 1970s suggested that between a seventh and a third of a gram of cannabis was included in a cigarette, [73, 74] and more recent research in Ireland and the United Kingdom** has found that this has changed little over the years. This may be because of the local consumption culture: cannabis cigarettes smoked in the United Kingdom and in Ireland are typically mixed with tobacco and a single rolling paper is used, so there is little room for more cannabis.

Cannabis cigarettes in the Netherlands are typically composed of the tobacco of one cigarette with a small amount of high potency cannabis. "Coffee shops" in the Netherlands offer pre-rolled cannabis cigarettes, with a filter, containing about 0.1 g of cannabis and 0.9 g of tobacco and cannabis cigarettes sold on the street average around 0.25 g of cannabis [40] (see table 5). A study in the Netherlands showed life-sized pictures of cannabis cigarettes to 400 frequent users and asked them to indicate which picture represented what they typically consumed. On this basis, an average of 0.16 grams of cannabis per cannabis cigarette was found to be an average, or over 6 cannabis cigarettes to the gram. This was much less than what users themselves estimated they used when asked directly how many cannabis cigarettes they thought they got from a gram of cannabis: four, or 0.25 grams per cannabis cigarette [76]. This tendency to overestimate consumption should be kept in mind in evaluating other self-reported use data.

Figures from the United States are much higher, because tobacco is rarely used, low-potency cannabis from Mexico dominates the market and "multi-skin" cannabis cigarettes are common. Estimates range from 0.4 grams [77], to 0.5 grams [39], to 0.8 grams,*** to an entire gram or more in a single cannabis cigarette (see table 5).**** "Blunts" can contain up to 3 grams of cannabis [78], but the product used is typically low-grade. Jamaican "spliffs" can be about 10 centimetres long and were once said to contain as much as 2 or 3 grams of cannabis [79].

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*One British study of heavy users in treatment found that those who did not mix their cannabis with tobacco were able to garner fewer cannabis cigarettes per gram of cannabis than those who mixed [72].

**Cannabis cigarettes in Ireland tend to fall in the middle of the spectrum found in the United Kingdom (0.18-0.26 grams). Cannabis cigarettes rarely exceed half a gram [75].

***This is the typical size of cannabis cigarettes formerly produced by the United States Government for medical use, prepared from the low-THC cannabis grown at its University of Mississippi farm.

****Some medical users who have developed a tolerance may use cannabis cigarettes this size ([41], p. 3).

Table 5. Variations in size of cannabis cigarettes

Country	*Cannabis per cigarette (Grams)*	*Addition of tobacco*	*Made up mostly of sinsemilla*	*Cigarettes per gram of cannabis*
Canada	0.2-0.33	Sometimes	Yes	3-5
Ireland	0.15-0.25	Yes	Yes	3-7
Jamaica	2-3	No	No	0.5-0.33
Netherlands	0.1-0.25	Yes	Yes	4-10
United Kingdom	0.15-0.33	Yes	Yes	3-7
United States	0.4-0.5	No	No	2

For most users, a cannabis cigarette should not be seen as a unit of consumption because these are usually consumed communally. As will be discussed below, most users who do not consume cannabis on a regular basis would be hard pressed to smoke an entire cannabis cigarette on their own in a single sitting. As a result, an increase in cigarette size does not necessarily indicate an increase in consumption.

Other drugs are often used in tandem with cannabis, either in sequence or simultaneously. Alcohol is often consumed with cannabis. Cannabis is used to ease the "come down" from ecstasy (methylenedioxymethamphetamine) use. The "white pipe" combination of methaqualone, tobacco and low-grade cannabis ("majat", possibly treated with a solvent) is the primary way methaqualone is consumed in South Africa [56]. Use of cannabis cigarettes laced with phencyclidine (1-(-phenylcyclohexyl)piperidine) (PCP) or "embalming fluid" (which may include PCP) [80] is a small-scale but recurring practice in the United States [81]. Crack, heroin and methamphetamine can be mixed with cannabis and smoked, but this is not an efficient means of consuming the other drugs. In many parts of the Caribbean, the presence of cannabis cigarettes spiked with crack has been noted [82].

Demand-side production estimates

To produce demand-side estimates of total cannabis production, three things need to be known:

- What share of the global population consumes cannabis annually?
- How many days in a year do they consume it?
- How much do they consume on the days when they use the drug?

One key issue in trying to determine the amount of cannabis required to meet global demand (in tons) is that not all cannabis is created equal. Cannabis resin and sinsemilla are concentrated forms of the drug and consumers use less of these drugs (in terms of weight) than they would of low-grade cannabis herb. In order to

relate demand to production, the markets for these products need to be calculated separately, but there is very little reliable data on what share of the market they command.

What share of the global population consumes cannabis annually?

Answering this question requires some extrapolation, as there are massive gaps in the survey data globally. The traditional approach is to use subregional averages to calculate use levels for those countries for which data are lacking. It is also possible to extend data from a limited subsample of the population (the most obvious example being school surveys) to the population as a whole on the basis of ratios determined from countries where both sets of data exist.

Of course, all this hinges on the survey data. There has been considerable debate about the veracity of self-reporting on matters involving criminal activity* and the level of inaccuracy may vary considerably by cultural context: in areas where drug use is highly stigmatized, subjects may be unwilling to report use, even if confidentiality is assured. Cases in point may be found in Latin America, where large quantities of cannabis are regularly seized but where annual use rates are generally low (less than 5 per cent). In some instances (such as Mexico), this is because of the existence of large export markets, but that is not always the case. Brazil, for example, claims an annual use rate of less than 1 per cent, yet it also consistently reports some of the highest volumes seized in the world. Most of this must be for domestic consumption, as the bulk of the region's cannabis markets are supplied from Colombia and Paraguay, and Brazil is not known as the source of major supplies to any other region. On the other hand, surveys in some countries show such high rates of admitted use that underreporting levels must be very low. For example, in Scotland, lifetime prevalence among 14 year olds has been found to be as high as 70 per cent [84].

With these caveats in mind, survey data show that cannabis is far and away the most commonly consumed street drug in the world. An estimated 162 million people used cannabis in 2004, equivalent to 4 per cent of the global population between the ages of 15 and 64 years (see table 6). In some parts of the world, cannabis herb is the most popular, while in others people prefer cannabis resin, but most Member States say that cannabis is the most widely used illicit substance in their countries. Cannabis use is most prevalent in the Oceania region, followed by North America and Africa. It is less common in Asia, but owing to the size of the population, Asia still contains about a third of global cannabis users.

It also appears that cannabis use is increasing. According to expert opinions solicited from Member States, far more countries felt that cannabis use was

*For a discussion of the reliability of the survey data, see National Research Council [83].

increasing (46 per cent of 101 countries responding) than declining (16 per cent) in 2003. In the last decade, the consensus is that cannabis use has been growing faster than use of cocaine or opiates.

Table 6. Annual prevalence of cannabis use by region, 2003-2005

	Number of users	*Proportion of the population aged 15-64 years (percentage)*
Europe	30 800 000	5.6
Western and Central Europe	23 400 000	7.4
South-eastern Europe	1 900 000	2.3
Eastern Europe	5 500 000	3.8
Americas	36 700 000	6.4
North America	29 400 000	10.3
South America	7 300 000	2.6
Asia	52 100 000	2.1
Oceania	3 200 000	15.3
Africa	39 600 000	8.1
Total	**162 400 000**	**4.0**

Sources: UNODC annual reports questionnaire data; Government reports; reports of regional bodies; and UNODC estimates.

In Europe, for example, school surveys among students aged 15-16 years found that the share of students reporting having ever tried cannabis rose by an average of almost 25 per cent between 1999 and 2003, for a total increase of more than 80 per cent between 1995 and 2003. The increase seems to be most pronounced in Central and Eastern Europe, where usage among young people has become almost as common as in Western Europe in recent years.

However, expert opinion in the Netherlands indicates that while more young people are consuming cannabis, they consume it less frequently and in lesser quantities than was the average in the past [85, 86]. The countries where cannabis consumption is most common, namely Australia and the United States, have not shown increases. The share of students aged 15-16 years in the United States reporting having tried cannabis fell by 14 per cent between 1999 and 2003. Annual prevalence of cannabis use among the general population and among high-school students in the United States is about a third less than it was in the late 1970s [87, 88, 89]. Cannabis use among the general population in Australia has declined by almost 37 per cent since its peak in 1998 [90].

How many days a year do cannabis users consume the drug?

Of course, the 162 million people who use cannabis around the world do not all consume cannabis at the same rate. Some of them may have experimented with the

drug once or twice, while others consume the drug on a daily basis. It is estimated that 10 per cent of people who try cannabis will progress to daily use for some period of their lives, with a further 20-30 per cent using the drug on a weekly basis [91]. This leaves, however, a large share of people whose use is less frequent. The extent of use tends to vary depending on the stage in life of the user. For example, about 60 per cent of French 19-year-old boys have tried cannabis and, of these, more than one in three uses cannabis 20 times a month or more. This share drops greatly in later life stages [59].

Understanding global cannabis demand requires the creation of a typology of users and the obvious source for the data on which to base this typology is household and school survey data. Unfortunately, while the number of people who have used cannabis during the previous month (past-month users) is often a feature of the standard surveys, more precise questions about the number of days the drug was used are often lacking.

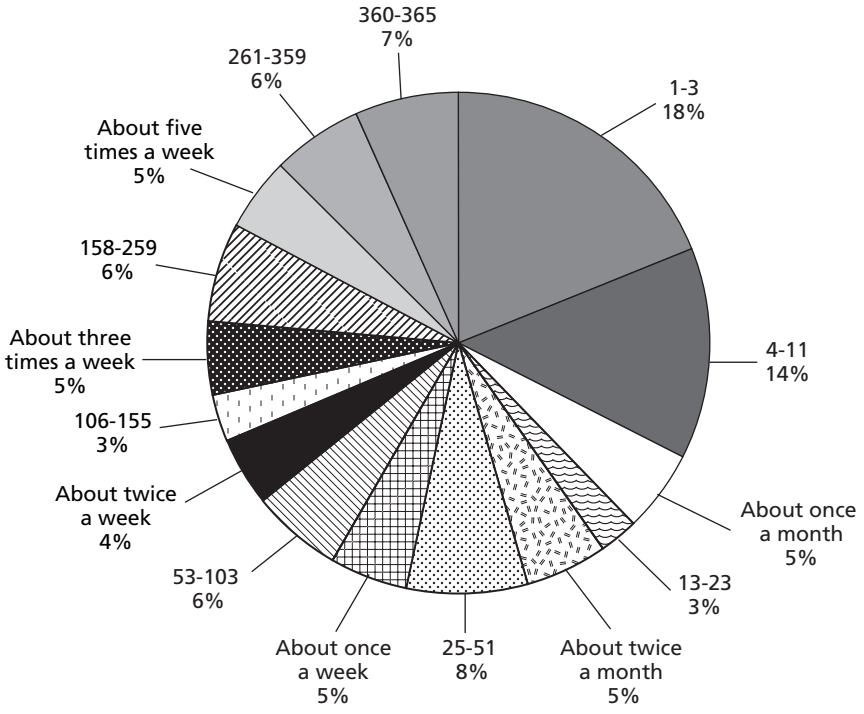
In the United States, the National Survey on Drug Use and Health (formerly known as the National Household Survey on Drug Abuse) has been conducted regularly since 1972. According to data from the survey, of the 25 million United States citizens over 12 years of age who used cannabis in 2003, 14.5 million of them said they had used it in the past month, or about 58 per cent. This is almost exactly what has been found in Australia, where 60 per cent of annual users consumed the drug in the past month [90]. A similar share is seen in the Netherlands (61 per cent), with slightly lower levels seen in France (52 per cent), Greece (53 per cent), Ireland (51 per cent) and Latvia (47 per cent).* A slightly higher level is seen in the United Kingdom (63 per cent) ([92], p. 47).

For a small share of these respondents, their use in the past month may have been the only time cannabis was used in the past year. In other words, use in the past month does not mean that the drug was used every month of the previous year: past-month use does not mean monthly use. This would suggest that the share of annual users that are also monthly users would be slightly lower than the figures discussed above. On the other hand, some heavier users might, for whatever reason, have not used cannabis in the previous month. Data from the United States (discussed below) show that 68 per cent of the annual respondents said they used cannabis 12 or more times per year (i.e., on average once a month). Thus it would appear, if any conclusion can be drawn, that the number of those who say they used cannabis in the past month may be slightly less than the number that used cannabis on a monthly basis (12 or more times in the past year). For the purposes of this discussion, 55 per cent of the annual users will be designated "regular" (about once a month or more) users and 45 per cent will be designated "casual" (less than 12 times in the previous year) users.

*Based on data from EMCDDA.

The household survey data from the United States provide more detailed information about the exact number of days annual users consumed cannabis. Users were able to state their estimated cannabis use as the number of days they had used in the past year, or the average number of days they used per month, or the number of days they used in a typical week. As a result, the data have strong nodes at once a month (5 per cent), twice a month (5 per cent), once a week (5 per cent), twice a week (4 per cent), three times a week (5 per cent) and five times a week (5 per cent). Figure X shows the estimated number of days cannabis was consumed in the past year by annual users. Overall, about 32 per cent of the respondents said they consumed cannabis less than once a month (11 times or less); a full 5 per cent said they smoked cannabis about once a month (12 times); another 16 per cent said they consumed cannabis more than once a month but less than once a week (13-51 times); about 5 per cent said they consumed cannabis once a week (52 times); around 24 per cent said their consumption was more than once a week but less than five times a week (53-259 times); 5 per cent said they used cannabis five times a week (260 times); and 13 per cent said they consumed it more than that (261-365 times).

Figure X. Number of days cannabis was used in the survey year, United States



Source: United States, National Survey on Drug Use and Health.

In Australia, National Drug Strategy Household Surveys have been conducted regularly since 1998. According to the 2001 data, 16 per cent of annual users over 14 years of age consumed the drug every day, 23 per cent once a week or more, 12 per cent about once a month and 49 per cent less often [90].

Comparing the figures from Australia and those from the United States shows a different breakdown in levels of usage between the two areas. Only a third (32 per cent) of users in the United States said they consumed the drug less than once a month, whereas nearly half (49 per cent) of those surveyed in Australia fell into this category. On the other hand, 16 per cent of cannabis users in Australia were daily consumers, compared to just 7 per cent of respondents in the United States. Taken at face value, data concerning Australian users seem to be at the extremes, with users in the United States more likely to fall somewhere in the middle. If the categories are made somewhat less exact, however, the fit is better. For example, if "daily" use is considered to be five times or more per week, 18 per cent of respondents in the United States meet the criteria, close to the figure for users in Australia of 16 per cent. New Zealand uses a softer standard for "heavy" use: 10 or more times in the past month, but 20 per cent of annual users fall into this category ([60], p. 27).

Statistics from European household surveys as compiled by EMCDDA show rates of cannabis use among those who have used in the past 30 days. These figures show that between 1 per cent (Finland) and 7 per cent (Spain) of those who had used cannabis during the year had also consumed the drug in the past 30 days. Among past-month users, between 5 per cent (Latvia) and 34 per cent (Spain) had consumed the drug more than 20 days out of the past 30 and are designated by EMCDDA as "daily or almost daily users" (see table 7).

Table 7. Frequency of cannabis use among all users in selected European countries in the past 30 days

Country	*Year*	*Annual prevalence (percentage)*	*Respondents who had used in past 30 days (percentage)*	*Number of users*	*Number of days used per month (percentage)*			
					1-3 days	*4-9 days*	*10-19 days*	*20+ days*
France	2000	8.4	4.4	497	42.5	15.5	15.5	26.4
Greece	1998	4.4	2.3	104	37.7	27.3	15.6	19.5
Ireland	2002/2003	5.1	2.6	126	40.9	22.3	14.3	22.5
Italy	2001	6.2	4.7	171	38.0	30.4	12.3	19.3
Latvia	2003	3.8	1.8	81	57.1	24.2	13.3	5.4
Netherlands	2000/2001	6.1	3.7	744	41.5	21.1	13.8	23.6
Portugal	2001	3.3	3.3	336	33.7	23.8	19.2	23.2
Spain	2001	9.7	6.8	1 058	29.5	24.8	12.1	33.6

Source: EMCDDA, *Statistical Bulletin 2004.*

Consumption on more than 20 days out of 30 would correspond to more than 240 days of cannabis use in the past year, close to five times a week or more (260 days a year). Thus, we would expect the European figures for those who have used cannabis on more than 20 days in the past month to be close to the 16-18 per cent seen in Australia and the United States and, as table 8 shows, they are in several cases.

Table 8. Ratios of annual cannabis users to more frequent users in selected European countries
(Percentage)

Country	*Share of respondents who are annual users*	*Share of respondents who are past-month users*	*Share of annual users who are monthly users*	*Share of monthly users who are daily users*	*Share of annual users who are daily users*
France	8.4	4.4	52	26	14
Greece	4.4	2.3	53	20	11
Ireland	5.1	2.6	51	23	12
Italy	6.2	4.7	76	19	14
Netherlands	6.1	3.7	61	24	15

Source: Calculations based on EMCDDA data.

This analysis shows that survey data from a number of countries (Australia, France, Greece, Ireland, Italy, the Netherlands and the United States) show that past-month users comprise about half of annual users and that "daily or almost daily" users comprise 10-20 per cent of the annual user pool, with a mean, median and mode of 14 per cent.

There are also studies of subpopulations (generally youth) that find similar levels of daily use among annual users. In Canada, the Ontario Student Drug Use Survey deals with a subsample of the general population: young people enrolled in school grades 7-13. But this group has much higher annual use levels (29 per cent in 2001 and 30 per cent in 2003) than the general population of Ontario (11 per cent in 2000). Conducted biannually since 1981, the 2003 survey showed that 29 per cent of the annual users consumed the drug just one or two times, 13 per cent three to five times, 12 per cent six to nine times, 12 per cent ten to nineteen times, 9 per cent twenty to thirty-nine times and 25 per cent forty times or more. About 14 per cent used the drug on a daily basis ([93], p. 80). Similarly, in the United Kingdom, the Youth Lifestyles Survey (of 12-30 year olds) found that 13 per cent of the annual cannabis users consumed the drug daily [94].

Thus, sources from a wide range of countries suggest that about 14 per cent of annual cannabis users are daily users, a higher figure than might be expected. If these figures could be generalized to the total global population, this suggests that about 22.5 million people use cannabis on a daily or near-daily basis, with the other 138.5 million people using it less often. This figure is important because only

at the level of daily or near-daily use does tolerance develop and this has an impact on the amount of cannabis consumed, as discussed below.

How much cannabis do users consume during each day of use?

How much cannabis do users need to consume in order to experience the desired effects? Like all drugs, cannabis dosage is highly dependant on factors such as body weight, individual metabolism and tolerance and there is limited material on what constitutes a "dose" among recreational users. There are two ways of approaching this problem, both of which are pursued below. One is to determine, on the basis of scientific testing, how much cannabis a user needs to consume to receive the desired effects. Owing to the extreme variability in potency, however, cannabis dosages would need to be expressed in the amount of THC absorbed by the system, rather than the weight of the product consumed. The second approach would be look at actual use patterns based on survey or other data.

The question of what an "average" user consumes is complicated by the issue of tolerance. Ironically, in casual users, experience with consumption may actually increase sensitivity to the effects of the drug [95]. This may be related to an improved inhalation technique, among other things. But tolerance has been documented both in the laboratory and the field. For example, one study of over 1,000 chronic users of cannabis resin found that users continuously increased their consumption levels over several years before reaching a peak and that if use was suspended, users found they could only consume a fraction of their peak dosage until tolerance was established again.* While the extent of tolerance has not been precisely quantified, it appears to build up within a few days of chronic use and dissipate just as fast ([97], p. 257). In other words, tolerance is not an issue for anyone but daily or near-daily users, but there are likely to be stark differences in the dosage levels and, consequently, the consumption levels, between these two groups.

Determining dosage levels in a laboratory setting is complicated by a number of factors. For example, testing of blood THC levels of those known to have consumed a set quantity of cannabis demonstrates that smoking technique makes a considerable difference in the amount of THC absorbed. When smoked, only 15 per cent-50 per cent of the THC in a cannabis cigarette is absorbed into the blood stream, but experienced users are able to access about twice as much THC as casual users, because they have a superior inhalation technique ([98], p. 67).**

Using this absorption range, smoking an average (United States sized) 0.5 gram cannabis cigarette of fairly good potency (say 10 per cent THC, about halfway

*Weiss, cited in Schafer and others [96].

**One study of heavy medical users, however, also uses an absorption ratio of about 15 per cent, despite the experienced nature of the users [99].

between the 2004 United States averages for seized low-grade cannabis and seized sinsemilla) would result in the ingestion of 7.5-25 milligrams of THC. Lower potency cannabis would require more of a cannabis cigarette to be smoked, obviously, but larger cigarettes would require less.

Medical guidelines for dosage of synthetic THC (dronabinol) given orally suggest a starting daily dosage of 5 milligrams per day, administered in two doses of 2.5 milligrams. Maximum daily dosage is set at 20 milligrams and most patients are said to respond to 5 milligram dosages given three or four times a day. Of course, oral administration is less efficient than smoking, suggesting that these doses would be significantly less if the THC was smoked. On the other hand, the effects on the central nervous system desired by cannabis smokers are considered an unwanted side effect when the objective is appetite stimulation for chemotherapy patients, occurring in 3-10 per cent of such patients.*

According to the World Health Organization (WHO), when cannabis is smoked just 2-3 milligrams are sufficient to produce the desired effect in most people.** Grotenhermen argues that 0.03-0.1 milligrams of THC per kilogram of body weight is needed, or 2-5 milligrams for an adult ([100], p. 351).

Using the WHO standards, this would mean consumption of perhaps 10 per cent (with a good inhalation technique) to, at most, 40 per cent (with a poor inhalation technique) of a fairly potent cannabis cigarette should be sufficient to experience the desired psychoactive effect. This represents a "dose" level of 0.05-0.2 grams. Using Grotenhermen's upper threshold of 5 milligrams, this would be 20 per cent (with good inhalation technique) to 66 per cent (with poor inhalation technique) of a cannabis cigarette.

In other words, one average cannabis cigarette of good quality represents enough cannabis to satisfy 2-10 people, according to WHO standards. Of course, threshold levels are often exceeded. Grotenhermen adds that a "dose for a marked intoxication" would be 10-20 milligrams [100]. This is still less than an entire cannabis cigarette if the user's technique is any good.

Thus, however convenient the unit, a cannabis cigarette should not be considered a "dose". Consumption of an entire cannabis cigarette in a single sitting by a casual user would be rare, rather like a casual drinker consuming an entire bottle of wine. Cannabis of reasonable quality is actually more like spirits: just a few "shots" is enough to produce intoxication.

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*Dosage information taken from www.marinol.com.

**WHO uses a much wider range of possible values in its own calculations, however, arguing that the THC in an average cannabis cigarette (0.5-1 grams of cannabis with a THC content of 1-15 per cent) ranges from 5-150 milligrams, of which 5-24 per cent actually enters the bloodstream when smoked. This gives a range of 0.25-36 milligrams of THC being absorbed from a single cannabis cigarette, so individual experiences may vary by a factor of 144.

The fact that the most common unit of consumption does not correspond to the average dose is one reason why cannabis is usually consumed communally, with a single cannabis cigarette being passed around. Under these circumstances, there is almost no lower limit to the amount consumed by casual users. In other words, survey respondents who say they have consumed cannabis in the past year (especially novice users) may have had only a few inhalations on one or more occasions.

This level of use is reflected in the survey data from New Zealand, which is unique in asking users how much they consumed on each occasion they used the drug. In 2001, the average annual user smoked just six tenths of a cannabis cigarette. This average includes the 20 per cent of annual users who were classed as "heavy" smokers (using 10 or more times in the past month), so modal values for occasional users would be much less. The New Zealand surveys also ask about sharing cannabis cigarettes and the results show that nearly all consumption takes place in groups of two or more. In 2001, only 4 per cent of respondents smoked alone during a "typical" consumption session, while 14 per cent shared with one other, 29 per cent with two others, 24 per cent with three others, 17 per cent with four others, 6 per cent with five others, 3 per cent with six others and 2 per cent with seven others. A large share (45 per cent in 2001) never bought the cannabis they consumed and another significant part (26 per cent) received at least some of their cannabis for free ([60], pp. 35-36). This is consistent with figures from the United States and Ireland.

According to at least one source in the grey literature, a standard "hit" from a bong or pipe is generally one twentieth of a gram (0.05 grams) and one to three "hits" (up to 0.15 grams) are generally enough to produce the desired effect, which lasts for two to five hours. This figure (0.15 grams) is perfectly in line with those discussed above (0.05-0.2 grams). High potency cannabis is said to be consumed in amounts of up to 0.1 grams, not more.* The source goes on to conclude that one eighth of an ounce (3.5 grams) of mid-quality cannabis could get around 20-30 people reasonably high: between a tenth and a fifth of a gram apiece.**

Further evidence of a low dose thesis is the existence of "one hitters": pipes designed to hold just one inhalation of cannabis. While these small bowls can obviously be re-loaded, the work that involves would suggest that such a process is not intended to be frequently repeated. Imagine, for comparison, the limited utility of "one puff" tobacco cigarettes.

While there is virtually no floor to the amount of cannabis that might have been consumed by an annual user, it also seems that the ceiling on use is very high. Unlike other drugs, it is virtually impossible to "overdose" on cannabis. Experienced

*www.eroid.org/plants/cannabis/cannabis_dose.shtml.

**www.erowid.org/plants/cannabis/cannabis_basics.shtml.

smokers can consume the drug continuously if there are no social barriers to their behaviour. Those who grow their own supply may also circumvent financial constraints on consumption. For these users, the only ceiling on their use is the time it takes to prepare and consume the drug.

Surveys of users in New Zealand show that 95 per cent of annual cannabis smokers surveyed said that they never used the substance at the workplace, so employment may form a major impediment to constant consumption [101]. A study of users in Amsterdam, the Netherlands, where the drug is widely tolerated, found that declining to consume at work was the single most commonly followed "rule" concerning consumption and that 27 per cent of the sample of experienced users in the survey adhered to this rule; a further 20 per cent abstained from smoking cannabis during the day and 15 per cent abstained during the morning [102]. In France, just under a quarter (24 per cent) of "heavy" (20 times a month or more) users only "sometimes" or "never" consumed in the morning or afternoon [59]. Thus, a reasonable division could be hypothesized between daily users who have a cannabis cigarette or two in the morning and/or evening and those whose lifestyles allow them to be continuously intoxicated.

One source of information on dose levels for heavy users is the literature on medical use of cannabis. There is a great deal of contradictory information on what constitutes a "normal" use pattern among medical cannabis recipients, some of which is probably rooted in the politics of the medical cannabis debate; inflated average usage figures may provide protection to those found in possession of large amounts of the drug. Using the prescription guidelines for synthetic THC as a guideline, one study found that 1-5 grams of cannabis with THC levels of 10-20 per cent would be necessary to deliver 30-90 milligrams of THC, the daily dosage of synthetic THC [99]. In other words, users needing to be constantly under the influence of cannabis would have to smoke 2-10 standard 0.5 grams cannabis cigarettes of good potency per day. The study notes that this figure corresponds to actual average use levels reported by medical cannabis projects in the states of California and Washington in the United States, as well as dosages used in clinical studies. Other reports have suggested higher amounts. One study of four long-term medical cannabis patients found consumption levels of 7-9 grams per day, although this dosage was the product of years of constant use and lower consumption levels had been adequate at earlier stages [42].

Unfortunately, the ability to generalize actual medical usage patterns to the public at large is limited because medical users tend to have access to better quality cannabis than the general public [103]. It seems likely that heavy users would also use a more potent product and would be more likely to grow their own sinsemilla (for financial reasons, if nothing else), but the extent to which this is true is unclear. If low-grade cannabis were used, the quantities consumed could be much greater.

Another source of information on user habits is the regulated industry of the "coffee shops" in the Netherlands. According to the Ministry of Health, Welfare

and Sports of the Netherlands, the 600,000 users of cannabis products in the Netherlands consume an average of 2 grams per week per customer [104]. Of course, this average consumption level obscures considerable variation in individual use levels and, like medical cannabis, the quality of this product is likely to be much better than that available to users in other parts of the world.

Field accounts of use levels among non-medical regular users vary in quality and the question of sampling is always an issue. The Independent Drug Monitoring Unit in the United Kingdom makes use of a sample of "regular" users gathered at "pop-festivals and pro-cannabis rallies . . . subcultural magazines, snowballing, via direct mailings to pressure groups, and at other events." This sample is clearly not representative of annual cannabis users, but does give information on the upper end of the use scale.

The Independent Drug Monitoring Unit notes that even within this pool of users, the majority of the regular users consume relatively small amounts of the drug, with a mean consumption of 1 g per day. However, among daily users, the average was over six cannabis cigarettes a day, with some examples of much heavier use [61]. Other work in the United Kingdom also suggests that daily users may consume as many as five cannabis cigarettes a day ([105], p. 931). Informal interviews conducted in connection with the study with a number of employed daily users suggest a monthly consumption level of about 1 ounce (28 grams), which is enough cannabis for about two cannabis cigarettes a day.*

One qualitative study of drug users in Milan, Italy, found that while most users consumed only occasionally, daily users smoked between two and five cannabis cigarettes, or 1-2 grams of cannabis, a day. One dealer, however, claimed that at one point in his life he had consumed up to 20 g in a day. A more typical user said he smoked between six and nine cannabis cigarettes a week, but cautioned, "I cannot talk about a weekly or monthly frequency because I go through phases where I don't have as many commitments . . . or I see certain friends . . . [while] in other phases, for work or study reasons, it may happen that for about two months I smoke very rarely" ([106] p. 84).

One study of long-term, regular cannabis users in Australia** found a median use pattern of two "standard" cannabis cigarettes a day (50 per cent smoked between one and four cannabis cigarettes a day), but there were some stark outliers.

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*The standard sales unit in various locations provides some clues as to dose levels. In the United States, cannabis is sold in fractions of an ounce: one sixteenth (1.75 grams, enough for 1-2 joints), one eighth (3.5 grams, enough for 4-8 joints), one quarter (7 grams, enough for 8-14 joints), and one full ounce (28 grams, enough for up to 50 joints). A daily user consuming one or two joints a day would therefore use between a half and a full ounce per month. In Italy, cannabis resin was sold in 2000 by the deca (10,000 liras worth), which amounted to about 0.7 grams, enough for one or two cannabis cigarettes ([106], p. 121).

**A total of 92 per cent used at least two times a week, 86 per cent four or more times a week and 60 per cent used daily.

Overall, one third of users smoked cannabis throughout the day, while the rest restricted themselves to evenings or other times ([23], p. 25).

A recent study of 450 cannabis-dependent adults found that, on average, the users consumed cannabis three to four times a day and were intoxicated at least six hours daily.*

In Costa Rica, a study of 41 long-term users found that 10 cannabis cigarettes a day were smoked, but the total weight of the cannabis was only 2 grams with an average THC level of 2.2 per cent [108].

There are some studies that suggest much higher levels of use, however, as outlined below:

- In the United States, a study of 10 young people who used cannabis constantly for religious reasons found self-reported use of a mixture of tobacco and cannabis (assumed to be about 50 per cent cannabis) of 2-4 ounces a day. THC levels of the mixture were found to be 4.14 per cent. This represents the equivalent of smoking, on the high end, 56 grams or 112 standard (0.5 grams) cigarettes of pure cannabis of good quality per day, completely off the scale of other use studies [109].
- In Jamaica, Rubin and Comitas delineated three types of daily smoker: light (one to four "spliffs" daily), moderate (four to seven "spliffs") and heavy (more than eight "spliffs"). The average level of use was seven "spliffs" of 2-3 grams of cannabis of just under 3 per cent THC, combined with tobacco. This represents an average of about 18 grams per day of rather weak cannabis, the equivalent of 36 standard 0.5 gram cannabis cigarettes.** This use level has been criticized by others working in the field as "extremely excessive" and not representative of present consumption levels [110].

There are fewer studies focusing on levels of consumption of cannabis resin among heavy users. In Greece, a population of 31 users in Athens was documented, who had consumed an average of 8 grams (ranging from 2 to 24 grams) of rather weak (4 per cent) cannabis resin a day in the past. Owing to difficulties in accessing the drug, however, their current consumption levels averaged 3 grams a day.***

How much cannabis do users consume in a year?

The discussion above suggests that 162 million people use cannabis each year, of whom about 72 million could be classed "casual" users, 66 million could be classed

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*_Drug and Alcohol Findings_, No. 13 (2005), p. 10, summarizing Babor and the Marijuana Treatment Project Research Group ([107], p. 455).

**Rubin and Comitas cited in Schafer and others [96].

***Fink and others, cited in Shafer and others [96].

"regular" users, 15 million "daily" users and 7 million "chronic" users. These groups can be expected to consume at different rates.

Casual users are unlikely to finish a cannabis cigarette by themselves in any of the 1-11 sessions of use in the year. New Zealand's figure of average consumption of 60 per cent of a cannabis cigarette was derived from data that included the 20 per cent who were heavy users and so is undoubtedly excessive for the casual-user group. More likely, these users had two to three "hits" from a 0.5 gram cannabis cigarette shared by three or four people, representing about 0.15 grams of cannabis consumption per usage session. The distribution curve for individuals who use less than 12 times a year is heavily skewed towards one to three sessions of use according to the United States data and a weighted average of this category is about four sessions per year. Thus, 72 million people smoked an average of 0.15 grams of cannabis an average of four times a year, for a total of 43.2 tons of total global consumption.

While those who do not consume cannabis on a near-daily basis are not likely to build up much tolerance to the drug and are more likely to consume the drug alone or to consume cannabis more than once in a single day of use. They are also more likely to prefer premium cannabis (which may be up to 10 times stronger) and to have a better inhalation technique (which can increase THC absorption four-fold), both of which would mean that they would require less cannabis to become intoxicated than casual users. If this assumes that these factors cancel each other out to some extent, it can also be assumed that the average use-level remains at about 0.15 grams per day of use. The distribution of responses in the United States is also skewed towards the lower end in this group, with a weighted average of about 100 days of use. This represents 66 million people smoking an average of 0.15 grams an average of 100 times a year, for a total of 990 tons of global consumption.

Daily users, according to most sources, consume between one and four cannabis cigarettes a day. The weighted average in this category, based on the United States data, is about 320 days of use. Thus, 15 million people smoked an average of one gram of cannabis per day for 320 days a year, for a total of 4,800 tons of global consumption.

Chronic users can consume huge amounts of the drug. Use patterns vary so widely that it is impossible to come up with an average, but on the basis of medical cannabis guidelines and field reports, it appears that about 10 cannabis cigarettes, or 5 grams of cannabis, is a reasonable level for fairly constant intoxication. These seven million users consume every day, so total consumption should be about 12,775 tons. Thus, based on demand-side estimates, global consumption can be estimated at about 19,000 tons. This estimate supports the frequently made assumption that "regular" (usually taken to mean "monthly") users consume the bulk of the cannabis produced.

Reconciling with supply-side estimates

Supply- and demand-side estimates have proved to be difficult to reconcile for a range of analysts. The *World Drug Report 2006* [111] estimates global cannabis production at about 45,000 tons and the global consumer base at 162 million people annually. Dividing the one quantity by the other results in about 277 grams per user, or over a quarter of a kilogram apiece. If we use the United States Drug Enforcement Administration figure of 0.5 grams of cannabis per cannabis cigarette, 277 grams therefore equals 554 cannabis cigarettes per year, or more than one a day per user. At United States prices of $10 per gram, this represents $2,770 spent on cannabis per user per year. With a United States national average per capita income of $35,750 (according to the United Nations Development Programme), this expenditure would represent almost 8 per cent of the pre-tax income of every citizen of the United States who smoked cannabis last year. This seems impossibly high, particularly given that many users fall on the high side of this average.

Two possibilities are apparent:

- The amount of production is being overestimated, or
- The number of users is being underestimated.

The *World Drug Report 2006* [111] reports that over 6,000 tons of cannabis were seized in 2004, which would mean that 13 per cent of estimated global production is seized. Even the United States does not consolidate information on all the local seizures of cannabis made in the country, focusing instead on cross-border seizures or other large-scale operations, so this figure should be a minimum estimate. A seizure rate of more than 15 per cent seems infeasible, particularly given recent trends towards smaller-scale indoor production within consumer countries and production for personal use. Thus, it is unlikely that production is being overestimated.

The number of annual users, at nearly 4 per cent of the global population aged 15-64 years, is already incredibly high. Even doubling this rate would only halve the average consumption per annual user to 139 grams, which is still over $1,000 a year per user in the United States. Doubling the United States annual use estimates would also mean that more than a quarter (26 per cent) of Americans aged 15-64 years spent that amount of money on an illegal drug last year.

The problem may lie with the seizure figures rather than the production figures. Countries reporting the highest seizure levels are often under intense pressure to show success in drug interdiction. Since it is unlikely that all seizures are weighed and it is likely that eradicated crops are added into the total in some cases, an element of estimation exists in generating seizure figures. In theory, the entire cannabis plant could be used for psychoactive purposes; in practice, increasing demand for high quality in today's market means that user-ready sales often

comprise the flowering tops of the cannabis plant only. Thus, seizure estimates may be dealing with a large amount of bulk matter that would never translate into saleable street product. If seizure amounts were scaled down, production figures could also be adjusted without exaggerating the interception rate.

Turning to the figures generated by the present review, demand-side estimates place global production at 19,000 tons per year. However, this is 19,000 tons of cleaned product, not 19,000 tons of the product as it is generally sold. Buyers of commercial cannabis clean their product of stems and seeds before consuming it. Since these are the heaviest parts of the plant, it is possible that half the product (by weight) as bought is not consumed.

On the supply side, an estimated 231,000 hectares are under cultivation, but the majority of these are dedicated to cannabis resin. An estimated 45,000 tons of cannabis herb and 7,500 tons of cannabis resin are produced annually, of which 6,189 tons of cannabis herb and 1,471 tons of cannabis resin were seized, leaving about 38,811 tons of cannabis herb and 6,029 tons of cannabis resin for consumers. The difference as regards herbal cannabis could be attributable to cleaning the product.

While unsatisfying, these global estimates are probably the best that can be made based on very patchy data. They are also likely to obscure the great diversity of cultivation and use patterns seen throughout the world. In the end, it makes the most sense to study cannabis locally. To highlight this point, the following section of the present review considers the cannabis markets in various regions of the world.

III. WORLD CANNABIS MARKETS

As suggested above, cannabis markets tend to be highly localized. Where transnational trafficking does occur, it usually happens on a regional basis. There are a number of reasons for this. Cannabis herb is bulky, relatively easily detected and, compared to other drugs, has a low value to volume ratio. It just so happens that the most profitable markets have conveniently located producer countries nearby, notably Mexico for the United States and Morocco for Europe. Just a few decades ago, when the markets were less competitive, more remote producers could compete, but market pressures associated with increased law enforcement have made this increasingly difficult. As the big consumer markets turn to domestic indoor production, these pressures are likely to increase, making long-distance cannabis trafficking even more unprofitable.

Markets for cannabis herb

Herbal cannabis market in North America and the Caribbean

The United States is the world's largest consumer of cannabis herb, with an estimated 26 million annual users and nearly 5 million regular users (more than 20 days in the past month). According to the United States Office of National Drug Control Policy:

> "Commercial-grade cannabis prices have remained relatively stable during the past decade, ranging from $400 to $1,000 per pound in south-west border areas and $700 to $2,000 per pound in the mid-west and north-east. The national price range for sinsemilla, a higher quality of marijuana, is $900 to $6,000 per pound. BC Bud, a type of marijuana produced in Canada, sells for $5,000 to $8,000 per pound in most major U.S. metropolitan areas. Variables such as buyer/seller relationships, quantities purchased, frequencies of purchase, and purity affect drug prices." [112]

It is estimated that users of cannabis herb in the United States spent approximately $10.4 billion on cannabis herb in 2000 [113]. This was slightly less than was spent in the United States on heroin ($11.9 billion). It should be noted, however, that these estimates are of the amount consumed, not produced, and were generated using demand-side indicators. As a result, they are considerably less than production estimates using supply-side figures: demand-based estimates of national consumption are just over 1,000 tons, about one thirtieth of the high-end, supply-side values discussed below.

About 92 per cent of this market is supplied from within North America. According to the response to the UNODC annual reports questionnaire, in 2003 authorities in the United States reported that about 56 per cent of the cannabis trafficked into the country was from Mexico, with about 20 per cent coming from Canada. The balance is supplied by Colombia and other countries outside North America.

From the 1930s to the mid-1970s, Mexico supplied nearly all the cannabis consumed in the United States, but this dominance ended with the spraying of "paraquat", a herbicide toxic to humans, on Mexican crops in 1975 [68]. Fears of poisoning opened the market to producers in Colombia, while action by the Government in Jamaica eliminated another rival from the market. By 1979, Mexico supplied only an estimated 11 per cent of the market and by 1981 this figure had dropped to 4 per cent [68]. During the 1980s, Colombia was the source of 75 per cent of the cannabis consumed in the United States [114], but by the mid-1980s Mexico was already beginning to stage a comeback. Today, Mexican groups are again relegating groups from Colombia to a supporting role across drug markets [115]. Jamaica has again declined greatly in importance as a source of cannabis, although it is still the major source of cannabis oil to the Canadian market [37].

The three North American countries rate among the largest cannabis producers in the world. The proportion of global cannabis herb seizures made in North America rose from 32 per cent in 1990 to 58 per cent in 2003. There are several reasons for this shift, including an increase in local enforcement and a genuine shift in the patterns of international production.

Mexico has consistently topped the world in cannabis seizures in recent years and was responsible for a reported 37 per cent of the cannabis seized globally in 2003, over 2,000 tons ([116], p. 86). Mexico has undertaken a very aggressive eradication programme, destroying 31,000 hectares of cannabis in 2004. If that crop had been brought to harvest, it could have made up the bulk of global cannabis herb production. The United States Drug Enforcement Administration estimates that eradication eliminates up to 80 per cent of all the cannabis grown in Mexico ([117], pp. 12-13).* The authorities in Mexico, on the other hand, say they have been eradicating 98 per cent of the cannabis crops located in the states of Chihuahua, Durango, Guerrero, Jalisco, Michoacán, Nayarit, Oaxaca, Sinaloa, Sonora and Zacatecas since 1994, but that residual areas of cannabis plant cultivation remain in the Sierra Madre mountains ([118], p. 36). Despite an increase of about 20 per cent in crop eradication, the net cultivation of cannabis plant after eradication increased by 70 per cent between 2002 and 2003, to 7,500 hectares [119]. Production was estimated at 13,500 tons of cannabis herb that year, before

*This estimate is based on the ratio of hectares eradicated and net cannabis plant cultivation. However, the figures provided by the Drug Enforcement Agency differ markedly from those contained in the International Narcotics Control Strategy Reports prepared annually by the United States Department of State.

declining to 10,400 tons in 2004 [37]. According to its response to the UNODC annual reports questionnaire in 2003, the Government of Mexico estimates that 70 per cent of this production is destined for the United States and 30 per cent for local markets. In addition to crop eradication, between 1,000 and 2,000 tons of processed cannabis have been seized in Mexico since 1998, with another 750 kilograms to one ton seized at the border ([117], pp. 12-13).

Canada has also stepped up enforcement efforts, seizing 1.1 million cannabis plants per year between 1998 and 2002, a sixfold increase over 1993 [120]. In 2003, 1.4 million cannabis plants were eradicated and 21.5 tons of processed cannabis were seized [37]. According to its response to the UNODC annual reports questionnaire for 2004, an estimated 960 to 2,400 tons of cannabis are produced in Canada each year. In addition to local consumption and exports to the United States, cannabis from Canada is said to supply markets as far afield as Japan and Taiwan Province of China.

In the United States, cannabis enforcement increased throughout the 1990s, with 113 per cent more arrests related to cannabis in 2002 than in 1990 [121]. Eradication efforts have fluctuated over the years, however, from eradication of just under 4 million cultivated plants in 1985 to nearly 8 million in 1992, and then returning to a low of 2.5 million plants eradicated in 1998 and 3.65 million in 2003. A Government estimate of cannabis production in the United States lies at between 3,100 and 7,100 tons ([122], p. 4), but other figures have placed it as high as 19,000 tons.

Even taking the advanced enforcement capabilities of the North American countries into account, being responsible for nearly 60 per cent of global seizures suggests a huge amount of local production. The United States authorities estimate production of cannabis in North America at nearly 32,000 tons on the high end, exactly the same as the UNODC global production figure. Comparing low-end figures with the UNODC global total, the figures come into line: about a third of global cannabis herb production takes place in North America.

In the United States, most of the large-scale, low-grade production, at least outdoors, seems to be concentrated in just a few states. Eradication of outdoor cannabis plants was highest in 2003 in the states of California, Tennessee, Kentucky, Hawaii and New York. Indoor production was highest in California, Washington, Florida, Oregon and Texas [37]. This is a different profile from previous decades, where the mid-west (including in respect of former and current corn farmers with little affinity for the drug) played a more prominent role. This suggests that enforcement efforts in the mid-west (including asset forfeiture) have had a long lasting impact on a producer community that is sensitive to deterrence.

In recent years, much of the outdoor production of cannabis in the United States has been found in "guerrilla" cultivation on public lands, such as the national

forests and parks of the states of California and Kentucky. As enforcement strengthens in California, outdoor cultivation has moved to public lands in the states of Oregon and, increasingly, Washington [123]. The move onto public lands may be spurred in part by the threat of asset forfeiture. It exposes the crops to increased risk of theft, which may increase the violence associated with the industry. It also poses an environmental threat to protected areas, as both cultivation and eradication efforts can damage delicate ecosystems. This phenomenon is not unique to cannabis and it is not unique to the United States: cannabis has long been cultivated on public lands in Australia [124], and a similar problem is found with coca bush in Colombia, for example [125].

Formerly, most Canadian production of cannabis had been concentrated in the state of British Columbia, but this is no longer the case. Seizure and eradication figures suggest that Ontario and Quebec have recently caught up and, more recently, major operations have been detected in other provinces, such as Manitoba [126] and Nova Scotia [127, 128]. In September 2005, police in Manitoba seized over 40,000 cannabis plants in five separate law enforcement operations [129], enough to produce about 4 tons of herbal cannabis. At present, according to Canada's response to the UNODC annual reports questionnaire in 2004, about 40 per cent of cannabis in Canada is produced in British Colombia, with 25 per cent coming from Ontario, 25 per cent from Quebec and 10 per cent from other provinces.

Owing to eradication pressures, cannabis production in Mexico is highly dispersed and concealed, occurring in small plots averaging less than 1,000 square metres [130]. In 2004, the authorities in Mexico reported seizing 254,554 whole plants in 72,559 separate seizures, an average of just 3.5 plants per seizure. Cultivation micro-regions occur in a long arc though the mountain ranges of the Sierra Madre Occidental to the Sierra Madre del Sur, roughly coincident with the opium poppy producing areas. The authorities in Mexico divide cannabis production into two major zones: on the Pacific Ocean (Guerrero, Jalisco, Michoacán, Nayarit, Oaxaca and Sinaloa states), responsible for 52 per cent of production, and in the central-northern area (Baja California, Chihuahua, Coahuila, Durango, Sonora and Zacatecas states), responsible for 47 per cent. In recent years, the share cultivated in the area adjacent to the Pacific Ocean has declined and that in the central-northern area has increased. According to the response of Mexico to the UNODC annual reports questionnaire in 2004, just seven states (Chihuahua, Durango, Guerrero, Jalisco, Michoacán, Sinaloa and Sonora) are responsible for 83 per cent of production. Sinaloa, the country's breadbasket and long the traditional home of the drug trade, is the main cannabis producing state, with 96 per cent of the production being found in just nine municipalities. In 2000, 58 per cent of the processed cannabis seized was taken in the states of Chihuahua, Durango, Jalisco, Oaxaca, Sinaloa and Sonora ([118], p. 36).

As the discussion above indicates, polls conducted in the United States suggest that much of the cannabis cultivation and distribution takes place through social

networks. Nonetheless, a $10 billion market attracts organized criminal elements. A recent assessment of gang activity in the United States found that 65 per cent of law enforcement agencies surveyed said that gangs were involved in the distribution of cannabis in their areas, a much higher share than for any other drug [131]. A large share of the outdoor cannabis plant cultivation in California occurs on land in national parks and is controlled by Mexican organized criminal groups, while the indoor market is overwhelmingly controlled by white Americans [37], with some Vietnamese involvement in the Pacific north-west. Rangers eradicating crops on public lands in California are frequently met with violent resistance from the organized criminal groups controlling the trade and booby traps on "guerrilla" cultivations are not uncommon.

Drug trafficking organizations in Mexico have evolved over the years. While Mexico has been the source of supplies of cannabis to the United States since the 1930s, demand was not great enough to attract organized criminal groups until the 1960s. In the interim, after the main opium producing regions of the world were lost to the enemy during the Second World War, the Allies faced shortages of morphine needed for the treatment of injured soldiers. The United States supported the cultivation of opium poppy in Mexico, which was the genesis of the heroin trade in that country. This added to the sophistication of trafficking operations.

"Operation Intercept" was an attempt in 1969 to stop the cross-border traffic of drugs through vigorous enforcement and it was during this time that Mexican traffickers learned to use low-flying aircraft to evade United States radar networks ([132], chap. 59). After losing market share owing to the use of the herbicide "paraquat" in 1975, Mexico became a trafficking route for cannabis from Colombia and domestic production began to grow. The Colombians switched from cannabis production to cocaine as North American cultivation undermined the demand for regional imports of cannabis. In the mid-1980s, when law enforcement shut down the state of Florida in the United States as a viable trafficking route, the Colombians enlisted cannabis traffickers to handle cocaine shipments (a development similar to what appears to be occurring today with the use of cannabis resin trafficking routes to traffic cocaine into Europe). More recently, it has been argued that the Mexican drug trafficking organizations have all but supplanted Colombian trafficking, reducing them to a supply role [115]. This position has been challenged recently by the authorities in Mexico, which claim that Colombian elements have taken over operations within Mexico [133]. In either case, the drug trade from Mexico to the United States, which includes cocaine and amphetamines, is extremely lucrative and the market has grown increasingly violent over the years. Recent conflicts include the use of military armaments and assassination of public officials and journalists.

In Canada, most of the medium- and large-scale cannabis production operations are controlled by organized criminal groups. "Outlaw" motorcycle groups, such as the Hell's Angels, control outdoor and hydroponic cultivation, while Vietnamese

groups control indoor organic (soil-based) production [36]. Vietnamese involvement in indoor cultivation in London in the United Kingdom has also been reported [134]. The Hell's Angels dominate cannabis production in Quebec and the Vietnamese groups are increasingly controlling urban cannabis production in cities in Canada such as Calgary, Montreal, Toronto and Vancouver. Canadian groups of South Asian descent are allegedly involved in moving cannabis across the border in commercial trucks [135]. However, despite some inter-group violence, these ethnic divisions seem to be dissolving as groups find it more profitable to cooperate than to clash.

The increasing involvement of organized criminal groups is reflected in the growing size of shipments across the border from Canada into the United States [37]. Money derived from cannabis operations may be allowing minor organized criminal groups to graduate to trafficking in weapons and explosives, cocaine smuggling and stock-market fraud. According to a report of the Royal Canadian Mounted Police, "[t]he inter-provincial and international marijuana trade . . . has allowed several organized crime groups to expand into other criminal enterprises that may have previously been well beyond their grasp." [136]

Back in the mid-1990s, before Canada became a major source for cannabis imported into the United States, "virtually all marijuana smuggled into the United States, whether grown in Mexico or trans-shipped through Mexico from other locations such as Colombia, was smuggled across the south-west border." [137] While less true than in the past, land routes over the south-western border of the United States continue to be the primary place of importation, with false compartments in heavy goods vehicles being a perennial favourite concealment technique ([117], p. 13). Most seizures at official points of entry are made at El Paso and Laredo in Texas and San Ysidro, Otay Mesa and Calexico in California; the counties of Pima and Santa Cruz in Arizona rank highest for seizures not made at official points of entry. Along the northern border, various points in the state of Washington account for most of the cannabis entering the United States from Canada, but points in Michigan, New York and other states are growing in importance. Annual seizures in the north are generally around 1 per cent of those in the south-west, however [37]. Authorities seized 4.4 tons entering the United States from Canada in 2001-2002, 12.2 tons in 2002-2003 and 15.8 tons in 2003-2004 [122]. Sea and air routes are also used and tunnels have been found across both the south-western and northern borders of the United States. Helicopters are increasingly used to move cannabis across the Canadian border [138].

Remarkably, cannabis is also imported into Canada, including some from the United States. Between 2000 and 2003, 7.8 tons of cannabis were seized entering Canada, including 1.23 tons at the United States border [122]. There is no recorded pattern of trafficking of cannabis from the United States to Mexico. There appear to be some exports of cannabis from North America to Asia. For example, the Government of the Republic of Korea attributes the source of 55 per cent of the

cannabis trafficked into the country to the United States, while cannabis is said to be exported from Canada to Japan and Taiwan Province of China.

Once in the United States, imported cannabis is distributed through Mexican drug trafficking organizations throughout the country, although Jamaican groups are prominent in the north-east and Vietnamese groups are seen in the north-west. Since white North Americans dominate domestic outdoor production in the Appalachian area and indoor production throughout the country, they tend to control distribution within these markets as well. Street-level sales are conducted by individuals and gangs of all descriptions [37].

The Caribbean region, and Jamaica in particular, has traditionally been a source of cannabis destined for the United States and Canada, as well as the United Kingdom and Europe, although the market share commanded by this product seems to have been in decline for some time. For example, while Jamaica appears to have been the source of one third of the cannabis herb consumed in the United Kingdom in the late 1970s, it appears to comprise less than 7 per cent of the market today [139]. For all Caribbean nations, the picture is clouded by the fact that seizure figures may reflect both trans-shipped cannabis (in particular from Colombia) as well as locally produced cannabis.

In 2004, Jamaica eradicated over 400 hectares of cannabis plant and destroyed more than 5 million cannabis seedlings at 403 nurseries. In response to enforcement, cultivation operations have shifted from large plantations to smaller plots hidden in more remote areas. A new strain of cannabis plant growing to only 3 feet tall at maturity was recently discovered in Westmoreland, Jamaica. Very sophisticated cultivation methods, including portable irrigation systems, generators and floodlights, have been discovered [37].

The Government of Trinidad and Tobago reports eradicating over one million plants and seedlings in 2004 and has reported eradication of as many as 10 million plants in the past [37, 140]. If these plants had been allowed to develop, they could have produced as much as 1,000 tons of cannabis. Growing conditions are such that three annual harvests are said to be possible and, despite eradication, according to its response to the UNODC annual reports questionnaire in 2003 the Government estimates that over 17 tons are produced each year. The country also imports more potent cannabis from Colombia and from Saint Vincent and the Grenadines [141].

Several countries and territories in the Caribbean report annual seizures of 2-12 tons annually, including the Bahamas, the Cayman Islands and Cuba. Of these, the Cayman Islands claim that 100 per cent of the cannabis in the Cayman Islands comes from Jamaica, brought over on boats.

Intermediate countries and territories in terms of seizures include the Dominican Republic, Saint Vincent and the Grenadines and the Netherlands Antilles. Of

these, Saint Vincent and the Grenadines is frequently listed as a source country for cannabis imported for consumption in the Caribbean [141].

Many small island countries and territories in the Caribbean consistently report smaller seizures, with occasional windfalls, including Antigua and Barbuda, Bermuda, the British Virgin Islands, Dominica, French Guiana, Grenada, Guadeloupe, Haiti, Saint Kitts and Nevis and the Turks and Caicos Islands.

In a study by the Inter-American Drug Abuse Control Commission conducted in six Caribbean countries, the use of cannabis and cocaine in combination was documented in four of the countries studied. In Haiti, it is known as "juicy lucy", in Martinique as "black joint" and in Dominica and St. Kitts and Nevis as "spranger" [82]. This combination is known as "season spliff" in Jamaica.

Herbal cannabis market in North Africa and West/Central Africa

After North America, Africa leads the world in seizures of cannabis herb, responsible for 26 per cent of seizures and an estimated 28 per cent of global production (12,000 tons). Most of this cannabis is consumed by Africa's 37 million annual users (8 per cent of the African population aged 15-64 years, nearly a quarter of all global users), but a substantial amount is exported, primarily from Western and Southern Africa. France, for example, estimates that 30 per cent of the cannabis herb trafficked into the country is of African origin.

In Egypt, cannabis herb is referred to as "bango" and it continues to be illicitly cultivated in northern Sinai. Seizures of cannabis herb rose from 7 tons in 1996, to 31 tons in 1998 and to over 59 tons in 2002, but only 12 kilograms were seized in 2004. This may be because only five people were arrested for drug trafficking that year, four of whom were arrested for cannabis trafficking. Egyptian authorities say that 65 per cent of the cannabis trafficked in the country comes from Eritrea and 35 per cent from the Sudan. Eritrean nationals are identified as traffickers of cannabis and other drugs. In contrast, authorities in Israel estimate that 99 per cent of the cannabis consumed in their country comes from Egypt.

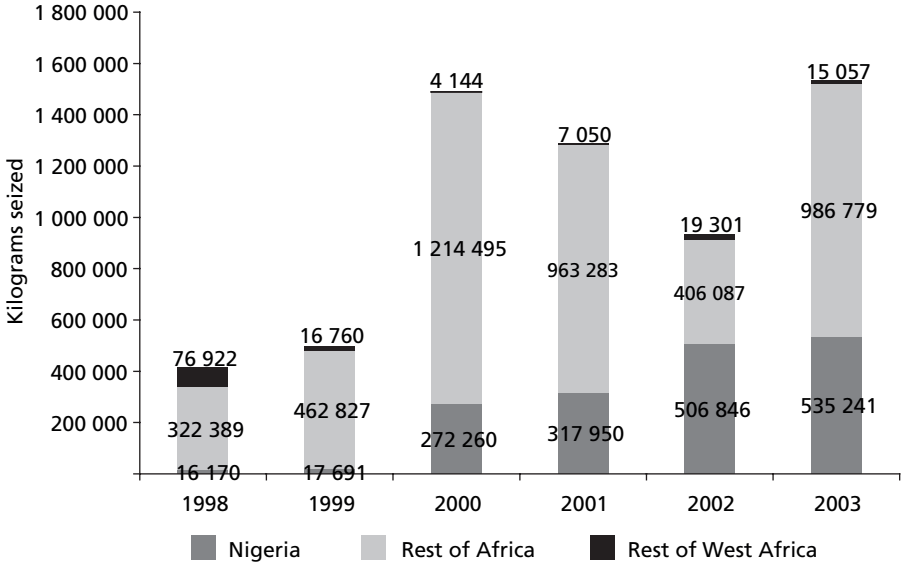
The important role of West Africa in global cannabis trafficking is remarkable because, unlike the rest of the continent, cannabis appears to have been introduced to West Africa only recently and does not play a role in traditional herbal medicine or rituals in the area.

Given the lack of a long-standing cultural role for cannabis, the primary factor driving cultivation in the area seems to be economic. A 1995 study by the French Observatoire géopolitique des drogues of cannabis production in five West African countries found that the prices commanded by cannabis, while low by international standards, were so much higher than for other agricultural commodities that

the incentives for cultivation were very high. The study also highlighted extreme price differences within the region and between rural and urban areas [142].

While West African organized criminal groups are a significant factor in the drug trade worldwide, the only drug produced in the region in any quantity is cannabis. Nigeria, by far the largest country in the region, is also one of the global leaders in cannabis seizures, ranking fifth in the world in 2003. Nigeria's share of both West African cannabis seizures and total African cannabis seizures has been growing in recent years (see figure XI).

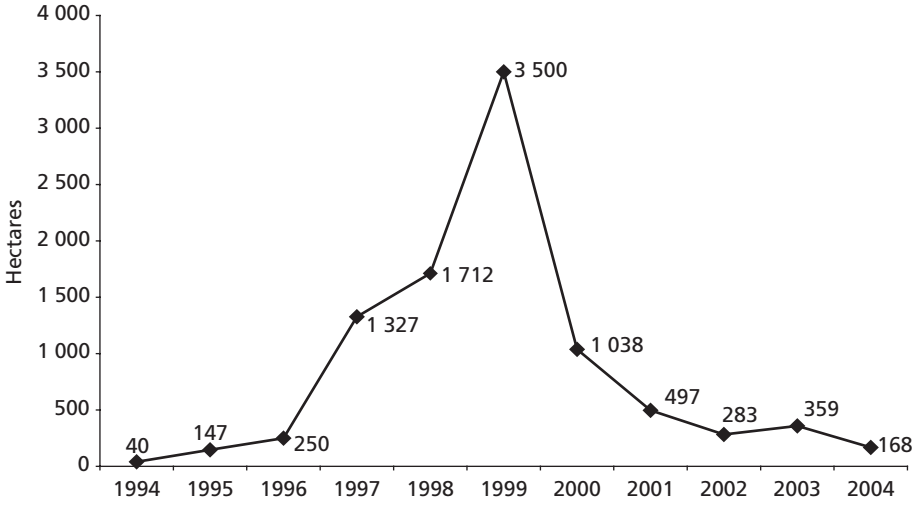
Figure XI. Breakdown of cannabis seizures in Africa by area, 1998-2003



Source: UNODC annual reports questionnaires.

According to local academics, cannabis (known officially as "Indian hemp") was only introduced into Nigeria after the Second World War by soldiers returning from India and Myanmar [143]. According to Nigeria's response to the UNODC annual reports questionnaire in 2003, the Dublin Group and the United States Drug Enforcement Administration, cannabis is currently cultivated in all 36 states of Nigeria, but is most widespread in the north of the country and in the states of Ondo (40 per cent), Delta (30 per cent), Edo and Cross River in the south [144, 145]. Operation "Burn the weeds" was launched in 1994 and has become the title of Nigeria's ongoing eradication programme. After a peak in the late 1990s, a relatively small area was subject to eradication efforts in the first years of the twenty-first century, contrary to some international reports (see figure XII). Preliminary figures from the 2005 eradication effort suggest that renewed attention is being given to the matter.

Figure XII. Eradication of cannabis plant in Nigeria, 1994-2004



Source: Nigeria, National Drug Law Enforcement Agency.

Cannabis is known to be trafficked from Nigeria to the rest of West Africa. For example, in both Benin [144] and Cameroon about half the local supply is said to be brought in by Nigerians, presumably from domestic production. Cannabis is also known to be sent from Nigeria to Europe, often by sea, compacted and hidden among other products. The authorities in Poland have identified Nigeria as the origin of a significant amount of cannabis resin trafficked through Poland to the Netherlands and Germany. This is possibly a reference to trafficking by Nigerians of cannabis resin from Afghanistan, Morocco or even Senegal. As reported in the response to the UNODC annual reports questionnaire in 2003, the authorities note the recruiting of Polish nationals by Nigerian organized criminal groups. According to responses to the UNODC annual reports questionnaire in 2004, Nigerian nationals have been arrested for cannabis trafficking in countries all over the world.

Ghana has one of the highest known rates of annual cannabis use, with 22 per cent of those aged 15-64 years reporting having used the drug in 1998. Cannabis production in Ghana has expanded greatly since the 1960s [146]. In 1998, 1999 and 2002, between 4 and 5 tons were seized annually, but in 2003 over 9 tons were seized. Ghana has been the source of a number of recent major seizures (in excess of 1 ton) of cannabis herb destined for Belgium and the United Kingdom. The authorities in Belgium estimate that 25 per cent of the cannabis trafficked into their country comes from Ghana and Ghana is listed as a major source of supply to Italy, after Albania. Atha mentions Ghana as a supplier of rather low potency (0.7 per cent-4.3 per cent) cannabis to the United Kingdom [147]. These consignments are typically concealed on container ships transporting food (including in refrigerated containers).

In the 1960s, cannabis plant was cultivated in the Western, Eastern, Ashanti and Brong Ahafo regions of Ghana, primarily by intercropping [148]. Today, the Volta, Brong Ahafo, Western and Ashanti regions are the principal growing areas [149]. Although cannabis is extremely cheap in Ghana (about $0.10 for a cannabis cigarette), it is still worth more than alternative crops, so there is no shortage of willing cultivators [150].

In Senegal, where the drug may have been introduced earlier in the twentieth century by Arab traders, cannabis is known as "yamba". It is grown in the Casamance region and along the southern border with the Gambia, in the Niayes area (north of Dakar), along the Senegal River and in the regions of Kolda, the Karones Islands and the islands of the Saloum Delta [144]. Its distribution is mostly regional, with Dakar, other urban centres in Senegal and the Gambia being significant outlets [151, 152]. In 1998, nearly 70 tons of cannabis were seized, but success in more recent interdiction efforts has been more modest, over 7 tons in 1999 and just under 5 in 2002. Trafficking in cannabis has become a source of funding for the insurgents of the Movement of the Democratic Forces of Casamance, although its relative importance is debatable and the issue may have been exaggerated for political purposes [151, 152]. It has been claimed that the National Patriotic Front of Liberia traded guns for cannabis from the Movement of the Democratic Forces of Casamance.*

There is also documented production of cannabis resin in Senegal, although the extent to which this product is trafficked internationally remains unclear. In 2003, the police in Germany seized 2.7 tons of cannabis resin in a motor home in Hamburg, Germany, which they said had originated in Senegal and had transited through Mauritania and Morocco. Its ultimate destination was said to be the Netherlands ([154], p. 7).

Multi-ton seizures in West Africa have been made in Cape Verde (where an 8.7 ton harvest was destroyed in 2003) [144], Benin (in the counties of Zou, Collines, Mono and Plateau [144], with 2 tons seized in 2002), Guinea (almost 3 tons in 2003) and Côte d'Ivoire (4 tons seized in 2002). Smaller seizures have been made with some consistency in Cameroon, the Congo, the Gambia and Togo, and other areas are said to produce cannabis for local consumption. Equatorial Guinea is said to export cannabis to Spain.

Herbal cannabis market in Southern and Eastern Africa

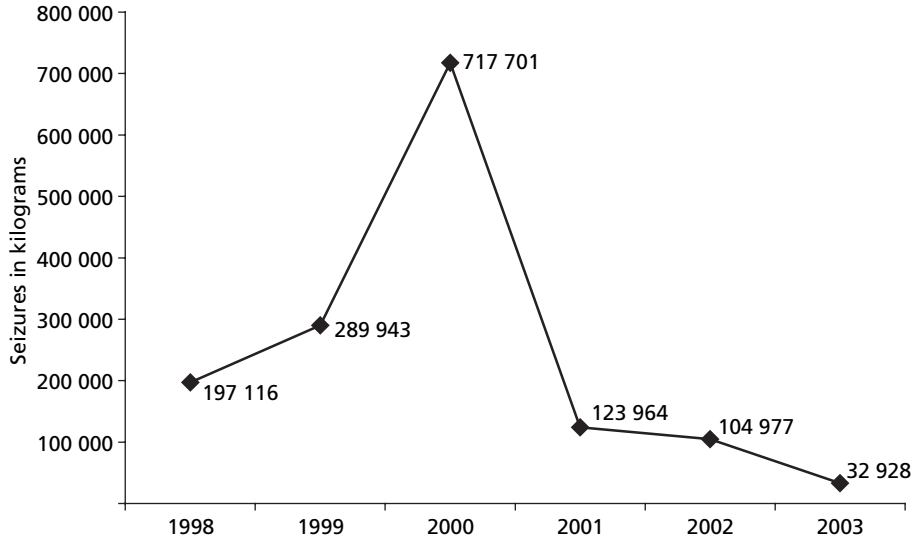
Lesotho, South Africa and Swaziland are the source of large amounts of cannabis, although exactly how significant those amounts are is a matter of debate. Cannabis is also exported from Malawi, including to South Africa and the United Republic of

*Prkic and Deng, cited in Ellis [153].

Tanzania. Little is known about what goes on in the licit economy of the Democratic Republic of the Congo, let alone the criminal economy, but there is also reason to believe that substantial production for local consumption does take place. Interdiction in the United Republic of Tanzania is erratic, but its 2003 seizures ranked third in the world, after Mexico and the United States.

According to Interpol, South Africa was among the world's top four source countries for cannabis herb at least as recently as 2001.* In addition to substantial domestic production, cannabis (known locally as "dagga") is imported into South Africa from other countries, either for local use or re-export, especially from Lesotho and Swaziland but also from Malawi, Mozambique and Zimbabwe [56]. After a peak in 2000, when a very surprising 700 tons of cannabis were reportedly seized, South Africa's eradication figures have declined, indicating a lower priority on the issue relative to other, more pressing, crime problems (see figure XIII).

Figure XIII. Cannabis seizures in South Africa, 1998-2003



Source: UNODC annual reports questionnaire.

Estimates of the total area under cannabis plant cultivation in South Africa vary, but are generally between 1,000 and 2,000 hectares, mainly located in small, semi-cultivated plots in KwaZulu-Natal and Eastern Cape provinces. Average plot size is said to be about 300 square metres [156]. Per hectare annual yields are said to be quite high (2.12 tons per hectare) but it has been questioned whether these figures are actually references to total dry-plant weight. It is also possible that these

*Interpol, cited in South Africa: Country Profile on Drugs and Crime [155].

figures could reflect two or more annual harvests, as it has been suggested occurs in Lesotho. Other estimates have placed per hectare yields at around 1.2 tons per harvest [156].

National prevalence of annual use is relatively low, at 8 per cent of the population aged 15-64 years. This suggests a substantial export market. Authorities estimate that excess production enabled exports to grow from 15 per cent of total production in 1991 to 70 per cent of total production by 1996 [155].

The potential for export from South Africa, however, includes much of the output of Lesotho and Swaziland. It has been suggested that much of what is marketed as "Durban poison" is, in fact, from Lesotho. Cannabis is trafficked from South Africa to Europe and at one point South Africa was said to be the number one source of foreign supply to the United Kingdom. In 2003, the authorities in Ireland reported that 96 per cent of the cannabis herb trafficked into their country came from South Africa, 20 per cent of which was believed to be destined for the United Kingdom. They noted that it was generally carried in by couriers believed to be South African, in quantities of 20-40 kilograms, but volumes were down in recent years, which was attributed to key arrests of traffickers at Dublin airport.

Swaziland is known for producing high-quality cannabis ("dagga" or "insangu") in the north of the country. The seed stock, including strains such as "rooibaard" and "Swazi gold", has been marketed internationally, largely by nationals of the Netherlands. In 2002, the police in Swaziland noted cannabis exportation to Japan, the Netherlands, the United Kingdom and the United States [157] and this situation does not appear to have changed much in more recent times. Cannabis from Swaziland is often compacted for export and police have seized mechanical devices for compressing cannabis. Substantial efforts at eradication have occurred over the years and the quality of cannabis from Swaziland seems to have declined.

Cannabis is called "matekoane" in Lesotho and it is thought to be the third largest source of income for its people, after foreign aid and remittances from expatriate workers (who are largely based in South Africa, many involved in the mining industry). It is grown in the Berea, Mokhotlong, Thaba-Tseka and Qacha's Nek areas. Fields are rarely larger than one hectare and the plant is grown alongside corn. As in South Africa, small farmers sell their produce to wholesalers, who consolidate the many small inputs for trafficking in 50 kilogram mealie sacks. The crop is sun dried. Weeded males are harvested early and sold as "majat" in South Africa, which is used in smoking "white pipe", a combination of cannabis, tobacco and Mandrax (the sedative methaqualone). This allows "two harvests" per year ([158], p. 193).

Malawi is world renowned for the quality of its cannabis, so much so that it exports to South Africa. The traditional wrap is the well-known "Malawi cob", wrapped in banana leaves, but these are rarely seen in export markets nowadays.

About 3 to 9 tons are seized annually in this small, under-policed country of about 13 million people, suggesting a substantial export market.

The United Republic of Tanzania recently leapt onto the cannabis seizure map in 2003, coming third in the world after Mexico and the United States for the first time, with a huge haul of 750,000 kilograms. From January through June 2004, over 230,000 kilograms of cannabis were destroyed, nearly as much as the annual total in the previous record year, in 2001 [159].

According to official reports, 80 per cent of the cannabis consumed in the United Republic of Tanzania is grown domestically, with 20 per cent being imported from Malawi; 90 per cent of locally produced cannabis is consumed locally according to the response to the UNODC annual reports questionnaire for 2003. This is remarkable because only 0.2 per cent of the local population aged 15-64 years is estimated to use cannabis, about 39,000 people.* This would leave each user with about 19 kilograms of cannabis apiece, if 2003 seizures had not been made. Clearly, some part of this equation is incorrect: it could be that the United Republic of Tanzania has much higher levels of use than generally believed; or exports are perhaps much greater (to unknown destinations); there could be substantial transshipment of which the authorities are unaware; or the size of seizures could have been somehow miscalculated. Of these, it is likely that the user population has grown in the last five years, since over 5,000 people were arrested for cannabis in 2003, a substantial share of the estimated user population, and over 2,000 people were arrested for selling cannabis in the first half of 2004 alone [159].

As in West Africa, it would appear that many poor farmers in the United Republic of Tanzania are seeking to compensate for the declining prices commanded by the traditional cash crops of coffee, cotton, cashew nuts and sisal, and cannabis is far more lucrative than any other crop. Wholesalers tend to be Somali or Arab in origin, except along the Kenyan border where nationals from that country advance money to local farmers to grow cannabis. Cannabis is cultivated in 10 of the 20 regions of the mainland of the United Republic of Tanzania, especially in those that border on the neighbouring countries of Burundi, the Democratic Republic of the Congo, Kenya, Malawi, Mozambique, Rwanda, Uganda and Zambia, and police believe that as many as half of the families in these 10 regions of the country are involved in the cultivation of cannabis [160]. It is not clear where all this product is being shipped, however.

In Mozambique, cannabis herb for local consumption is produced throughout the country, particularly in Cabo Delgado, Manica, Nampula, Niassa, Sofala, Tete and Zambezia provinces. Limited amounts are exported to neighbouring countries, especially South Africa. The Government of Mozambique has no estimates on crop size. Intercropping is the most common method of production [149].

*This estimate, based on 1999 survey data that were not nationally representative, must be deemed tentative, however.

Uganda has consistently reported annual seizures in excess of 5 tons (except in 2002), and in 2003 reported 25 tons seized. Aside from supplying a small local demand, "enjaga" as cannabis is known in Uganda, is exported to Kenya and beyond.

In Kenya, fairly large-scale cannabis cultivation occurs in the Lake Victoria basin, in the central highlands around Mount Kenya and along the coast. As much as 1,500 hectares of cultivation have been estimated in this area, some in the lower farmlands concealed among traditional crops and smaller cultivation in the higher reaches in areas regarded as national wildlife reserve [161]. Despite two highly publicized, successful targeted raids on 14 farms around Mount Kenya in 2001 and 2002, which collectively destroyed 461 tons of cannabis, police noted increased cultivation of cannabis during targeted raids (some of which were successful, some not) in 2004. Kenyan authorities seized 190 tons of cannabis in 2004 and arrested 3,292 suspects. Officials believe that Kenyan coastal waters and ports are major transit points for the shipment of cannabis resin from Pakistan to Europe and North America [161].

Smaller seizures are consistently made in Ethiopia, Mauritius and the Seychelles. Low-grade cannabis cultivation is also reported for the Comoros and Madagascar.

Substantial seizures of cannabis resin have also been made in Southern and Eastern Africa, including Mozambique (15 tons in 2000), South Africa (11 tons in 2000), Kenya (6 tons in 2000) and the United Republic of Tanzania (2 tons in 2002). This is almost certainly trans-shipped cannabis resin from Pakistan, as there is very little evidence of local cannabis resin production.

Herbal cannabis market in South America

Two countries in South America are major sources of cannabis: from one (Colombia) cannabis is exported beyond the region, and from the other (Paraguay) cannabis is exported primarily for regional consumption. South America is unusual in having high levels of seizures and, according to surveys, low levels of domestic use. No South American country has reported that more than 6 per cent of the population aged 15-65 years consumes cannabis each year. The country with the highest recorded use levels, Chile (5.3 per cent in 2004) [162], is one of the most developed countries with the lowest crime level in the region; it also has one of the lowest levels of seizures. This suggests that the relatively high use rates may be an indication of the accuracy of data collection rather than pointing to an exceptionally high consumption problem in Chile. In contrast, Brazil (with 1 per cent of the population aged 12-64 years reporting cannabis use in 2001), Colombia (an estimated 4.3 per cent), Paraguay (an estimated 1.8 per cent), Argentina (3.7 per cent of the population aged 16-64 years) and Peru (1.8 per cent) were all among the top

20 countries in terms of the weight of cannabis seized in 2003. If the survey figures are correct, either interdiction rates are extremely high, or much of the cannabis cultivated in the region is exported. With the exception of Colombia, however, none of the South American countries is known to export cannabis in any great quantity outside the region.

High regional levels of production with low levels of use pose something of a puzzle. For example, only 1 per cent of the population aged 12-65 years in Brazil reported using cannabis in 2001, a total of just over 1 million annual users. But nearly 200 tons of herbal cannabis were seized in the country in 2002, for an average of about 200 grams seized per user for the year. In addition, almost 2.5 million cannabis plants were eradicated that year. If these had been missed, they could have produced another 250 tons, raising the per-user production to almost half a kilogram apiece. As will be discussed below, after cleaning, this is more than one cannabis cigarette a day per person, which is probably more than was actually consumed by these annual users, many of whom use only occasionally. Moreover, this is just the amount destroyed. Unless interdiction rates are above 50 per cent, this suggests an export market, but Brazil is not known to be a major exporter of cannabis. In fact, it is a major importer. As discussed below, officials argue that most of the cannabis consumed in the country comes from Paraguay.

In a school survey of seven Latin American countries, Paraguay had the second lowest levels of annual cannabis use (1.7 per cent) and cannabis was only the second most popular drug, after "jarra loca" (a mix of wine and tranquilizers) ([163], p. 16). Yet only Brazil and Colombia claim higher seizures than Paraguay, with about 80 tons seized per year, or about 1.3 kilograms for each of about 60,000 annual users. Of course, Paraguay is known to be a major exporter, in particular to Argentina, Brazil, Chile and Uruguay. Still, it is surprising that a country with such a large production to population ratio would have so little local consumption.

This would suggest that either the survey figures on consumption are substantially underestimated (perhaps because of cultural stigma against cannabis use) or local law enforcement is extremely effective in seizing the cannabis circulating in these countries.

In Brazil, cannabis is known as "maconha". As reported in the response to the UNODC annual reports questionnaire for 2003, official sources estimate that most (80 per cent) of the cannabis consumed in Brazil (especially in urban centres like São Paulo) comes from Paraguay, with only 20 per cent being produced locally. The cannabis from Paraguay enters Brazil by land or air through the borders of Mato Grosso do Sul and Paraná states, through the neighbouring cities in Paraguay and Brazil of Ciudad del Este and Foz do Iguaçu, Salto del Guairá and Guaíra, Pedro Juan Caballero and Ponta Pora, and Fuerte Olimpo and Pôrto Murtinho. It is then brought to the illicit markets in the states of Rio de Janeiro, São Paulo, Espírito Santo, Minas Gerais, Paraná, Santa Catarina, Rio Grande do Sul, Goiás and the

Federal District. It sometimes reaches the north-eastern region of Brazil, from Bahia to Rio Grande do Norte states [164].

Cannabis produced in the north-eastern region of Brazil is primarily destined for domestic use, according to the Government of the United States, which states that drug production is not an issue in Brazil: "with the exception of some cannabis grown in the interior of the north-east region, which is primarily consumed domestically . . ." [149] Estimates of the area under cultivation in the north-eastern part of Brazil vary widely, from 3,500 hectares to 118,000 hectares. Production is said to involve plantation style operations, utilizing forced labour, with connections to urban-based organized criminal groups ([165], pp. 9-10).

It is true that most of the eradication in Brazil today occurs in the north-east of the country, in particular the Submédio São Francisco region, where cultivation began in the mid-1980s, but also in Maranhão, Rio Grande do Norte and Paraíba states. However, large numbers of cannabis plants (over 1 million) have also been eradicated in other parts of the north as recently as 2001. Processed cannabis seizures are highest not in the north-east but in the mid-western, south-eastern and southern parts of the country. There are also reports of cultivation in the Bahia and Pernambuco region (the so-called "cannabis polygon"), along the border with Paraguay (Mato Grosso), and in the south-east (the interior of São Paulo, Ribeirão Preto and Bauru states) ([165], pp. 9-10).

Cannabis grown in Brazil supposedly has a 90-day production cycle, allowing three to four annual harvests in the irrigated areas of the north-east and three harvests in the rain-fed areas of the north. Farmers are estimated to make as much as $150 per month (on average) by growing cannabis. The price of 1 kilogram of cannabis at the producer level is less than $30. This can be sold for approximately $220 on the streets [164].

Cannabis is marketed in the favelas of Rio de Janeiro by three competing families of drug gangs, which also sell cocaine. All of these families emanated from prison gangs: the *Comando Vermelho*, the *Terceiro Comando* and the *Amigos dos Amigos*. These factions compete violently for the more profitable sales points (*bocas de fumo*), with additional violence applied within the groups, between the groups and communities and against the police.

In addition to being the primary source of cannabis sold in Brazil, Argentina, Chile and Uruguay all claim that nearly all the cannabis in their countries comes from Paraguay. For example, in 2003, Uruguay, a country with a 1.5 per cent annual use rate, seized only 30 cannabis plants. It credits Paraguay as the source of 100 per cent of the cannabis consumed, with most of it arriving by air.

In 2004, authorities in Paraguay destroyed 753 hectares of an estimated 5,500 hectares under cannabis cultivation [149], an area that is about the same

size as the area cultivated in Colombia. In 2005, authorities estimated the total land area under cultivation to be 6,000 hectares, comprising two harvests of 3,000 hectares each (cultivars have been introduced that can grow during the dry season), producing 15,000 tons of cannabis, 85 per cent of which is destined for the Brazilian market, 10-15 per cent of which is for other Southern Cone countries and 2-3 per cent of which is for local consumption ([166], p. 1). The authorities in Paraguay estimate the yield of cannabis crops at 3 tons per hectare [167]. Since it does not appear that this is a result of multiple harvests on the same ground, more research is required to understand this high level of productivity. Many of the trafficking organizations in Paraguay are headed by Brazilian nationals ([166], p. 1). In 2002, Brazilians comprised some 20 per cent of the people arrested for drug crimes in Paraguay [168].

Paraguay has also been the source of some significant seizures of cannabis resin, apparently of local origin. "Cera paraguaya" is the name given to the small balls (about 3 grams each) of cannabis resin produced in that country. They are trafficked to Argentina and Brazil.

Colombia has long been the region's primary exporter of cannabis, cocaine and heroin. In the 1970s, when deliveries from Colombia to the United States were at their peak, some 30,000 hectares were estimated to be under cannabis cultivation. More recently, the United States has estimated that 5,000 hectares have been under cannabis cultivation every year since 1996, with a potential yield of 4,000 tons, of which less than 6 per cent was seized in Colombia. The authorities in Colombia report eradicating 20 hectares and estimate that 2,000 remained for production. Most of this is produced in the areas of Magdalena, Guajira, Cesar and Cauca. Colombian authorities also eradicated some 11,000 cannabis plants in three major operations.

Chile, the country with the highest reported per capita use levels in the region, destroyed nearly 80,000 cannabis plants in 2003 (about 8 tons of potential cannabis), showing sizeable domestic production, mostly in the centre of the country. It estimates local production capacity at about 80 tons, suggesting a reasonable 10 per cent eradication rate. Despite this, the Government of Chile estimates that 78 per cent of its supply comes from Paraguay, that some 20 per cent of the cannabis consumed locally is of unknown origin and that about 2 per cent is from Peru. Some 4 tons of cannabis were seized in 2003; since Chile is not part of an obvious trafficking route to anywhere, these were probably intended to be consumed in the country.

The authorities in Peru say that all the cannabis consumed in their country is locally produced, mostly around the cities of Huánuco and Lima and in the region of San Martin, and that 100 per cent of the locally produced cannabis is locally consumed. Over 19 tons of cannabis were seized in 2003 and over 17 tons of cannabis plants were destroyed.

In 1998 and 2000, Ecuador seized about 18 tons of cannabis, but this performance has not been approximated in any other recent year.

Between 5 and 19 tons of cannabis have been seized in the Bolivarian Republic of Venezuela every year since 1996, 100 per cent of which is said to come from Colombia and about 30 per cent of which is said to be destined for the local market and 70 per cent for various Caribbean islands. Most of this is brought in on the highways, hidden in passenger cars or among foodstuffs in commercial vehicles. The Government of the Bolivarian Republic of Venezuela asserts in its response to the UNODC annual reports questionnaire for 2003 that "Venezuela is a transit country, not a production country."

In Bolivia, the cultivation of cannabis has been found in the regions of Tarija, Chuquisaca and Cochabamba [169].

Some cannabis is produced in Argentina and about 14,000 cannabis plants were eradicated from small patches in 2003, but most cannabis found in Argentina is said to come from Paraguay. Cannabis is moved across the river border with Paraguay and through the provinces of Misiones and Corrientes [149]. According to the response of Argentina to the UNODC annual reports questionnaire for 2003, about 40 per cent of this product will continue on to Chile. The Federal Police and Naval Prefecture of Argentina, in a joint operation in October 2003, seized 5,984 "small balls" of cannabis resin [170], most likely "cera paraguaya".

While cannabis is cultivated and consumed in most Central American countries, exports are small and interdiction capacity is limited. In 1995 and 2000, the Inter-American Observatory on Drugs described Central American seizures as "insignificant" ([171], p. 29). Costa Rica, however, a country with just over four million citizens, claims to have eradicated about two million cannabis plants in 1999, 2000 and 2001, and about one million plants in 2002 and 2003, enough for 100 to 200 tons of production [172].

Herbal cannabis market in Oceania

The market for cannabis herb in Oceania is probably best viewed as many small markets, as there is presently little evidence of widespread cross-island trafficking; there is little need for trafficking, as cannabis plants grow wild in many of the region's countries, including Australia, Fiji, Micronesia (Federated States of), New Zealand, Papua New Guinea and Samoa, as well as in the territory of American Samoa [173].

An estimated 5,000 hectares of cannabis plant are cultivated in Australia in the outdoors [174], often on public lands, but the most commonly detected method of cultivation is actually indoors ([175], p. 34). This combined production exists

almost entirely to supply sizable local demand (14 per cent annual use among those aged 15-64 years in 2004) and almost all cannabis consumed in the country is locally produced. The importation of cannabis into Australia has declined greatly in recent years, owing in part to law enforcement efforts and in part to increased domestic production, in particular indoor production. In 1996-1997, over 24 tons of cannabis were stopped at Australia's borders [176]. In contrast, the 642 detections of imported cannabis in 2003-2004 weighed a total of only 15.3 kilograms, with an average weight of less than 25 grams per detection ([175], p. 33).

Licit hemp production occurs in the Australian states New South Wales, Queensland, Tasmania and Victoria, suggesting illicit outdoor cultivation would be successful in all those areas, but cannabis produced indoors commands twice the price of the product produced outdoors. Authorities report that domestic outdoor cultivation has shifted to a larger number of smaller plots in recent years, in response to interdiction efforts ([124], p. 19).

New Zealand is another country where cannabis production basically meets demand for the drug, and cannabis is neither imported nor exported to any great extent. New Zealand has pursued a considerable crop eradication programme, destroying about half a million cannabis plants annually, but this has had little effect on price [177]. Most plots are situated in the more remote areas of New Zealand's North Island. There appears to be a relationship between cannabis cultivation operations and the manufacture of methamphetamine; the New Zealand authorities reported in the response to the UNODC annual reports questionnaire in 2003 that seven clandestine methamphetamine laboratories had been found during the course of a two-month cannabis spraying operation. Despite this, one cannabis market study concluded: "outdoor cannabis cultivation in New Zealand is currently carried out by a large number of small independent operators and some locally based gang operations, and . . . market violence is not a central feature of the 'business'." [178]

In Papua New Guinea, cannabis is known as "spak brus" and annual use levels are believed to be the highest in the world (30 per cent of those aged 15-64 years in 1995). It was allegedly introduced to the area by Australians after the Second World War, but only reached some of the current cultivation areas during the 1970s [179]. The country produces "nuigini gold", a distinct cultivar characterized by its red stem. "Nuigini gold" was formerly exported to Australia, but is no longer widely available in that country [71]. In 1998-1999, Papua New Guinea was the embarkation point for 30 kilograms of cannabis intercepted by Australian customs authorities, but by 2003-2004, that figure was less than 1 kilogram ([175], p. 34).

Cannabis is produced in remote areas of the highlands in Papua New Guinea, from where it has to be transported by foot, and much of the cultivation appears to be on a small scale. Seizure figures have not been provided to UNODC, but newspaper reports suggest the amounts trafficked are also relatively small [180]. Local

demand is high. In the cities, the drug is dealt by urban street gangsters (known as "raskols").

There have been persistent rumours that the cannabis trade to Australia had fuelled violence in indigenous Papua New Guinea communities, as cannabis was being traded for automatic weapons [181]. It has even been suggested that a submarine was being used in the trade. Nevertheless, if this was ever a major trafficking issue, it does not appear to be one today, if for no other reasons than that large supplies of the weapons in demand are not readily available in Australia and the growth of domestic production of high potency cannabis in Australia seems to have squeezed imports out of the market. If trade is occurring, it seems to be largely opportunistic and to involve lower calibre weapons ([71], p. 62).

In Indonesia, over 200,000 cannabis plants were uprooted by the Government in 2004 and 24 tons of the drug were seized in 2003. The authorities in Indonesia claim that half the local production is consumed domestically, while the other half is exported to Australia, although this conflicts with what the authorities in Australia say. It has been alleged that the Free Aceh Movement was funding itself in part through trafficking in cannabis. The police in Indonesia report recently seizing over 40 tons of cannabis and arresting a number of members of the Movement guarding the production areas. As in other areas where insurgencies are allegedly involved in cannabis, the Movement is said to levy a tax on rural production, which is controlled by Jakarta-based trafficking organizations [37].

Herbal cannabis market in Europe

Cannabis consumption has increased substantially in almost every country in Europe over the past 10 years and Europe currently accounts for about 20 per cent of global cannabis consumption. While Europe is best known for its cannabis resin market, it also possesses a substantial and growing market for cannabis herb. Indeed, in Austria, Belgium, the Czech Republic, Estonia and the Netherlands, the market for cannabis herb is estimated to exceed that of cannabis resin ([10], p. 44). If estimates in respect of the growing market share commanded by home-grown product in the United Kingdom are accurate, then its market for cannabis herb may also be larger. While it is believed that cannabis resin is still more popular in Germany, the margin is small and may be growing smaller. As discussed above, in countries where cannabis herb represents a cheaper source of THC than cannabis resin, resin may be facing a declining market share.

The Netherlands has long been the epicentre of cannabis cultivation in Europe and the world.

The authorities in Belgium report that 90 per cent of the cannabis produced in that country is for export and that cultivation areas are found mostly along the

border with the Netherlands. Despite this, small-scale production for personal consumption appears to be on the increase. According to the response of Belgium to the UNODC annual reports questionnaire for 2003, some 70 per cent of the cultivation operations detected in 2003 involved less than six plants. Groups operating from Belgium and the Netherlands are said to "control" indoor production in France.

In Eastern Europe, Albania remains a major exporter of cannabis herb. Mass production of cannabis began in the southern parts of Albania in the early 1990s ([182], p. 5). Cannabis herb is said to be trafficked by road from Albania through the former Yugoslav Republic of Macedonia and Bulgaria to Turkey ([183], p. 43). All of the cannabis trafficked into Montenegro and Serbia comes from Albania and about half of this amount remains there, with the rest going on to Bosnia and Herzegovina and Croatia. Albanian cannabis is also trafficked to Italy and Greece (according to the UNODC annual reports questionnaire). Cannabis production in the southern areas of Albania is believed to be destined almost exclusively for export to Italy [184]. Drug trafficking groups are said to be small (three to nine members) and linked by family or "clan" ties. The authorities of Albania report an increase in domestic cannabis prices, attributed to enforcement efforts. Cannabis oil has also been detected, according to the response to the UNODC annual reports questionnaire.

Cannabis is also cultivated in Greece and Italy. Some 200,000 cannabis plants were eradicated by the authorities in Italy in 2003. The authorities in Greece uprooted 21,000 plants in 2003, about 40 per cent of which were found on the island of Crete. The growth in Albanian cannabis production is believed to be linked in part to the crackdown on cannabis cultivation in some areas of Greece [184].

In Bulgaria, cannabis is grown in the south-west (Sandanski and Petrich) and in the north and north-west (Silistra and Dobrich). Many of the growers are elderly, and are paid by people linked to organized criminal groups. Production on public lands is also reported [183]. About half the cannabis herb that is trafficked in Bulgaria is domestic in origin, while most of the balance is from Albania and this product may be trafficked on to Greece and Turkey. Some 12 tons of cannabis plants were destroyed in a relatively small number (31) of eradication operations in 2003, suggesting the existence of large-scale cultivation.

About 20 per cent of cannabis herb that is trafficked in Croatia is domestic in origin, with the balance being brought into the country from Bosnia and Herzegovina (about half of the total), Montenegro, Serbia and other countries. About half of this remains in Croatia, while the rest is sent on to Western Europe. All domestically produced cannabis is consumed in the country, however.

The authorities in Poland report cultivation of cannabis plants in central, south-eastern and western Poland in cereal fields, by forest roads, in gardens and in greenhouses. In 2003, the authorities eradicated over 6 hectares of cannabis

plants and seized 32 indoor operations. They estimate that about 45 per cent of locally produced cannabis is destined for export, mainly to Germany and the Netherlands.

As suggested above, the cannabis market in the United Kingdom seems to be undergoing a transition from reliance on imported cannabis herb and cannabis resin to locally produced cannabis herb. Despite this, large amounts of cannabis are still brought into the United Kingdom. A recent example is the seizure of 5 tons of cannabis from Mexico hidden in a shipping container in October 2005 [185].

Herbal cannabis market in Central Asia

Central Asia, in particular Kazakhstan and Kyrgyzstan, contains what appears to be the largest areas of cultivation of cannabis plant in the world. In Kazakhstan's Chui Valley alone, as much as 400,000 hectares of cannabis plant grow wild, with a potential output of 6,000 tons, although the estimated harvest is only 500 tons [186]. This wild cannabis has an unusually high THC content, up to 4 per cent [187], making it viable for low-end international sale and good stock for cannabis resin production. The consensus, however, is that most of this cannabis is consumed in the region and that its value does not warrant long-range trafficking across multiple borders [188]. Thus, while the productive potential of this area remains immense, it is likely to remain unrealized unless circumstances change.

In the Kyrgyzstan districts surveyed by UNODC, approximately 3,005 hectares of cannabis plant were identified, mostly in Jalalabad province and in four districts within the Issyk-Kul province. More than 70 per cent of the cannabis plant cultivation was found either on abandoned farmland or on land being used for agricultural purposes [187].

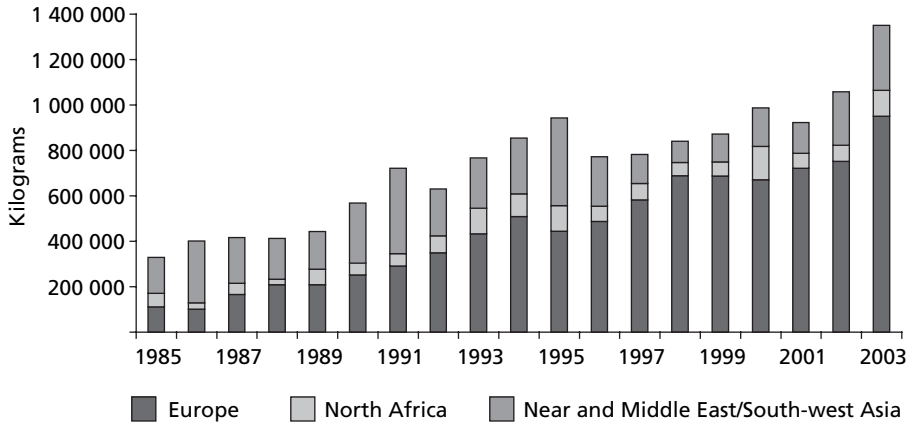
The authorities in the Russian Federation stated in their response to the UNODC annual reports questionnaire for 2004 that 70 per cent of the cannabis herb consumed in that country was locally produced, with another 15 per cent coming from Kazakhstan and Ukraine and 15 per cent coming from Kyrgyzstan and Moldova. In some areas, such as the Russian Far East and the Caucasus region, the demand for cannabis is still almost entirely satisfied by local production [189]. According to the response to the UNODC annual reports questionnaire for 2003, the authorities estimate that 63 per cent of domestic cultivation of cannabis plant occurs in the province of Kursk, with 13 per cent occurring in the Moscow region.

Markets for cannabis resin

Global cannabis resin seizures increased by 25 per cent in 2003 to 1,361 tons, reaching a new all-time high. Cannabis resin seizures increased most significantly

in North Africa (63 per cent), in the Near and Middle East and South-west Asia (21 per cent) (following an increase of 74 per cent a year earlier) and in Europe (26 per cent) (see figure XIV).

Figure XIV. Cannabis resin seizures, 1985-2003



Source: UNODC annual reports questionnaire.

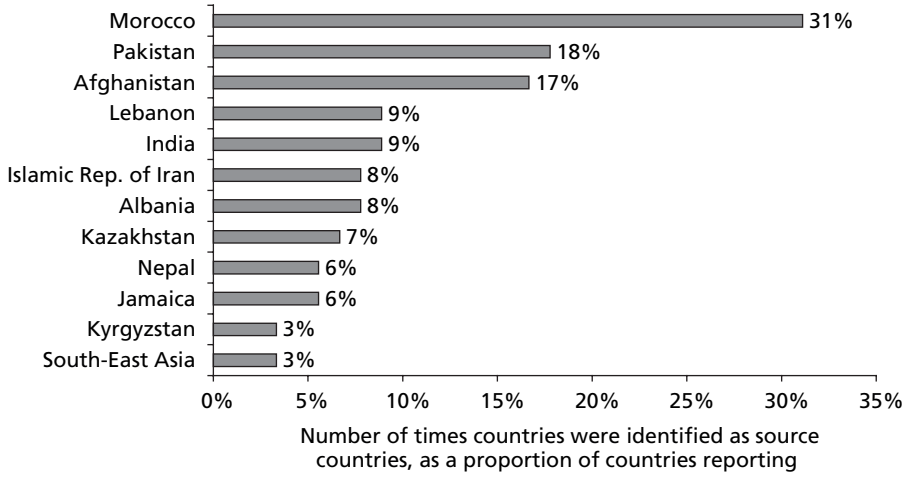
Cannabis resin market in Europe

Over half of the cannabis resin seized in the world in 2003 was seized in Spain (727 tons out of 1,361 tons seized) and 100 per cent of the cannabis resin seized in Spain is believed to come from Morocco. Adding in the rest of West and Central Europe accounts for 70 per cent of the global total (947 tons) and another 96 tons were seized at source in Morocco. Thus, the Western Europe/Morocco cannabis resin market is responsible for just under 80 per cent of global cannabis resin seizures.

The North African expatriate community is an important link in the distribution network for cannabis resin. Some 10 per cent of the people arrested in France in 2003 for trafficking in cannabis were Moroccan or Algerian, and about 12 per cent of the arrests related to cannabis in Italy were of Moroccans, Tunisians or Algerians. The main countries identified as sources of cannabis resin are shown in figure XV.

Morocco is said to supply all of the cannabis resin consumed in Portugal and Spain, 82 per cent of the cannabis resin consumed in France, 80 per cent of that consumed in Belgium, 85 per cent of that consumed in Sweden and 70 per cent of that consumed in the Czech Republic. Much of the cannabis resin transits the Netherlands and Spain before being shipped to other countries. The remainder of

Figure XV. Main sources of cannabis resin, 1999-2003[a]



[a]Based on information from 90 countries.

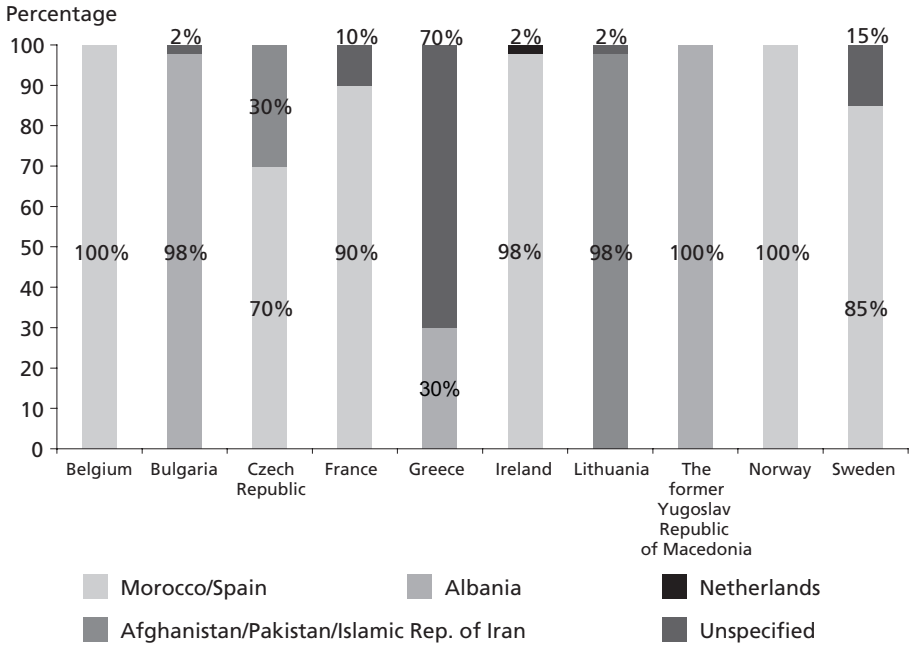
Source: Responses to UNODC annual reports questionnaires.

the cannabis resin supply originates in Afghanistan or Pakistan (e.g. 10 per cent of the cannabis resin consumed in Belgium and 30 per cent of that consumed in the Czech Republic), Central Asia (mostly for the Russian Federation, other members of the Commonwealth of Independent States (CIS) and some of the Baltic countries) or from within Europe (mainly Albania, supplying the markets of various Balkan countries and Greece) (see figure XVI).

In Germany, the bulk of cannabis products seized when entering the country in 2003 came from two sources: relatively small shipments (average about 2 kilograms) from the Netherlands, or massive shipments (average about 1 ton) directly from Morocco (together amounting to about 3.5 tons, out of 8.6 tons imported). Spain was also the origin of a significant amount (just under 1 ton) of medium-sized shipments (average 15 kilograms). In 2004, the size of the shipments of cannabis originating in Morocco dropped drastically (to an average of 64 kilograms) and the leading source of cannabis became clearly the Netherlands, responsible for half of the volume and 78 per cent of the incidents ([190], p. 35).

As noted above, the world's most significant source of cannabis resin for the Western European market is Morocco. About 80 per cent of cannabis resin seized in Western Europe is estimated to have originated in Morocco. Since cannabis resin is the primary form of cannabis consumed in most of Europe, an analysis of cannabis production for the European market must focus on Morocco.

Figure XVI. Sources of trafficked cannabis resin in selected European countries



Source: Responses to UNODC annual reports questionnaires.

UNODC and the Government of Morocco conducted comprehensive cannabis resin surveys of the country in 2003, 2004 and 2005. The resulting estimates are based on the analysis of satellite photographs (from SPOT 5 and IKONOS)* covering the whole of the Rif area of northern Morocco, and subsequent ground truthing. The 2003 survey placed total cannabis resin production at about 3,070 tons, cultivated on 134,000 hectares of land in the Rif region (equivalent to 10 per cent of the total land or 27 per cent of the agricultural area in the five provinces** investigated) by some 96,600 families, providing income for some 800,000 people in the region. This was significantly higher than the previous estimate by the European Union of 80,000-85,000 hectares for the late 1990s ([191], p. 514) or the 44,500 hectares estimated by the Moroccan authorities in 1995.

The 2004 survey showed a 10 per cent decline in the land dedicated to cannabis plant cultivation (120,500 hectares), with production falling to 2,760 tons ([54], p. 5). This decline was mainly because of lower levels of cannabis plant cultivation

*The survey was based on an analysis of 16 SPOT 5 (multispectral, 10 metre resolution) and 13 IKONOS (panchromatic, 1 metre resolution) photographs.

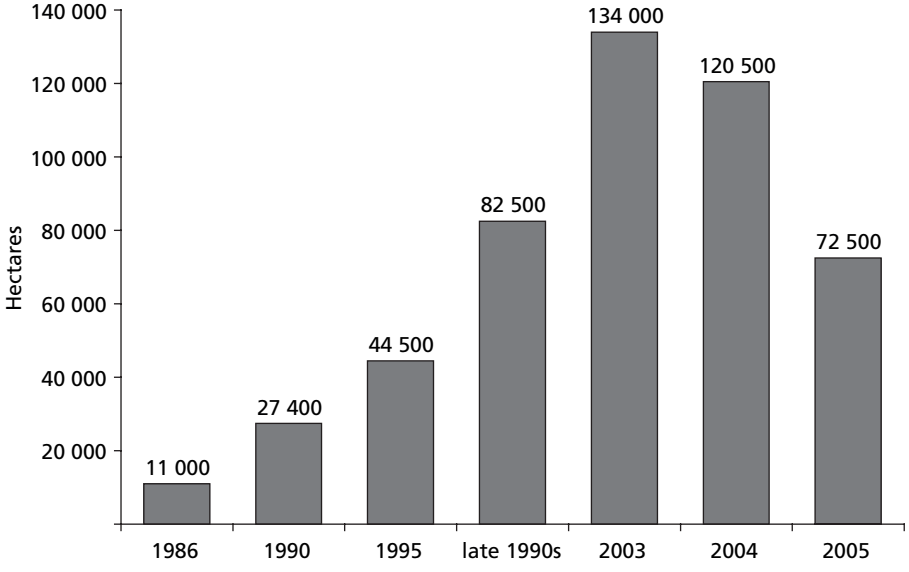
**Al Hoceima, Chechaouene, Larache, Taounate and Tétouan.

in the provinces of Taounate (-43 per cent) and Al Hoceima (-54 per cent), an indirect consequence of the earthquake in early 2004, which led to increased interest and assistance from the authorities. Most cannabis was produced in the province of Chechaouene (50 per cent in 2003 and 62 per cent in 2004).

In 2005, drought caused a drastic reduction in cannabis cultivation, down 40 per cent to only 72,500 hectares. Since much of this production (80 per cent) was on rain-fed land, total cannabis production slid even more drastically, down 43 per cent to 53,300 tons. Further, the cannabis resin extraction rate also dropped, from 2.8 per cent to 2 per cent, resulting in a 62 per cent drop in cannabis resin production, down to just over 1,000 tons ([192], p. 4).

The area dedicated to cannabis plant cultivation of 120,500 hectares in Morocco in 2004 (see figure XVII) was less than the area found in a previous UNODC cannabis survey in Kazakhstan (330,000 hectares in 1998/1999; although most of this was "wild cannabis") [193] and less than opium poppy cultivation in Afghanistan in 2004 (131,000 hectares), but more than opium poppy cultivation in Myanmar (44,200 hectares) or the Lao People's Democratic Republic (6,200 hectares) and more than the area under coca bush cultivation in Colombia (80,000 hectares), Peru (50,300 hectares) or Bolivia (27,700 hectares) ([116], pp. 41 and 61).

Figure XVII. Area under cannabis plant cultivation in Morocco, 1986-2005



Sources: UNODC, Maroc: enquête sur le cannabis 2004 [8]; UNODC, annual reports questionnaire data; United States Department of State, Bureau for International Narcotics and Law Enforcement Affairs, International Narcotics Control Strategy Report [192].

Despite the decline of cannabis production in Morocco to 2,760 tons in 2004, production is still higher than in the late 1990s, when it was estimated at around 2,000 tons per annum ([191] p. 514). The increase in production also meant that prices of cannabis resin at the point of source declined, from around 7,000 Moroccan dirhams per kilogram (equivalent to €690 per kilogram) in 1999/2000 to an average of 1,400 dirhams per kilogram (€125 per kilogram) in 2004 ([54] p. 5).*

The yield estimates for 2004 were based on a scientific yield study, conducted on 30 plots across the five provinces of the survey. The yield on rain-fed land was found to amount to 750 kilograms per hectare and the yield on irrigated land was on average 1,270 kilograms per hectare in 2004. The rain-fed area amounted to 106,100 hectares; the irrigated area was 14,500 hectares. Thus, total production of cannabis material was estimated at 98,000 tons. Out of this cannabis material, the farmers produced 1,019 tons of first quality cannabis resin, 921 tons of second quality cannabis resin and 823 tons of third quality cannabis resin, i.e. in total some 2,760 tons of cannabis resin (This was equivalent to 2.8 per cent of all cannabis material) ([54] p. 42).

Subsequent analysis of the THC content, based on samples from the 30 plots in the survey, revealed that the dry cannabis leaf had, on average, a THC content of 1.2 per cent; the dried flowering tops had a THC content of, on average, 2.7 per cent (with a confidence interval of 2.1-3.4 per cent) and the cannabis resin had on average a THC content of 8.3 per cent (with a confidence interval of 7.1-9.4 per cent), with a THC content of the samples analysed ranging from 5.5 to 11.3 per cent ([54], pp. 29-33).

The income for the farmers from the production of cannabis resin was around €260 million in 2004, equivalent to 0.7 per cent of the gross domestic product of Morocco. The amount of money earned from Moroccan cannabis resin in Western Europe (deducting seizures made in Morocco and in Western Europe) was estimated at around €10.8 billion.

Despite the decline of cannabis production in Morocco in 2004, both seizures and estimates of consumption of cannabis resin suggest that the long-term trend since the early 1990s is towards a growth in global production. The *World Drug Report 2004* [194] placed global production at between 5,100 and 7,400 tons. The *World Drug Report 2005* [116] put production at the high end of that range. It would appear that more than 40 per cent of the global cannabis resin supply is being produced in Northern Africa and more than a quarter in the Near and Middle East ([116], p. 83). These two regions account for more than two thirds of global cannabis resin production. Other cannabis resin producing regions of importance are Central Asia, South Asia and, to a lesser extent, South-eastern Europe and the Caribbean.

*Some of the decline appears to have been a consequence of an earthquake, resulting in increased attention being given by the national authorities and the international community to the region concerned.

Cannabis resin market in Central Asia

The second largest market for cannabis resin is the Near and Middle East/ South-western Asia region. This region is mainly supplied with cannabis resin produced in Afghanistan and Pakistan and, to a lesser degree, from cannabis resin originating in Lebanon. Some of the cannabis resin from Afghanistan and Pakistan is also being shipped to Canada and to countries in Eastern Africa.

Afghanistan has long been a centre of cannabis resin production, both for regional use and for export to Europe. While today Afghanistan commands only a minority share of the market for cannabis resin in Europe, production remains considerable. Cannabis plants are grown like a hedge around opium poppy plots, with the same farmers cultivating both drugs.

According to the official response to the 2004 UNODC annual reports questionnaire, in 2003 the authorities in Afghanistan reported the area under cannabis plant cultivation to be 52,000 hectares, compared to 80,000 hectares of opium poppy in that year. Each hectare is said to produce 85 kg of cannabis resin a year. This indicates the harvesting of two crops of about 4 per cent yield. Estimated total cannabis resin production was thus 4,420 tons according to the authorities in Afghanistan.

Cannabis production was reported to take place in most provinces of Afghanistan. Research by UNODC in connection with the annual opium survey suggested a cultivation area of about 30,000 hectares. This information was based on interviews with farmers in villages throughout the country. According to these sources, two thirds of the cannabis plant cultivation occurs in just three provinces: Sari Pul (33 per cent), Balkh (18 per cent) and Paktya (17 per cent). Interviews with village leaders produced slightly different results, with both Kandahar and Nangahar also figuring prominently. About two thirds of the villages where villagers said they grew cannabis plant also said they produced opium.

In Afghanistan in 2003, there were more people arrested for cannabis trafficking (62) than for heroin trafficking (41). Cannabis seizures were exclusively of cannabis in the form of cannabis resin (81.2 tons). This accounted for 20 per cent of all seizures made in Afghanistan in 2003. Trafficking in cannabis resin was reported to have increased, with the product going mainly to central Pakistan (often going via Peshawar, crossing the Torkham border) and to the Islamic Republic of Iran and Central Asia (Tajikistan and Turkmenistan). Domestic cannabis trafficking patterns included the movement of cannabis resin from Kunduz, Baghlan, Balkh, Samangan and Sari Pul to Ghor province and then to the Islamic Republic of Iran, as well as cannabis resin from Badakhshan, Takhar, Mazari Sharif, Kunduz, Paktya, Logar and Kapisa being trafficked to markets in Peshawar, Pakistan. The Government of Afghanistan reports that 5 per cent of the cannabis is locally consumed, while the rest is exported.

Most of the processing of the cannabis is reported to take place in the regions bordering with Pakistan. It is processed in the inaccessible areas of Pakistan's Orakzai and Kurram tribal agencies and the Tirah area of the Khyber agency [195]. It is thus difficult to differentiate between cannabis products from Afghanistan and from Pakistan and, while it is widely believed that cannabis is produced throughout Pakistan, it would appear that the bulk of the cultivation occurs on the Afghan side of the border.

Turkey reports that about half of the resin trafficked into that country comes from Lebanon, with 27 per cent coming from the Syrian Arab Republic and 18 per cent coming from the Islamic Republic of Iran. Lesser amounts are also said to come from Jordan. The authorities in both Jordan and the Syrian Arab Republic assert that all this cannabis resin comes from Lebanon. Nationals of the Islamic Republic of Iran are said to be involved in trafficking cannabis resin into Turkey. In 2003, unlike the previous year, no cannabis was detected coming in from Albania. The cannabis plant grows wild in Turkey and production of cannabis herb is known to occur in more than 15 provinces, of which Kastamonu and Ağri are the largest known producers, accounting for 40 per cent of the total.

Lebanon was once the world's leading producer of cannabis resin. In the late 1980s, cultivation of cannabis plant was estimated to cover as many as 11,000 to 16,000 hectares, yielding up to 1,000 tons of cannabis resin. In the period 1991-1993, forces in Lebanon and the Syrian Arab Republic eradicated illicit cultivation in the Bekaa Valley, Lebanon. Despite this, 40 tons were seized in 1994 [196]. The authorities in Lebanon assert that 98.8 per cent of the cannabis resin produced in the country is also consumed there, with a small share being exported to Bulgaria and Dubai, United Arab Emirates. Most production in Lebanon today occurs in the Bekaa Valley, in the areas of Baalbek and Hermel.

The authorities of the Syrian Arab Republic say 100 per cent of the cannabis resin trafficked in their country comes from Lebanon, and that 95 per cent of it is headed to the Gulf States, with 5 per cent being destined for Turkey. They assert that there is no drug production in the Syrian Arab Republic.

Cannabis herb and cannabis resin markets of Asia

Asia as a whole has the lowest per capita rate of cannabis consumption of any major region in the world (2.2 per cent), but sheer population size means that it is home to the largest number of users. Cannabis also commands a smaller share of treatment demand in Asia than in any other major region (13 per cent).

Asia does host some cannabis supplier countries, however. In Nepal, cannabis plant is cultivated in the southern parts of the country and grows wild through much of the north. Cannabis resin produced in Nepal is trafficked around the

world, with seizures made in Canada, Denmark, the Hong Kong Special Administrative Region (SAR) of China, New Zealand and the United Kingdom. There have been claims that Maoist revolutionary groups are using cannabis to fund their insurgency. Maoist groups are known to have called upon local residents in the Birgunj area of Nepal to increase cannabis production. The authorities of Nepal report that the Maoist groups levy a 40 per cent tax on cannabis production in certain areas [37, 197]. There is evidence that the Maoist insurgents both charge a levy on cannabis resin passing through territory they control and operate a system whereby growers are authorized to cultivate a certain hectarage per year for the payment of a fee [198].

In India, cannabis herb is known as "ganja", a name whose usage has spread to the many parts of the world with substantial Indian expatriate and immigrant communities. While exports are comparatively light, India is a major cannabis consumer country. In 2004, UNODC and the Ministry of Social Justice and Empowerment of India jointly released the National Survey on the Extent, Pattern and Trends of Drug Abuse in India, the first of its kind. It showed that 2.3 million Indians were dependent on cannabis [198].

Cannabis resin found in India is imported from Afghanistan, Nepal and Pakistan. It is smuggled into India from Nepal across the land border in the states of Bihar and Uttar Pradesh, from where it finds its way to New Delhi and Mumbai [198]. It is also produced in India itself, especially in the Kullu Valley in Himachal Pradesh. In addition, cannabis plants are grown in Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Kerala and Manipur states. In 2004, the Government of India eradicated 214 hectares of cannabis plant. Authorities say that while a percentage of Indian produced cannabis products are destined for export, the vast majority are consumed locally [199]. Cannabis resin from Nepal is trans-shipped through India to other destinations.

Sri Lanka is said to have about 500 hectares under cannabis plant cultivation, especially in the east and the south of the country. The estimated number of regular users is 600,000.

The authorities of Bangladesh say their country receives all its cannabis resin from India and that all of it is consumed locally. About 60 per cent of the cannabis herb in the country is produced domestically, with about 32 per cent being imported from India and 8 per cent coming from Nepal. About 30 per cent of the imported cannabis found in the country is destined for export to Europe. Cannabis is cultivated in the districts of Naogaon, Rajshahi, Jamalpur and Netrokona in the north-western region, as well as the hilly districts near Cox's Bazaar, Bandarban, Khagrachari and Rangamati in the south-east (bordering Myanmar) [198].

Despite substantial industrial cultivation, cannabis use is not believed to be widespread in China. The drug has been seized in the special economic areas of

Shenzhen, Zhuhai and Shantau, all of which border on Guangdong province, which is close to the Hong Kong and Macau SARs of China. The seized cannabis was produced in Cambodia and Thailand. Eradication campaigns have been carried out in Yunnan province and Xinjiang Uighur Autonomous Region of China. In Xinjiang, cannabis is produced solely for making cannabis resin. Cannabis is marketed by local ethnic minorities and, in Beijing, by Afghan and Pakistani expatriates. Street dealers in Beijing are often unemployed men, waiters and kebab salesmen, while wholesalers are often restaurant owners ([198], p. 62). In the Hong Kong SAR of China, cannabis herb is imported from the Golden Triangle, Cambodia and the Netherlands (sinsemilla), often via South Africa, Dubai or Thailand, whereas cannabis resin is imported from South Asia.

Cannabis plant also continues to be cultivated in and smuggled out of Cambodia, the Lao People's Democratic Republic, Indonesia, Myanmar and Thailand. Information from customs authorities suggest that Indonesia and Thailand are also sources of cannabis resin.

Some 14 hectares of cannabis plant were eradicated in Cambodia in 2004 and production is said to be as much as 1,000 tons. Analysis of seizures in recent years indicates that Europe is the major destination for Cambodian cannabis, with other destinations including Australia, the United States and Africa. Much of the production occurs in Cambodia's north-western provinces and is reputed to be "contract cultivation", carried out by Cambodians operating with the financial help and under the control or influence of foreign (especially Thai) criminal syndicates.

A similar phenomenon is seen in the Lao People's Democratic Republic, where low-grade cannabis production largely takes place in the lowlands, in the southern part of the country, and in particular in areas near to the Mekong River (provinces of Vientiane, Bolikhamxai, Salavan, Champasak and Savannakhet). Most of this is for export to Thailand, undertaken on contract for Thai organized criminal groups, who advance money and consolidate production emanating from Cambodia, the Lao People's Democratic Republic and Thailand [200].

Some of this produce is trans-shipped through Viet Nam, confusing its source of origin, while cultivation in Viet Nam is said to be "insignificant" [201]. However, the Vietnamese were once producers of potent cannabis for export to the United States market. Today, Vietnamese nationals have been implicated in cannabis plant cultivation, particularly indoor, soil-based cultivation, in Australia, Canada, the United Kingdom and the north-eastern United States. Viet Nam has a long tradition of cannabis plant cultivation [202], but it has been suggested that widespread cultivation to produce cannabis for psychoactive purposes was taken up only when the practice was introduced by servicemen from the United States during the Viet Nam war.*

*Ayres, cited in Brecher [132].

Cannabis plant cultivation in the Philippines appears to have increased dramatically, with 107 plantations identified in 2005, up from just 9 three decades earlier [203]. In the Philippines in 2004, using manual eradication, the Government destroyed 2,361,581 cannabis plants and seedlings. The largest areas of cannabis plant cultivation are the mountainous areas of Northern Luzon (particularly the Cordillera Administrative Region), Regions 1 and 2, Regions 6 and 7 in Central Visayas, Davao Oriental and Davao del Sur in Eastern Mindanao, and Sulu, Maguindanao and other adjoining provinces in south-western Mindanao [204]. The Communist group the New People's Army is said to provide protection to growers in the northern areas in exchange for a "revolutionary tax". The Abu Sayyaf Group also collects protection money and controls a thriving production site for cannabis herb in Basilan. Most of the cannabis herb produced in the Philippines is for local consumption, with the remainder supposedly smuggled to Australia, Japan, Malaysia, Taiwan Province of China and Europe [149].

IV. IMPACT

Potency

It is clear that a large number of people in various countries have worked very hard over the course of decades to produce more potent cannabis. But it is still being debated whether their work has had any impact on the potency of the global cannabis supply. As early as 1980, claims were made that cannabis potency had increased by a factor of 10 (from 0.2 to 2 per cent) over a period of five years ([205], p. 12). There have been subsequent claims that cannabis potency has increased by a factor of 30 or even 60 since the 1970s. These claims have been criticized as exaggerated as they rely on the very low THC levels found in some early tests, which may have been inaccurate owing to storage problems and other methodological difficulties.

Claims of extreme increases in potency have cast doubt on the general argument that cannabis today is different than cannabis was in the past. This is unfortunate, because there can be little doubt that cannabis has changed, and that it is possible to mass produce cannabis today of a potency level that would have been unimaginable just 25 years ago. The real question is what share of the market this high-potency cannabis presently commands. Two data sources have been advanced to answer this question. One is the average potency figures from scientific testing and the other is survey data from users on which forms of cannabis they consume. The former suffers from a lack of randomness in the selection of samples tested and other methodological difficulties, and the latter suffers from the limited ability of users to distinguish accurately high-potency and low-potency forms of the drug.

The potency debate has generally hinged on measurements from police forensic testing. This information is collected for other purposes, not to create internationally comparable, time-series data. There is really no systematic programme monitoring cannabis potency levels anywhere in the world. Probably the closest is the United States Marijuana Potency Monitoring Project, but this programme does not involve a random sampling of the cannabis available in the country.* From this core problem are derived several others, relating to terminology, sampling and more technical aspects of testing.

*The Marijuana Potency Monitoring Project in the United States analyses only samples seized under the supervision of the national (federal) Government. These may be expected to differ from those consumed by the general public, given the level at which most federal efforts are pitched, including large-scale and import interdiction. This is especially important given the data on the extent of small-scale production and social network distribution, as indicated in the survey data discussed in the opening to section II of the present review (trafficking).

First, there is no universal agreement on how the various cannabis products are defined. In some jurisdictions, no distinction is made between cannabis herb and cannabis resin and THC figures are simply aggregated. The various grades of cannabis herb are rarely captured, although some countries do distinguish between sinsemilla and other forms of cannabis herb. Differences in terminology make comparative work difficult.

Secondly, laboratories generally test THC levels when requested to do so by the police. This cannot be said to be a truly random sample of either the cannabis seized or the cannabis available in a society. Depending on enforcement priorities, the police may be more likely to seize certain types of cannabis (e.g. low potency imports at borders, rather than home-grown sinsemilla that is not sold to the general public). They may send samples about which they are especially curious, including samples connected to large seizures or expected to possess high levels of THC.

Another sampling issue relates to the parts of the plant that are tested. Laboratories generally test what they are given and most do not attempt to prepare it in such a way as to mimic the product actually used by the public. In other words, most laboratories test the THC levels of what is sold, not what is consumed. Since seeds may be included in non-sinsemilla samples, this may result in artificially low THC levels for low-grade cannabis. Even for sinsemilla, the presence of stems or other extraneous material results in a THC reading lower than that of the product that is actually consumed. In addition, there is often no attempt to weight the samples tested in terms of the size of the overall seizure made by the police. A single, high-potency cannabis cigarette could be given as much weight in aggregated national figures, for example, as a container-load of low-grade cannabis.

There are also complications related to the nature of cannabis itself. THC degrades over time, so the age of the sample and the conditions under which it was stored are highly relevant. The moisture content also varies greatly and, for this reason, samples seized on the street cannot be compared to samples taken during field eradication, unless the moisture levels are standardized.

Since different laboratories conduct THC testing for different purposes, comparing findings is difficult. Differing techniques are evident in the fact that some Western European countries where most cannabis resin comes from Morocco, such as Italy and Portugal, report dramatically different THC levels. Even within a given jurisdiction, techniques have improved over time. This makes comparing figures between countries or over time difficult.

Combining the forensic data with other information sources, however, gives good reason to believe that high-end cannabis is more potent than in the past and that this product is commanding a growing share of the market in many important consumer countries.

First, there can be little doubt that knowledge about the cultivation of cannabis plant and use of cannabis as a drug has improved since the 1960s. The medical cannabis provider in Canada, Prairie Plant Systems Inc., is able to mass produce 14 per cent THC cannabis herb. While individual samples of similar or greater potency may have been found in the past, it is highly unlikely that any cannabis producer operating 30 years ago would have been able to achieve anywhere near this performance. The sinsemilla technique, selective breeding for potency, more selective cleaning of cannabis herb, a greater understanding of ripeness, curing and storage techniques and improvements in cultivation technology have made it possible to produce a far more potent product than was possible in the past.

However, just because the technology exists does not mean that cultivators use it. In many countries, cultivators lack the knowledge, the resources and the incentive to produce better quality cannabis. The market for the low-potency product remains strong and producing higher quality requires both more work and more input costs. One of the great advantages of cannabis as a crop is that it requires little tending and so small-scale cultivators in poor areas can maintain a lucrative plot on the side without having to give up other productive activities. Even if a cannabis farmer in a developing country wanted to improve potency, he would have to find a market for the product. Local consumers may not be able to afford his produce and his international connections would be linked to established low-potency markets.

A good example is found in Morocco. The cannabis from which Moroccan cannabis resin is produced is not strong enough to be sold to Europe as cannabis herb. Tests conducted in Morocco show a THC content of 1.2 per cent for dried cannabis leaves, with the dried flowering tops averaging 2.7 per cent [54]. There are several reasons for this. The practice in Morocco of cultivating cannabis plant outdoors in an area that is awash with pollen at the end of the season means that sinsemilla cannot be grown. Given limited indoor space, most Moroccans sun-dry their harvest and the heat and light degrade the THC content. While there has long been Western influence in production of cannabis resin in Morocco (indeed, it is said that Western hippies taught the Moroccans to make “hashish”), efforts to introduce improved technology to the process have largely failed. For example, improved breeds are immediately crossed with the local plant, eroding potency. In the end, though, the Moroccans have little incentive to change. Their product dominates the well-established European market for cannabis resin for a number of reasons, the most significant being proximity and established smuggling routes.

Thus, a higher potential potency does not necessarily mean an increase in the average potency consumed by users. In order to understand the real impact of the new technology used in cultivating cannabis plant, the relative market shares of the high-end and low-end markets need to be observed over time.

The 2004 EMCDDA study on cannabis potency in Europe [10] is probably the best recent cross-national study of forensic information. The study cites estimates of the market share of four product types in Europe: imported cannabis herb, imported cannabis resin, sinsemilla and domestic resin. Most cannabis consumers prefer one product or the other (similar to the preferences of powder-cocaine and crack-cocaine users), so the herbal and resin markets should be seen as distinct, not agglomerated. Within the herbal cannabis market, data distinguishing between sinsemilla and imported cannabis were available for only three countries: Ireland, the Netherlands and the United Kingdom.

- In the Netherlands, 67 per cent of the cannabis consumed is sinsemilla, 29 per cent imported resin, 3 per cent imported cannabis herb and 1 per cent domestic resin.
- In the United Kingdom, in contrast, sinsemilla holds only 15 per cent of the total market, but it holds 50 per cent of the herbal cannabis market. In other words, imported cannabis herb also holds 15 per cent of the market and imported cannabis resin 70 per cent. Other analysts suggest that as much as half the cannabis consumed in the United Kingdom might be produced domestically. Most of this is likely to be indoor-produced sinsemilla from high-potency strains [66].
- In Ireland, herbal cannabis is also evenly split between local sinsemilla and imports, with most of the market (90 per cent) being imported cannabis resin.

Thus, for the three European countries for which sinsemilla information was available, the sinsemilla market either equalled or exceeded the herbal cannabis import market.

The EMCDDA estimates for the market share of sinsemilla in the United States are much more modest: only 5 per cent. This is surprising, because the share of cannabis cultivation operations that are located indoors in the United States has increased in recent years, from 2 per cent indoor cultivation in 1985 to 7 per cent in 2003, with the greatest change being seen between 1989 and 1992 ([206], table 4.38). According to the United States *National Drug Threat Assessment 2005*, the prevalence of sinsemilla is growing in the United States ([37], p. 41). Indeed, in a national survey of law enforcement agencies, more police officers said that indoor production of cannabis plant took place in their jurisdictions (76 per cent) than outdoor production (75 per cent), while 44 per cent reported that hydroponic production took place in their area ([37], p. 41). This does not necessarily mean that more cannabis is produced indoors than outdoors in the United States, but it does indicate that indoor production is very widespread.

In addition, Canada is playing an increasingly important role in cannabis imports to the United States, contributing 20 per cent of the cannabis imported into the United States in 2003, according to the response to the UNODC annual

reports questionnaire for 2003. Most of this imported product is grown indoors. Between 1997 and 2000, some 78 per cent of cannabis production operations detected in British Columbia, the Canadian province that produces over 40 per cent of the detected cannabis plant cultivation operations in the country and a major supplier to the United States, were indoors. The number of detected indoor operations tripled during the same time period [207]. A slightly lower share of all operations detected in the country were indoors [36]. Canadian authorities consider all the cannabis they test to be sinsemilla and average potency levels were 9.6 per cent in 2003, compared with 7.4 per cent for United States sinsemilla [122]. The trend has been towards larger and larger indoor operations, due in part to the growing involvement of organized criminal groups in production operations [124]. In January 2004, an operation was discovered inside a former brewery in Ontario that involved over 20,000 cannabis plants. Aside from what this says about the domination of sinsemilla in Canada, United States sources estimate that Canada produces about 12 per cent of the cannabis consumed in the country (about 1,000 tons per annum) ([208], p. 12). This would suggest that Canadian sinsemilla imports alone should comprise more than 8 per cent of the United States market. Add this to domestic sinsemilla production and its market share should be much higher than the EMCDDA estimate.

Other countries have also shown a growing market for indoor, sinsemilla, high-potency cannabis. In New Zealand, the number of national survey respondents who had ever used "skunk" increased from 10 per cent in 1998 to 14 per cent in 2001 ([60], p. 31). In the United Kingdom, Atha and others concluded that "skunk" was the only type of herbal cannabis to improve its market share among regular users between 1994 and 1997, up to just under 10 per cent ([35], p. 25). In Australia, after many years of winning market share from both imports and a remarkable outdoor industry [209], hydroponic production is now the most commonly detected method of cultivating cannabis ([175], p. 34). Survey data indicate that 94 per cent of Australian daily cannabis smokers, as well as 88 per cent of weekly smokers, typically smoked a more potent form of cannabis. These users consume an estimated 96 per cent of the cannabis smoked in the country [210], so the bulk of the market must cater to the high potency demand. In 2003, the authorities in Hong Kong SAR of China noted for the first time the importation of "buds" from the Netherlands (according to the response to the UNODC annual reports questionnaire).

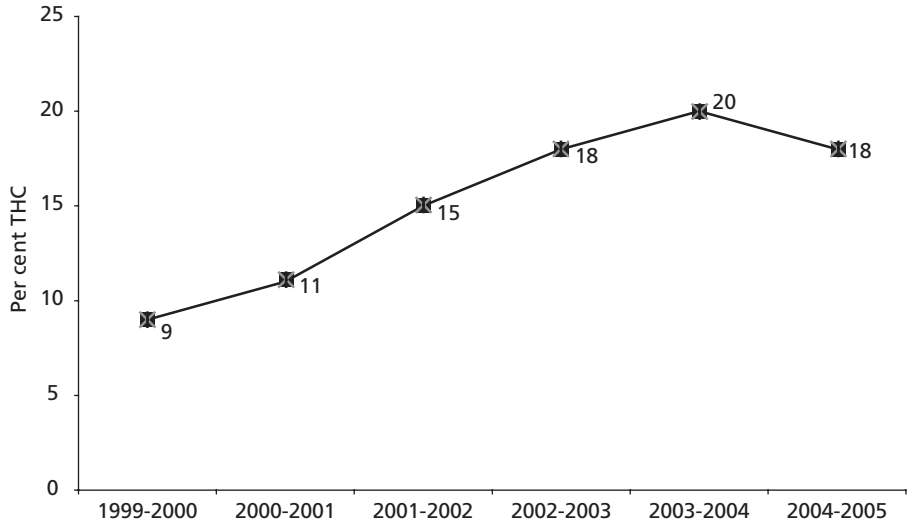
Furthermore, as discussed above, global cannabis markets appear to be becoming more limited in their reach, with consumer countries relying more and more on domestic production rather than imports. In many developed countries, this means an increase in indoor produced cannabis. In Europe, for example, the International Narcotics Control Board of the United Nations notes that "Cannabis herb is increasingly being cultivated locally, particularly in member States of the European Union" ([211], p. 72). In Spain, legal constraints on carrying, but not consuming, cannabis have led to an increase in cultivation for personal consumption since 1992 ([212], p. 649). While much of this is likely to be produced on terraces and rooftops,

those desiring potency like that of "hashish" may be compelled to grow indoors. Similarly, in Iceland, "Domestically cultivated marijuana has become increasingly competitive with imported marijuana, and current estimates indicate it makes up anywhere from 10 to 50 per cent of the total cannabis market." [149]

Thus, it would appear that the supply of high-potency cannabis is growing, although demand remains for low-quality products as well.

Within this growing share of the market, potent products appear to have been made much more potent in the last decade. The EMCDDA study and subsequent literature show quite dramatic increases in the sinsemilla potency in the United Kingdom (up from about 6 per cent in 1995 to over 12 per cent in 2002) and the Netherlands (up from about 9 per cent in 1999-2000 to about 16 per cent in 2001-2002) [10]. More recent figures from the Netherlands drawn from about 60 annual samples of the most popular strains of "nederwiet" (sinsemilla) purchased from "coffee shops" show a doubling in potency between 1999 and 2003, with levels stabilizing at about 18 per cent since that time (see figure XVIII).

Figure XVIII. Sinsemilla tetrahydrocannabinol levels in the Netherlands, 1999-2005

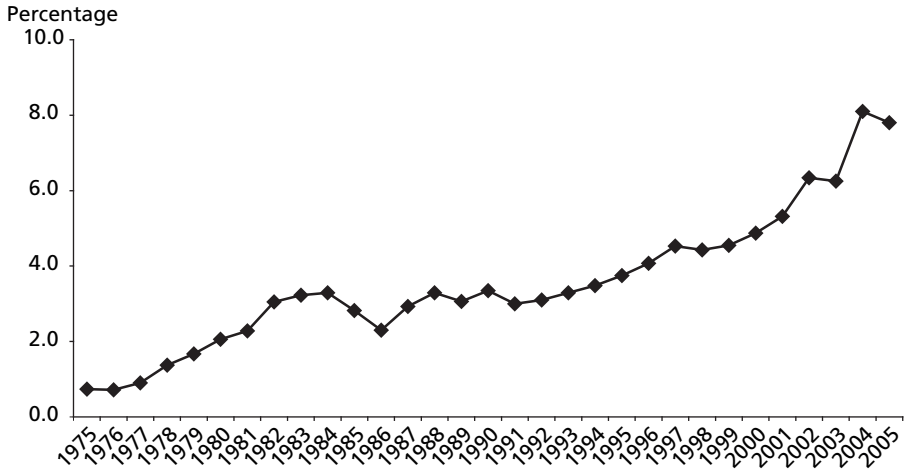


Source: Niesink, Rigter and Hoek [20].

In Germany, the European country with the largest sample base, no distinction is made between sinsemilla and low-grade cannabis. Despite this, aggregate herbal cannabis potency has clearly been going up recently. In 1996, samples averaged about 5 per cent; in 2004, they were about 11 per cent ([190], p. 44). This is very significant, as EMCDDA estimates that cannabis herb commands 40 per cent of the growing cannabis market in Germany.

In the United States, virtually all cannabis seized by the agencies of the federal Government is tested by the Marijuana Potency Monitoring Project at the University of Mississippi, which has been in place for over 20 years. The trend generally reported is an aggregated one, but it has been unmistakably upward for some time (see figure XIX).

Figure XIX. Tetrahydrocannabinol average of all cannabis samples submitted to the United States Marijuana Potency Monitoring Project, 1975-2005

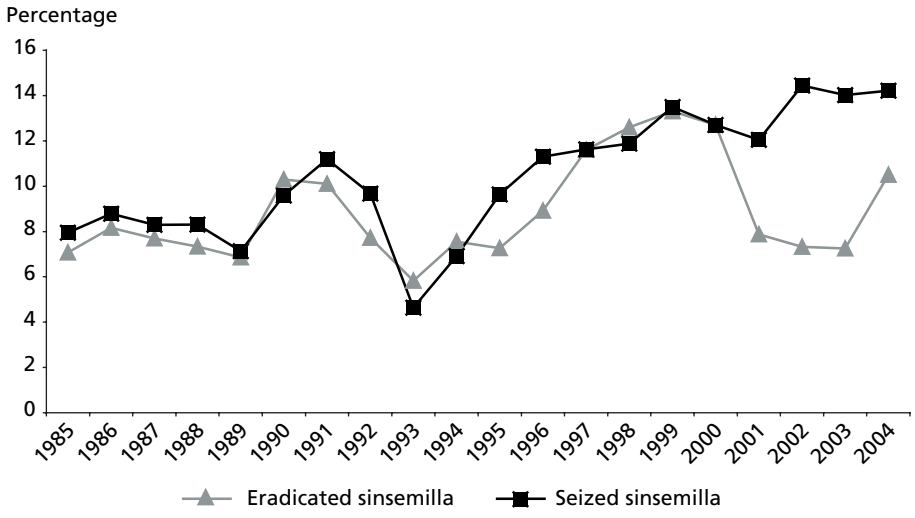


Source: United States, Marijuana Potency Monitoring Project.

Looking specifically at the sinsemilla trend, however, the general trend has also been upwards, but far from smooth (see figure XX).

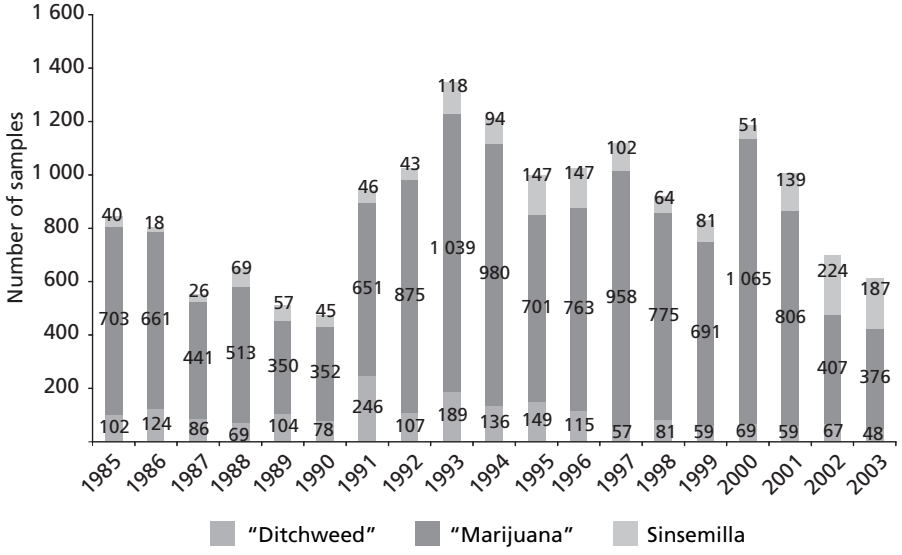
The wild fluctuations in the recorded potency levels of sinsemilla are partly a result of varying sample sizes and compositions. For example, the number of seized sinsemilla samples varied from 12 in 1985 to 5 in 1993 (a year when THC levels "dropped" precipitously) and 342 in 2003. Of course, it is impossible to speak reliably of potency levels of nationally seized sinsemilla on the basis of five samples. The inclusion of varying shares of "ditchweed" (wild cannabis), low-grade cannabis and sinsemilla in the annual sample also makes it difficult to speak of aggregate potency levels (see figure XXI). The relative market shares of these products do not vary in the way they do in the samples from the United States Marijuana Potency Monitoring Project, so it is difficult to see the sample as nationally representative. Even as a time series, the sample could be affected by changing national enforcement priorities. For example, enhanced southern border control could lead to more low-potency Mexican imports being seized, whereas a move against Asian organized criminal groups in the north-west United States could increase the indoor sample.

Figure XX. Sinsemilla tetrahydrocannabinol levels in the United States, 1985-2004



Source: United States, Marijuana Potency Monitoring Project.

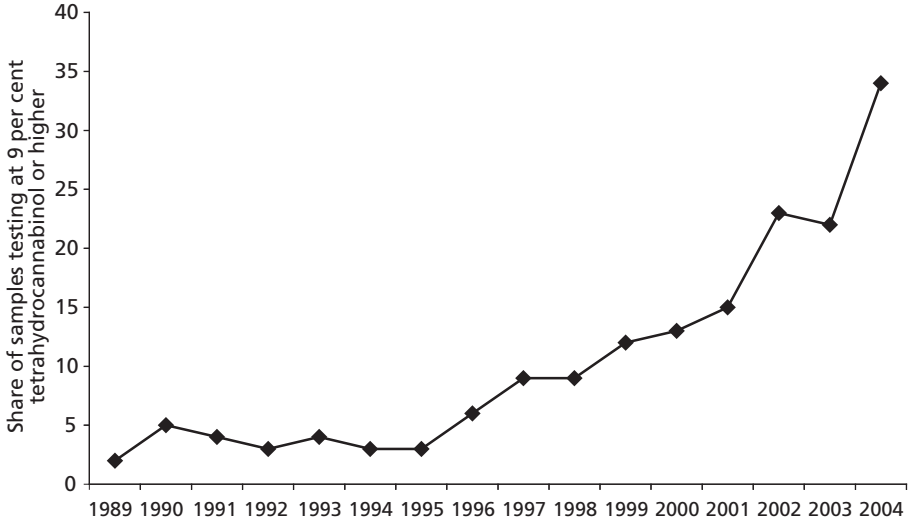
Figure XXI. Relative shares of various cannabis products in samples tested by the United States Marijuana Potency Monitoring Project, 1985-2003



Source: United States, Marijuana Potency Monitoring Project.

The underlying trend is best seen in looking at the increase in the share of all samples testing at 9 per cent THC or more (see figure XXII). Unless enforcement efforts were redirected to the higher end of the market, this trend strongly suggests an increased availability of good quality product since the mid-1990s. As in the Netherlands, the increase has been particularly pronounced since 1999.

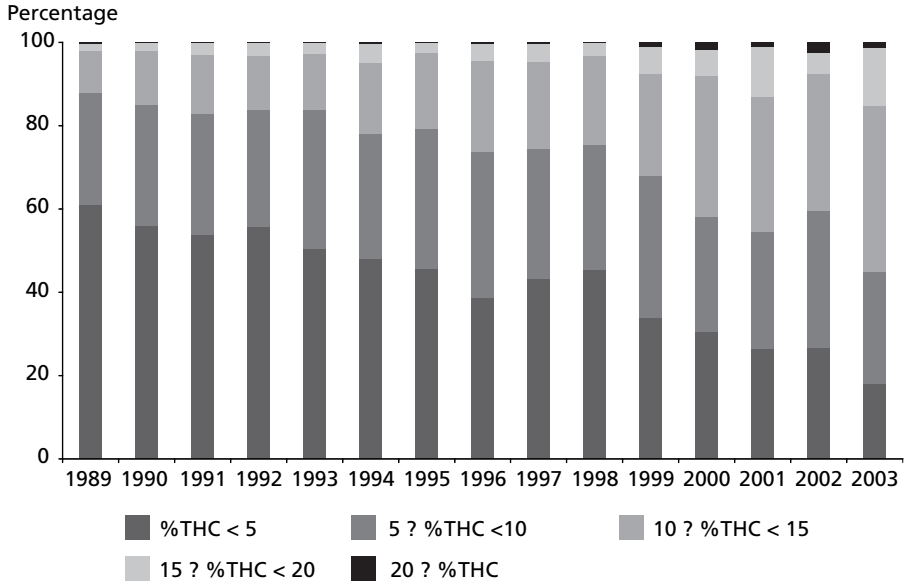
Figure XXII. Share of United States Marijuana Potency Monitoring Project samples testing at above 9 per cent tetrahydrocannabinol, 1989-2004



Source: United States, Marijuana Potency Monitoring Project.

In Canada (see figure XXIII), before the early 1980s, THC seldom reached 1 per cent, but by the late 1990s it was over 6 per cent [36]. A declining share of tested samples has less than 5 per cent THC and a growing share registers above 10 per cent. Very high-potency samples (above 20 per cent) remain relatively rare, but have certainly increased in share since 1999. These changes are partly attributed to changes in the make-up of samples admitted for analysis.

Figure XXIII. Levels of tetrahydrocannabinol in cannabis samples in Canada, 1989-2003



Source: Adapted from Viau, Marro and Walker [213].

What is the real impact of growing potency?

The existence of products with higher THC levels and the growth of the high-potency market do not inevitably mean that more THC is being ingested. It is worth noting that the winners of the annual "cannabis competitions" are not necessarily the most potent products; cannabis users appear to prefer certain strains for reasons more difficult to quantify than THC levels. This is clear in the preference for herbal cannabis in many markets, over the (generally) more potent cannabis resin. If, as the EMCDDA study suggests, price varies linearly with potency, users may prefer to smoke twice as much of a strain half as strong to achieve the desired effect, while others may seek to reduce the negative effects of smoking by utilizing high-grade product. Prices are relatively low in the cannabis market and, unlike some other drugs, cannabis use does not produce the kind of dependency that requires a set amount of the drug to be consumed each day in order for the user to function. This allows consumers to be somewhat indulgent in their smoking habits and brand preferences.

On the other hand, higher potency products, especially if not clearly identifiable, do pose a risk, as would any product where the concentration of active ingredient is not known. While cannabis users may be able to "auto-titrate" (regulate their level of intoxication by moderating consumption), this skill is less

developed in novice users. Some studies have found that, in practice, "users have limited ability to titrate their dose of THC" [210]. Luckily, high-THC cannabis products are often expensive and thus may be out of reach for many young people. However, as discussed above, survey data show that most people get their cannabis for free and that home-grown cannabis in particular is often distributed without cost to the user. Being part of a social network in which someone grows their own cannabis may be a more important determinant of access to high-potency cannabis than income.

In other drug markets, it is generally recognized that high variability in purity levels poses a risk for users. Many jurisdictions place age restrictions on access to more potent forms of alcohol. Spikes in heroin potency are accompanied by widespread overdoses. While it is more difficult to consume too much cannabis unwittingly than too much heroin, it is possible that even experienced users will be caught unaware by an unexpectedly powerful product. High-potency cannabis is effective within a "hit" (inhalation) or two and even given the rapid onset of action of cannabis, stronger herbal cannabis poses a greater risk of getting more intoxicated than desired.

Finally, all evidence indicates that, despite increases in potency in many markets, the size of cannabis cigarettes has not decreased in recent years. In fact, the data that do exist suggest that cannabis cigarettes have become bigger in many important markets. Larger cannabis cigarettes in the context of increasing potency without evidence of other changes in use patterns suggest an increase in THC consumption.

What evidence is there that the increase in high-potency market share is actually causing public health problems? If an increasing share of users is getting more than they bargained for from the cannabis they consume, this could be reflected in the number of people showing up at emergency rooms complaining of unexpected effects such as panic attacks, paranoia and delusions. Information on the number of people seeking emergency medical assistance with drug problems is available from the United States. It has also been argued that problematic symptoms of high-potency cannabis use could lead to more users seeking treatment and data on treatment admission are available from several developed countries. Both of these data sources are discussed below.

Has increased potency affected emergency room statistics?

One of the best data sets for evaluating the extent to which cannabis use contributes to acute medical problems comes from the United States. The Substance Abuse and Mental Health Services Administration of the Department of Health and Human Services is responsible for collecting a range of important indicators

about the state of substance abuse in the United States. These include the Drug Abuse Warning Network (DAWN), which records the number of cases in which medical staff from a representative sample of hospital emergency rooms determined that trauma of individuals presenting themselves for treatment was related to the use of legal or illegal drugs (referred to as "mentions"), and deaths that coroners determine to be drug-related ([83], p. 85). Of course, there are very few deaths attributable to cannabis use, but the number of cannabis-related emergency room episodes is substantial and has risen over the years.

According to the medical professionals participating in the DAWN system,* "marijuana" (which in this case includes "hashish") was a feature in 45,259 emergency room episodes in 1995. This represents 19 mentions per 100,000 members of the population, less than cocaine (58), heroin (30), or anti-depressants (23), but more than methamphetamine (7). The number of mentions grew to 119,472 in 2003, an increase of 164 per cent. Looking at these figures as rates, which would take into account the increase in population during this period, there were 47 mentions per 100,000 in 2002, an increase of 139 per cent over 1995. This increase is less than was seen for methylenedioxymethamphetamine (767 per cent), but more than for cocaine (33 per cent) or heroin (22 per cent).

These figures would support the argument that cannabis emergency room admissions have increased and have increased at a rate that is disproportionate to most other drugs of abuse. But other data from the Substance Abuse and Mental Health Services Administration indicate that overall levels of cannabis use also increased during this period. According to the United States National Survey on Drug Use and Health, the number of annual users of cannabis was 17,755,000 in 1995. This figure rose to 25,755,000 in 2002, an increase of 31 per cent.

Using these figures, we can calculate the number of drug users per emergency room cannabis mention. In 1995, there was one visit for every 392 people who used the drug that year. In 2002, there was one visit for every 216 users, an increase of 55 per cent. This suggests that the share of total cannabis users who find themselves in an emergency room has increased.

The total number of emergency room episodes captured by DAWN increased from 457,773 in 1995 to 681,957 in 2002, an increase of 33 per cent. During that same period, the number of users of any drug, according to the United States National Survey on Drug Use and Health, also increased, from 22,662,000 to 35,132,000, an increase of 34 per cent. Thus, the share of total annual drug users who visited an emergency room and mentioned a drug during admission did not change during these two years: about one visit for every 50 users. This suggests that the reach of the DAWN system remained fairly constant during this interval and

*See the website of the Substance Abuse and Mental Health Services Administration www.oas.samhsa.gov/dasis.htm#teds2).

that the increases are real increases, not just a product of better data collection: if the chances of any given drug user showing up in an emergency room with a drug-related problem remained constant during this period, the increase in the number of cannabis mentions is probably not a recording phenomenon.

However, when cannabis was mentioned, it was usually mentioned in combination with other drugs. In 72 per cent of the cases when cannabis was mentioned, other drugs were also mentioned. Thus, in only a minority of cases could it be clearly argued that cannabis was the only drug that might be involved in precipitating the visit to the emergency room. But the share of "cannabis only" mentions has increased since 1995, when 78 per cent of the episodes where cannabis was mentioned also featured other drugs, which supports the notion that the drug, on its own, is becoming more problematic.

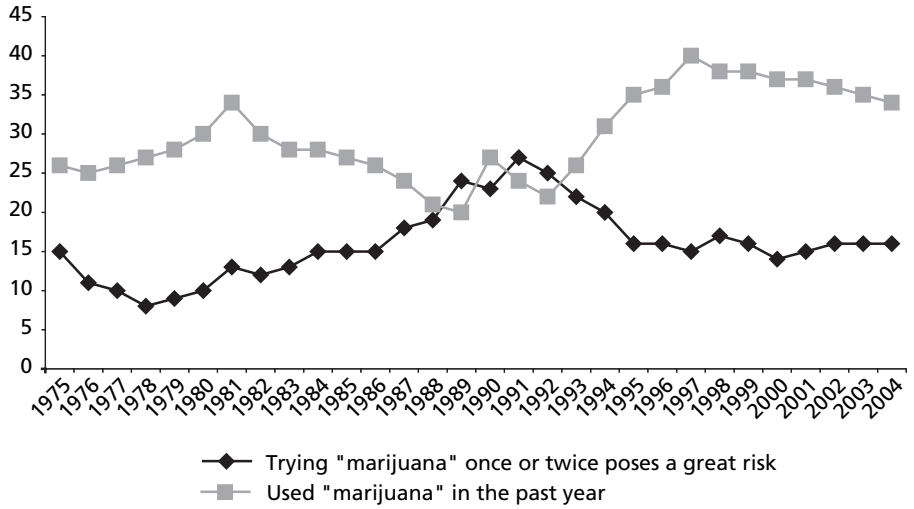
The DAWN data also explores the reasons for coming to the emergency room. Using the data sets available online (1994 and 1996), of those incidents where cannabis alone was mentioned, a large minority (48 per cent in 1994 and 43 per cent in 1997) said they had visited the emergency room because of an "unexpected reaction". The next most common response was "other" (21 per cent in 1994 and 20 per cent in 1997), followed by "accident/injury" (12 per cent in 1994 and 19 per cent in 1997). Few people mentioned "overdose" (less than 5 per cent), a need for detoxification (less than 5 per cent), or "withdrawal" (less than 1 per cent).

Thus, 40-50 per cent of the people who only mentioned cannabis said they were experiencing an unexpected reaction to the drug. This is high compared to other drugs, which would support the argument that cannabis, usually regarded as a fairly unproblematic drug, is surprising people to the point that they are seeking medical attention. The share of people so reporting, however, decreased between 1994 and 1996.

It is also clear from survey data that the perceived dangers of cannabis have varied over time. The fact that there are more emergency room mentions could be because more people who use the drug consider this fact to be relevant to their admission and are therefore reporting it in cases where they might not have done so before. But, at least among young people, perceptions of cannabis risk in the United States were highest in the late 1980s and early 1990s, when use was lowest. They declined through the 1990s and have been fairly low and stable since the turn of the century. Between 1994 and 1996, the belief that trying cannabis posed a great risk declined by about 4 per cent (see figure XXIV).

Thus, it would appear that emergency room mentions related to cannabis use are on the increase and that the most common reason for these visits is an unexpected reaction to the drug. This is consistent with the kind of effect that would be expected with the increasing circulation of high-potency cannabis.

Figure XXIV. Perception that trying cannabis is dangerous, and annual use among United States pupils in the twelfth grade, 1975-2004
(Percentage)



Source: Monitoring the future project [89].

Has increased potency affected treatment admissions?

In addition to acute episodes, high-potency cannabis could contribute to chronic problems in a variety of ways. It has been argued that increased potency represents increased addiction potential [214]. In addition, incidents of excessive intoxication due to a decline in the ability to auto-titrate could persuade users that their consumption is problematic.

Once again, the best data on treatment presentations comes from the largest cannabis market, the United States, in the form of the Treatment Episode Data Set, which tracks some 1.5 million admissions to drug treatment in facilities that report to state administrative data systems ([83], p. 305). Unfortunately, using these figures to determine the extent to which drug users are finding their consumption to be problematic is complicated by the fact that a large share of people entering treatment do not do so voluntarily. Some people enter treatment not because they find their drug use problematic, but because they were forced to do so by employers, the criminal justice system or their parents.

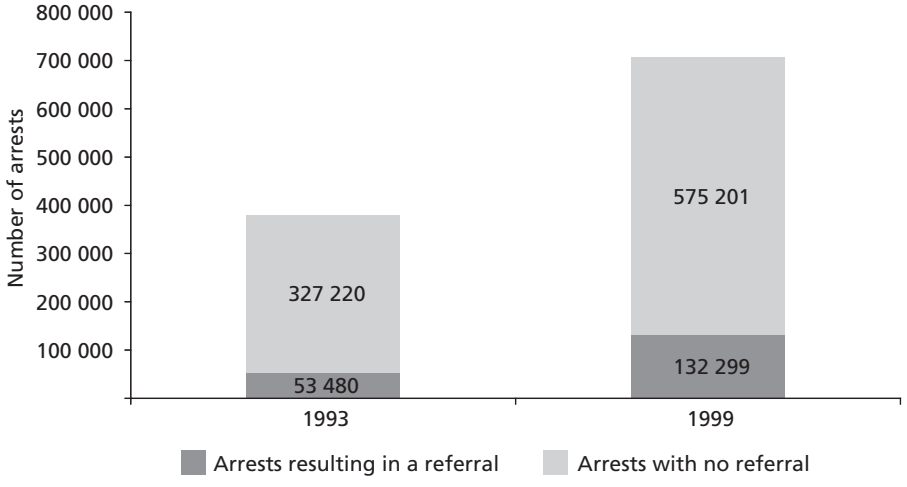
Workplace testing for drugs has increased considerably in the past few years, but only a small share of referrals for treatment to cannabis use come from employers, usually less than 2 per cent. The criminal justice system, on the other hand, represents a very significant source of referrals. Those apprehended in possession of cannabis (especially young people) are often given a choice in court: enter a

diversion programme for treatment or go to jail. These admissions may include experimental users caught with the drug on one or more occasions and an increase in their numbers could be more reflective of law enforcement priorities than changes in the dangers posed by the drug.

Within the Treatment Episode Data Set sample, national rates of admission to treatment for cannabis as a primary drug of abuse almost doubled between 1993 and 1999, from 55 admissions per 100,000 people to 103 [215]. According to the Data Set, 111,418 people were admitted to treatment in 1993 with cannabis as their primary substance of abuse, comprising 7 per cent of the overall treatment population. In 1999, this number was 232,105, comprising 13 per cent of the treatment population. In other words, the number of admissions related to treatment of cannabis use more than doubled in six years and, in addition, cannabis users nearly doubled their share of the treatment population.

This overwhelming increase would appear to provide very strong evidence that something dramatic had changed in the nature of the drug or the way that it was being used. But this increase took place at a time of renewed law enforcement focus on cannabis use: the number of cannabis arrests increased from 380,700 in 1993 to 707,500 in 1999, an increase of 85 per cent. During this same period of time, non-cannabis drug arrests increased by just 11 per cent [216]. Partly as a result of the increase, the share of cannabis users in treatment who were there following a criminal justice referral increased during this period (see figure XXV).

Figure XXV. Arrests related to cannabis in the United States resulting in a referral to treatment, 1993 and 1999

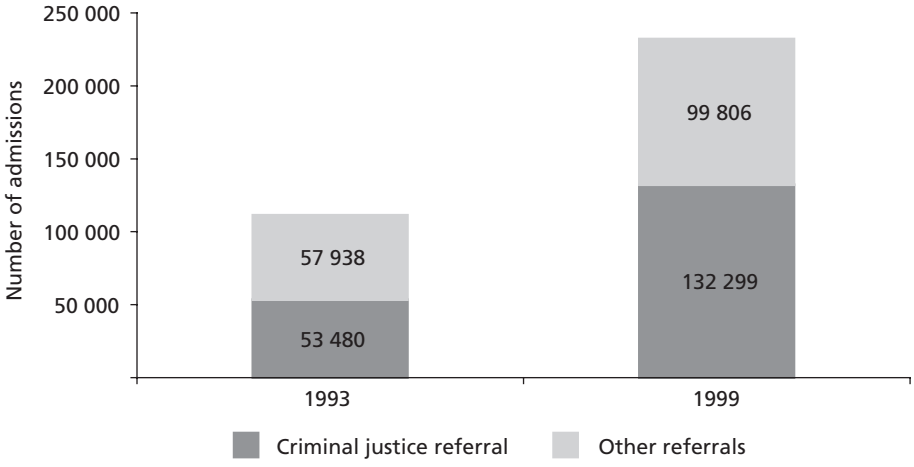


Source: United States, Treatment Episode Data Set and Uniform Crime Reports of the Federal Bureau of Investigation.

Evaluating the relationship between increased enforcement, increased diversion and increased treatment figures is not as straightforward as it might initially seem. Primary cannabis admissions increased in 41 states in the United States between 1992 and 2002, while decreasing in only 3. This is important because law enforcement in the United States is highly decentralized and generating such a widespread policy shift would be difficult, especially given the fact that several states have shown sustained interest in medical cannabis, in defiance of federal policy [217].

Within the Treatment Episode Data Set sample, almost half (48 per cent) of admissions for treatment for cannabis use were referred by the criminal justice system in 1993 (53,480 people); in 1999, the figure increased to 57 per cent (132,299 people) (see figure XXVI). In other words, criminal justice referrals to treatment in 1999 were responsible for 78,819 additional admissions, almost two thirds of the additional 120,687 cannabis admissions in 1999. In 2003, cannabis and stimulants (including ecstasy) were the only two drug categories in which the majority of referrals to treatment came from the criminal justice system. Non-criminal-justice referrals were more likely to report both daily cannabis use and the use of other drugs: in other words, they were more likely to reflect a serious drug problem [218].*

Figure XXVI. Share of cannabis admissions to treatment as a result of criminal justice referral, 1993 and 1999



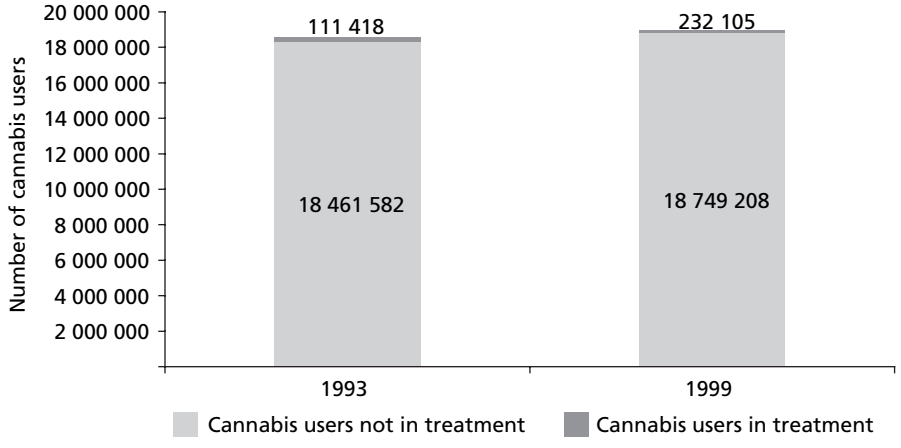
Source: United States of America, Treatment Episode Data Set.

*Of "marijuana" criminal justice referrals, 88 per cent were male, a larger share than those referred to treatment by other sources (66 per cent). Black people made up a larger share of criminal justice referrals (31 per cent) than of other source referrals (25 per cent). This also suggests that this increase is due to enforcement patterns, rather than changes in drug risk.

This still leaves an increase of 41,868 non-diversion cannabis admissions to account for between the two periods. Another factor to consider is the growth in the cannabis-using population during this time period. If the risk were to remain constant, a larger number of people being exposed to the drug could result in a larger number of admissions. According to United States National Survey on Drug Use and Health data, the total number of annual cannabis users in the United States was fairly stable between 1993 and 1999, rising slightly from 18,573,000 in 1993 to 18,981,313 in 1999, about a 2 per cent increase. In 1993, about one out of every 321 annual cannabis users entered treatment in one of the facilities monitored in the Treatment Episode Data Set without the criminal justice system being involved. In 1999, it was one out of every 191. Thus, there was a real increase in the likelihood that users would wind up in treatment, independent of the increase in criminal justice referrals. This suggests there were other factors at work than the increase in enforcement, the increase in diversion and the mild increase in general use.

As with emergency room mentions, a changing public perspective on the risks of using cannabis could account for a greater number of people entering treatment, especially among young people, who may be pressured into treatment by their parents and who represent a growing share of the treatment population. However, as argued above, young people were less likely to consider cannabis use risky in 1999 than in 1993. There are no measures of parental attitudes available, but the feelings of the general public, according to 1993 and 1999 data from the National Survey on Drug Use and Health, are the same. Although the question in this area changed between the two study periods, about 40 per cent of the general population thought that occasional cannabis use posed a great risk in both periods.

Figure XXVII. Share of cannabis users in treatment in the United States, 1993 and 1999



Source: United States, Treatment Episode Data Set and National Survey on Drug Use and Health.

A complicating factor, both in the United States and elsewhere, is the declining age of the treatment population. Younger people are more likely to use cannabis as their primary drug, so when the share of young people in treatment increases, cannabis admissions should also increase.

In summary, there are so many possible factors that may lead to an increase in admissions to treatment that it is impossible to say whether increases in potency might be the cause. It appears that changes in criminal justice policy were responsible for the bulk of the dramatic increase between 1993 and 1999, but they do not account for all of it. With regard to the treatment data, therefore, the case of the United States is inconclusive.

Another study sidesteps these difficulties and looks directly at nationally representative survey data on abuse and dependence. The survey finds that "overall rates of past-year abuse or dependency increased from 30.2 per cent in 1991-1992 to 35.6 per cent in 2001-2002". The study concludes that "A number of factors could have led to increases in addiction potential, operating independently or co-jointly. The first is increased marijuana potency . . . Increasing rates of marijuana use disorders among marijuana users in the absence of increased quantity and frequency of use strengthens the argument that the increasing rates may be attributable, in part, to increased potency of marijuana." [214]

Furthermore, the United States is not alone in seeing an increase in the number and share of cannabis admissions to treatment. A similar trend is seen in Europe, where most countries have been liberalizing their cannabis policies, rather than cracking down on users, in recent years. Treatment data within Europe are not uniform, so it is difficult to compare between countries. However, it would appear that cannabis has increased its share of the treatment population in all European countries for which records are available in recent years (see table 9). The increase is lowest in Greece and Italy, two countries that receive most of their herbal cannabis from Albania. Some of the countries where the market share of sinsemilla has increased, such as Germany and the Netherlands, have also seen dramatic increases in treatment share for cannabis. Exceptions include the United Kingdom (believed to be using more sinsemilla but with modest increases in treatment share) on the one hand and Sweden (still largely consuming cannabis resin but tripling admission share) on the other.

These figures refer to the share cannabis holds of the treatment population and thus documents that cannabis is becoming more problematic relative to other drugs. In most cases, this would also suggest an increase in absolute numbers of cannabis users seeking treatment. In 2004, 25 per cent of all new admissions to treatment in Europe listed cannabis as their primary drug of abuse.* This is a much higher share than in the past.

*EMCDDA, cited in Report of the International Narcotics Control Board for 2004 [211].

Table 9. Share of primary cannabis users in the treatment populations of European countries
(Percentage)

	1996	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*Increase*
Denmark	. .	11	. .	. .	. .	. .	27	145
Germany	. .	. .	18	. .	. .	. .	30	66
Greece	. .	. .	6	. .	. .	. .	7	17
Spain	. .	4	. .	. .	. .	. .	11	175
France	. .	11	. .	14	. .	. .	. .	27[a]
Ireland	. .	11	. .	. .	21	. .	. .	91
Italy	. .	. .	8	. .	. .	. .	9	12
Luxembourg	. .	4	. .	. .	. .	. .	11	175
Netherlands	. .	. .	11	. .	. .	. .	17	55
Finland	. .	18	. .	. .	. .	. .	23	28
Sweden	7	. .	. .	. .	. .	. .	30	429
United Kingdom	. .	8	. .	. .	. .	. .	10	25

Source: EMCDDA annual reports, 1999 [219] and 2002 [220].

Note: Two dots (. .) indicate that data is unavailable or is not separately reported.

[a]The Observatoire français des drogues et des toxicomanies notes that if the variation in the number of organizations responding to the survey is taken into consideration, admissions for cannabis increased by 40 per cent between 1997 and 1999.

In some instances, the change in cannabis admissions in Europe has been quite dramatic recently. For example, one study of seven health board areas in Ireland (most of the country outside Dublin), a country where sinsemilla commands about half the small herbal cannabis market, the number of people seeking treatment who reported cannabis as a problem drug almost trebled between 1998 (626) and 2002 (1,831), with 70 per cent of these people reporting cannabis as their main problem drug. In addition to an increase in cannabis supply, an increase in access to services and an increase in the monitoring umbrella, the researchers involved credit "an increase in cannabis toxicity" for the growth in patient numbers ([221], p. 7).

In Australia, the "national censuses of Australian addiction treatment services indicate that the proportion of persons presenting for a primary cannabis-related problem . . . steadily increased from 4 per cent in 1990 to 7 per cent in 1995" ([210], p. 505). In 2002-2003, cannabis commanded 43 per cent of the non-alcohol treatment admissions (some 27,000 individuals), ahead of heroin and amphetamines ([222], p. 8). Criminal justice referrals made up at least 37 per cent of this treatment population, however ([222], p. 26). Independent of these data, it has been argued that an increasing number of people are seeking treatment for cannabis problems in centres used to treating alcohol and opiate dependence [223]. The reasons for this increase remain unclear.

Even in South Africa, a country with a plentiful supply of cannabis from outdoor growth, there are indications that indoor cannabis has grown in popularity in recent years. Cannabis has also grown in its share of admissions to treatment in the major urban centres, including Cape Town (4 per cent in 1996 to 11 per cent in

2004), Durban (10 per cent in 1996 to 25 per cent in 2004) and Gauteng, which includes Johannesburg and Pretoria (11 per cent in 1998 to 19 per cent in 2004), as well as the rural province of Mpumalanga (14 per cent in 1999 to 24 per cent at the end of 2004).* This is remarkable in that a number of other street drugs were growing in popularity during this time, so that cannabis largely filled the spots vacated by a decline in alcohol admissions. Since it is unlikely that the severity of alcoholism in the country declined during this period, this means that cannabis admissions essentially displaced alcohol admissions. Whether this is possibly due to increased potency is unknown: South African cannabis is rarely tested for THC levels and other factors, such as the declining age of the treatment population, may be responsible.

Health effects

The widespread use of cannabis is clearly related to the public perception that smoking herbal cannabis is virtually harmless.** Ironically, this is, in part, a reaction to early demonization of the drug, which undermined the credibility of subsequent health warnings. In addition, a sizeable share of the population in the world has experimented with cannabis and not experienced dramatic negative repercussions. It is widely understood that, unlike other drugs, one cannot die of a cannabis overdose and few people develop cannabis habits that force them into street crime or prostitution. Cannabis is not associated with violent behaviour in many countries and its role in accidents is vague in the public mind. The stereotypical "stoner" character has become celebrated in the popular media as harmless and somewhat endearing. Claims of purported medical benefits of cannabis have created the impression that cannabis is not only virtually harmless but that it can actually be beneficial to health.

Despite the good press, cannabis remains a powerful drug. As will be discussed, cannabis use affects virtually every organ system of the body, from the central nervous system to the cardiovascular, endocrine, respiratory and immune systems [225]. The psychological effects of the drug are frequently underestimated. Its impact on the psyche and behaviour of users can be considerable. Few casual users of cannabis know that cannabis dependence is a major issue in countries where use levels are high. A significant share of people who use cannabis regularly find it hard to stop and say it has other negative effects on their quality of life.

There have been many recent reviews of the literature on the health impacts of cannabis. The present article uses the one published by WHO in 1997 [226] as a point of departure, focusing on the major new findings since that review was

*The differing time frames are due to availability of data ([224], p. 7).

**The National Surveys on Drug Use and Health in the United States have shown that trends in cannabis use levels are strongly linked to public perceptions about the harmfulness of the drug.

conducted. The health effects of cannabis were also examined in an edition of the *Bulletin on Narcotics* in 1998 [227].

Effects on the brain and behaviour

People smoke cannabis because it significantly changes their state of mind. The acute effects of cannabis use are an altered state of consciousness characterized by euphoria and relaxation, perceptual alterations, time distortion and the intensification of ordinary sensory experiences. When used in a social setting it can produce infectious laughter and talkativeness [228]. It is not surprising that the overwhelming reason for taking cannabis given by recreational users is simply "pleasure" [229, 230].

But altered consciousness comes at a cost. Short-term memory and attention, motor skills, reaction time and skilled activities are impaired while a person is intoxicated [228]. This has a potential impact on driving skills and involvement in accidents. Moreover, cannabis has the ability to produce dysphoric reactions, including severe anxiety and panic, and paranoia. These reactions are dose-related and more common in naïve users, anxious subjects and psychologically vulnerable individuals [231, 232].

In addition to its acute effects, cannabis use can produce long-term psychological problems. There is growing evidence that it can trigger latent psychosis and promote personality decompensation in diagnosed schizophrenics. Finally, some regular cannabis users find it difficult to stop using the drug, even when it is having adverse consequences for their lives.

Is cannabis use associated with vehicular accidents?

The debate around cannabis and driving has been protracted. Many early reports suggested that cannabis was not associated with vehicular accidents, noting that cannabis smokers seemed more aware of their inebriation than drivers under the influence of alcohol and were able to compensate by driving more carefully [233]. WHO, in contrast, states that there is sufficient consistency in the experimental evidence and studies among accident victims to conclude that there is an increased risk of accidents in people who drive when intoxicated with cannabis ([226], p. 15]. Subsequent research has pointed in both directions.

Research in this area has been complicated by the way cannabis is metabolized. THC is fat-soluble and quickly passes out of the blood into the brain and other organs, where it and its metabolites can remain for extended periods of time before slowly being excreted. Thus, the detection of cannabis metabolites in urine only serves to prove that the subject has used cannabis at some time in the recent past, not that intoxication was indicated at the time of the testing. And, unlike

alcohol, even blood tests are not always reliable measures of the level of intoxication, particularly if they measure metabolites instead of THC. Perhaps partly as a result, the more recent studies in this area reach conflicting conclusions.

For example, a prospective observational case-control study from the Netherlands of accidents requiring hospitalization showed no increased risk for road trauma for drivers exposed to cannabis, although high relative risks were found for drivers using a combination of drugs and for those using a combination of drugs and alcohol [234]. In a review by Bates and Blakely (1999), the authors conclude that, in contrast to alcohol, there is no significant evidence of a causal role for cannabis alone in traffic accidents [235]. A longitudinal study of a birth cohort of 907 young New Zealanders (age 18-21 years) did detect a statistically significant relationship between reported annual cannabis use and annual accident rates, but these increased risks may simply reflect the characteristics of the young people who used cannabis (i.e., higher rates of drinking and driving; risky or illegal driving behaviours; driver attitudes; and gender differences) [236].

On the other hand, surveys that established recent use of cannabis by directly measuring THC in the blood showed that drivers with THC positives, particularly at higher doses, were about three to seven times more likely to be responsible for accidents in which they were involved as compared to drivers that had not used drugs or alcohol [237]. In addition, laboratory studies of driving by subjects given known quantities of THC have repeatedly found a connection between cannabis intoxication and bad driving, as THC impairs cognition, psychomotor function and actual driving performance in a dose-related manner. The degree of performance impairment observed in experimental studies after doses of up to 300 micrograms per kilogram THC were equivalent to the impairing effect of an alcohol dose producing a blood alcohol concentration of 0.05 gram per decilitre, the legal limit for driving under the influence in most European countries. Highly automated behaviours, such as road tracking control, were more affected by THC as compared with more complex driving tasks requiring conscious control [237]. Other research has reached similar conclusions, including:

- A recent study of over 10,000 accidents in France ("*Stupéfiants et accidents mortels de la circulation routière*") found that cannabis smokers were almost twice as likely to be responsible for an accident, although this was still less than those even moderately intoxicated by alcohol [238].
- O'Kane and others (2002) in a review of laboratory studies, real driving studies and recent epidemiological studies concluded that cannabis had a significant impairing effect on driving when used alone and that this effect was exaggerated when combined with alcohol [239].
- In a placebo-controlled double-blind study, the performance of 60 healthy drug-free volunteers on a battery of psychomotor and cognitive tests was assessed in baseline condition and then after smoking a regular cigarette

or one containing THC. The authors found that perceptual motor speed and accuracy were significantly impaired immediately after cannabis consumption, but not on re-testing 24 hours later [240].

- Several studies have found high rates of positive urine tests for cannabis metabolites among trauma patients suffering from non-motor accidents as well.*

Progress in this debate might be assisted by standardizing methodologies and finding more accurate ways of documenting current cannabis intoxication. One way of sidestepping the scientific problems is to ask the users themselves if they feel that the perceptual distortions associated with cannabis consumption affect their driving. For example, one survey of regular cannabis users in Australia reported a quarter (25 per cent) of respondents felt that their driving performance was impaired, their reflexes and reaction times slowed and their concentration affected when attempting to drive under the influence of cannabis ([23], p. 34). The fact that over half of those polled in the national surveys on drug use in New Zealand say they never drive when under the influence of cannabis also demonstrates that cannabis users themselves feel that cannabis impairs their driving performance ([60], p. 34).

Does cannabis use have an impact on cognition?

The short-term impact of cannabis on cognitive and psychomotor performance has been recognized for many years. The effects are similar to those of alcohol and benzodiazepines and include the slowing of reaction time, motor incoordination, impairment in short-term memory, difficulty in concentration and slower problem-solving. The effects are dose-related but can be demonstrated after relatively small doses (5-10 milligrams of THC), even in experienced users [231].

The long-term impacts are the subject of ongoing research and debate. WHO, in contrast to earlier heavy-user studies, concluded that long-term use resulted in "subtle and selective impairments of cognitive functioning" ([226], p. 16). Since then, there have been a number of studies that have detected a range of effects, and some that have found none.

In the past, research in this area has struggled to distinguish between effects that might be attributable to current intoxication, withdrawal effects and true brain

*Studies of other forms of accidents suffer from the same weaknesses as the vehicular studies, but next to alcohol, cannabis is the substance most associated with injury in adult trauma patients. While baseline figures for the general population were not available, of 105 adult trauma patients admitted to one South African trauma unit, 43.7 per cent tested positive for cannabis in the urine [241]. Of 111 patients with trauma injuries who presented to the Accident and Emergency Unit, University Hospital of the West Indies, 50 per cent of road accident victims and 55 per cent of interpersonal violence victims tested positive for cannabis, compared with 43 per cent and 27 per cent for alcohol, respectively [242]. Studies of non-clinical samples have shown that cannabis use is related to intentional injuries and injuries in general. A higher risk for all types of injuries was indicated among cannabis users [243].

damage. This work has generally involved administering computerized cognitive batteries and pencil-and-paper tests to long-term users and comparing them to groups of controls. Solowij and others [244] performed a multi-site retrospective cross-sectional neuropsychological study in the United States between 1997 and 2000 among 102 near-daily cannabis users who had come seeking treatment for cannabis dependence (51 long-term users: mean, 23.9 years of use; 51 shorter-term users: mean, 10.2 years of use), compared with 33 non-user controls. A battery of tests of attention, memory and executive functioning were carried out. The longer-term cannabis group performed significantly worse on the test battery than the shorter-term users and the controls. Performance measures often correlated significantly, with performance being worse with increasing years of use.

The possibility of dose-related neurocognitive effects of cannabis use has been investigated by Bolla and others. It had been shown that as the number of cannabis cigarettes smoked per week increased, performance decreased on tests measuring memory, executive functioning, psychomotor speed and manual dexterity. The heavy-users group performed significantly below the light-users group. In this study, however, it was found that the duration of use had little effect on neurocognitive performance [245].

Two recent neurophysiological studies of selective attention and information processing confirmed previous findings. Visual information processing (as measured by the binocular depth inversion illusion) [246] and auditory information processing (as measured by auditory evoked potential latency) [247] were both found to be impaired in chronic cannabis users compared to non-users. However, these findings are probably reflections of acute cannabis intoxication and do not necessarily indicate long-term or permanent alterations.

The inspection time task was used to investigate the effects of acute and sub-acute cannabis use on information processing in a study in 22 heavy users, compared to 22 non-cannabis-using controls. Findings indicated that users displayed significantly slowed information-processing speeds (longer inspection times) compared to controls, when not presently under the influence. Remarkably, this deficit appears to be normalized while users are under the influence. These results may be explained as a withdrawal effect, but may also be due to tolerance development as a result of long-term cannabis use. If regular cannabis users require the drug to perform normally, these results may assist in providing an explanation for the development of dependence with chronic cannabis users [248].

On the other hand, an epidemiological study of 1,318 individuals performed by Lyketsos and others showed no significant cognitive differences between heavy users, light users and non-users of cannabis. The authors conclude that over long time periods, in persons under age 65 years, cognitive decline occurs in all age groups. This decline is closely associated with ageing and educational level but does not appear to be associated with cannabis use [249].

Does cannabis use lead to psychiatric problems?

The excesses of the "reefer madness" propaganda of the early anti-drug campaigns in the United States are responsible in no small part for the lack of credibility given to official pronouncements on the risks of cannabis and drugs more generally. The experiences of the millions of people that have tried cannabis attest to the fact that madness does not inevitably follow from cannabis use but, despite this, there is growing evidence that use of the drug may have an important impact on mental health. In the past eight years, several major reviews of the psychiatric problems associated with cannabis use have been conducted, including those by Hall and Degenhardt [250], Johns [251] and Iversen [252].

With regard to the acute effects of the drug, it is clear that cannabis can cause some dysphoric effects when used in high doses, including panic and delusions. One survey found that anxiety and panic attacks were the most commonly experienced negative side effects of the drug, experienced by 22 per cent of the users polled, and that 15 per cent experienced psychotic effects [253]. Whether this amounts to "cannabis psychosis" is debated and WHO found that the existence of such a disorder would require further research evidence. More recently, Hall and Degenhardt concluded from their review of the literature that true "cannabis psychosis", if it exists, must be very rare [250]. This position found confirmation in a recent review by Schaub and others (2004): very high doses of cannabis can induce a brief psychosis, but this condition is extremely rare [254]. In contrast, Johns mentions in his review that an appreciable proportion of cannabis users report short-lived adverse effects, including psychotic states, following heavy consumption [251].

With regard to long-term effects, several impacts have been hypothesized. One of the early attempts to describe the negative impact of cannabis on the mental state of users is the so-called "amotivational syndrome", a personality deterioration with loss of energy and drive to work [255]. Again, WHO was unable to confirm the existence of such a syndrome based on the research in 1997. The state of evidence on amotivational syndrome largely comprises uncontrolled studies of long-term cannabis users in various cultures [256]. Evidence to the contrary is seen in cultures where cannabis is traditionally consumed to increase work output, such as South Africa and Jamaica. Due to the lack of a strong evidence base, the validity of this diagnosis remains uncertain [256].

More worrying is the conflicting evidence around the claim that cannabis can either cause psychosis in vulnerable individuals or precipitate latent psychosis. WHO argues that there is clear evidence of an association between cannabis use and schizophrenia. One recent review of the literature determined that cannabis exposure is associated with an increased risk of psychosis, possibly by interacting with a pre-existing vulnerability for these disorders. A dose-response relationship was found between cannabis exposure and risk of psychosis and the association

was independent from potential confounding factors such as exposure to other drugs and pre-existence of psychotic symptoms [257].

This effect appears to be particularly strong when the user has developed cannabis dependence (according to the fourth edition of the Diagnostic and Statistical Manual of the American Psychiatric Association; see the discussion of "dependence" below). Increased rates of psychotic symptoms were found to be associated with the development of cannabis dependence in young people (ages 18 and 21 years) in a longitudinal study of a birth cohort of 1,265 individuals in New Zealand, even when pre-existing symptoms and other background factors were taken into account [258].

Since some schizophrenics "self-medicate" with cannabis, it can be difficult to determine the lines of causation. The causal relationship between schizophrenia and cannabis use was studied in a representative first-episode sample of 232 patients with schizophrenia in Germany. While cannabis use almost always preceded the first positive symptoms of schizophrenia, the comparison of the onset of cannabis abuse and of the first (prodromal) symptoms of schizophrenia differentiated three equally sized groups of patients: group one had been using cannabis for several years before the first signs of schizophrenia emerged, group two experienced their first signs of schizophrenia within the same month of starting cannabis use, and group three had started to use cannabis after the onset of symptoms of schizophrenia [259].

An association between use of cannabis in adolescence and subsequent risk of schizophrenia was also reported in a follow-up study of Swedish conscripts. The authors later extended the follow-up period and identified additional cases. Between the two studies, 50,087 subjects participated. Cannabis was associated with an increased risk of developing schizophrenia, consistent with a causal relation. This association was dose dependent both for subjects who had ever used cannabis and for subjects who had used only cannabis and no other drugs. Among subjects in the cannabis-only group who had used cannabis more than 50 times, the odds ratio (a measure of relative risk) was 6:7. Similar results were obtained when analysis was restricted to subjects developing schizophrenia more than five years after conscription, in order to exclude cases that might have already been in the early stages of schizophrenia at the time of their conscription [260].*

Studies have also indicated that early use of cannabis is associated with the later development of psychosis. The Dunedin longitudinal study of adolescent cannabis use found that using cannabis in adolescence increased the likelihood of experiencing symptoms of schizophrenia in adulthood among psychologically vulnerable individuals. Moreover, the authors added that early cannabis use (by age 15) conferred greater risk for schizophrenia outcomes than later cannabis use (by age 18). This risk was specific to cannabis use, as opposed to use of other drugs [262].

*A further analysis of this cohort was performed by Zammit and others [261].

The adverse effect of cannabis use on the clinical course of schizophrenia has been confirmed in a three-year follow-up study of psychotic and non-psychotic subjects in the Netherlands. Cannabis use increased the risk of both the incidence of psychosis in psychosis-free persons and a poor prognosis for those with an established vulnerability to psychotic disorder. The severity of symptoms was correlated with the length of the preceding cannabis use [263]. These results confirm the previous findings of a study comparing two matched groups of 39 schizophrenic patients each with or without a history of cannabis use. Patients with previous cannabis abuse had a more severe course of symptoms during the follow-up period [264].

Aside from full-blown psychosis, cannabis is associated with other forms of mental illness. Troisi and others found that the prevalence of co-morbid psychiatric disorders and the severity of depressive and anxiety symptoms increased progressively with the degree of involvement with cannabis [265].

Arendt and Munk-Jorgensen compared 1,439 heavy cannabis users with 9,122 abusers of other substances. The authors found that even though cannabis users were generally young, 27.5 per cent had, at some point, been inpatients at psychiatric hospitals with disorders unrelated to psychoactive substance abuse. As to psychiatric co-morbidity, cannabis users had significantly raised levels of depression and personality disorders while the prevalence of schizophrenia was also marginally raised [266].

A link between cannabis and major depression was found in an epidemiological study of 6,792 young adults in the United States. The risk of major depression was moderately associated with the number of occasions of cannabis use and with more advanced stages of cannabis use [267]. These data were later confirmed in a review of cohort studies and well-designed cross-sectional studies in the general population. A modest but significant association was found between early-onset, regular cannabis use and later depression. On the other hand, some evidence was also found of an increased risk of later cannabis use among people with depression. This would support the hypothesis that people dealing with mental illness may turn to cannabis or other drugs in an attempt at self-medication. Little evidence was found of an association between depression and infrequent cannabis use [268].

In addition, previously, in a nationally representative sample of 1,941 men from the 1944-1954 birth cohort in the United States, a small increased risk of developing depression in adulthood after early cannabis use was observed. Adult frequency of cannabis use, however, was not significantly associated with increased depression in adulthood. Finally, cannabis users who used the drug to cope with problems were more depressed than those who did not use it to cope with problems [269].

Depression and anxiety were observed in a seven-year cohort study of 1,601 secondary school students in the Australian state of Victoria, aged 14-15 years

at the start of the study. By the age of 20 years, some 60 per cent of participants had used cannabis and 7 per cent were daily users. Weekly or more frequent cannabis use in teenagers predicted a doubling of the risk for later depression and anxiety. The authors found a significant interaction between sex and daily cannabis use. Female students with a history of daily cannabis use had over a fivefold increase in risk of later depression. In contrast, depression and anxiety in teenagers predicted neither later weekly nor daily cannabis use. This allowed authors to conclude that frequent cannabis use in teenage girls predicts later depression and anxiety, rather than that these mental symptoms predict later cannabis use [270].

Furthermore, research based on the Christchurch cohort study (a 21-year longitudinal study of a birth cohort of 1,265 New Zealand children) concluded that a significant link existed between the frequency of cannabis use and negative psychosocial outcomes, including property and violent crime, depression, suicidal behaviours and other illicit drug use. Especially for the measures of crime, suicidal behaviours and other illicit drug use, there was evidence of age-related variation in the strength of association with cannabis use, with younger (14-15 years old) users being more affected by regular cannabis use than older (20-21 years old) regular users. The association between cannabis use and depression did not vary with age [271].

In contrast, work in the Dunedin longitudinal study came to the conclusion that early cannabis use (by age 15 years) did not predict later depression [262]. The different outcomes in the last two studies may be due to differences in methodology, quantitative measures of symptoms and cannabis use, diagnostic labels and definitions of cannabis users [272].

However, cannabis use and other psychosocial problems may have common roots. Preliminary evidence of an association between childhood maltreatment and cannabis dependence among an especially vulnerable population was shown in a recent study. In a study of 18 African American, socially disadvantaged, first-episode schizophrenia-spectrum patients, those with cannabis dependence (8 patients) were found to have experienced greater levels of childhood abuse and neglect than similar patients without cannabis dependence, suggesting an association between childhood maltreatment and cannabis dependence among this vulnerable population [273].

A significant association between cannabis use and poor mental health was found in adolescents and young adults during the Dunedin long-term prospective study. Cannabis use and poor mental health were linked to low socio-economic status, a history of behavioural problems in childhood and low parental attachment in adolescence. Mental disorder at age 15 led to a small but significantly elevated risk of cannabis use at age 18; by contrast, cannabis use at age 18 elevated the risk of mental disorder at age 21. The authors conclude that the primary causal direction leads from mental disorder to cannabis use among adolescents and the reverse

in early adulthood. In contrast, alcohol use and cigarette smoking had independent associations with later mental health disorders [274].

Current heavy cannabis use appears to have a negative impact on intelligence. In one study, intelligence quotient (IQ) scores were examined before, during and after cessation of regular cannabis use to determine any impact of the drug on this measure of cognitive function. It was found that current cannabis use was significantly correlated in a dose-related fashion with a decline in IQ over the ages studied. Current cannabis use had a negative effect on global IQ score only in subjects who smoked five or more cannabis cigarettes per week (heavy users). A negative effect was not observed among subjects who had previously been heavy users but were no longer using the substance. Smoking at least five cannabis cigarettes weekly should not be interpreted as a definitive threshold, as subjects were at low risk for other factors that could have a negative synergetic effect on IQ score. The authors conclude that cannabis does not have a long-term negative impact on global intelligence; however they identified the need for further investigation of the cognitive consequences of both current and previous cannabis use, especially a residual cannabis effect in more specific cognitive domains such as memory and attention [275].

Cannabis use in early adolescence appears to have the ability to interfere with the normal development process. For example, one study pointed out that long-term cannabis users with an early age of onset of drug consumption (age 14 to 16 years) showed a specific deficit in visual scanning. A group of cannabis users (17 participants) compared with a control group (20 participants) showed less effective search behaviour, including longer response times and more fixations at about the same error level [276].

Furthermore, an early age of onset, rather than other potential predictors of test performance such as present age, degree of acute intoxication or cumulative toxicity, was found to be the only factor predicting enduring effects on specific attentional functions in adulthood. Visual scanning undergoes a major maturation process around the age of 12-15 years and it is known to react specifically and sensitively to cannabinoids. A comparison of a group of young adults who were regular users of cannabis (and only cannabis) with a group of non-users on a battery of tests of selective attention, one of which was a test of visual scanning attention, showed that the performance of cannabis users was selectively worse on the visual scanning attention test, and the only feature that correlated with this impairment was the age at which participants had begun to use cannabis. Apparently, vulnerable periods during brain development exist that are subject to persistent alterations by interfering exogenous cannabinoids [277].

Is cannabis use associated with aggression and violence?

The argument is made by many that cannabis is a "soporific" and therefore the historical associations the drug has with violence are unfounded. For example,

Booth discounts the claim that the Nizari Ismaili, the medieval militant Islamic sect who gave rise to the term "assassin", fought under the influence of cannabis resin, because "'hashish' does not produce any mental state that would incite either violence or brutal murder" ([278], p. 85). Similarly, he rejects the claim that Zulu warriors smoked cannabis to steel their courage prior to military confrontations. In both cases, he writes off contemporaneous accounts as biased by intercultural misunderstanding.

This position seems to underestimate the importance of "set and setting" in understanding the impact of any drug. Research has illustrated that the effects of a drug are not simply a product of its chemistry, but rather the interaction of this chemistry with the user's situation, mindset and immediate environment when taking the drug. So, while in the Western paradigm, cannabis is seen as a drug inducing levity and sloth, this may not be the only interpretation that could be given to its physiological effects.

Depending on the dose, cannabis is generally classed as a "hallucinogen", not a sedative or depressant. According to Grotenhermen, "In many species the behavioural actions of low doses of delta-9 THC are characterized by a unique mixture of depressant and stimulant effects in the central nervous system." He notes clinical observation of both euphoria and dysphoria; of anxiety and reduction of anxiety. Heart rate is raised, body temperature drops and thought processes are disturbed, for better or worse ([279], p. 56). Some users refer to cannabis as a "mood enhancer".

There may also be a chemical basis for the differing views on the subjective effects of cannabis on aggression. In South Africa to this day, African people see cannabis as a stimulant, which eases labour, fuels creativity and can fuel violence [56]. Rottanburg and others note that South African cannabis smokers seem to be particularly prone to psychosis with hypomanic features.* The cannabis native to this area is considered a pure sativa, with very little CBD ([13], pp. 21-24), which is believed to affect perceptions of the stimulant effects of the drug,** and which may possess anti-psychotic properties ([280], p. 6). It may be that more attention needs to be paid to the variability of the cannabis plant before generalizing about its subjective effects.

There is little in the Western scientific literature to support the contention that cannabis is strongly associated with violence, however. One study tracked domestic

*Rottanburg and others, cited in Mechoulam and Hanuš ([280], p. 6).

**Absence of CBD has been noted in samples from Brazil, Costa Rica, Cyprus, Nigeria and other parts of Southern Africa. India and Mexico have produced both low and high CBD samples (see Baker, Gough and Taylor [15]). Other low CBD varieties are found in Ghana, Jamaica, Kenya, Myanmar and Thailand (see Clarke [47]). In Jamaica, cannabis is used as a stimulant to allow manual labourers to work harder (Dreher, cited in Grinspoon [95]). According to Grinspoon, "Many psychiatrists in India, Egypt, Morocco and Nigeria have declared emphatically that the drug can produce insanity." It is possible that at least the Indian and Nigerian reports may be rooted in the low CBD plants available in these areas.

violence incidents among a group of 149 violent men entering a drug abuse treatment programme during a 15-month period. No significant association of cannabis and violence was found. In contrast, the use of alcohol and cocaine were associated with significant increases in the daily likelihood of male-to-female physical aggression [281]. A negative association of cannabis and interpersonal violence was also found in a study of 204 incarcerated adolescents [282]. One review concluded that cannabis was likely to reduce violence during intoxication, but noted that mounting evidence associated withdrawal with aggression [283]. For example, an association between aggression and cannabis withdrawal was seen in one study of daily, long-term users [284].

There is some research that does find a link between cannabis and violent crime. For example, one study looked at the association between 10 types of drug and criminal offences in a high-risk sample. Greater frequency of cannabis use was "unexpectedly" associated with weapons offences and this association was not found for any other drug besides alcohol. Cannabis use was also associated with attempted homicide and reckless endangerment offences [285]. Another study found that one third of murderers who had ever used cannabis had consumed it in the 24 hours preceding the murder, three quarters of whom reported experiencing effects of the drug during the crime, and 7 per cent of the entire sample felt that their cannabis use had been a factor in their crimes [286]. While these studies fall far from demonstrating that cannabis and violence are deeply linked, they do contradict the view that cannabis intoxication makes violence unthinkable.

Is cannabis a "gateway" to other drugs?

One of the perennial debates surrounding the impact of cannabis relates to the so-called "gateway" hypothesis: cannabis opens the door to the subsequent use of other drugs. Much of the early work in this area suffered from the *post hoc ergo propter hoc* logical fallacy. The fact that many users of other drugs report first using cannabis does not demonstrate a causal link between the two behaviours and even a cursory look at the survey data illustrates the fact that most people who try cannabis do not go on to use other drugs.

Early discussions of the gateway hypothesis were undermined by a lack of a clear argument on the mechanism of causation. Does cannabis cause some sort of change in the brain that compels users to pursue other substances, or is the hypothetical causation the result of social factors? One of the most compelling of these possible links is the claim that cannabis introduces users to the experience of procuring illegal drugs, that cannabis vendors may sell multiple substances, and that these vendors have a profit incentive to move users on to the consumption of other drugs. This argument is also used by those who champion decriminalization of cannabis sales, as decriminalizing cannabis would "take it out of the hands of criminals". Both of these perspectives are substantially challenged by survey

evidence that most cannabis circulates among friends* with only a minority of purchases being made from professional polydrug dealers.

More sophisticated recent studies indicate there may be more to the gateway hypothesis than its early incarnations suggested, however. One remarkable study of twins was conducted in Australia. A national volunteer sample of 311 young adult, identical and fraternal same-sex twin pairs were assembled. In each case, one twin had used cannabis before the age of 17 years, while the other had not. Individuals who used cannabis by age 17 years were 2.1 to 5.2 times more likely than their co-twin to have experienced other drug use, alcohol dependence and drug abuse or dependence. Controlling for known risk factors (early onset alcohol or tobacco use, parental conflict or separation, childhood sexual abuse, conduct disorder, major depression and social anxiety) had only negligible effects on these results. The authors concluded that associations between early cannabis use and later drug use and abuse or dependence cannot solely be explained by common predisposing genetic or shared environmental factors. They argue, as suggested above, that association may arise from the effects of the peer and social context within which cannabis is used and obtained. In particular, early access to and use of cannabis may reduce perceived barriers against the use of other illegal drugs and provide access to those drugs [287].

Cannabis dependence

Traditionally, cannabis was regarded as a non-addictive drug because of the lack of observed physiological withdrawal symptoms. Further, animals failed to self-administer the drug, a behaviour usually associated with drugs of addiction [288].** However, the terminology around addiction changed with the publication in 1994 of the fourth edition of the American Psychiatric Association Diagnostic and Statistical Manual. Rather than "addiction", the Manual refers to "substance dependence", a condition that requires no physical withdrawal symptoms. The emphasis is now on the inability to end use despite the desire to do so and the problems that use causes in the lives of the dependent person [290]. At the same time, new research indicates that heavy cannabis users do experience a clinically significant withdrawal syndrome, although its effects appear to be relatively mild. Animal studies have indicated chronic administration of cannabinoids leads to adaptive changes in the brain, some of which are similar to those seen with other drugs of dependence ([291], p. 32). Animals will "work" to be given the opportunity to self-administer the drug [292].

According to data from the United States National Survey on Drug Use and Health, 27 per cent of lifetime cannabis users have only used the drug once or twice

*See the opening discussion of section II above.

**Later research, however, found tolerance, withdrawal and dependence in animals (see Farrell [289]).

and 54 per cent have used it 10 times or less. The majority of people who try cannabis do not become dependent, or even regular users. But survey data from Ireland show that a significant minority (28 per cent in 2002/2003) of lifetime users have, at some point in their smoking career, consumed the drug regularly (20 days or more a month). Of those who had been regular users in the past, some 12 per cent said they had tried to stop and failed and 30 per cent said they had never tried to stop [24]. WHO cites research indicating that about half of those who use cannabis daily will develop dependence, which is roughly consistent with these findings. WHO also points out that the low number of users presenting for treatment relative to the size of the user population suggests that there is a high rate of remission even in the absence of treatment.*

As Budney and Moore concluded in their review of the past 10-15 years of clinical and research experience, there is strong evidence demonstrating that cannabis can and does produce dependence. Clinical and epidemiological studies indicate that cannabis dependence is a relatively common phenomenon associated with significant psychosocial impairment [293].

For example, a prospective longitudinal study of a representative sample of 2,446 German cannabis users aged 14-24 years found the probability of developing cannabis dependence was 8 per cent [294]. A similar figure (7 per cent) was found in the Victorian Adolescent Health Cohort Study, in Australia. Cannabis dependent subjects were more likely than alcohol dependent subjects to report compulsive and out-of-control use [295]. In a study of the Dunedin Multidisciplinary Health and Development Study birth cohort, 10 per cent of the cannabis users developed cannabis dependence. Cannabis dependence, as distinct from occasional use, was associated with high rates of harder drug use, selling of drugs and drug conviction [296]. Similarly, 10 per cent of the New Zealand birth cohort study showed clear symptoms of cannabis dependence by the age of 21 years, especially males who were prone to other forms of risk-taking behaviours [297].

One comparative review of drug dependence risk found an estimated 9 per cent of lifetime users will develop cannabis dependence at some point. This risk, however, is less than with many other drugs, including legal drugs. It is estimated that 15 per cent of alcohol users, 23 per cent of opiate users and 32 per cent of tobacco users will develop dependence on the drug [298].

Of the 9 per cent of those who try cannabis and go on to develop dependence, it is estimated that 80 per cent of these people will not seek treatment [223]. Despite this, just under one million people participate in rehabilitation programmes every year for help with their cannabis problems in the United States alone. Globally, more people receive treatment for cannabis than for any other drug group besides

*Anthony and Helzer cited in Cannabis: a Health Perspective and a Research Agenda ([226], p. 18).

heroin. As discussed in section I, the exact numbers may be misleading, because in places like the United States, convicted users may be given a choice between time in prison and treatment. But even in countries where this policy does not exist, large shares of the total treatment population say their primary drug is cannabis according to responses to the UNODC annual reports questionnaires and its Database for Estimates and Long-term Trend Analysis. In a number of African countries, cannabis exceeds even alcohol in demand for treatment.*

Other reviews have suggested lower levels of dependence among lifetime users. A study of over 10,000 Australian adults found 1.5 per cent (according to criteria in the American Psychiatric Association *Diagnostic and Statistical Manual*) or 1.7 per cent (according to criteria in the tenth revision of the WHO *International Statistical Classification of Diseases and Related Health Problems*) of lifetime users developed dependence. However, almost one third of the current cannabis users in the study (31.7 per cent) met criteria for cannabis dependence and abuse [299, 300]. Similarly, among a group of French high school students who regularly or occasionally used cannabis, 47.2 per cent indicated substance dependence. Data concerning tolerance, withdrawal and excessive consumption indicated that subjects were significantly affected by their addictive behaviour. Among those having smoked for one year or less, 31.4 per cent reported signs of dependence versus 68.6 per cent who consumed on a recreational basis; among those having used cannabis for three years or more, 63.6 per cent reported dependence, while 36.4 per cent admitted to recreational usage [301]. In an Australian study of a sample of long-term cannabis users, more than half received a dependence diagnosis on each of three measures in the past year, and 44 per cent had a diagnosis of dependence on all three examinations. Longitudinal analyses revealed that quantity of use and severity of dependence at baseline were the primary predictors of those same variables at follow-up. These data suggest that cannabis use and dependence are fairly stable among long-term users [302].

As previously mentioned, case reports and laboratory research indicate the existence of a cannabis withdrawal syndrome. Wiesbeck and others analysed data from 5,611 subjects through the Collaborative Study of the Genetics of Alcoholism. Almost 16 per cent of the more frequent cannabis users related a history of a cannabis withdrawal syndrome. Even when alcohol and drug use patterns were statistically taken into account, cannabis use was still significantly related to self-reporting of a history of cannabis withdrawal. The typical withdrawal symptoms included "nervous, tense, restlessness", "sleep disturbance" and "appetite change" [303].

Another study found that two thirds of cannabis-dependent patients reported withdrawal symptoms on cessation of use. Progression from first to regular cannabis

*Alcohol is included in the calculations when it was included by the Member State in the breakdown of the national treatment population and for all Southern African countries. Unspecified substances, "other drugs" and "multiple drugs" (which could include cannabis) were excluded from the calculations.

use was as rapid as tobacco progression and more rapid than that of alcohol, suggesting that cannabis was a reinforcer. The data indicated that for adolescents with conduct problems, cannabis use was not benign and that the drug potently reinforced cannabis-taking, producing both dependence and withdrawal [304]. A review of the actions of cannabis on the brain reward circuitry also showed that THC had effects on core brain reward circuits that were fundamentally similar to those of other abused drugs, although the exact mechanisms may differ [292].

Budney and others, in a review of the validity and significance of a cannabis withdrawal syndrome, propose the following cannabis withdrawal syndrome criteria: common symptoms are anger or aggression; decreased appetite or weight loss; irritability; nervousness or anxiety; restlessness; and sleep difficulties, including strange dreams. Less common symptoms are chills, a depressed mood, stomach pain, shakiness and sweating [305].

The time course and clinical importance of withdrawal symptoms following cessation of heavy cannabis use have been reported by Budney and others. A 50-day outpatient study assessed 18 cannabis users during a 5-day smoking-as-usual phase followed by a 45-day abstinence phase. Onset of withdrawal symptoms typically occurred between the first and third days, peak effects between the second and sixth days and most effects lasted 4-14 days. The magnitude and time course of these effects appeared comparable to tobacco and other withdrawal syndromes [306].

In contrast to these findings, Smith, after reviewing the published literature on cannabis withdrawal symptoms in human users, concluded that the studies conducted up to that point in time did not provide strong evidence for the drawing of any conclusions about the existence of a cannabis withdrawal syndrome in human users, arguing that cannabis did not provide as clear a withdrawal pattern as other drugs of abuse, such as opiates [307].

Prenatal exposure to cannabis

WHO points out that research in this area is complicated by sampling issues and questionable self-reported data. Despite these, they conclude that there is reasonable evidence that cannabis use during pregnancy leads to reduced birth weight, possibly due to the same mechanism as tobacco smoking, foetal hypoxia. They conclude that there is little evidence to support the idea that cannabis smoking causes chromosomal or genetic abnormalities or birth defects.

The results of the Avon Longitudinal Study of Pregnancy and Childhood in over 12,000 women (5 per cent of whom reported smoking cannabis before and/or

during pregnancy) suggest that the use of cannabis during pregnancy was not associated with increased risk of perinatal mortality or morbidity. However, frequent and regular use of cannabis throughout pregnancy may be associated with small but statistically detectable decrements in birth weight [308]. These results correlate with previous findings that cannabis use in pregnancy is associated with reduced birth weight [309, 310, 311] and length at birth [312]. Furthermore, as indicated by Fried and colleagues, although a smaller head circumference observed at all ages reached statistical significance among the early adolescents born to heavy cannabis users, prenatal exposure to cannabis was not significantly related to any growth measures at birth [313].

Most studies have confirmed the WHO conclusion by finding no relationship with either minor or major morphologic abnormalities [314]. However, the Atlanta Birth Defects Case-Control Study comprised 122 isolated cases of simple ventricular septal defects and 3,029 control infants born during the period 1968-1980 in the metropolitan Atlanta area in the United States. Data on alcohol, cigarette and illicit drug use were obtained through standardized interviews with mothers and fathers. A twofold increase in risk of isolated simple ventricular septal defects was identified for maternal self- and paternal proxy-reported cannabis use. Risk of isolated simple ventricular septal defects increased with regular (three or more days per week) cannabis use. This is the first study to identify an association between maternal cannabis use and ventricular septal defects in offspring [315].

Three case-control studies have found associations between cannabis use during pregnancy and increased risk of cancer in children. The mothers of children with acute non-lymphoblastic leukaemia were 11 times more likely to have used cannabis before and during pregnancy then were mothers of controls [316]. Two case-control studies have reported an increased risk of rhabdomyosarcoma [317] and astrocytomas [318] in children born to women who reported smoking cannabis during pregnancy. However, neither study was a planned investigation of the association between these childhood cancers and maternal cannabis use.

Mild but significant cognitive impairments in the offspring of mothers who smoked cannabis during pregnancy were found in the Ottawa Prospective Prenatal Study [319]. These data were confirmed through other studies. Prenatal cannabis use was significantly related to increased hyperactivity, impulsivity and inattention symptoms at age 6 [320] and age 10 [321, 322]. Furthermore, it had a significant effect on academic performance: learning and memory of 10-year olds [322] and deficits in reading, reading comprehension, spelling and overall lower rating on the teachers' evaluations of the children's performance [323].

A follow-up study by Fried and others of the same group between the ages of 13 and 16 years indicated that those who had been exposed to cannabis in utero had poorer performance on tasks involving visual memory, analysis and integration [275].

Cannabis smoking and the lungs

As WHO has concluded, smoking cannabis is not good for the lungs. Moreover, as cannabis smokers inhale more deeply, smoking a cannabis cigarette results in exposure to significantly greater amounts of combusted material per inhalation than smoking a tobacco cigarette. Of course, most cannabis users consume fewer cigarettes than most tobacco smokers, but this may not be the case with those classified as "chronic" consumers.

The histopathological effects of cannabis smoke exposure include changes consistent with acute and chronic bronchitis. Cellular dysplasia has also been observed, suggesting that, like tobacco smoke, cannabis exposure has the potential to cause malignancy. In addition, in many parts of the world, cannabis is consumed with tobacco. Almost all studies indicate that the effects of cannabis and tobacco smoking are additive and independent [324].

Daily herbal cannabis smoking has been clearly shown to have adverse effects on pulmonary function and produce respiratory symptomatology (coughing, wheezing and sputum production) similar to that of tobacco smokers [325]. Several studies have demonstrated that, after even limited exposure to cannabis smoke, airway inflammation develops. Examination of the lungs of cannabis smokers who smoked an average of only a few cannabis cigarettes per day showed the same degree of airway injury as that detected in tobacco smokers who smoked 20 to 30 cigarettes per day. This underscores the importance of deep inhalation in enhancing the relative injury caused by cannabis smoke [326].

Cannabis smoke is also a potential cause of cancer because it contains many of the same carcinogenic substances as cigarette smoke. A review of the basic science work concluded that the evidence clearly demonstrated the ability of cannabis smoke to produce mutations and cancerous changes [327].

In a case-control retrospective study of 173 previously untreated cases with carcinoma of the head and neck and 176 cancer-free controls, the relationship between cannabis use and head and neck cancer was investigated. The risk of cancer was 2.6-fold greater in cannabis smokers than in non-users. Strong dose-response relationships were observed for frequency of cannabis use and years of cannabis use. Furthermore, the effects of cannabis use and tobacco smoking were more than multiplicative [328].

In a review of all of the current evidence, Hall and others conclude that there are good grounds for believing that chronic smoking of cannabis carries a significant risk of cancer in the aero-digestive tract and lung [329]. Other recent research, however, does not appear to support that conclusion.

It is also believed that cannabis use compromises the immune system. Cannabis smoke impairs the functioning of alveolar macrophages, the first line of the

body's immune defence system in the lungs. Alveolar macrophages from cannabis smokers are severely limited in their ability to kill both bacteria and tumour cells. The ultimate outcome of these effects may be an enhanced susceptibility to infectious disease, cancer and HIV/AIDS [330]. However, there is as yet no epidemiological evidence that rates of infectious disease are increased among chronic heavy cannabis users. Several large prospective studies of HIV-positive men who have sex with men have not found that cannabis use increases progression to AIDS [331].

Cannabis and the heart

Acute cardiovascular effects of cannabis are dose dependent tachycardia, which can lead to increased cardiac output and is generally associated with a mild increase in blood pressure. At high doses, sympathetic activity is inhibited and parasympathetic activity increased, leading to bradycardia and hypotension [332].

The cardiovascular effects of cannabis are not associated with serious health problems for most young, healthy users, although occasional myocardial infarction, stroke and other adverse cardiovascular events are reported. Cannabis smoking by people with cardiovascular disease poses health risks because of the consequences of the resulting increased cardiac work, increased catecholamine levels, carboxyhemoglobin and postural hypotension [333].

Smoking cannabis has been shown to be a rare trigger of acute myocardial infarction. This was observed in the Myocardial Infarction Onset Study. Of the 3,882 patients, 124 (3.2 per cent) reported smoking cannabis in the prior year of myocardial infarction symptoms. Compared to the patients who were not cannabis users, the users were more likely to be males, cigarette smokers and overweight. The risk of myocardial infarction onset was nearly five times as high as baseline within one hour after smoking herbal cannabis. The elevated risk rapidly decreased thereafter [334].

Cannabis is not "harmless"

As noted previously, the fact that the therapeutic effects of cannabis are being researched and legal changes are being made to accommodate this work may have obscured one simple fact: cannabis use is not good for your health.

- According to a number of studies and many users, cannabis smoking impairs one's ability to drive a car safely and perform complex operations requiring motor skills.
- A significant share of cannabis users (about one fifth, according to one study) have experienced unwanted psychic effects during cannabis intoxication, including panic attacks, paranoia and "psychotic symptoms",

and the risk of this happening may be increased by the growing availability of high-potency cannabis.

- Numerous studies find an association between cannabis use and psychosis and this effect is also likely to be influenced by the potency of the cannabis consumed.
- Despite early claims to the contrary, cannabis dependence is a reality: many people who consume cannabis (several studies indicate just under 10 per cent) find it difficult to stop, even when it interferes with other aspects of their lives, and more than one million people from all over the world enter treatment for cannabis dependence each year.
- Research indicates that younger users, whose brains are still developing, may be especially vulnerable to the negative effects of cannabis.
- Cannabis smoking is bad for the lungs for all the same reasons that tobacco smoking is.
- There appear to be significant risks associated with prenatal exposure to cannabis and the effects of cannabis on the cardiovascular system.

Whether these negative effects are greater or lesser with cannabis than with other substances, including legally available substances, is of little relevance to the users whose lives are affected by them. Despite its normalization in some countries and its celebration in popular culture, it should be noted that cannabis is a powerful drug that has recently become more powerful in many parts of the world.

It would be an error to generalize the experiences of the well-educated, upwardly mobile cannabis-smoking generation of the 1970s to the broader world today. Users today in many parts of the world are starting younger and consuming cannabis of much higher potency than in the past. In developing countries, they may see few more attractive alternatives to the positive feelings induced by the drug. The risks of substance dependence in this context are qualitatively different to those experienced in some countries where cannabis use has become a "rite of passage" today.

CONCLUSION: AREAS FOR FURTHER RESEARCH

In its resolution 59/160 of 20 December 2004, on the control of cultivation of and trafficking in cannabis, the General Assembly requested UNODC to perform a global "market survey" of cannabis. The present review has highlighted the limits of our knowledge of world cannabis markets today. While cannabis is the world's most commonly consumed illicit drug, there are several factors that limit our understanding of the global cannabis market, many of which are subject to clarification through further research and the promotion of international standardization:

- The various cannabis products are ill-defined and this makes international comparisons based on existing records difficult. This is partly a consequence of the inherent variability of the plant and partly due to the rapidly changing nature of the world's diverse consumption cultures. In developed countries in particular, however, there is a need for standardization of terminology, in particular with regard to distinguishing high-potency sinsemilla from less potent herbal cannabis. User surveys would benefit if they were to distinguish, at the very least, between consumption of cannabis herb and consumption of cannabis resin.
- The share of the market commanded by high-potency cannabis remains to be determined. This question could be clarified by both greater precision in household drug-use surveys and by proper randomization of cannabis samples submitted for national potency testing.
- Many countries of the world, including some of the most advanced, are incapable of estimating the scale of cultivation in their own territories. There is a need for standardized methodologies for making this assessment.
- The methods used for calculating the volumes of cannabis seized by law enforcement agencies need to be documented and standardized, in particular for the handful of countries responsible for the bulk of the seizure statistics.
- While the present article suggests some rough rules of thumb, there is a need for a better understanding of the productivity of the cannabis plant. Average yields resulting from the various cultivation styles should be determined and claims of multiple productive seasons in tropical areas further investigated.
- It is well known that cannabis users "clean" the seeds and stems from the cannabis they purchase on the lower end of the market. In order to

reconcile supply-side and demand-side estimates, it is necessary to know how much product weight is lost in that process.

- The rate at which both casual and cannabis-tolerant users consume the drug is in need of further documentation, as is the question of cannabis "dosage".
- Further examination is required of the growing share of cannabis users in treatment populations and whether dysphoric episodes are becoming more common in countries where high-potency cannabis is becoming more common. Qualitative research could clarify the linkage between high-potency consumption and dysphoric episodes.
- The role of cannabinoids other than THC in the recreational cannabis experience should be further investigated and the social impact of the varying availability of distinct chemovars in different geographic locations explored.

Despite the widely held notion that cannabis has been exhaustively researched, large gaps in our understanding remain. Given that an estimated 4 per cent of the world's population consumes the drug each year and that in several countries the majority of young people have tried it, cannabis remains a topic about which we cannot afford to be ignorant.

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