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A System Description of the Cocaine Trade

Bonnie Dombey-Moore, Susan Resetar, Michael Childress

Arroyo Center
Project AIR FORCE
Drug Policy Research Center

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Prepared for the
United States Army
United States Air Force
RAND's Drug Policy Research Center

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Preface

This report describes and discusses applications for a spreadsheet-based, comprehensive "system description" of the quantity and flow of cocaine from initial cultivation and processing, through international transportation, to domestic distribution and consumption. This work was originally conducted under RAND's Arroyo Center and Project AIR FORCE. More recent efforts, including refinements to the cocaine model and the development of similar systems descriptions for the heroin and marijuana trades, are being jointly sponsored by RAND's Arroyo Center and Drug Policy Research Center. This study should interest policymakers and analysts supporting the National Drug Control Program at the national level and others involved in resource allocation for or analysis of the drug problem.

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Summary

The United States has devoted substantial resources toward stemming the flow of illegal drugs. Yet it is difficult to accurately characterize the drug system, given that the production and trafficking of drugs are illegal enterprises cloaked in secrecy. Gaps and inconsistencies in the picture of the cocaine trade increase the difficulty of making good choices about resource allocation and drug fighting strategies. They also make it more difficult to evaluate the effectiveness of existing policies. While it is generally not possible to validate the basic parameters of the drug trade, a better understanding may help policymakers, law enforcement agencies, and analysts in evaluating and executing effective responses to the drug problem.

Purpose

A comprehensive accounting framework for estimating the quantities and flows of drugs would go a long way in providing such an understanding. To this end, RAND has developed—and this report documents—a computer spreadsheet–based "system description" for the cocaine trade. This system description serves as a database and an analytical tool. It consists of four interrelated spreadsheets—a database and three others that mirror the general pattern of the heroin trade: production, transportation, and U.S. distribution. The database provides primarily production-related data from 1985 through 1991. This report also provides detailed information on how to use the model. The spreadsheets are available for either IBM (DOS) or Apple-based machines upon request to RAND.

Approach and Application

Using information available in the open literature, we constructed an end-to-end description of the cocaine trade with an emphasis on quantities entering the United States. Despite the fact that data are limited, we were able to tell a reasonably comprehensive story. More importantly, the system framework has given us (and any other user) a means to pool information from various sources while imposing consistency on these disparate data.

To examine the potential utility of this tool, this report details three distinct but related applications: improving the estimation processes, conducting sensitivity analyses, and guiding planning and assessment. In improving the estimation process, an analyst can use the comprehensive framework to evaluate assumptions or data in terms of their downstream effects on other indicators. Sensitivity analysis can be used to understand the import of certain parameters versus others (this may be helpful in allocating intelligence resources, for example) and to evaluate first-order effects of change in the system, such as an eradication program.

Acknowledgments

The authors are grateful to RAND colleagues Carl Builder, who conceived of this effort and provided early guidance and direction, and Peter Reuter, who as co-director of the Drug Policy Research Center has been a fountain of knowledge and insights. Jennifer Duncan assisted in the initial data collection effort. Jon Caulkins gave us the benefit of a thorough and thoughtful review, but, as always, any remaining errors are solely the authors' responsibility. Deborah Elms and Doris Siegel were skilled and efficient in helping to prepare this document for publication.

1. Introduction

Background

The priority afforded to reducing illegal drug use in the United States increased considerably during the 1980s. This emphasis is evidenced by federal spending on anti-drug efforts, which increased from $1.5 billion in 1981 to a projected $12.7 billion in 1993, an increase of nearly 750 percent.[1] Most of this funding has been aimed at the cocaine trade. And even this increase in federal expenditures may present only a partial picture, since some previously purchased resources have also shifted to the drug war. The U.S. military's increasing role in anti-drug efforts is a prime example.

The foundation for the U.S. military's involvement in the drug war was laid in 1981 when Congress amended the *Posse Comitatus* Act of 1878, paving the way for the military to assist civilian law enforcement agencies in the drug war.[2] By the late 1980s, illegal drug trafficking was declared a threat to U.S. national security,[3] and Congress had expanded the military's role in the drug war by mandating that the Department of Defense (DoD) play a leading role in at least four broad areas: (1) equipment loans; (2) training of law enforcement agency officials; (3) radar coverage of major drug trafficking routes; and (4) intelligence gathering and dissemination.[4]

Despite all the resources dedicated to stemming the illegal flow of drugs, the basic data and analytical tools available to decisionmakers have important gaps and limitations. For example, the government neither systematically estimates basic quantities of cocaine consumed nor assesses the impacts of different drug control programs.

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[1]Office of National Drug Control Policy (1992), p. 8. There was nearly a 400-percent increase from 1981 to 1989. See Carpenter and Rouse (1990), p. 2.

[2]The *Posse Comitatus* Act of 1878 prohibited the use of the military for civilian law enforcement. See U.S. Congress, House (1981).

[3]President Reagan signed a National Security Decision Directive (NSDD) in April of 1986 stating that the drug trade is a threat to U.S. national security. See Richburg (1986).

[4]U.S. General Accounting Office (1987), p. 2.

Limitations of Current Information About the Drug Trade

Owing in part to the clandestine nature of the drug trade and in part to the fractionation of responsibility among both federal and state agencies, published information about the characteristics of the drug trade is sketchy. Worse, the published data often appear contradictory. This increases the difficulty of making good choices about how and where to allocate scarce resources aimed at reducing the problem. It also complicates the task of measuring the effectiveness of chosen policies.

The existing estimates in the International Narcotics Control Strategy Report (INCSR) and the National Narcotics Intelligence Consumers Committee Report (NNICC) for the supply side of the cocaine trade, for instance, show significant and persistent inconsistencies.[5] Figure 1.1 shows the high and low estimates for the INCSR and NNICC for 1985 through 1989.[6]

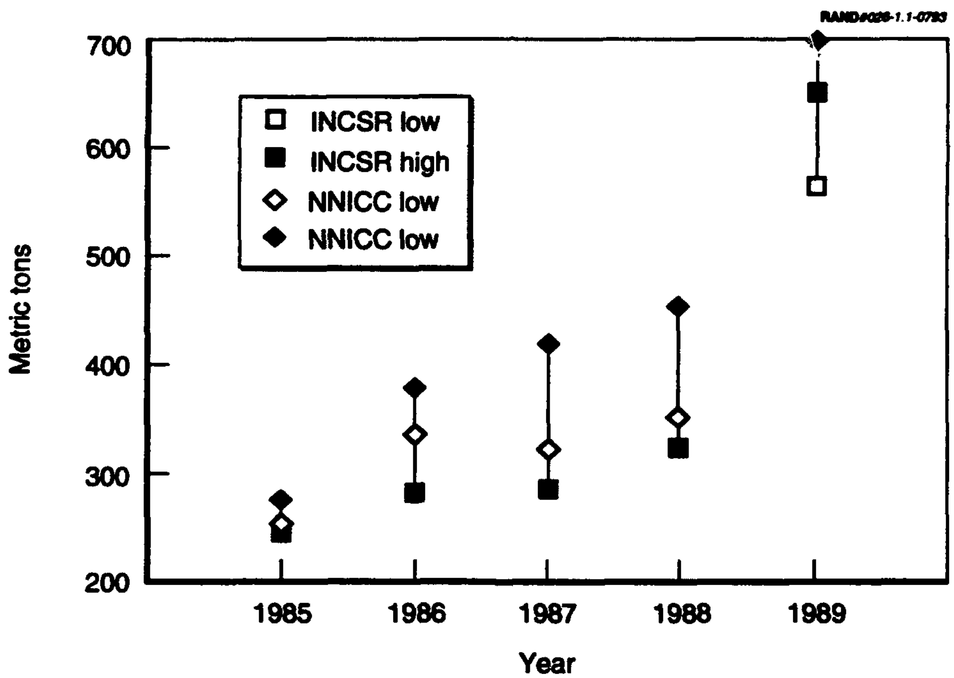


Figure 1.1—Cocaine Hydrochloride for Export: INCSR and NNICC Estimates

[5]The INCSR is an annual publication of the Department of State. The NNICC is an annual publication of an interagency committee headed by the Drug Enforcement Administration. The inconsistencies in the estimates are even more striking for heroin and marijuana production.

[6]For most of these years, the INCSR provides only a point estimate, not a range.

For cocaine production, the NNICC estimates have been consistently higher than INCSR estimates.[7] The divergence over time between the two series has also tended to increase: In 1985, the midpoint of the estimates in both series differed by about 9 percent; in 1987, the difference was 32 percent. These differences have become somewhat smaller since 1987, although in 1989 they were still greater than 20 percent. In 1990, disagreements about estimates were relegated to footnotes because a decision was made to report the INCSR estimate as the formal consensus.[8]

Numerous revisions of estimates have also been made within the NNICC and INCSR series, again reflecting the uncertainties involved in producing such estimates. The 1992 INCSR shows large upward revisions of prior-year estimates of coca leaf yield, attributed to new data from field studies of the yield of mature coca bushes. There have also been numerous revisions of prior-year estimates without explanation: For example, 1988 Colombia cocaine cultivation was reported as 27,000 hectares in the 1989 INCSR but then as 34,000 hectares in the 1991 INCSR.

Moreover, there is no apparent effort to reconcile or understand major differences in estimates of production on the one hand and estimates of consumption and/or numbers of drug users on the other hand.[9] One result of this disconnect, as shown in Figures 1.2 and 1.3, is a picture of sharply increasing supply of cocaine and decreasing prevalence since 1985.[10] For instance, according to the 1991 National Household Survey on Drug Abuse, most illicit drug use in the United States has stabilized at the five-year low reached in 1990, with about half as many users as in 1985.[11]

Although this apparent discrepancy might be *partly* explained by increases in the average consumption of individual users (associated with the decline in retail price and/or the increasing dependence of the user population), no estimates of daily consumption levels per user have been offered to test this proposition.

---

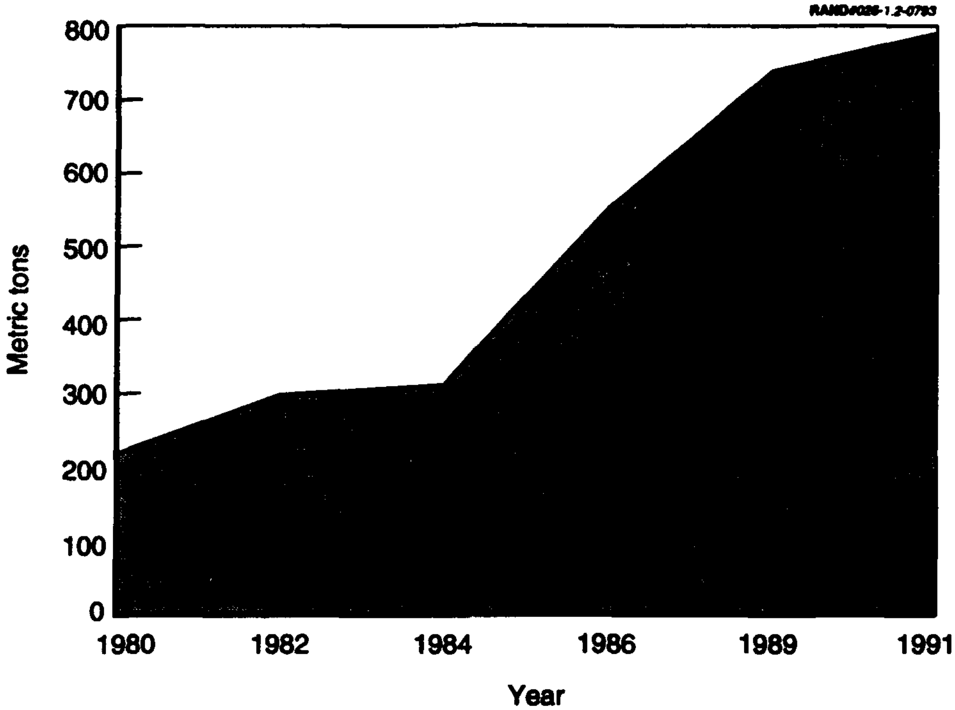
[7]The reverse has been true for opium/heroin and marijuana estimates; INCSR estimates are consistently higher.

[8]See Reuter and Ronfeldt (1992), Appendix, for greater detail on the trends and plausibility of estimates for other drugs for which RAND has developed system descriptions: opium/heroin and marijuana production.

[9]At times, production estimates have been derived from estimates of the numbers of users, with the percentage from each source country estimated from sample analyses of seizures. This methodology would ignore production-related intelligence, such as numbers of hectares cultivated.

[10]See Abt Associates (1991) for a comparison of the production and consumption based estimates.

[11]Press Conference Remarks of Secretary Louis W. Sullivan, summarized in U.S. Department of Health and Human Services, "HHS NEWS," December 19, 1991. The National Household Survey on Drug Abuse has been done annually since 1971; it is sponsored by the National Institute on Drug Abuse under the Alcohol, Drug Abuse and Mental Health Administration (ADAMHA).



SOURCE: INCSR, various years.

Figure 1.2—Cocaine Production

Some or all of the difference may also be explained by increasing shipments to other nations, particularly in Western Europe, where cocaine seizures rose from less than 1 metric ton in 1985 to over 12 metric tons in 1990. This explanation raises its own questions, however, since there has apparently not (yet) been a significant increase in cocaine activity from the view of treatment personnel or of individuals knowledgeable about street-level activity.[12] A better understanding of these differences is important for formulating national drug policy.

Nevertheless, the drug trade is a "system," and as such it is impossible, for instance, to end up with more final product than the sum of the raw materials with which it started.[13] And, by the same logic, there should be some relation

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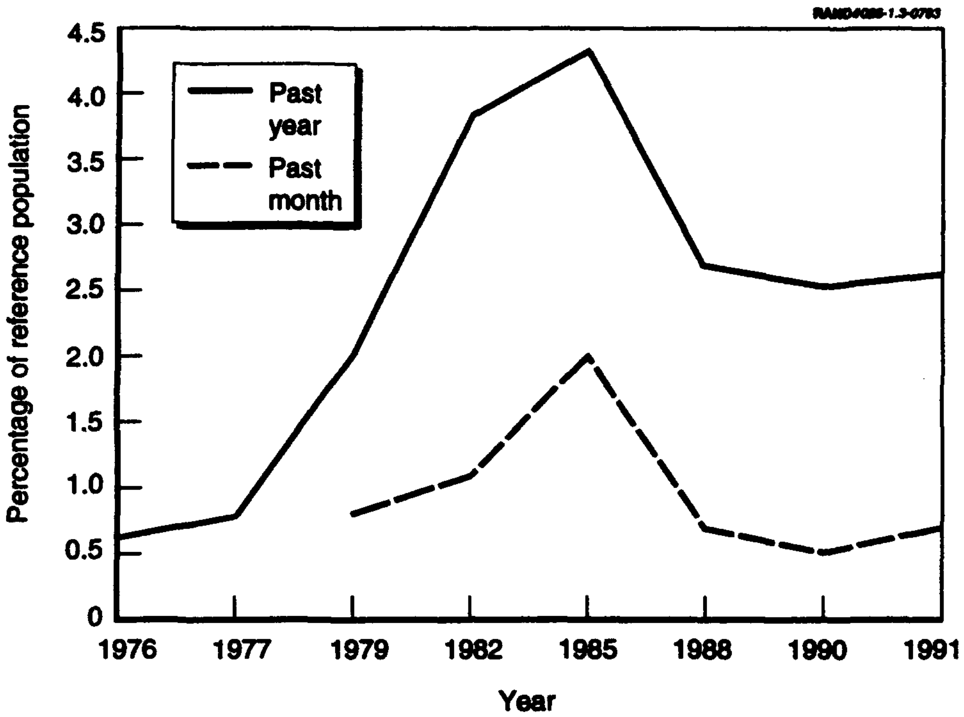
[12]In "Current Activities and Priorities of the Pompidou Group," December 1990. The Pompidou Group comprises 20 western European countries, plus Hungary and Yugoslavia. Similar observations were made by Dr. John Strang, Consultant Psychiatrist in Drug Dependence at the Maudsley and Bethlem Royal Hospitals in London, advisor on drug dependency to the United Kingdom's Chief Medical Officer, and a member of the editorial board of the *British Journal of the Addictions*, during a presentation at RAND on April 21, 1992.

[13]This is meant as a general statement. If one is specifying a particular time period, some final product could come from storage and not from the raw materials of that period. It is also possible that some of what is consumed as cocaine is active adulterant, such as procaine.



SOURCE: National Household Survey on Drug Abuse.

Figure 1.3—Adult Cocaine Use

between prevalence, or amount of drug consumed, and the amount of drug produced or imported. The system description imposes a framework that either forces consistency in assumptions or data or highlights sources of inconsistency. Essentially, it is an elaborate accounting scheme for reconciling estimates of the quantities and flows of drugs.

Purpose

This study provides decisionmakers and analysts a tool to assist in estimating quantities and charting the flow of cocaine. The tool is a spreadsheet-based model that provides a system description of the cocaine trade. In addition to a mostly production-related database, the descriptive model contains three other spreadsheets that mirror the general pattern of the cocaine trade: production, international transportation, and U.S. distribution. The model is designed to allow users to substitute their own data or assumptions about parameters.[14]

[14]Similar system descriptions have been developed for heroin and marijuana. See Childress (1993a, b). The "set" of descriptions makes it possible to get a broader picture of the illegal drug trade and to examine substitutability among drugs.

Organization of This Report

Section 2 provides a narrative account of cocaine cultivation and processing. This section provides some information about the underlying process modeled in the spreadsheets. Section 3 gives a general "system overview" of the model, and Section 4 discusses some of the possible applications the model could support. Appendix A lists the regional organization of the United States used in the model. Appendices B and C provide more detailed information about the structure and operation of the spreadsheet model. Appendix D presents a short primer on the INCSR's data collection methodology, and Appendix E displays the output from a simulation to test for the effect of propagating errors in the model.

2. The Cocaine Production Process

This section provides a brief overview of the cocaine production processes that underlie the spreadsheet model. It describes the steps in the process, the general conversion factors as processing moves from stage to stage and some of the uncertainties surrounding these factors, and summarizes the roles of various countries in production and transport.[1]

The first subsection provides a generic description of how cocaine is produced. It describes the stages, ingredients, equipment, and time required for the various stages. But the description is idealized in the sense that it does not take into account any production differences that may occur in any of the cocaine-producing countries. It also treats the process as though it took place in a single location with no interruptions. But such is not always—or is even rarely—the case. Production normally occurs in multiple locations, and the second subsection describes the varying roles of the different countries that participate in the drug trade.

Producing Cocaine

How It Is Made

Manufacturing cocaine (cocaine hydrocholoride) from the coca leaf is a three-step process. The primary raw material is the coca leaf, and the two intermediate products are coca paste and coca base. Table 2.1 shows the three steps in the production process and provides a general sense for the ingredients and time required and the end product of a given stage (right column). The amount listed for the product in the first row of each processing phase also gives a general sense for the loss of weight (or yield) from the previous phase. Thus, 250 to 500 kg of leaf produce about 2.5 kg of paste, which in turn yield about 1 kg of base. Yields at each stage can vary widely, depending on the leaf's alkaloid content (which is a function of the species and growing conditions), weather conditions

[1]For another overview of coca cultivation and processing, see the brochure by the same name published by the U.S. Department of Justice, Drug Enforcement Administration. For a more in-depth discussion of cocaine production in the Andean region, see Morales (1989). For an overview of the trade in a particular year, see the *National Narcotics Intelligence Consumers Committee Report*, published annually by the Drug Enforcement Administration, and for more information on specific country involvement, see the *International Narcotics Control Strategy Report* published annually by the Department of State, Bureau of International Narcotics Matters.

Table 2.1

Cocaine Hydrochloride Production

Ingredients Required[a]	Amount (per kg of C.HCl required)[a]	Processing Time[b]	Equipment[c]	Product
Coca leaf	250–500 kg	3–5 days	Cement or plastic pit	Paste
Potassium carbonate	30 l		Filter	
Kerosene[d]	50 l			
Sulfuric acid	10 l			
Sodium carbonate				
Water				
Coca paste	2.5 kg	5–10 days	Glassware	Base
Sulfuric acid	500 ml		Drying tables	
Potassium permanganate[e]	10 kg		Heat lamps (electrical source)	
Ammonium hydroxide				
Water			Filter	
Cocaine base	1–1.1 kg			Cocaine hydrochloride
Ethyl ether	5 l			
Acetone, methyl ethyl ketone, benzene, or toluene	5 l			
Hydrochloric acid	250 ml			

[a]SOURCE: Personal communication with Frank Sapienza, DEA, Office of Controlled Substances, December 1989. Most of the chemicals have substitutes, and recipes differ.

[b]SOURCE: Paste—Morales (1989), p. 71 (values are for Peru only); Defense Science Board (1987), p. 34. Base—Defense Science Board (1987), p. 34.

[c]SOURCE: Morales (1989) and Golob (1989), Annex.

[d]Although less effective, gasoline is a substitute.

[e]Optional, increases purity.

during harvest and processing, experience and skill of the "cooks," and quality of chemicals.

The first step involves harvesting the coca leaves, which can be done two to six times per year. (A coca plant cultivated from seed will generally be mature and ready for harvesting within 12 to 24 months.) The most abundant harvest usually occurs after the March rains. Once harvested, the leaves are dried, which can take as little as a half a day with sufficient sun. Dried leaves can be stored for long periods without losing much of their alkaloid content.[2]

[2]Morales (1989), p. 75.

The second step turns the leaves into paste. Today, most peasants who grow coca also make paste, since the process is not overly complex. In addition, drug traffickers realized it was more convenient to have peasants manufacturing paste in small facilities, which are easy to construct and are more difficult to detect by law enforcement agents than large centralized refineries.[3]

Although paste production is relatively simple and demands neither complex facilities nor extensive expertise, paste quality can vary for many reasons. For example, the ease with which alkaloid is extracted depends on the specific leaf variety. In addition, sulfuric acid quality is important, as is the accuracy achieved when combining ingredients in the mixing pits.[4]

In contrast to paste production, the next step, conversion of paste to base, is a more sophisticated process. Instead of a cook, a chemist (a distinction some regard as dubious) is required for quality control. According to the Defense Science Board, typical labs in Colombia can produce 500 kilos of base per week, using about 50 laborers and one chemist. Colombia, the major processing country, has both small (tens of kilos) and large (thousands of kilos) labs.[5] Some believe traffickers move from one to the other depending on their perceived risk.[6, 7] The final step converts the base to cocaine hydrochloride. This stage is also relatively sophisticated, requiring several chemicals to render the base into cocaine. Cocaine HCl is the normal form of transport and use, although it can be further processed into "crack" cocaine relatively easily.[8]

Who Does What?

The major coca leaf producing nations are Peru, Bolivia, and, to a lesser extent, Ecuador and Colombia.[9] Although coca has been grown in other areas of the

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[3]The Panos Institute (1990), p. 4.

[4]Morales reports that, in Peru, the most common cause of bad-quality paste is the use of a lighter sulfuric acid (Morales, 1989, p. 77).

[5]Defense Science Board (1987), p. 34.

[6]Treaster (1990), p. A6.

[7]Cocaine traffickers are reportedly using aqueous solutions of paste and base for storage and transportation, known as *aguarica*.

[8]Conversion to crack usually takes place in small batches near the retail level within the U.S. market.

[9]Note that there is some concern that coca cultivation has spread to Brazil as well. While there have been eradication efforts in Brazil, we have not seen estimates of the total cultivated area. Some believe that significant expansion into Brazil may be unlikely for political and environmental reasons. The Brazilian government maintains a strong public security force and therefore has greater control over its own boundaries than the Peruvian government. Yields per hectare, a critical factor in cocaine manufacture, are much lower in Brazil because of the coca plant variety that grows there. (Remarks of Mr. Rosenquist at the CRS seminar documented in *Cocaine Production, Eradication, and the Environment: Policy, Impact, and Options*, p. 55.)

world—most notably Java, India, Ceylon, Africa, and Indonesia—the plant is of lesser quality and is unsuitable for cocaine hydrochloride production.[10] Of the more than 200 species of coca plant, only 17 can be used to produce cocaine, and only two species contain relatively high levels of cocaine alkaloid. In 1985, approximately 197,000 hectares were cultivated for coca; and in 1989, an estimated 217,000 hectares were cultivated in the Andean region.[11] Peru is the largest cultivator in the Andean region, with Bolivia growing approximately half the Peruvian amount. Colombian cultivation is a close third (although the yield is much lower), while Ecuadorian production is minimal by comparison. Other, more limited information suggests a wide variation in estimates of cocaine cultivation in both Bolivia and Peru. For example, in 1988 the Bolivian government estimated cultivated area over 20 percent greater than U.S. State Department values as reported in the INCSR (approximately 61,000 hectares versus 50,000 hectares, including legal production).[12] Other sources estimate that in 1987 and 1988 Peruvian acreage devoted to coca cultivation was in the range of 100,000 to 500,000 hectares, with 200,000 being the nominal value. The INCSR values for these years were 107,500 and 115,630, respectively (including 17,913 hectares for licit use).[13]

Estimates of coca leaf yields, which are applied to the areas cultivated to calculate gross coca leaf production, vary as well. According to above-mentioned sources, coca leaf yields per hectare generally range between 0.8 and 2.6 metric tons (some jungle regions report 5.5 metric tons per hectare). U.S. sources use figures in the range of 0.8 and 1.6, Colombia having the lowest yield and Bolivia the highest.[14] These figures vary depending on the altitude, plant variety, plant age, insecticide use, and price of leaf (if it is too low, farmers do not harvest the crop).

Lack of Consensus on Productivity Factors

Table 2.2 presents some of the data we have collected; the range in values is quite evident. Between 1989 and 1990, the State Department's INCSR publication

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[10]Coca leaf is grown in elevations ranging from 1,000 to 6,000 feet and suffers severe damage if temperatures fall below 55°F.

[11]Some portion of this production is for licit use. Licit production is used within the country for mastication and tea, and it is exported (to the United States among others) for use as a local anesthetic.

[12]JPRS (1989), p. 9.

[13]Remarks of Dr. Eduardo Bedoya, *Cocaine Production, Eradication, and the Environment: Policy, Impact, and Options*, Congressional Research Service, August 1990, p. 6.

[14]Colombia's yields per hectare are low because of the variety of coca plant that is primarily cultivated in the southern region. Colombian coca, *erythroylum coca* var. *ipadu* or Amazonian coca, is only about 0.25 percent cocaine, whereas the average for Huanaco or Bolivian coca is 0.63 percent cocaine.

Table 2.2

Data on Productivity and Conversion Ratios

	Leaf: Hectare[a]	Leaf: Paste[b]	Paste: Base[c]	Base: C.HCl[d]	C.HCl (Country Total)[e]
Bolivia					
1988 GOB	2.6 Chapare				
1988 NNICC	1.4				500
1989 INCSR	1.6 Chapare (70%)				
	1.2 Yungas (30%)	75–110	2.6–3.0	1.0–1.1	195–365
1990 INCSR	1.4	110	4.0	1.1	485
DIRECO	2.4	96	1.0	2.5	240
Colombia					
1988 NNICC	0.8				500
1989 INCSR	0.8			1.1	500
1990 INCSR	0.8			1.1	500
Ecuador					
1988 NNICC	1.65				500
1989 INCSR	5.5 jungles				
	1.65 mountains	100	3.0	1.0	300
1990 INCSR	1.5				180
Peru					
1988 NNICC	1.0				
1989 INCSR	1.0	200	2.5	1.0	500
1990 INCSR	1.14	115	2.8–3.0	1.0	334

[a]Metric tons of leaf yield per hectare.
[b]Metric tons of leaf to yield one metric ton of paste.
[c]Metric tons of paste to yield one metric ton of base.
[d]Metric tons of base to yield one metric ton of C.HCl.
[e]Metric tons.

estimated that the productivity of Bolivian coca (in terms of cocaine hydrochloride produced from coca leaf) increased by approximately 75 percent, and their estimate of Peruvian coca productivity decreased by 35 percent.

The *Los Angeles Times* reported that new CIA studies found the cocaine trade to be more sophisticated than government experts previously believed. The studies reportedly offered evidence that cocaine traffickers have found ways to produce the drug more efficiently than in the past. For example, according to the study, they found that a single hectare of coca, previously believed to yield 1.5 kilos of cocaine, could produce as much as 2.5 kilos.[15]

[15]Jehl (February 17, 1990), p. A20.

U.S. estimates of productivity factors are generally regarded as conservative. According to the Panos Institute, Bolivian and Peruvian estimates of cocaine production for 1988 were three times U.S. estimates.[16]

Cocaine processing does not necessarily take place in the country of origin. Because Colombia has the financial resources, it has developed into the major cocaine processing center. However, there is considerable concern that processing will spread to nearby countries, such as Argentina, Brazil, Costa Rica, Paraguay, and Venezuela, and will be pushed back up the pipeline into Bolivia and Peru as pressure on Colombian trafficking organizations increases.[17] In Peru, coca paste and base manufacturers have little trouble in obtaining chemicals, such as kerosene, sulfuric acid, potassium permanganate, and ammonia, since these are all produced in Peru and have too many commercial uses to be controlled. However, imports of ether and acetone, two key chemicals for converting base into hydrochloride, are monitored by the Peruvian government. Unfortunately, after acetone and ether have entered the country and are resold, these controls break down.[18] Key precursor chemicals, such as acetone, ether, and sulfuric acid, are also smuggled across Bolivia's borders, and the flow of essential precursor chemicals through Venezuela to Colombia and other countries is of concern.[19]

Table 2.3 lists the countries involved in the drug trade and briefly summarizes their major roles. As an overview, three countries—Bolivia, Colombia, and Peru—produce most of the cocaine. Considerable internal transportation of drug products occurs as it moves through the production process. Once the cocaine is produced, five other countries—Argentina, Brazil, Ecuador, Mexico, and Paraguay—largely serve a transport role, moving the drug from production location to distribution centers in the market countries.

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[16] Ardila (1990), p. 2.
[17] Gugliotta (1990), p. 19.
[18] *International Narcotics Control Strategy Report*, March 1990, p. 147.
[19] Ibid., pp. 112 and 157.

Table 2.3

Cocaine Drug Trade Countries at a Glance

Country	Primary Role	Cultivation	Eradication	Drug Use	Industries
Argentina	Transit point for Bolivian and Colombian cocaine, mainly to Europe	Illegal		Illegal, est. 100,000 users for all drugs	Producer of chemicals
Bolivia	Cultivation and refining to paste/base	Illegal in most areas[a]	Yes, generally voluntary, no herbicides	300,000 to 1,500,000 estimated chewers of coca leaf	
Brazil	Transit point, cultivation is emerging	Illegal[b]	Yes		Chemicals produced (ether and acetone), diversion to illicit considered minimal
Colombia	Refining (base to C.HCl) and trafficking	Illegal	Yes, no herbicides[c]	Illegal, estimated 650,000 users	Agriculture
Ecuador	Transit point (chemicals, cocaine), cultivation, money laundering	Illegal	Yes[d]	Illegal	
Mexico	Transit point				
Paraguay	Transit point for U.S. and Europe (Bolivian cocaine), money laundering	Illegal	(e)		
Peru	Cultivation and processing	Some licit			Producer of precursor chemicals

[a]Bolivia—licit use is estimated at 30 percent of crop, according to the INCSR report. However, a Bolivian report estimated that only 10 percent of 1988 crop production went to licit uses.

[b]Brazil—no licit crops are grown because of poor soil and drought conditions. Coca is grown in jungle areas, which are difficult to spot under the canopy.

[c]Colombia—because coca cultivation occurs in remote jungle areas controlled by leftist guerrillas, eradication is difficult.

[d]Ecuador—herbicide spraying is not cost-effective because of the rugged terrain and small, widely distributed plots.

[e]Paraguay—the climate is not conducive to cocaine cultivation.

3. Overview of the System Description

RAND has developed a series of spreadsheets to model the cocaine production process described in the previous section. We label these spreadsheets in the aggregate a system description. This section provides a general overview of the system description. The system description consists of four related spreadsheets, which can serve both as a database and an analytical tool. We designed flexibility into the system description so analysts can easily substitute data or modify assumptions.

Components of the System Description

While the specifics of the drug industries can vary, each follows the same overall pattern, which provides the basis of our system description. Figure 3.1 describes the pattern and compares it with our system description components.

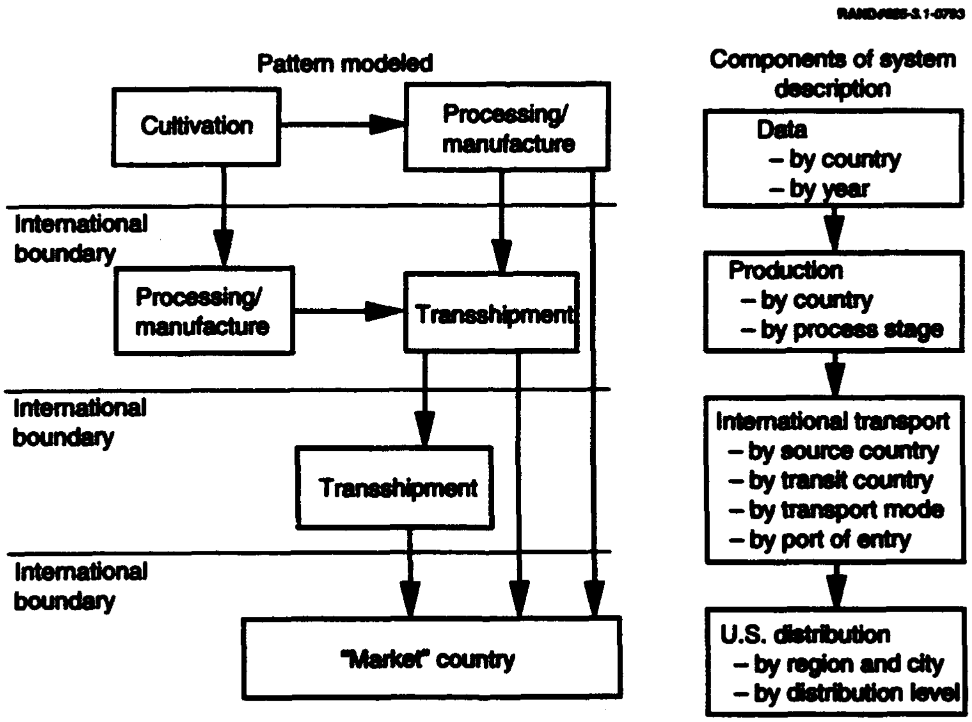

Figure 3.1—Pattern of Drug Flow Compared to System Description

The various activities or functions can be characterized as: production, processing, international transportation, and domestic distribution (including domestic production). Individual countries can be involved in any one or combination of these activities.[1]

Four computer-based spreadsheets form the system description for cocaine.[2] The first is a longitudinal **Database**, consisting primarily of production-related data (from 1985) that are linked to the system spreadsheets and can provide the initial conditions. An entry in the database is an observation for a specific combination of year, country, source reference, and the low and high values for each source. Production data are taken from the open literature, primarily the INCSR and the NNICC.

Three system spreadsheets mirror the categories of activities noted above: **Production, International Transportation, and U.S. Distribution.** The system spreadsheets model the flows through the entire system for one year at a time; an extract from the database spreadsheet can provide the initial conditions for a given year, or the analyst can substitute others. The diagram on the right side of Figure 3.1 provides a schematic of the spreadsheet structure.

Production Spreadsheet

The production spreadsheet begins with cultivated area and ends with an estimate of the amount of cocaine hydrochloride ready for shipment to markets. It builds the estimate of finished product using detailed parameters for each stage in the cocaine manufacturing process and for each participating (or source) country. Losses due to seizures, consumption, and so forth are accounted for, as well as transfers of intermediate products between processing countries. (Information about transfers of intermediate product can be useful for some nontraditional program planning and assessment, as we discuss in more detail in the section on applications.)

Built-in graphs show the gross and net production for each producer country at each stage of the manufacturing process. Figure 3.2 is an example of a summary graph that displays each country's "market share" for each stage of the production process. For instance, Peru and Bolivia together account for about

[1] Not all of these activities are relevant for all drugs. The word "country" refers to a geographic location and does not imply that these are government-sanctioned activities.

[2] The software is Excel, and the model can be made available for either PC or Macintosh hardware.

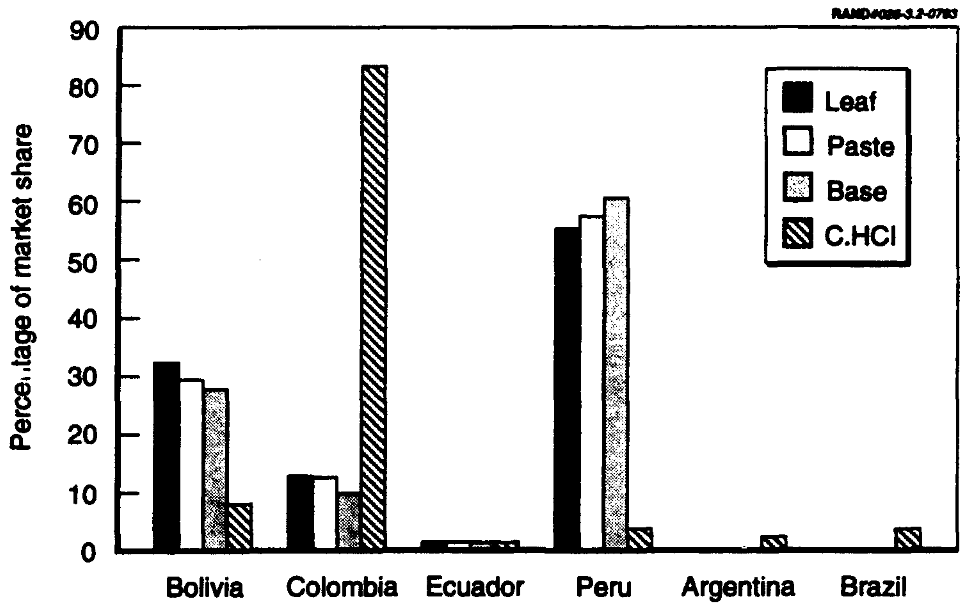

Figure 3.2—Processing and Movement: Country Shares

90 percent of the market up to the last stage, when Colombia dominates virtually the entire market.[3]

International Transportation Spreadsheet

The international transportation spreadsheet is the most complex of the spreadsheets. It takes final product ready for export from the production spreadsheet and estimates the amount successfully smuggled into the United States. It comprises five different input matrices that systematically divide the volume of drug from producer countries, to shipping countries, to markets,[4] to U.S. regions by transportation mode. Again, built-in graphs such as Figure 3.3 provide a variety of summary information.

One matrix takes the drug from producer countries and distributes it to the shipping countries. For example, cocaine produced in Bolivia is shipped to Colombia and Brazil. A second matrix takes the drug from the shipping countries and distributes it to markets worldwide, including the United States. A third matrix distributes the drug within the United States.

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[3]The examples in this report are for 1989.

[4]We have included storage as a "market" from which cocaine can be made available for a later year. For simplicity, we have provided one storage point, although conceptually there could be storage at various stages in the system.

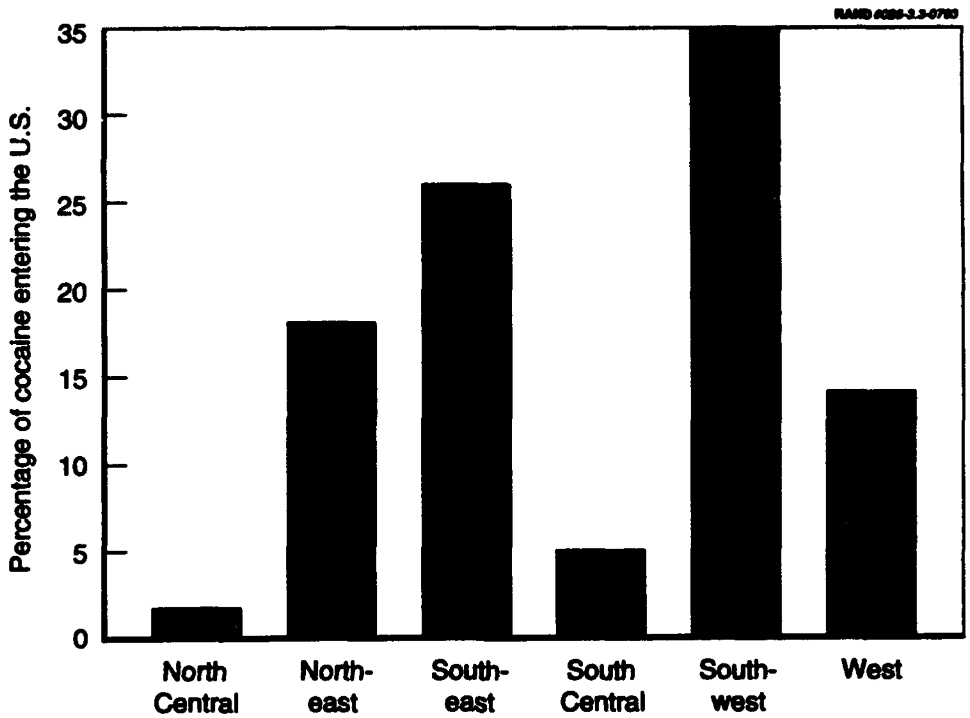

Figure 3.3—Distribution of Cocaine Smuggling by U.S. Entry Region

At this point in the system description, the United States has been divided into six regions (see Appendix A for a list of states composing each region).[5] The sources of cocaine vary among the regions, as do the primary transportation modes. Another matrix defines the drug flow by transportation modes: land, sea or air, and private or commercial carrier. Thus, according to the data we have gathered, we can see that in 1989 the Southwest region has a lot of small-plane traffic delivery and private surface transportation from Mexico, while the Northeast gets most of its cocaine via commercial container cargo. The cocaine arriving in most regions predominantly originated in Colombia, although the final transshipment countries vary considerably. Venezuela is shown to be the main supplier of many eastern parts of the United States, while Mexico is the final source of much of the western U.S. supply.

The final matrix operating in this spreadsheet accounts for seizures, roughly those drugs seized at the U.S. borders.

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[5]Federal seizure data are collected for these regions.

U.S. Distribution

The final spreadsheet tracks the domestic distribution of drugs.[6] It begins with the amount successfully smuggled into each of the U.S. entry regions.[7] (As with all of the spreadsheets, the analyst can substitute other estimates.) Interregional transfers can be estimated, as can be losses—owing either to domestic law enforcement or other removals or inventory losses. The spreadsheet has the facility to include domestic production. This feature is not particularly relevant for cocaine, but we have tried to preserve consistency with system descriptions for other drugs, and one could conceive of some synthetic domestic production, for example. Tables drawn from the spreadsheet generate an estimate of the total quantity of cocaine available for domestic distribution by region. The user has the option to further distribute regional quantities to cities within the region. The cities listed have been identified as high-intensity drug trafficking areas by ONDCP and/or as Level I or II cities (in terms of trafficking) by the FBI.

A final spreadsheet feature allows estimates of the numbers of individuals involved in the trade at each level in the market and compares the supply-based estimate of the number of users to the estimate from the National Household Survey on Drug Abuse or some other exogenous estimate. The figure for numbers of sellers starts with an estimate of the number of users and incorporates informed guesses about how many buyers the average seller services.[8]

Limitations

Limitations of the system description fall into two categories. The first is analytic; it is a description and takes behavior as given. Second, it rests on incomplete and often questionable data. (Of course, this same weakness is what makes the system approach so useful.)

From an analytic perspective, the framework is not adaptive. By itself, it cannot provide information on how the system might respond to policy choices or strategies. However, it can incorporate findings from economic and/or behavioral models of particular sectors and show a first approximation of the systemwide effect of policies directed at those sectors.

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[6]This spreadsheet is provided for the sake of completeness, because resources are distributed on the basis of estimates about such flows, and because some users may have reasonable data. Data presented here could fairly be characterized as guesses.

[7]The U.S. regions were taken from the El Paso Intelligence Center's Drug Movement Indicator Profile and are the regions for which drug seizure data are reported.

[8]See Moore (1977); Reuter and Kleiman (1986).

Also, the framework generally models drug flows in only one direction—from production through consumption. This means if an analyst overrides the data in, for example, the international transportation spreadsheet, the model will show the downstream implications of the analyst's estimates (i.e., the amount entering the United States and distributed in the United States), but it will not automatically show the upstream changes in production or processing estimates required to be consistent with the analyst's data. However, we have incorporated a recent feature of the Excel software—Goal seeker—that allows the user to derive the upstream estimates that would be consistent with changes in downstream data, albeit at a more aggregate level of detail.

The model does not currently incorporate all inputs of potential interest. Precursor chemicals have not been included as raw materials, although this may be added as a modification. (Table 2.1 in Section 2 contains a list of precursor chemicals.) The model also only estimates domestic labor in the U.S. Distribution spreadsheet; it does not estimate labor in other stages of the system. Again, it is certainly possible to add labor as an input for other sectors as well.

Finally, available information for each part of the system varies in both quality and quantity. Area under cultivation may be estimated with tolerable accuracy, given the central role of aerial surveillance, though weather conditions apparently lower the quality of observation in Peru's Upper Huallaga Valley, and source-country eradication efforts tend to increase efforts to disperse and camouflage production. The sources of data on leaf yield per hectare are much weaker; these can be obtained only through ground activities, and there may be considerable variation both within and among primary growing regions. Similarly, there is considerable uncertainty about the coca content of leaves from different areas and about the efficiency of refining at different stages. There is much understandable uncertainty about international smuggling activities, although some information is available. Information on domestic consumption (quantity consumed, not frequency of use) and the interregional transfer of drugs within the United States is sparse to nonexistent.

4. Applications for the System Description

The system description has at least three distinct, but related, uses: improving the estimation processes, sensitivity analysis, and planning and assessment.

Improving Estimation

The inconsistency and frailty of estimates of production and consumption have themselves become a serious issue for policy makers. Basic disagreements about whether the drug problem is improving or deteriorating would be at least partially resolved if it were possible to link indicators from different parts of the system. The systems description forces consistency (which is not to be confused with accuracy or validity) on the estimation process.[1]

It may well be that some inconsistencies are primarily a function of a heretofore inadequate accounting framework. For example, some observers believe that the European market for cocaine has expanded to a point now where it might account for a substantial share of the additional production in the Andean region estimated by U.S. agencies. The spreadsheets, by requiring additional cells to account for shipments from the region to Europe, can impose that consistency explicitly. The spreadsheets can also be used creatively to gauge the reasonableness of such estimates or assertions. Substituting estimates of the amounts going to Europe (instead of the United States), and seeing the downstream prevalence in Europe that such a quantity implies, offers another indicator (which could be compared with their official estimates) to test the plausibility of estimates of drug quantities headed for Europe.

Sensitivity Analysis

Given the limitations of available data, one of the most important contributions of the model—aside from imposing a logical/conditional framework on disparate sources of information—is the ability to perform parameter sensitivity

[1]These terms are often confused. Consistency means that the system description is free from internal contradiction. Accuracy means that the model's numbers are correct, in the sense that they conform to the truth, which we do not claim. Validity refers to the fidelity of the model's representation of the real world from the perspective of the intended uses of the model.

analysis easily. For instance, Table 4.1 illustrates the percentage change in the three output measures for a 50-percent increase in selected parameter values.

Even from this limited analysis, one can clearly see that changes in some parameters have a much greater impact on the "system" than changes in other parameters. This information can be useful, among other things, for allocating intelligence resources. Knowing, for instance, that increasing the yield of paste per unit leaf in Peru by 50 percent increases estimates of U.S. cocaine imports by 68 percent or estimated users by 88 percent suggests the importance of getting that figure as correct as possible. On the other hand, eradication and producer-country consumption figures are not particularly important in this case.[2]

Intelligence resources need to be allocated where they will produce the greatest returns. Resources might be focused on the most uncertain parameters, but also on the parameters that sensitivity analysis has shown to be critical in the determination of the flow of cocaine to the United States. Of course, it is also essential to consider the cost of attaining a given percentage reduction in the parameter uncertainty.

Table 4.1

Sample Parameter Sensitivity Analysis: Percentage Change for a 50-Percent Increase in Parameter Value

	Percent Increase or Decrease in		
Parameter Increased	Gross Supply of Cocaine	Cocaine Sent to the U.S.	Estimated Number of Users
MT of leaf per hectare			
Bolivia	20	19	25
Colombia	5	6	8
Peru	36	37	48
MT of paste per metric ton of leaf			
Bolivia	31	29	39
Colombia	11	12	16
Peru	66	68	88
Peru's leaf consumption	–3	–3	–4
Bolivia's eradicated area	–1	–1	–1
U.S. border seizures	n/a	n/a	–15
Drug purity	n/a	n/a	–30
Annual consumption per user	n/a	n/a	–33

[2]The impact of certain parameters may seem somewhat tautological. Peru, for instance, represents almost 60 percent of the market through the leaf, paste, and base stages of processing, so it is somewhat predictable that changes in the processing parameters for Peru will have a large impact on the "bottom line." On the other hand, other parameters could have had a muting or swamping effect.

Another type of sensitivity analysis might address the following type of question: How much additional cultivated land would be required in Bolivia to replace a 50-percent loss of production in Peru, perhaps as a result of a good eradication program? Using 1989 data, it would require an 84 percent increase in Bolivian cultivation—from 53,920 hectares to 99,212 hectares. Some estimates of the amount of time it would take to bring that amount of land into full production and the amount of labor involved could be produced exogenously. These figures could help illustrate the *potential* duration of the impact of an effective eradication or substitution program in Peru.[3]

Planning and Assessment

Tracking regional flows serves a number of programmatic and analytic purposes. For instance, it can help the analyst pay attention to the consequences of an increase or decrease in production on the flows of traffic along different routes. According to the data, most of the cocaine that comes to the United States directly from Bolivia goes to the Southeast; thus, an increase in production or direct distribution from Bolivia may have an effect on the flows into this region. Likewise, evaluating assumptions in light of their differing impacts or downstream indicators may help resolve disagreements or uncertainties about particular parameters.

The system description also identifies quantities that may be of assistance in assessing the effectiveness of programs. For instance, it might be useful to know how many plane flights are needed to get Bolivian paste to Colombia, given average loads and the estimate of flows. Our data indicate that Bolivian base deliveries to Colombia totaled 300 tons in 1989 and are generally flown in 2-ton shipments. So there would be approximately 150 flights, or roughly three per week. How many flights is our intelligence network picking up compared with this estimate? And, going back to sensitivity analysis, if there is wide variation in the loads transported, as shown by seizure data, how would that affect estimates of the amount of air traffic?

Finally, this framework may serve as a useful tool for better integration of strategic intelligence and estimates between the law enforcement agencies (LEAs) and the military or at least for facilitating a dialogue. The military is strategically oriented and has a well-developed data collection and analysis capacity, while

[3]Again, this is a first-order approximation. Unless results from a behavioral model are explicitly incorporated, the model will not take account of the effects of adaptive or perhaps preemptive behavior on the part of the coca growers or traffickers to such a program.

domestic law enforcement is naturally oriented more toward the short term and is reactive. The system description may help the two sides develop a common strategic focus and language of criminal methods and infrastructure.[4]

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[4]We owe thanks to Mr. J. D. Davis, Colonel W. R. Lipke, and Lieutenant Colonel Jim Carter of the Army, Office of the Deputy Chief of Staff for Intelligence, for raising our awareness of this issue.

5. Conclusions

The amount of resources devoted to stemming the flow of illegal drugs into the United States is substantial, and yet considerable uncertainty surrounds the basic parameters of the drug system. This situation is understandable given that the production and trafficking of illegal drugs are generally conducted in secrecy. Moreover, it is not generally possible for one to effectively evaluate the accuracy of basic factors on the cocaine trade. Nevertheless, if policymakers, law enforcement agencies, and analysts are to promulgate, execute, and evaluate responses to the drug problem, the basic facts about the drug system need to be understood as well as possible.

The model described in this report has at least three distinct, but related, uses that can facilitate a more informed response to the cocaine trade. First, the model can be used to improve the estimation process. Many estimates are published in the public domain with little or no substantive explanation of how they are derived. Consequently, it is almost impossible to evaluate the accuracy of many basic estimates on the cocaine system. However, this model can be used to evaluate these estimates by examining their perturbation on the system and asking whether these perturbations are sensible (this is especially effective if the analyst has relatively high certainty about some estimates, which can be used as "constraints" on the system). Second, the model can be used to perform sensitivity analysis. Since there is a lot of uncertainty over many of the estimates, knowing which ones have the biggest impact on important outcomes in the United States can facilitate a more cost-efficient allocation of analytic resources. Third, the model can be used as a tool for increasingly effective planning and assessment. The model can help planners in their strategic framework by linking assumptions on production to cocaine flows in the United States.

Appendix

A. U.S. Region Definitions

The U.S. regions below are used by drug control agencies in tracking the movement and concentration of drugs. Table A.1 shows the regional compositions.

Table A.1

Regional Definitions

NORTHEAST	SOUTH CENTRAL	NORTH CENTRAL
Connecticut	Alabama	Colorado
Delaware	Arkansas	Idaho
Maine	Louisiana	Illinois
Massachusetts	Mississippi	Indiana
Maryland	Tennessee	Iowa
New Hampshire		Kansas
New Jersey	SOUTHWEST	Kentucky
New York	Arizona	Michigan
Pennsylvania	New Mexico	Minnesota
Rhode Island	Oklahoma	Missouri
Vermont	Texas	Montana
		Nebraska
SOUTHEAST	WEST	North Dakota
District of Colombia	California	Ohio
Florida	Nevada	South Dakota
Georgia	Oregon	Utah
North Carolina	Washington	Wisconsin
South Carolina		Wyoming
Puerto Rico		
Virgin Islands		
Virginia		
West Virginia		

B. More Detail About the Spreadsheet System

This appendix describes the system model in greater detail and should be useful for users, potential users, and anyone wanting greater specificity about the system description. Appendix C is geared toward the actual user.

The Spreadsheets

A schematic of the spreadsheet organization is shown in Figure B.1 where the linkages are denoted by an arrow. Because the data are sparse, the database spreadsheets represented with shaded lines do not exist; they are included in the figure for conceptual accuracy. The data contained in these spreadsheets come primarily from the *International Narcotics Control Strategy Report* (INCSR) and the *National Narcotics Intelligence Consumers Committee Report* (NNICC). The

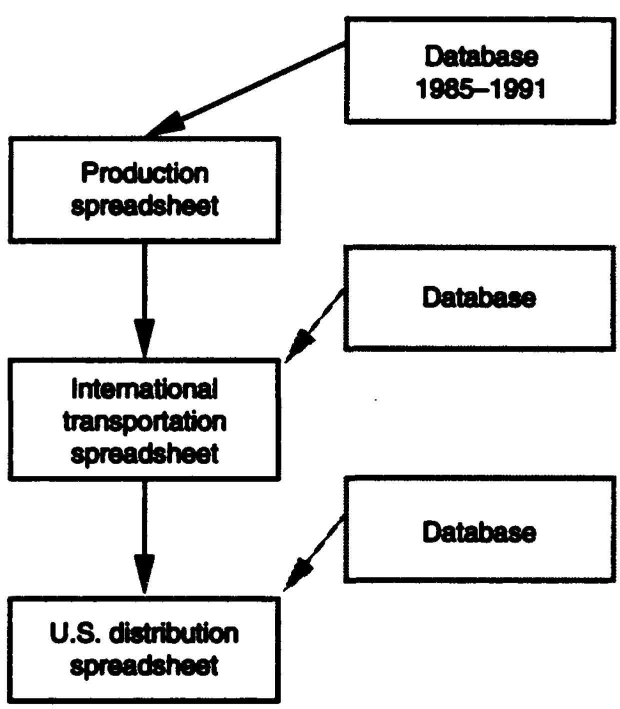

Figure B.1—Spreadsheet Schematic

production-related database contains data over several years, but the system spreadsheets model the quantities and flows of drug for one year at a time.

Database Spreadsheet

The first spreadsheet is the database and is the starting point for the model; it provides the initial conditions for the other spreadsheets. The user can also substitute his or her own data. This spreadsheet, schematically displayed in Figure B.2, includes a glossary of terms, the database, a "criteria" range, and a "data extract" range, which is linked to the next spreadsheet.[1]

An entry in the database is an observation for a specific combination of country, year, source reference, and reference low or high value. Table B.1 shows a selection of observations. Column A contains the country, column B the year, and column C the source reference.[2] For each observation, over 25 data elements or "fields" can be tracked. Table B.2 shows the list of data elements and their definitions reproduced from the glossary in this spreadsheet.

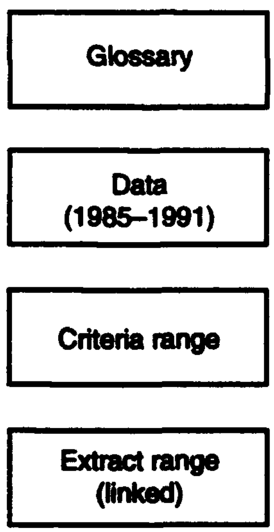

Figure B.2—Database Spreadsheet Outline

[1]These are spreadsheet terms. The criteria range is where the user defines what data he or she wants to extract from the database; for instance, all observations for Peru from 1984 to 1986. The extract range is where the subset of data defined in the criteria range is displayed.

[2]The source reference numbers are coded to specific reports identified on the spreadsheet. These sources contain information on a variety of information catalogued in the database. Sources that are used in a more limited way are included in the other spreadsheets as notes behind the relevant data cell(s).

Table B.1

Observation Format

A	B	C
Country	**Year**	**Reference**
Peru	1988	[3] Low
Peru	1988	[3] High
Bolivia	1989	[1] Low
Bolivia	1989	[1] High
Bolivia	1989	[2] Low
Bolivia	1989	[2] High
Colombia	1989	[1] Low
Colombia	1989	[1] High
Colombia	1989	[2] Low
Colombia	1989	[2] High

NOTE: Bracketed figures [ ] refer to specific source, e.g., INSCR.

The last two areas in the database spreadsheet are devoted to defining and extracting data from the database for use either in the system spreadsheets or for summary statistics.[3] These areas are partially reproduced in Table B.3. The criteria range is where the user enters the desired characteristics of observations to be extracted. In our example, we have requested observations for 1989 and the low value for reference 2 (which is the INCSR, March 1990). By using the Excel data extract command, the program places observations that meet the criteria in the data extract range. It is the extract range that is linked to the **Production** spreadsheet. This is the form of the criteria request that should be used if the user wants the extracted data to be used by the system spreadsheets, although any combination of year and reference may be used. Otherwise, if the user wants to use the database in a stand-alone fashion, many creative combinations of criteria can be applied.

Production Spreadsheet

The first system spreadsheet is the production spreadsheet. This spreadsheet begins with the cultivation of the necessary raw material and works through each of the intermediate products where applicable. It also tracks interregional transfers of intermediate products. The production spreadsheet concludes with

[3]A database can provide an analyst with summary statistics about the data. For instance, the DAVERAGE function can be used to find the average cultivation area for all (or some subset of) the observations in the database.

Table B.2

Cultivation and Conversion Factors: Cocaine

Glossary Variable Name	Units of Measure	Description
LEAFYIELD	metric tons/hectare	Amount of leaf per cultivated hectare
LEAF2PASTE	kg leaf/1 kg paste	Leaf to paste conversion factor
PASTE2BASE	kg paste/1 kg base	Paste to base conversion factor
BASE2C.HCL	kg base/1 kg C.HCl	Base to C.HCl conversion factor
LEAF2C.HCL	kg C.HCl/kg leaf	Leaf to C.HCl conversion factor
CULTIVAREA	hectares	Cultivation area
ERADAREA	hectares	Eradication area
LEAFHARVEST	metric tons	(Cultivation minus eradication) times yield
LEAFCONSUMD	metric tons	Leaf consumed in country
LEAFSEIZD	metric tons	Leaf seized in country
LEAFLOST	metric tons	Other leaf losses in country
NETLEAF	metric tons	Leaf harvest minus the three loss categories
GROSSPASTE	metric tons	NETLEAF/LEAF2PASTE
PASTECONSUMD	metric tons	Paste consumed in country
PASTESEIZD	metric tons	Paste seized in country
PASTELOST	metric tons	Other paste losses in country
NETPASTE	metric tons	Gross paste minus the three loss categories
GROSSBASE	metric tons	NETPASTE/PASTE2BASE
BASECONSUMD	metric tons	Base consumed in country
BASESEIZD	metric tons	Base seized in country
BASELOST	metric tons	Other base losses in country
NETBASE	metric tons	Gross base minus the three loss categories
GROSSC.HCL	metric tons	NETBASE/BASE2C.HCL
C.HCLCONSUMD	metric tons	C.HCl consumed in country
C.HCLLOST	metric tons	Other C.HCl losses in country
C.HCLXPORT	metric tons	C.HCl available for export

the amount of cocaine hydrochloride that is ready for export to various markets. Data are presented on:

- hectares cultivated,
- productivity factors,
- loss factors (including consumption, in-country seizures, and other losses), and
- intermediate product transportation routes and quantities.

(Almost all data elements in this spreadsheet are linked to the previous **Database** spreadsheet. However, they can be easily overridden if alternative data are available.)

The general procedure followed in this spreadsheet is to calculate the gross intermediate product, subtract losses, transfer the intermediate product, then process it to the next stage (or intermediate product).[4] Table B.3 is a representation of the spreadsheet for the initial calculation—harvested area. Notice, it begins with cultivated areas, subtracts losses due either to eradication or other (i.e., fields left fallow), yielding the harvested area. Factors shown for leaf yields per hectare are applied and the multiplication takes us to the first stage—leaf. Losses from in-country consumption, seizures or other (i.e., spoilage, inventory shrinkage, etc.) are subtracted from gross leaf yield. The net leaf yield is either transferred to other countries or remains in country for further processing. Leaf-to-paste conversion factors are shown, taking us to the next step, and so on. Leaf, paste, and base parallel the same format in the spreadsheet.

As can be seen in Table B.4, Bolivia cultivated an estimated 53,920 hectares of coca in 1989, and approximately 5 percent of this area was eradicated (none was left fallow). On average, in 1989, one hectare yielded 1.48 metric tons of coca leaf, yielding about 76,096 metric tons of leaf available for further processing. Looking to the next stage, we see that Bolivia begins with 76,096 metric tons of

Table B.3

Database Criteria and Extract Range

Criteria						
Country	Year	Reference	Leafyield	Leaf2Paste	Paste2Base	Base2C.HCL
	1989	[2] Low				
			XXXX			
Extract Range						
Country	Year	Reference	Leafyield	Leaf2Paste	Paste2Base	Base2C.HCL
Bolivia	1989	[2] Low	1.48	110	3	1.1
Colombia	1989	[2] Low	0.8	130	4	1.1
Ecuador	1989	[2] Low	1.5	100	3	1
Peru	1989	[2] Low	1.14	115	2.8	1

[4]The implicit assumption is that the losses are of goods produced in country.

Table B.4

Format of the Production Spreadsheet

Cultivation/Production (1)		-Minus-			(2)
Cultivated Hectares Before Losses		Area Eradicated	Other Loss	Cultivated Hectares After Losses	Leaf Yield Factors
Bolivia	53,920	2,504	0	51,416	1.48
Colombia	42,500	641	0	41,859	0.80
Ecuador	240	60	0	180	1.50
Peru	120,415[a]	1,285	0	119,130	1.14
Total	217,075		Total	212,585	

Second Stage—Leaf (In Metric Tons)		-Minus-			
Leaf Before Losses and Transfers		Leaf Consumed	Leaf Seized	Leaf Other Loss	Leaf After Losses
Bolivia	76,096	10,000	0	7,610	58,486
Colombia	33,487	0	203	0	33,284
Ecuador	270	0	0	0	270
Peru	135,808	11,536	444	0	123,828
Total	245,661			Total	215,869

Transfer T[illegible]
Leaf

Transfer From		Transfer To			Total Outgoing
	Argentina	Brazil	Colombia	Ecuador	
Bolivia	0%	0%	0%	0%	0
Colombia	0%	0%	0%	0%	0
Ecuador	0%	0%	0%	0%	0
Peru	0%	0%	0%	0%	0
	0	0	0	0	0
					Total Out
					0
					Total In

[a]Eradicated area is linked to Cocadata; Other Loss is not linked.

leaf, of which some is consumed and some is lost, giving a net coca leaf available of 58,486 metric tons. We also see that no leaf was transferred between Bolivia and other producer countries. Therefore, Bolivia has 58,485 metric tons available to process to paste, and so on. As described earlier in this report, built-in graphs provide summary information for this and other spreadsheets.

International Transportation

This spreadsheet begins with final product ready for export from the **Production** spreadsheet just described and estimates the amount that is successfully smuggled into the United States. Simply, as the schematic in Figure B.3 shows, it is a series of input matrices that systematically divides the drug volume from producer countries, to shipping countries, to markets, to U.S. regions, and finally to U.S. regions and transportation modes. This spreadsheet contains the following estimates:

- the amount transiting each smuggler country
- the amount exported to markets other than the United States
- the amount coming into the United States
- the amount, net of seizures, that makes it into the United States by region and transportation mode.

The first matrix distributes the drug from producer countries to shipping countries. For example, Bolivian cocaine is shipped to Colombia and Brazil, and

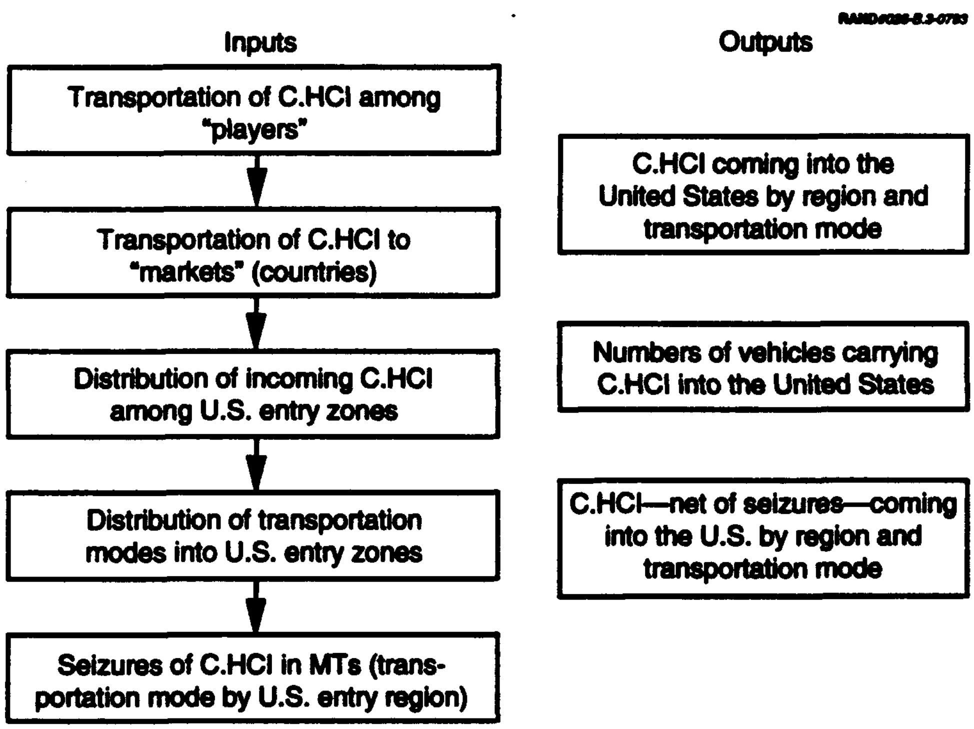

Figure B.3—International Transportation Spreadsheet: A Schematic Representation

some Peruvian cocaine is shipped to Ecuador and Brazil. The amounts are strictly the amounts sent to transshipment nodes and not markets.

The second input matrix distributes the drug to the markets. Table B.5 is a representation of this matrix; sample shipping countries are listed in the left-hand column and the markets are identified across the top row. The United States and Canada are identified separately; all other markets are denoted by continent. We have included an additional "market"—storage—which can hold the product for distribution in a later year.[5] Below each shipping country listed in the left-hand column is a figure representing the metric tons of cocaine ready for shipment to market. The user would enter the percentage of this amount that is distributed to each market, and the computer will calculate the metric tonnage right below the input value. For example, according to our calculations for 1989, Argentina had 7.9 metric tons of cocaine to smuggle, of which 100 percent was shipped to Europe. The source or rationale for the 100-percent estimate is included in a note "behind" the cell and, in this example, is an estimate based on the Drug Enforcement Administration (DEA) smuggling routes map (1989), the INCSR (1990), and other miscellaneous information.[6] Alternatively, the user can simply input the estimated percentage headed for the U.S. market and ignore the other markets. In either case, this matrix estimates the volume of drug being sent to the United States. The next step is to estimate how much is being smuggled into each region of the United States.

Table B.5

Input Matrix for C.HCl Distribution to Markets (in percent, converted to metric tons)

	Transport To:						
From:	Canada	S.E. Asia/ Pacific	Europe/ Middle East	To Storage	Subtotal to Other Markets	Amount to U.S.	Alternative Amount to U.S.
Argentina	0	0	100	0	100	0	N/A
7.9	0	0	7.9	0	7.9	0.0	N/A
Bolivia	0	0	0	0	0	100	N/A
16.6	0	0	0.0	0	0.0	16.6	N/A
Brazil	0	0	90	0	90	10	N/A
35.3	0	0	31.8	0	31.8	3.5	N/A

[5]For simplicity, we have provided one storage point; conceptually, there could be storage at most stages of the production process.

[6]The existence of a note behind a cell is indicated by a small square (an arrow on the Macintosh) in the upper right-hand corner of the cell.

The third input matrix is patterned very similarly to the second. Smuggling countries are shown in the left-hand column with the amount destined for the U.S. market, and the regions of the United States are shown across the top row (these regions are defined in Appendix A). The user enters the percentage that is smuggled from each shipping country to each region of the United States. The routes identified in this spreadsheet were approximated from a DEA map of drug trafficking routes. The absence of an entry indicates that there is no route between the shipping country and the U.S. region.[7]

The next input matrix is again patterned similarly to the previous two matrices. It distributes the drug flow into each U.S. region among a number of transportation modes:

- Commercial air
- Commercial sea
- Commercial land
- Private air
- Private sea
- Private land

Commercial air includes passengers carrying illicit drugs, as well as packaged drugs contained in cargo. Commercial land includes tractor trailers, while private land includes private and recreational vehicles, as well as persons carrying packages. The others are self-explanatory. The distribution of drug traffic into these transportation modes can be based on seizure or other relevant data. For convenience, illustrative default distributions are provided. The distributions are specific to each entry region; that is, every route feeding the Southeast United States will have the same distribution based on the seizures in that region. (Default values can be easily overridden.)

The final input matrix in the **International Transportation** spreadsheet is for estimates of seizures, roughly limited to those at U.S. borders.

Several columns to the right of these input matrices in the spreadsheet are tables of results. The first table shows the amount of drug smuggled over the various routes to the United States. Table B.6 shows a section of this table. Each entry in the table represents the estimate of metric tonnage of cocaine that traveled from the shipping countries listed in the left-hand column, to the U.S. entry region listed along the top row, sorted by transportation mode. For example, an estimated 36.96 metric tons traveled from Colombia to the southeast United States by private air in 1989.

[7]Drug Trafficking Routes, DEA Map, 1989.

Table B.6

Output: Volume of C.HCl by Route and Transportation Mode (in metric tons)

	North-Central	North-east	South-east	South-Central	South-west	West
Commercial Air						
Argentina	0.00	0.00	0.00	0.00	0.00	0.00
Bolivia	0.00	0.00	2.82	0.00	0.00	0.00
Brazil	0.00	0.12	0.30	0.00	0.00	0.00
Colombia	0.00	2.97	15.26	0.00	0.00	0.26
Ecuador	1.95	0.37	0.95	0.00	0.00	0.13
Mexico	0.00	0.00	0.00	0.00	0.00	0.82
Panama	0.00	0.00	0.00	0.00	0.00	0.00
Peru	0.00	0.00	0.00	0.00	0.00	0.09
Venezuela	0.00	1.73	4.45	0.00	0.00	0.00
Private Air						
Argentina	0.00	0.00	0.00	0.00	0.00	0.00
Bolivia	0.00	0.00	6.11	0.00	0.00	0.00
Brazil	0.00	0.00	0.65	0.00	0.00	0.00
Colombia	0.00	0.00	33.06	1.27	16.21	0.26
Ecuador	3.31	0.00	2.05	0.63	1.34	0.13
Mexico	0.00	0.00	0.00	0.00	25.22	0.82
Panama	0.00	0.00	0.00	0.00	0.00	0.00
Peru	0.00	0.00	0.00	0.00	0.91	0.09
Venezuela	0.00	0.00	9.64	0.00	0.00	0.00
Subtotal						
Comair	1.95	5.18	23.77	0.00	0.00	1.31
Privair	3.31	0.00	51.51	1.90	43.68	1.31

The same format is repeated for the other transportation modes, and the summary statistics shown in Table B.7 are calculated at the end of the table in the spreadsheet. Built-in graphs also display summary information.

U.S. Distribution

The final system spreadsheet tracks the domestic distribution of cocaine. It begins with the amount successfully smuggled into each of the U.S. entry regions. (Again, while these values are linked to the previous spreadsheet, they can be overridden.) A column is available to add domestic production to the amount imported. While this is not necessarily relevant for cocaine, we wanted to maintain consistency of form with the other system descriptions. This table generates an estimate of the total amount of cocaine available for domestic distribution.

Table B.7

Summary Statistics for Volume of C.HCl by Route and Transportation Mode (in metric tons)

Totals by Region:	North Central	North-east	South east	South Central	South-west	West	Totals
	5.26	74.03	132.08	15.85	171.30	52.38	450.90
	1.17%	16.42%	29.29%	3.52%	37.99%	11.62%	100.00%

Totals by Transportation Mode		
AIR:	134	29.70%
commercial	32	7.14%
private	102	22.56%
LAND:	160	35.49%
commercial	21	4.58%
private	139	30.91%
SEA:	157	34.81%
commercial	79	17.51%
private	78	17.30%

Totals by Country		
Argentina	0.00	0.00%
Bolivia	15.67	3.47%
Brazil	3.33	.074%
Colombia	211.91	47.00%
Ecuador	31.56	7.00%
Mexico	131.87	29.25%
Panama	0.00	0.00%
Peru	7.12	1.58%
Venezuela	49.45	10.97%

The remainder of this spreadsheet distributes the drug throughout the United States and calculates the numbers of individuals in each of the drug-market hierarchy levels, based on estimates of the supply, purity levels, and annual usage. The final table compares the estimated user prevalence with the National Institute of Drug Abuse (NIDA) National Household Survey estimate.[8] Even fewer data are available for this part of the system description than for the production and international transportation sections, so almost all the numbers shown here are illustrative.

Figure B.4 shows a schematic of this spreadsheet. Once we have the estimate of the amount of drug entering the various U.S. regions (step A), we provide the capability to estimate interregional transfers (step B) to get an estimate of the gross amount ready for sales. The procedure here mirrors the procedure in the International Transportation spreadsheet: The user enters the estimate of the percentage of drug available that is shipped from the entry regions to the demand regions. In step C, the losses due either to domestic enforcement or inventory and other losses are subtracted. Step D, which is optional, allocates the regional quantities to cities within the region. The cities included are those identified as high-intensity trafficking areas by the National Drug Control Strategy Report, January 1990, augmented by those classified by the FBI as Level I or II cities for drug trafficking activities. Steps E and F contain inputs for the

[8] *National Household Survey on Drug Abuse: Population Estimates 1988*, U.S. Department of Health and Human Services, National Institute on Drug Abuse, 1989.

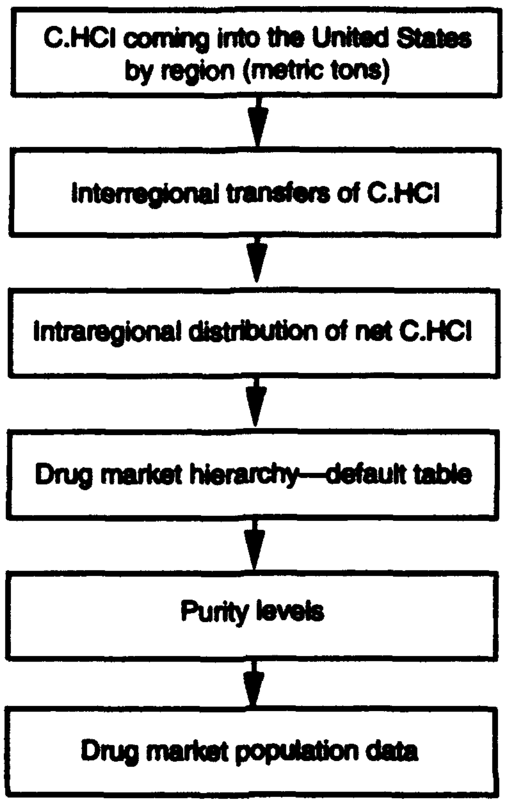

Figure B.4—U.S. Distribution Spreadsheet: A Schematic Representation

final table, step G, which in turn calculates the numbers of individuals involved in the trade at each level in the market. This final table is reproduced in Table B.8. The regions and cities appear in the left-hand column, and the trade hierarchy appears across the top. Each entry represents the numbers of individuals involved in the trade for the given year based on the drug supply.

The final columns compare the drug user prevalence (based on supply estimates) to a demand-based estimate of drug use to determine whether the two estimates are at all consistent. It is worth pointing out here that, using 1991 data, the calculated prevalence and NAS prevalence are markedly different (see Appendix C).[9]

[9]We have used data from the National Household Survey for our demand-based estimate, but as with all the data in the model, the user may substitute better data.

Table B.8

Drug Market Population Data

	Distrib-utors	Whole-salers	Mid-Level Dealers	Users (in 000s)	Popula-tion (in 000s)	Calculated Preva-lence	National Household Survey Preva-lence	Ratio
North Central								
Chicago (II)	0	0	0	0	0	NA	4.9%	NA
Detroit (II)	0	0	0	0	0	NA	4.9%	NA
All Other	846	1,691	4,026	2,416	58,031	4.2%	4.9%	0.85
North East								
Boston (II)	0	0	0	0	0	NA	4.2%	NA
Newark (II)	0	0	0	0	0	NA	4.2%	NA
New York (I)	0	0	0	0	0	NA	4.2%	NA
All Other	721	1,442	3,433	2,060	47,152	4.4%	4.1%	1.08
South East								
Atlanta	0	0	0	0	0	NA	2.6%	NA
Miami (I)	0	0	0	0	0	NA	2.6%	NA
All Other	426	851	2,027	1,216	30,996	3.9%	2.6%	1.51
South Central								
New Orleans	0	0	0	0	0	NA	2.6%	NA
All Other	90	180	429	257	14,860	1.7%	2.6%	0.67
South West								
El Paso (I)	0	0	0	0	0	NA	2.6%	NA
Houston (I)	0	0	0	0	0	NA	2.6%	NA
All Other	316	633	1,506	904	19,900	4.5%	3.3%	1.37
West								
Los Angeles (I)	0	0	0	0	0	NA	6.1%	NA
San Diego (II)	0	0	0	0	0	NA	6.1%	NA
San Fran. (II)	0	0	0	0	0	NA	6.1%	NA
Seattle	0	0	0	0	0	NA	6.1%	NA
All Other	478	955	2,274	1,365	30,193	4.5%	6.1%	0.74
U.S. Total	2,876	5,752	13,696	8,217	201,131	4.1%	4.1%	

NOTE: ONDCP has designated Houston, Los Angeles, Miami, New York City, and the entire Southwest Border as High-Intensity Drug Trafficking Areas—those with the most serious drug trafficking problems and most pressing needs for federal intervention. Simiiarly, the FBI classifies cities as first-, second-, or third-level drug distribution centers—indicated with roman numerals in the table.

C. For the User: Spreadsheet Guidelines

The data used in the main body of the text are from 1989. The data in the spreadsheets themselves have been updated to 1991. So the tables accompanying this appendix, which are taken directly from the spreadsheets, contain 1991 data.

The system description consists of four spreadsheets:

1. COCADATA for the cocaine database
2. COCAPROD for processing and movement
3. COCATRAN for international transportation
4. COCAUSA for U.S. distribution.

The graphs associated with the worksheets are saved in separate files known as chart files.

Each spreadsheet has cells that are linked to data in the previous worksheet, so all the spreadsheets must be open. The chart files should generally be open as well. Any spreadsheets not of immediate interest can be hidden with the *Window Hide* command. Once the worksheets are all open, they can be saved with the *File Save Workspace* command. A workspace file contains a list of all the documents open at the time you choose the *Save Workspace* command. So the next time you use the model, you can open the files all at once just by clicking on the workspace file.

A spreadsheet that has cells linked to data in another worksheet is called "dependent" on that other worksheet. For instance, COCAPROD is dependent on COCADATA; COCATRAN is dependent on COCAPROD; and so on. As long as all the dependent worksheets are open, if you save a worksheet under a different name, the linked cell references in the dependent worksheet(s) will also change. If a chart file is open (and not hidden), any changes made in the data it is linked to will be immediately reflected in the graph.

Linked cells use absolute addresses (not relative addresses for the cells they link to). So, let us say you expanded the database in COCADATA, and your data extract range now starts at row 230 rather than row 226. You will get incorrect (if any) data in the linked dependent cells in COCAPROD unless you manually change the address those cells link to. (See the Excel manual.) You will also need to redefine the database range in COCADATA using the ***Data Set Database*** command.

It is good practice to make a working copy of the original "master" files and store the master files in a safe place—perhaps a separate directory (PC) or folder (Mac). It is also good practice to click on the *Read Only* option in the Open Document dialog box. When this box is checked, the program allows you to view and edit the file, but requires you to save it under another name so you cannot overwrite the file you started with. This feature is especially helpful if you are doing, for example, sensitivity analyses and want to save several versions with different data estimates.

Nomenclature

Blue cells are meant to alert the user that they are linked to other worksheets. Of course, the user may override and enter other data, but restoring these links requires using the "master" version (or a knowledgeable user can restore them manually). Red cells indicate a user should enter his/her own data.

Other cells with a little red square (IBM) or arrow (Apple) in the upper right-hand corner have a note "behind" the cell explaining something about the data in the cell, or if there is a column of like numbers, the note may reference the entire column (in a column of numbers, it may only be the first cell that has a note). This note can be viewed by using the command *Formula Note* or by double-clicking on the cell. The dialog box will also show a list of other notes in the spreadsheet that can be viewed by clicking on any entry in the list. See the Excel manual about viewing or printing all the notes on a spreadsheet.

Some Features of Using the Database in COCADATA

Users who are unfamiliar with using a spreadsheet database are strongly encouraged to read the Excel manual chapter on analyzing and reporting database information.

The defined criteria range in the master spreadsheet has two rows under the field names. Excel treats criteria entered on the same row as a logical "and," while criteria entered on difference rows are treated as a logical "or." In the example in the main text, "1989" is entered under the field name "YEAR" and "[2]LOW" is entered in the same row under the field named "REFERENCE." In extracting records, the program interprets this to mean, pick those records that have a year of 1989 *and* a reference of [2]LOW. If no criterion is entered under a field name, the program interprets it to mean, pick any (all) criteria for that field. Thus, if an entire row in the criteria range is left completely blank, the program will extract all records in the database. It is good practice to put stoppers in the form of "XXXX" or the like under a field name in each row in the criteria range to avoid inadvertently extracting all the data records.

In the master spreadsheet, the extract range is at the bottom of the spreadsheet and is defined as the row of field names. This is done to avoid guessing at how much space might be needed to extract records. However, each time you use the ***Data Extract*** command, all previous data in the extract range are cleared. If you want to save these data for some reason, copy them to another area of the worksheet or to another worksheet.

A database can provide an analyst with summary statistics about the data. For instance, the DAVERAGE function can be used to find the average cultivation area. See Database Functions in the Excel manual.

Cell Locations

The figures on the following pages depict the various sections of the four spreadsheets. The text across from each figure describes that section of the spreadsheet.

	A	B	C	D	E	F	G	H	I	J	K
1	LINKED TO COCADATA									PAGE 1	
2	ALLOWS USER INPUT			PROCESSING AND MOVEMENT: COCAINE							
3					YEAR=	1991					
4	CULTIVATION/PRODUCTION										
5	(In Hectares)										
6											
7	(1)				--MINUS--		(2)				
8	CULTIVATED HECTARES				ERAD.	OTHER	CULTIVATED HECTARES			LEAF YIELD	
9	BEFORE LOSSES				AREA	LOSS	AFTER LOSSES			FACTORS	
10											
11	BOLIVIA		53,386		5,486	0	47,900			1.64	
12	COLOMBIA		38,472		972	0	37,500			0.80	
13	ECUADOR		120		80	0	40			1.00	
14	PERU		120,800		0	0	120,800			1.14	
15	TOTAL	TOTAL					TOTAL				
16			212,778				206,240				
17				Note: ERAD. AREA Linked to COCADATA;							
18				OTHER LOSS not linked.							
19											
20	SECOND STAGE -- LEAF										
21	(In Metric Tons)										
22											
23	(1)				-- MINUS--				(2)		
24	LEAF BEFORE LOSSES				LEAF	LEAF	LEAF		LEAF AFTER		
25	AND TRANSFERS				CONSUMED	SEIZED	OTHERLOSS		LOSSES		
26											
27	BOLIVIA		78,400		10,000	123	0		68,277		
28	COLOMBIA		30,000		0	140	0		29,860		
29	ECUADOR		40		0	0	4		36		
30	PERU		137,712		10,000	6	0		127,706		
31		TOTAL							TOTAL		
32			246,152						225,879		
33											
34											

Figure C.1—The Cultivation and Production of Coca Leaf (Cells A1 to K34)

Figure C.1 shows the first tables in the cocaine production spreadsheet, COCAPROD.XLS. Virtually all of the data shown in this figure are linked to the data spreadsheet, COCADATA.XLS. The user can, of course, override any of these values. One can see Bolivia's cultivated hectares before losses (53,386) in cell C11, eradication area (5,486) in cell E11, and other losses (0) in cell F11. The number of estimated hectares after losses (47,900) is shown in G11. The estimated coca leaf yield factor, or the metric tons of coca leaf produced from one hectare (1.64), is displayed in cell J11. Since Bolivia has an estimated 47,900 hectares and a leaf yield factor of 1.64, the resulting estimated production of coca leaf is 78,400 metric tons, which is illustrated in cell C27. Bolivian consumption (10,000), seizures (123), and other losses (0) are presented in cells E27, F27, and G27, respectively. The resulting estimate of Bolivian coca leaf production ready for conversion to paste (68,277) is shown in cell I27.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
35																	
36					TRANSFER TABLE												
37					--LEAF--				TOTAL								
38	TRANSFER FRO				TRANSFER TO				OUTGOING								
39																	
40				ARGENTINA	BRAZIL	COLOMBIA	ECUADOR										
41	BOLIVIA			0%	0%	0%	0%		0								
42																	
43	COLOMBIA			0%	0%		0%		0								
44																	
45	ECUADOR			0%	0%	0%			0								
46																	
47	PERU			0%	0%	0%	0%		0								
48																	
49																	
50				0	0	0	0		0	TOTAL OUT							
51					TOTAL INCOMING				0	TOTAL IN							
52																	
53																	
54			(3)														Pooled
55			LEAF AFTER LOSSES				LEAF TO PASTE						SOURCE DISTRIBUTION				Conversior
56			AND TRANSFERS				CONVERSION FACTORS					Bolivia	Colombia	Ecuador	Peru	SUM	Factor
57			BOLIVIA	68,277			109.67				Bolivia	100.0%	0.0%	0.0%	0.0%	100.0%	109.7
58			COLOMBIA	29,860			127.00				Colombia	0.0%	100.0%	0.0%	0.0%	100.0%	127.0
59			ECUADOR	36			104.35				Ecuador	0.0%	0.0%	100.0%	0.0%	100.0%	104.3
60			PERU	127,706			114.52				Peru	0.0%	0.0%	0.0%	100.0%	100.0%	114.5
61			ARGENTIN	0			113.88				Argentina	0.0%	0.0%	0.0%	0.0%	0.0%	0.0
62			BRAZIL	0			113.88				Brazil	0.0%	0.0%	0.0%	0.0%	0.0%	0.0
63				TOTAL													
64				225,879			NOTE: ARGENTINA AND BRAZIL FACTORS										
65							ARE AVG.'S, NOT LINKED TO COCADATA.										
66																	
67																	

Figure C.2—Transferring and Converting Intermediate Product (Cells A35 to Q67)

Figure C.2 shows the next section of the cocaine production spreadsheet, COCAPROD.XLS. The user may decide whether to ship coca leaf from one country to another (it could be shipped to another country for consumption, storage, or further processing). The percentage to be shipped should be entered in the cell range D41 to G47. No transshipments are reflected in this example. However, if a transshipment occurs, the amount of coca leaf after losses and transfers is shown in cells D57 to D62. The next step entails converting the coca leaf to paste, and the conversion factors are found in cells G57 to H62. In some cases, these conversion factors can be calculated, but in others the user must supply them. Finally, the source distribution matrix in cells K56 to P62 indicates the source of the coca leaf for each country's supply. For instance, 100 percent of Bolivia's 68,277 metric tons was grown in Bolivia. The pooled conversion factor takes these percentages into account when calculating the value of the coca leaf-to-paste conversion factor.

	A	B	C	D	E	F	G	H	I	J	K	L
68												
69	THIRD STAGE - PASTE											
70	(In Metric Tons)											
71												
72	(1)								(2)			
73	PASTE BEFORE LOSSES					-- MINUS--			PASTE AFTER			
74	AND TRANSFERS				CONSUME	SEIZED	OTHERLOSS		LOSSES			
75												
76	BOLIVIA		622.6		0	0.94	0		621.7			
77	COLOMBIA		235.1		0	0	0		235.1			
78	ECUADOR		0.3		0	0.305	0		0.0			
79	PERU		1,115.2		0	1.07	0		1,114.1			
80	ARGENTINA		0.0		0	0	0		0.0			
81	BRAZIL		0.0		0	0	0		0.0			
82		TOTAL							TOTAL			
83			1,973	NOTE: USER MUST INPUT DATA FOR ARGENTINA A					1,971			
84												
85												

Figure C.3—Coca Paste
(Cells A68 to L85)

Figure C.3 shows the next section of the cocaine production spreadsheet, COCAPROD.XLS. The user can input data on the amount of paste that is consumed, seized, or lost in the range of cells E76 to G81. Bolivia's value is 622.2 (cell C76). This is derived by taking its estimated amount of coca leaf, which is 68,277 metric tons (cell D57), and dividing it by its pooled conversion factor, which is 109.7 (cell Q57). Since 0.94 metric ton of paste is subtracted, Bolivia emerges with 621.7 metric tons (cell I76).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
86					TRANSFER TABLE												
87					--PASTE--				TOTAL								
88	TRANSFER FRO				TRANSFER TO				OUTGOING								
89																	
90				ARGENTINA	BRAZIL	COLOMBIA	ECUADOR										
91	BOLIVIA			0%	0%	0%	0%		0								
92																	
93	COLOMBIA			0%	0%		0%		0								
94																	
95	ECUADOR			0%	0%	0%			0								
96																	
97	PERU			0%	0%	0%	0%		0								
98																	
99																	
100				0	0	0	0		0	TOTAL OUT							
101					TOTAL INCOMING				0	TOTAL IN							
102																	
103				(3)													Pooled
104			PASTE AFTER LOSSES				PASTE TO BASE						SOURCE DISTRIBUTION				Conversion
105			AND TRANSFERS				CONVERSION FACTORS					Bolivia	Colombia	Ecuador	Peru	SUM	Factor
106			BOLIVIA	622	31.5%		2.91				Bolivia	100.0%	0.0%	0.0%	0.0%	100.0%	2.9
107			COLOMBIA	235	11.9%		4.17				Colombia	0.0%	100.0%	0.0%	0.0%	100.0%	4.2
108			ECUADOR	0	0.0%		1.77				Ecuador	0.0%	0.0%	100.0%	0.0%	100.0%	1.8
109			PERU	1,114	56.5%		2.51				Peru	0.0%	0.0%	0.0%	100.0%	100.0%	2.5
110			ARGENTIN	0	0.0%		2.84				Argentina	0.0%	0.0%	0.0%	0.0%	0.0%	0.0
111			BRAZIL	0	0.0%		2.84				Brazil	0.0%	0.0%	0.0%	0.0%	0.0%	0.0
112				TOTAL													
113				1,971	100.0%		NOTE: ARGENTINA AND BRAZIL FACTORS										
114							ARE AVG.'S, NOT LINKED TO COCADATA.										
115																	
116																	

Figure C.4—Transferring Paste and Its Conversion to Base (Cells A86 to Q116)

Figure C.4 shows the next section of the cocaine production spreadsheet, COCAPROD.XLS. The user may decide whether to ship paste from one country to another (it could be shipped to another country for consumption, storage, or further processing). The percentage to be shipped should be entered in the cell range D91 to G97. No paste is transshipped in this example. However, after this point, the amount of paste after losses and transfers is shown in cells D106 to D111. The next step entails converting the paste to base, and the conversion factors are found in cells G106 to H111. In some cases, these conversion factors are calculated from data in the model (but can be changed by the user). In other cases, the user must supply them. Finally, the source distribution matrix in cells K105 to P111 indicate the source of the paste for each country's supply. The pooled conversion factor (cells Q106 to Q111) takes these percentages into account when calculating the value of the coca leaf-to-paste conversion factor.

	A	B	C	D	E	F	G	H	I	J	K
117											
118	FOURTH STAGE – BASE										
119	(In Metric Tons)										
120	(1)								(2)		
121	BASE BEFORE LOSSES				-- MINUS--				BASE AFTER		
122	AND TRANSFERS				CONSUME	SEIZED	OTHERLOSS		LOSSES		
123											
124	BOLIVIA		213.5		0	3.12	0		210		
125	COLOMBIA		56.4		0	9.28	0		47		
126	ECUADOR		0.0		0	0	0		0		
127	PERU		443.4		0	4.41	0		439		
128	ARGENTINA		0.0		0	0	0		0		
129	BRAZIL		0.0		0	0	0		0		
130		TOTAL							TOTAL		
131			713	NOTE: USER MUST INPUT DATA FOR ARGENTINA A					697		
132											
133											

Figure C.5—Producing Cocaine Base
(Cells A117 to K133)

Figure C.5 shows the next section of the cocaine production spreadsheet, COCAPROD.XLS. The user can input data on the amount of cocaine paste that is consumed, seized, or lost in the range of cells E124 to G129. Bolivia's value is 213.5 (cell C124). This is derived by taking its estimated amount of paste, which is 622 metric tons (cell D106), and dividing it by its pooled conversion factor, which is 2.9 (cell Q106). Since 3.12 metric tons of base are subtracted due to seizures, Bolivia emerges with 210 metric tons (cell I124).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
134					TRANSFER TABLE												
135					--BASE--				TOTAL								
136	TRANSFER FRO				TRANSFER TO				OUTGOING								
137																	
138				ARGENTINA	BRAZIL	COLOMBIA	ECUADOR										
139	BOLIVIA			5%	0%	65%	0%		147								
140																	
141	COLOMBIA			0%	0%		0%		0								
142																	
143	ECUADOR			0%	0%	0%			0								
144																	
145	PERU			0%	5%	90%	0%		417								
146																	
147																	
148				11	22	532	0		584	TOTAL OUT							
149					TOTAL INCOMING				584	TOTAL IN							
150																	
151				(3)													Pooled
152			BASE AFTER LOSSES				BASE TO C.HCL						SOURCE DISTRIBUTION				Conversion
153			AND TRANSFERS				CONVERSION FACTORS					Bolivia	Colombia	Ecuador	Peru	SUM	Factor
154			BOLIVIA	63	9.1%		1.1				Bolivia	100.0%	0.0%	0.0%	0.0%	100.0%	1.1
155			COLOMBIA	579	83.1%		1.1				Colombia	23.6%	8.1%	0.0%	68.2%	100.0%	1.0
156			ECUADOR	0	0.0%		1				Ecuador	0.0%	0.0%	100.0%	0.0%	100.0%	1.0
157			PERU	22	3.2%		1				Peru	0.0%	0.0%	0.0%	100.0%	100.0%	1.0
158			ARGENTIN	11	1.5%		1.1				Argentina	100.0%	0.0%	0.0%	0.0%	100.0%	1.1
159			BRAZIL	22	3.2%		1.1				Brazil	0.0%	0.0%	0.0%	100.0%	100.0%	1.0
160				TOTAL													
161				697	100.0%		NOTE: ARGENTINA AND BRAZIL FACTORS										
162							ARE AVG.'S, NOT LINKED TO COCADATA.										
163																	
164																	

Figure C.6—Transferring Base and Converting It to Cocaine
(Cells A134 to Q164)

Figure C.6 shows the next section of the cocaine production spreadsheet, COCAPROD.XLS. The user may decide whether to ship base from one country to another (it could be shipped to another country for consumption, storage, or further processing). The percentage to be shipped should be entered in the cell range C139 to G145. For example, Bolivia is shipping 5 percent of its base to Argentina, as reflected in cell D139, and 65 percent to Colombia, as indicated in cell F139. Once the transshipments have occurred, the amount of base after losses and transfers is shown in cells D154 to D159. The next step entails converting the base to cocaine (C.HCl), and the conversion factors are found in cells G154 to G159. In some cases these conversion factors can be calculated, but in others, the user must supply them. Finally, the source distribution matrix in cells K153 to P159 indicates the source of the base for each country's supply. Using Colombia as an example, 23.6 percent of its base was produced from coca leaf grown in Bolivia, 8.1 percent was grown in Colombia, and 68.2 percent was grown in Peru. The pooled conversion factor takes these percentages into account when calculating the value of the base-to-cocaine conversion factor.

	A	B	C	D	E	F	G	H	I	J	K
165											
166	FINAL STAGE -- C.HCL										
167	(In Metric Tons)										
168	(1)								(2)		
169	C.HCL BEFORE LOSSES				-- MINUS--				C.HCL READY		
170					CONSUME	SEIZED	OTHERLOSS		FOR EXPORT		
171											
172	BOLIVIA		57.4		0.32	0	0		57.1		
173	COLOMBIA		561.2		2	0	0		559.2		
174	ECUADOR		0.0		0	0	0		0.0		
175	PERU		21.9		0	0.76	0		21.2		
176	ARGENTINA		9.6		0	0	0		9.6		
177	BRAZIL		21.9		0	0	0		21.9		
178		TOTAL							TOTAL		
179			672	NOTE: USER MUST INPUT DATA FOR ARGENTINA A					669		
180											
181											
182											

Figure C.7—Producing Cocaine
(Cells A165 to K182)

Figure C.7 shows the next section of the cocaine production spreadsheet, COCAPROD.XLS. The user can input data on the amount of cocaine that is consumed, seized, or lost in the range of cells E172 to G177. Bolivia's value is 57.4 (cell C172). This is derived by taking its estimated amount of base, which is 63 metric tons (cell D154), and dividing it by its pooled conversion factor, which is 1.1 (cell Q154). An estimated 0.32 metric ton is consumed (cell E172), but none is seized or lost. Consequently, Bolivia emerges with 57.1 metric tons of cocaine (cell I172).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1															SCREEN 1	
2					INTERNATIONAL TRANSPORTATION:						COCAINE					
3							YEAR =		1991							
4			C.HCL.													
5			FROM		INVENTORY											
6			"COCAPROD"		FROM		ALTERNATIVE									
7			(IN MTs)		STORAGE		INPUTS									
8			(1)		(2)		(3)									
9	BOLIVIA		57.1		0.0		#N/A		NOTE:							
10	COLOMBIA		559.2		0.0		#N/A		TABLE 1. USES COL. (1) DATA LINKED TO COCAPR							
11	ECUADOR		0.0		0.0		#N/A		PLUS COL.(2) DATA INPUT BY USER--							
12	PERU		21.2		0.0		#N/A		UNLESS ANY ALTERNATIVE DATA IS ENTERED IN (							
13	ARGENTINA		9.6		0.0		#N/A		COL. (2) INPUTS SHOULD BE STORAGE FROM PRI							
14	BRAZIL		21.9		0.0		#N/A									
15	TOTAL				TOTAL		TOTAL									
16			668.9		0.0		#N/A									
17																

Figure C.8—International Transportation of Cocaine (Cells A1 to P17)

Figure C.8 shows the first section of the cocaine transportation spreadsheet, COCATRAN.XLS. The user decides whether to add additional cocaine into the system. If so, these data would be added in the range of cells E9 to E14 for "storage" or G9 to G14 for alternative inputs. The source distribution matrix is located in range of cells AF7 to AK14. The source distribution table indicates where each country's cocaine supply was grown.

	A	C	E	G	I	K	M	O	Q	S	U	W	Y	AA	AC
18															
19	TABLE 1.	TRANSPORTATION OF C.HCL AMONG "PLAYERS"													
20		(INPUT IN PERCENTS, CONVERTED TO METRIC TONS)													
21				TRANSPORT TO:									AMOUNT	AMOUNT	AMOUNT
22	FROM:	ARGENTINA	BOLIVIA	BRAZIL	COLOMBIA	ECUADOR	MEXICO	PANAMA	PERU	VENEZUEL	GUATEMAL	CARIBBEA	EXPORTED	IMPORTED	REMAINING
23		------	------	------	------	------	------	------	------	------	------	------	------	------	------
24	ARGENTIN		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
25	9.6		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.6
26		------	------	------	------	------	------	------	------	------	------	------	------	------	------
27	BOLIVIA	0%		30%	35%	0%	0%	0%	0%	0%	0%	0%	65%		
28	57.1	0.0		17.1	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.1	0.0	20.0
29		------	------	------	------	------	------	------	------	------	------	------	------	------	------
30	BRAZIL	0%	0%		0%	0%	0%	0%	0%	0%	0%	0%	0%		
31	21.9	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.2	41.2
32		------	------	------	------	------	------	------	------	------	------	------	------	------	------
33	COLOMBIA	0%	0%	0%		5%	30%	0%	0%	15%	0%	0%	50%		
34	559.2	0.0	0.0	0.0		28.0	167.7	0.0	0.0	83.9	0.0	0.0	279.6	20.0	299.6
35		------	------	------	------	------	------	------	------	------	------	------	------	------	------
36	ECUADOR	0%	0%	0%	0%		0%	0%	0%	0%	0%	0%	0%		
37	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.6	38.6
38		------	------	------	------	------	------	------	------	------	------	------	------	------	------
39	PERU	0%	0%	10%	0%	50%	0%	0%		0%	0%	0%	60%		
40	21.2	0.0	0.0	2.1	0.0	10.6	0.0	0.0		0.0	0.0	0.0	12.7	0.0	8.5
41		------	------	------	------	------	------	------	------	------	------	------	------	------	------
42	AMOUNT														
43	IMPORTED	0.0	0.0	19.2	20.0	38.6	167.7	0.0	0.0	83.9	0.0	0.0	329.4	77.8	417.3
44		------	------	------	------	------	------	------	------	------	------	------	------	------	------
45															SUM CHECKS
46															
47															
48															
49															

	AF	AG	AH	AI	AJ	AK
34		Bolivia	Colombia	Ecuador	Peru	[illegible]
35	Bolivia	100.0%	0.0%	0.0%	0.0%	100%
36	Colombia	38.7%	7.0%	0.0%	[illegible]	100%
37	Ecuador	17.1%	[illegible]	0.1%	[illegible]	100%
38	Peru	0.0%	0.0%	0.0%	[illegible]	100%
39	Argentina	100.0%	0.0%	0.0%	0.0%	100%
40	Brazil	41.0%	0.0%	0.0%	[illegible]	100%
41	Mexico	[illegible]	0.1%	0.0%	[illegible]	100%
42	Panama	0.0%	0.0%	0.0%	0.0%	0%
43	Venezuela	[illegible]	0.1%	0.0%	[illegible]	100%

Figure C.9—International Transshipment Matrix
(Cells A18 to AK49)

Figure C.9 shows the next section of the cocaine transportation spreadsheet, COCATRAN.XLS. The user may decide whether to ship cocaine from one country to another. Bolivia's estimated cocaine production ready for export (57.1) is presented in cell C9. This value is then carried down to cell A28. Bolivia is shipping 30 percent of its cocaine to Brazil, as indicated in cell G27, and 35 percent to Colombia (cell I27). After the user inputs the relevant percentages, formulas will automatically calculate the appropriate amount of cocaine that is shipped to each country. (Note: The Source Distribution Table for this matrix is in the range AF34 to AK43).

	A	C	E	G	I	K	M	O	Q
50	TABLE 2: TRANSPORTATION OF C.HCL. TO "MARKETS" (COUNTRIES/CONTINENTS)								
51			(INPUT IN PERCENTS, CONVERTED TO METRIC TONS)						
52			TRANSPORT TO:			SUBTOTAL		ALTERNATIVE	
53			S.E.ASIA/	EUROPE/	TO	TO OTHER	AMOUNT	AMOUNT	
54	FROM:	CANADA	PACIFIC	MID.EAST	STORAGE	MARKETS	TO U.S	TO U.S	
55		----------	----------	----------	----------	----------	----------	----------	
56	ARGENTINA	0%	0%	100%	0%	100%	0%	#N/A	
57	9.6	0.0	0.0	9.6	0.0	9.6	0.0	#N/A	
58		----------	----------	----------	----------	----------	----------	----------	
59	BOLIVIA	0%	0%	0%	0%	0%	100%	#N/A	
60	20.0	0.0	0.0	0.0	0.0	0.0	20.0	#N/A	
61		----------	----------	----------	----------	----------	----------	----------	
62	BRAZIL	0%	0%	90%	0%	90%	10%	#N/A	
63	41.2	0.0	0.0	37.1	0.0	37.1	4.1	#N/A	
64		----------	----------	----------	----------	----------	----------	----------	
65	COLOMBIA	10%	0%	0%	0%	10%	90%	#N/A	
66	299.5	30.0	0.0	0.0	0.0	30.0	269.6	#N/A	
67		----------	----------	----------	----------	----------	----------	----------	
68	ECUADOR	0%	0%	0%	0%	0%	100%	#N/A	
69	38.6	0.0	0.0	0.0	0.0	0.0	38.6	#N/A	
70		----------	----------	----------	----------	----------	----------	----------	
71	MEXICO	0%	0%	0%	0%	0%	100%	#N/A	
72	167.7	0.0	0.0	0.0	0.0	0.0	167.7	#N/A	
73		----------	----------	----------	----------	----------	----------	----------	
74	PANAMA	0%	0%	0%	0%	0%	100%	#N/A	
75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	#N/A	
76		----------	----------	----------	----------	----------	----------	----------	
77	PERU	0%	0%	0%	0%	0%	100%	#N/A	
78	8.5	0.0	0.0	0.0	0.0	0.0	8.5	#N/A	
79		----------	----------	----------	----------	----------	----------	----------	
80	VENEZUELA	0%	0%	25%	0%	25%	75%	#N/A	
81	83.9	0.0	0.0	21.0	0.0	21.0	62.9	#N/A	
82		----------	----------	----------	----------	----------	----------	----------	
83	GUATEMA	0%	0%	0%	0%	0%	100%	#N/A	
84	0.0	0.0	0.0	0.0	0.0	0.0	0.0	#N/A	
85		----------	----------	----------	----------	----------	----------	----------	
86	CARIBBEAN	0%	0%	0%	0%	0%	100%	#N/A	
87	0.0	0.0	0.0	0.0	0.0	0.0	0.0	#N/A	
88		----------	----------	----------	----------	----------	----------	----------	TOTAL MT
89	TOTALS	30.0	0.0	67.6	0.0	97.6	571.4	#N/A	668.93
90		Canada	S.E. Asia/Pac.	Eur/M.E.	Storage	Other	U.S.		
91		4.5%	0.0%	10.1%	0.0%	14.6%	85.4%		
92	TABLE 3: FOREIGN SEIZURES								
93	571.4	estimated Metric Tons headed for the U.S. market BEFORE foreign seizures.							
94	32.86	estimated Metric Tons destined for the U.S. but seized in foreign locations.							
95	5.75%	of the total that is destined for U.S. but is seized in foreign locations.							
96	538.5	estimated Metric Tons headed for the U.S. market AFTER foreign seizures.							
97									
98									

Figure C.10—Transportation of Cocaine to "Markets" and Foreign Seizures (Cells A50 to R98)

Figure C.10 shows the next section of the cocaine transportation spreadsheet, COCATRAN.XLS. The user may decide on which markets to send a country's cocaine. Bolivia's estimated cocaine production ready for shipment to the world's markets (20) is presented in cell A60. This cocaine can be allocated to the world's markets by placing a percentage in cells C59 for Canada, E59 for Southeast Asia and Pacific, G59 for Europe and the Middle East, I59 for storage, and/or M59 for the United States. One can see, for example, that 100 percent of Bolivia's cocaine is shipped to the United States, as indicated in cell M59. The total amount of cocaine shipped to the United States (571.4) by all countries is presented in cell M89, which represents 85.4 percent of all cocaine shipped to market (cell M91). The estimate of 571.4 metric tons is carried down to cell A93. Alternatively, the user may ignore the other markets and input only the amount destined for the United States in column O. If an amount is entered in column O, it overrides any amount calculated in column M. The user may then provide an estimate of how much cocaine destined for the United States is seized in *foreign locations* (32.86), as shown in cell A94. This amount is subtracted from the system, and the resulting net amount (538.5) is provided in cell A96.

	A	C	E	G	I	K	M	O	Q
99	TABLE 4: DISTRIBUTION OF INCOMING C.HCL. AMONG U.S. ENTRY REGIONS								
100			*(INPUT IN PERCENTS, CONVERTED TO METRIC TONS)*						
101			*TRANSPORT TO:*						
102		NORTH-	NORTH-	SOUTH-	SOUTH-	SOUTH-		AMOUNT	
103	*FROM:*	CENTRAL	EAST	EAST	CENTRAL	WEST	WEST	REMAINING	CHECKSUM
104		----------	----------	----------	----------	----------	----------	----------	----------
105	ARGENTINA							100%	100.0%
106	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
107		----------	----------	----------	----------	----------	----------	----------	----------
108	BOLIVIA	0%	0%	100%				0%	100.0%
109	18.8	0.0	0.0	18.8	0.0	0.0	0.0	0.0	
110		----------	----------	----------	----------	----------	----------	----------	----------
111	BRAZIL	0%	50%	50%				0%	100.0%
112	3.9	0.0	1.9	1.9	0.0	0.0	0.0	0.0	
113		----------	----------	----------	----------	----------	----------	----------	----------
114	COLOMBIA	0%	20%	40%	5%	30%	5%	0%	100.0%
115	254.1	0.0	50.8	101.6	12.7	76.2	12.7	0.0	
116		----------	----------	----------	----------	----------	----------	----------	----------
117	ECUADOR	17%	17%	17%	17%	17%	17%	0%	100.0%
118	36.4	6.1	6.1	6.1	6.1	6.1	6.1	0.0	
119		----------	----------	----------	----------	----------	----------	----------	----------
120	MEXICO					75%	25%	0%	100.0%
121	158.1	0.0	0.0	0.0	0.0	118.6	39.5	0.0	
122		----------	----------	----------	----------	----------	----------	----------	----------
123	PANAMA							100%	100.0%
124	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
125		----------	----------	----------	----------	----------	----------	----------	----------
126	PERU			0%	0%	50%	50%	0%	100.0%
127	8.0	0.0	0.0	0.0	0.0	4.0	4.0	0.0	
128		----------	----------	----------	----------	----------	----------	----------	----------
129	VENEZUELA		50%	50%				0%	100.0%
130	59.3	0.0	29.6	29.6	0.0	0.0	0.0	0.0	
131		----------	----------	----------	----------	----------	----------	----------	----------
132	GUATEMALA			0%	0%	0%	0%	100%	100.0%
133	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
134		----------	----------	----------	----------	----------	----------	----------	----------
135	CARIBBEAN		0%	0%				100%	100.0%
136	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
137		----------	----------	----------	----------	----------	----------	----------	----------
138									
139	536.51	(mt) into the U.S. before DOMESTIC seizures and after FOREIGN seizures.							
140									
141									

Figure C.11—Distribution of Incoming Cocaine Among U.S. Entry Regions (Cells A99 to R141)

Figure C.11 shows the next section of the cocaine transportation spreadsheet, COCATRAN.XLS. The user may decide to which of the six U.S. entry regions to send a country's cocaine. In the example shown, Brazil has 3.9 metric tons in cell A112 carried down from the previous table, and the user has specified that 50 percent is shipped to the Northeast region (cell E111) and 50 percent is shipped to the Southeast region (cell G111).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
142	TABLE 5A. DISTRIBUTION OF TRANSPORTATION MODES INTO U.S. ENTRY REGIONS													
143					IN PERCENTS--DEFAULT TABLE									
144			NORTH-		NORTH-		SOUTH-		SOUTH-		SOUTH-			
145			CENTRAL		EAST		EAST		CENTRAL		WEST		WEST	
146	———		———		———		———		———		———		———	
147	OMMERCIA		0%		4%		14%		0%		0%		4%	
148	AIR													
149	———		———		———		———		———		———		———	
150	PRIVATE		100%		30%		18%		100%		14%		3%	
151	AIR													
152	———		———		———		———		———		———		———	
153	OMMERCIA		0%		0%						21%		8%	
154	LAND						XXX		XXX					
155	———		———		———		———		———		———		———	
156	PRIVATE		0%		0%						51%		70%	
157	LAND						XXX		XXX					
158	———		———		———		———		———		———		———	
159	OMMERCIA		0%		29%		54%		0%		14%		2%	
160	SEA													
161	———		———		———		———		———		———		———	
162	PRIVATE		0%		37%		14%		0%		0%		14%	
163	SEA													
164	———		———		———		———		———		———		———	
165	CHECKSUM		100.0%		100.0%		100.0%		100.0%		100.0%		100.0%	
166														
167														
168	TABLE 5B. DISTRIBUTION OF TRANSPORTATION MODES INTO U.S. ENTRY REGIONS													
169					IN PERCENTS--ALTERNATIVE TABLE									
170	NOTE: The column percentage must equal 100%. Otherwise, none of the cell percentages in that co													
171			NORTH-		NORTH-		SOUTH-		SOUTH-		SOUTH-			
172			CENTRAL		EAST		EAST		CENTRAL		WEST		WEST	
173	———		———		———		———		———		———		———	
174	OMMERCIA		37%		7%		18%		0%		0%		3%	
175	AIR													
176	———		———		———		———		———		———		———	
177	PRIVATE		63%		0%		39%		12%		26%		3%	
178	AIR													
179	———		———		———		———		———		———		———	
180	OMMERCIA		0%		0%						8%		10%	
181	LAND						XXX		XXX					
182	———		———		———		———		———		———		———	
183	PRIVATE		0%		0%						58%		78%	
184	LAND						XXX		XXX					
185	———		———		———		———		———		———		———	
186	OMMERCIA		0%		93%		5%		22%		0%		0%	
187	SEA													
188	———		———		———		———		———		———		———	
189	PRIVATE		0%		0%		38%		66%		8%		6%	
190	SEA													
191	———		———		———		———		———		———		———	
192	TOTAL		100.0%		100.0%		100.0%		100.0%		100.0%		100.0%	
193														
194														

Figure C.12—Distribution of Transportation Modes into U.S. Entry Regions (Cells A142 to N194)

Figure C.12 shows the next section of the cocaine transportation spreadsheet, COCATRAN.XLS. The user may decide on the transportation modes of the cocaine into the six U.S. entry regions. In the example shown, 100 percent of the cocaine entering the North Central region arrives through private air (cell C150). All of the percentages in Table 5A are derived automatically from illustrative seizure data in Table 6. Alternatively, the user can input other data in Table 5B. If any data are provided by the user in Table 5B, they will be used instead of the percentages in Table 5A. However, the user must ensure that the column totals 100 percent. Otherwise, none of the percentages in that column will be recognized by the model.

	A	C	E	G	I	K	M	O
195	TABLE 6. SEIZURES OF C.HCL (TRANSPORTATION MODE BY U.S. ENTRY REGION)							
196				IN METRIC TONS				
197		NORTH-	NORTH-	SOUTH-	SOUTH-	SOUTH-		TOTAL
198		CENTRAL	EAST	EAST	CENTRAL	WEST	WEST	BY MODE
199								
200	OMMERCIA							
201	AIR	0.000	0.577	6.470	0.000	0.000	1.120	8.2
202								
203	PRIVATE							
204	AIR	0.002	3.946	8.193	0.272	1.754	0.717	14.9
205								
206	OMMERCIA							
207	LAND	0.000	0.000	---	---	2.651	2.153	4.8
208								
209	PRIVATE							
210	LAND	0.000	0.000	---	---	6.564	19.566	26.1
211								
212	OMMERCIA							
213	SEA	0.000	3.941	24.229	0.001	1.784	0.530	30.5
214								
215	PRIVATE							
216	SEA	0.000	4.897	6.181	0.000	0.000	3.814	14.9
217								
218	TOTAL							99.4
219	BY REGION	0.0	13.4	45.1	0.3	12.8	28	99.4
220								
221								

Figure C.13—Cocaine Seizures
(Cells A195 to P221)

Figure C.13 shows the next section of the cocaine transportation spreadsheet, COCATRAN.XLS. The user may decide on the amount of cocaine that is seized by entry region *and* transportation mode. In the example shown, a total of 99.4 metric tons is seized (cell O218, O219). In the Northeast, for instance, 0.577 metric tons are seized by commercial air (cell E201), 3.946 metric tons by private air (E204), 3.941 metric tons by commercial sea (E213), and 4.897 metric tons by private sea (E216).

	A	B	C	D	E	F	G	H	I	J	K	L	M
1													
2					UNITED STATES DISTRIBUTION: COCAINE								
3					YEAR=		1991						
4													
5	TABLE 1. C.HCL COMING INTO THE UNITED STATES												
6			BY REGION (MTs)										
7													
8			IMPORTED C.HCL										
9					Domestic				Alternate				
10			Net of Seizures		Production		TOTAL		TOTAL				
11	----------		----------		----------		----------		----------				
12	NORTH-												
13	CENTRAL		6.05		0.00		6.05		#N/A				
14	----------		----------		----------		----------		----------				
15	NORTH-												
16	EAST		75.10		0.00		75.10		#N/A				
17	----------		----------		----------		----------		----------				
18	SOUTH-												
19	EAST		113.02		0.00		113.02		#N/A				
20	----------		----------		----------		----------		----------				
21	SOUTH-												
22	CENTRAL		18.49		0.00		18.49		#N/A				
23	----------		----------		----------		----------		----------				
24	SOUTH-												
25	WEST		192.10		0.00		192.10		#N/A				
26	----------		----------		----------		----------		----------				
27													
28	WEST		34.38		0.00		34.38		#N/A				
29	----------		----------		----------		----------		----------				
30							439.14						
31	TOTAL		439.14		0.00		439.14		#N/A				
32													
33													

Figure C.14—Cocaine Entering the United States (Cells A1 to M33)

Figure C.14 shows the first section of the cocaine U.S. distribution spreadsheet, COCAUSA.XLS. In the example shown, 6.05 metric tons enter the North Central region (after foreign and point of entry into the U.S. seizures), as reflected in cell C13. The numbers in this column are linked to COCATRAN.XLS. There is also a column for the user to input an alternative total (column I).

	A	C	E	G	I	K	M	O	Q	S	T
34	TABLE 2. INTER-REGIONAL TRANSFERS OF C. HCL.										
35		(INPUT IN PERCENTS, CONVERTED TO METRIC TONS)									
36			TRANSFER TO:								
37	TRANSFER	N. CENT	N. EAST	S. EAST	S. CENT	S. WEST	WEST	Transfers	Transfers	Amount	
38	FROM										
40	N. CENTRAL		0%	0%	0%	0%	0%	0%			
41	6.1		0.0	0.0	0.0	0.0	0.0	0.0	124.3	130.4	
42											
43	N. EAST	0%		0%	0%	0%	0%	0%			
44	75.1	0.0		0.0	0.0	0.0	0.0	0.0	28.3	103.4	
45											
46	S. EAST	25%	25%		0%	0%	0%	50%			
47	113.0	28.3	28.3		0.0	0.0	0.0	56.5	0.0	56.5	
48											
49	S. CENTRAL	0%	0%	0%		0%	0%	0%			
50	18.5	0.0	0.0	0.0		0.0	0.0	0.0	0.0	18.5	
51											
52	S. WEST	50%	0%	0%	0%		25%	75%			
53	192.1	96.0	0.0	0.0	0.0		48.0	144.1	0.0	48.0	
54											
55	WEST	0%	0%	0%	0%	0%		0%			
56	34.4	0.0	0.0	0.0	0.0	0.0		0.0	48.0	82.4	
57											
58											

Figure C.15—Interregional Transfers of Cocaine (Cells A34 to T58)

Figure C.15 shows the next section of the cocaine U.S. distribution spreadsheet, COCAUSA.XLS. The user may decide on any interregional domestic transfers of cocaine. In this example, 25 percent of the cocaine shipped into the Southeast region is shipped again to the North Central region, as shown in cell C46. Moreover, 25 percent is shipped from the Southeast to the Northeast, as reflected in cell E46. The user only needs to place a percentage in the cell; the amount of cocaine to be shipped will be calculated automatically.

	A	C	E	G	I	K
59						
60						
61						
62	Gross Amount in each Region		--Minus--		Net Amount in each Region	
63	Ready for Sales (kgs.)		Seizures	Other	Ready for Sales (kgs.)	
64			(kgs.)	Losses		
65	N. CENTRAL	130,359	445	0	129,914	
66	N. EAST	103,352	1174	0	102,178	
67	S. EAST	56,511	681	0	55,830	
68	S. CENTRAL	18,488	770	0	17,718	
69	S. WEST	48,024	1835	0	46,189	
70	WEST	82,404	2004	0	80,400	
71	TOTAL				TOTAL	
72		439,138	6,909	0	432,229	
73						
74						
75						
76	TABLE 3. REGIONAL DISTRIBUTION OF NET C.HCL READY FOR SALES					
77		*(INPUT IN PERCENTS, CONVERTED TO KILOGRAMS)*				
78						
79	NORTH-CENTRAL					
80	CHICAGO (II)	0%	0			
81	DETROIT (II)	0%	0			
82	ALL OTHER	100%	129,914			
83						
84	NORTH-EAST					
85	BOSTON (II)	0%	0			
86	NEWARK (II)	0%	0			
87	NEW YORK (I)	0%	0			
88	ALL OTHER	100%	102,178			
89						
90	SOUTH-EAST					
91	ATLANTA	0%	0			
92	MIAMI (I)	0%	0			
93	ALL OTHER	100%	55,830			
94						
95	SOUTH-CENTRAL					
96	NEW ORLEANS	0%	0			
97	ALL OTHER	100%	17,718			
98						
99	SOUTH-WEST					
100	EL PASO (~I)	0%	0			
101	HOUSTON (I)	0%	0			
102	ALL OTHER	100%	46,189			
103						
104	WEST					
105	LOS ANGELES (I)	0%	0			
106	SAN DIEGO (II)	0%	0			
107	SAN FRANCISCO (II)	0%	0			
108	SEATTLE	0%	0			
109	ALL OTHER	100%	80,400			
110						
111	TOTAL		432,229			

Figure C.16—State and Local Seizures and the Regional Distribution of Net Cocaine Ready for Sale (Cells A59 to L111)

Figure C.16 shows the next section of the cocaine U.S. distribution spreadsheet, COCAUSA.XLS. The user may decide on the amount of cocaine to be withdrawn from the system due to state and local seizures and, if desired, the amount of cocaine to ship to some major cities. Domestic seizures are withdrawn from the system by inputting values in cells E65 to E70. Also, other losses can be taken from the system in cells G65 to G70. If the user desires to allocate the cocaine to some major cities, this is accomplished by placing the percentage value in cells C80–81, C85–87, C91–92, C96, C100–101, and/or C105–108.

	A	C	E	G	I	K	M
112							
113	TABLE 4A. DRUG MARKET HIERARCHY--DEFAULT TABLE						
114				IN KILOGRAMS PER ANNUM			
115		NORTH-	NORTH-	SOUTH-	SOUTH-	SOUTH-	
116		CENTRAL	EAST	EAST	CENTRAL	WEST	WEST
117							
118	Distributors	100.0	100.0	100.0	100.0	100.0	100.0
119							
120							
121	Wholesalers	50.0	50.0	50.0	50.0	50.0	50.0
122							
123							
124	Street Dealer	25.0	25.0	25.0	25.0	25.0	25.0
125							
126							
127	USERS	0.036	0.036	0.036	0.036	0.036	0.036
128							
129							
130							
131							
132							
133							
134							
135	TABLE 4B. DRUG MARKET HIERARCHY--ALTERNATIVE TABLE						
136				IN KILOGRAMS PER ANNUM			
137		NORTH-	NORTH-	SOUTH-	SOUTH-	SOUTH-	
138		CENTRAL	EAST	EAST	CENTRAL	WEST	WEST
139							
140	Distributors	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
141							
142							
143	Wholesalers	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
144							
145							
146	Street Dealer	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
147							
148							
149	USERS:	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
150							
151							
152							
153							
154							
155							

Figure C.17—Drug Market Hierarchy Tables (Cells A112 to N155)

Figure C.17 shows the next section of the cocaine U.S. distribution spreadsheet, COCAUSA.XLS. The user may input an estimate on the average amount of cocaine consumed. This figure shows data for distributors, wholesalers, street dealers, and users. This figure indicates that 0.036 kg is the average annual value for users. This is presented in cells C127, E127, G127, I127, K127, and M127. An alternative table, Table 5B, allows the user to input values too. If any values are placed in this table, they will be used instead of the ones in Table 5A. If the user desires to input an alternative amount of average use, these values can be input into cells C149, E149, G149, I149, K149, and M149.

	A	B	C	D	E
156	TABLE 5. PURITY LEVELS				
157			Purity at Purchase		
158	------------------------		----------------		
159	Distributors	|	100.0%	|	
160		|		|	
161	------------------------	|	----------------	|	
162	Wholesalers	|	100.0%	|	
163		|		|	
164	------------------------	|	----------------	|	
165	Street Dealer	|	84.0%	|	
166		|		|	
167	------------------------	|	----------------	|	
168	USERS:	|	70.0%	|	
169		|		|	
170	------------------------	|	----------------	|	
171					

Figure C.18—Purity Levels
(Cells A156 to E171)

Figure C.18 shows the next section of the cocaine U.S. distribution spreadsheet, COCAUSA.XLS. The user may input an estimate on the average purity level of the cocaine. In this case, the average purity level for users (as opposed to distributors, wholesalers, or dealers) is 70 percent (cell C168).

	A	C	E	G	I	K	M	O	Q	S	T
172	TABLE 6. DRUG MARKET POPULATION DATA										
173											
174											
175				Street	USERS:		Population	Calculated	Nat'l Household		
176		Distributor	Wholesaler	Dealers	(in 000s)		(in 000s)	Prevalence	Survey Prevalence	RATIO	
177											
178	NORTH CENTRAL										
179	CHICAGO (II)	0	0	0	0		0	NA	2.8%	NA	
180	DETROIT (II)	0	0	0	0		0	NA	2.8%	NA	
181	ALL OTHER	1,299	2,598	6,188	5,099		58,031	8.8%	3.0%	2.95	
182											
183	NORTHEAST										
184	BOSTON (II)	0	0	0	0		0	NA	3.3%	NA	
185	NEWARK (II)	0	0	0	0		0	NA	3.3%	NA	
186	NEW YORK (I)	0	0	0	0		0	NA	3.3%	NA	
187	ALL OTHER	1,022	2,044	4,888	4,010		47,152	8.5%	3.2%	2.64	
188											
189	SOUTHEAST										
190	ATLANTA	0	0	0	0		0	NA	2.4%	NA	
191	MIAMI (I)	0	0	0	0		0	NA	2.4%	NA	
192	ALL OTHER	558	1,117	2,650	2,191		30,986	7.1%	2.4%	2.96	
193											
194	SOUTH CENTRAL										
195	NEW ORLEANS	0	0	0	0		0	NA	2.4%	NA	
196	ALL OTHER	177	354	844	695		14,860	4.7%	2.4%	1.95	
197											
198	SOUTHWEST										
199	EL PASO (~I)	0	0	0	0		0	NA	2.4%	NA	
200	HOUSTON (I)	0	0	0	0		0	NA	2.4%	NA	
201	ALL OTHER	462	924	2,190	1,813		19,900	9.1%	2.8%	3.16	
202											
203	WEST										
204	LOS ANGELES (I)	0	0	0	0		0	NA	4.8%	NA	
205	SAN DIEGO (II)	0	0	0	0		0	NA	4.8%	NA	
206	SAN FRANCISCO (II)	0	0	0	0		0	NA	4.8%	NA	
207	SEATTLE	0	0	0	0		0	NA	4.8%	NA	
208	ALL OTHER	804	1,808	3,829	3,155		30,193	10.5%	4.8%	2.18	
209											
210	US TOTAL	4,322	8,645	20,582	16,983		201,131	8.4%	4.1%		
211											

Figure C.19—Drug Market Population Data (Cells A172 to T211)

Figure C.19 shows the last section of the cocaine U.S. distribution spreadsheet, COCAUSA.XLS. The user must ensure that the population numbers presented in column M are basically correct. These figures are based on 1990 census data. The estimated number of users is presented in column I. These percentages are compared to the population numbers in column M to obtain the calculated prevalence percentage shown in column O. This percentage can be compared to the National Household Survey percentage presented in Column Q or an alternative estimate supplied by the user. Finally, the ratio in column S is the ratio of the model's calculated prevalence to the Household Survey's estimated prevalence.

D. A Short Primer on the INCSR's Data Collection Methodology

In this appendix we present a verbatim portion of the 1991 *International Narcotics Control Strategy Report* that discusses the methodology for estimating various factors in illegal drug production. It identifies the estimates in which there is the least (and most) certainty as well as some of the reasons for the differentials in certainty.[1] This discussion is applicable to cocaine, heroin, and marijuana.

> **Methodology for Estimating Illegal Drug Production: How much do we know?** This report (1991 INCSR) contains tables showing a variety of illicit narcotics–related data. While these numbers represent the United States Government's (USG) best effort to sketch the dimensions of the international drug problem, the reader should be aware that the picture is not always as precise as we would like it to be. The numbers range from cultivation figures, hard data derived by proven means, to crop production and drug yield estimates, where many more variables come into play. Since much information is lacking where yields are concerned, the numbers are subject to revision as more data becomes known.
>
> **What we know with reasonable certainty:** The most reliable information we have on illicit drugs is how many hectares are under cultivation. For more than a decade, the USG has estimated the extent of illicit cultivation in a dozen nations using proven methods similar to those used to estimate the size of licit crops at home and abroad. We can thus estimate the size of crops with reasonable accuracy.
>
> **What we know with less certainty:** Where crop yields are concerned, the picture is less clear. How much of a finished product a given area will produce is difficult to estimate, since small changes in such factors as soil fertility, weather, farming techniques, and disease can produce widely varying results from year to year and place to place. In addition, most illicit drug crop areas are inaccessible to the USG, making scientific information difficult to obtain. Moreover, we must stress that even as we refine our methods of analysis, we are estimating *potential* crop available for harvest. These estimates do not allow for losses, which could represent anything from a tenth to a third (or more) of a crop in some areas for some harvests. Thus, the estimate of the potential

[1] Refer to the *International Narcotics Control Strategy Report*, United States, Department of State, March 1991, pp. 7–8.

crop is useful in providing comparative analysis from year to year, but the actual quantity of final product remains elusive.

Harvest Estimates: Estimating the quantities of coca leaf, opium gum, and marijuana actually harvested and available for processing into finished narcotics remains a major challenge. *We currently cannot accurately estimate this amount for any illicit crop in any nation.* While farmers naturally have strong incentives to maximize their harvests of what is almost always their most profitable cash crop, the harvest depends upon the efficiency of farming practices and the wastage caused by poor practices or difficult weather conditions during and after harvest. A tenth to a third (or more) of a crop may be lost in some areas during harvests. Additional information and analysis may enable us to make adjustments for these factors in the future. Similar deductions for local consumption of unprocessed coca leaf and opium may be possible as well through the accumulation of additional information and research.

Processing Estimates: The wide variation in processing efficiencies achieved by traffickers complicates the task of estimating the quantity of cocaine or heroin which could be refined from a crop. These efficiencies vary because of differences in the origin and quality of the raw material used, the technical processing method employed, the size and sophistication of laboratories, and the skill and experience of local workers and chemists. The USG continues to estimate potential cocaine production as a range based on processing efficiencies that appear to be most common.

The actual amount of dry coca leaf or opium converted into a final product during any time period remains unknown, given the possible losses noted earlier. There are indications, however, that cocaine processing efficiencies improved during the 1980s, and that traffickers still have considerable room for improvement.

Figures will change as techniques and data quality improve: The reader may ask: are this year's figures definitive? The reply is, almost certainly, some are not. Additional research may result in future revision to USG estimates of potential drug production. For the present, however, these statistics represent the state of the art. As the art improves, so will the precision of the estimates.

E. A Simulation to Test for the Effect of Propagating Errors in the Model

Because of the high number of parameters in the model and the likelihood that most are estimated with some degree of error, there is the possibility that even slight errors in parameter values can propagate throughout the system and translate into large errors in the later stages of the model. We conducted a simulation to test the model's robustness in the face of these propagating errors. We chose six parameters and randomly changed each by an amount within 20 percent of the initial value.[1] Then, we compared the model's estimated number of users from each of the 50 iterations to the model's beginning value.[2]

The six parameters are taken from each of the model's spreadsheets (i.e., production, transportation, and domestic distribution) and represent all of the model's parameters in terms of their impact on the model's output. In short, some parameters have a large influence on the model's output, while others have relatively little impact. The six parameters are

- Peru Production Factor (metric tons of leaf per hectare)—Peru constitutes about 57 percent of the estimated hectares of coca under cultivation for 1991.[3] The sensitivity analysis presented in Table 4.1 reveals that this parameter exercises a significant impact on the model's output. For example, a 50-percent change in this parameter results in an 48-percent change in the estimated number of users.
- Bolivia Consumption (metric tons)—Approximately 10,000 metric tons were consumed in Bolivia during 1991, making it one of the largest domestic consumers of coca leaf among the four producing countries included in the model. However, it is likely that this parameter has an insignificant influence on the model's output. For example, as presented in Table 4.1, Peru's leaf consumption is also 10,000 metric tons, and a 50-percent change in its parameter results in a 4-percent change in the estimated number of users.

---

[1] We used Excel's random number generator to create a table of random numbers that ranged in value from −20 percent to +20 percent. The 20-percent figure is somewhat arbitrary, but we believe it is an appropriate amount for this illustrative exercise.

[2] Any propagating errors would ostensibly find their greatest impact at the end of the model, so we decided to use the estimated number of users because it is the final model estimate.

[3] This includes Bolivia, Colombia, Ecuador, and Peru.

- Foreign Seizures (metric tons)—With only around 33 metric tons of cocaine removed from the system, it is likely that this parameter will have a negligible impact on the model's output.
- Average Purity—This parameter can have a major influence over the model's output. Indeed, the sensitivity analysis presented in Table 4.1 reveals that a 50-percent change in this parameter results in a 30-percent change in the estimated number of users.
- Domestic Seizures (metric tons)—Since only about 7 metric tons of cocaine were extracted from the system in 1991, it is likely that this parameter will have a minor effect on the model's output.
- Annual Consumption (kilograms)—This parameter can potentially have a major effect on the model's output. The sensitivity analysis in Table 4.1 shows that a 50-percent change in its value results in a 33-percent change in the estimated number of users.

The output from the simulation is presented in Table E.1. The beginning value in the model for the estimated number of users is 16.9 million.[4] The minimum value obtained is 11.4 million (or 67 percent of the beginning value), the maximum is 28.9 million (170 percent of the beginning value), the median is 16.9 million (100 percent of the beginning value), and the mean is 17.6 million (104 percent of the beginning value).

Table E.1

Output from the Simulation

Iteration	Users (000)	Iter.	Users (000)	Iter.	Users (000)	Iter.	Users (000)	Iter.	Users (000)
1	24,781	11	17,406	21	17,013	31	13,996	41	21,712
2	23,716	12	16,933	22	17,234	32	17,364	42	20,639
3	20,034	13	16,373	23	19,020	33	14,575	43	16,102
4	13,630	14	18,862	24	14,645	34	12,051	44	18,678
5	14,607	15	15,527	25	16,163	35	28,912	45	12,541
6	12,368	16	17,828	26	17,424	36	15,986	46	16,700
7	15,025	17	15,583	27	21,620	37	16,148	47	16,186
8	27,427	18	11,379	28	14,773	38	21,512	48	16,047
9	15,007	19	18,262	29	19,558	39	14,964	49	16,888
10	21,452	20	16,611	30	17,719	40	24,187	50	18,701

[4]One should not interpret this as our definitive estimate of the number of cocaine users in the United States. Rather, it should be interpreted as the number of users there must be *if one accepts all previous parameter estimates in the model.*

These data are largely clustered around the beginning value. This is evidenced by the fact that 74 percent of the simulation output is within 25 percent of the beginning value, as illustrated in Figure E.1.

Morever, these data are more or less uniformly distributed around the beginning value, but some skewing is evident. This is illustrated in Figure E.2.

We conclude from this simulation that the model is generally robust in the face of propagating errors. The vast majority of the simulation output falls close to the beginning value of 16.9 million. Indeed, 74 percent of the simulation output falls within 25 percent of the beginning value. In a limited number of cases, however, the effect of propagating errors produces values that are significantly different from the beginning value. All of this suggests that in most cases (but not all) the errors will countervail each other.

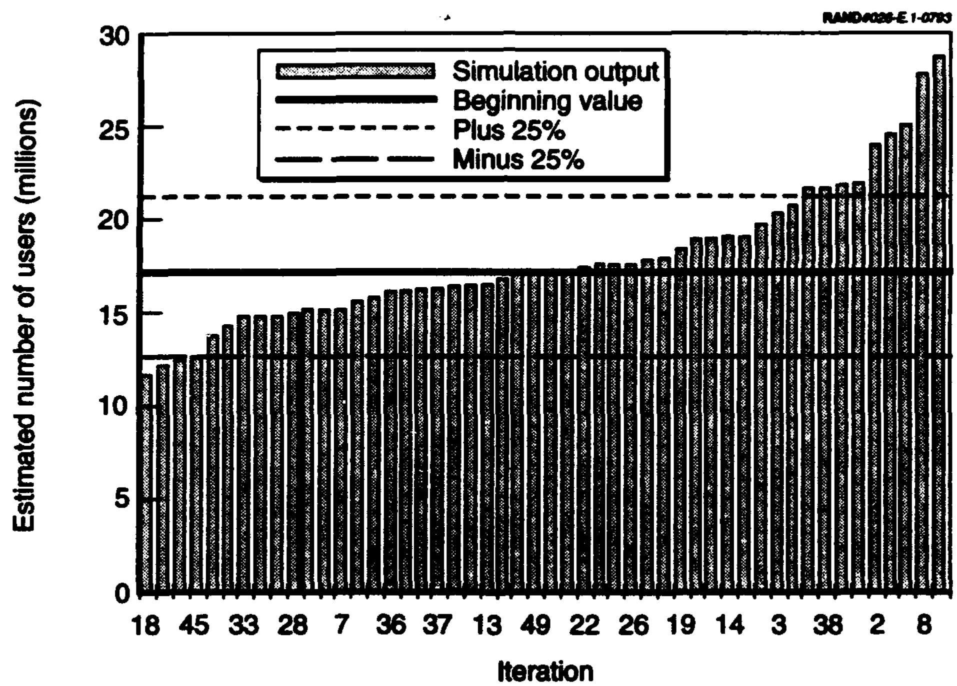

Figure E.1—Fifty Random Changes in Six Cocaine Parameters: 74 Percent of Simulation Output Is Within 25 Percent of the Beginning Value

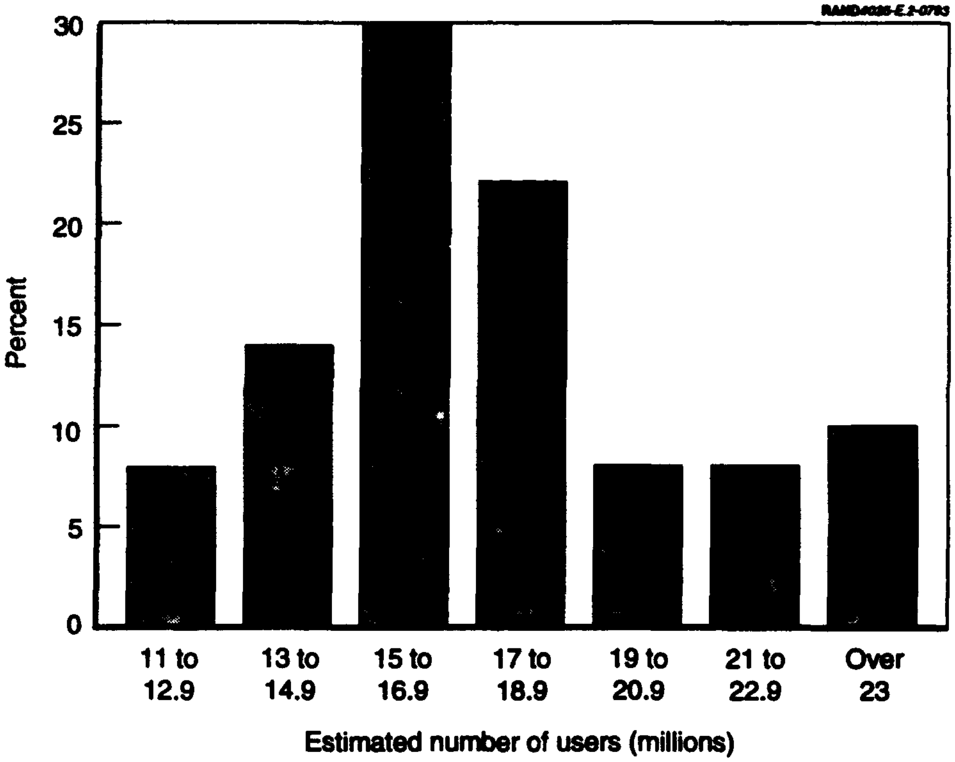

Figure E.2—Histogram of Cocaine User Output

Bibliography

Abt Associates, *What America's Users Spend on Illegal Drugs*, technical paper for the U.S. Office of National Drug Control Policy, June 1991.

Ardila, Patricia, *Beyond Law Enforcement: Narcotics and Development*, The Panos Institute, February 1990.

Carpenter, Ted Galen, and R. Channing Rouse, "Perilous Panacea: The Military in the Drug War," a CATO Institute Policy Analysis, No. 128, February 15, 1990.

Childress, Michael, *A System Description of the Heroin Trade*, Santa Monica, Calif.: RAND, MR-234-A/DPRC, 1993.

Childress, Michael, *A System Description of the Marijuana Trade*, Santa Monica, Calif.: RAND, MR-235-A/DPRC, 1993.

Congressional Research Service, *Cocaine Production, Eradication, and the Environment: Policy, Impact and Operations*, Proceedings of a Seminar Held by the Congressional Research Services, February 14, 1990, Committee on Governmental Affairs, U.S. Senate, S. Print 101-110, August 1990.

Defense Science Board, *Summer Study 1987: Detection and Neutralization of Illegal Drugs and Terrorist Devices*, 1987.

Drug Enforcement Administration, *Map of Drug Trafficking Routes*, 1989.

Golob, Major Michael, *Using Intelligence Preparation of the Battlefield to Fight the Drug War*, May 4, 1989.

Gugliotta, Guy, "Beating Back the Cocaine Kings," *U.S. News and World Report*, February 19, 1990, pp. 18–21.

INCSR—See U.S. Department of State.

Jehl, Douglas, "Cocaine Has a Made in USA Label," *Los Angeles Times*, December 5, 1989, pp. A1–A20.

Jehl, Douglas, "U.S. Solvents Helped Fuel Cocaine Trade in Colombia; Firms Assailed," *Los Angeles Times*, February 11, 1990.

Jehl, Douglas, "U.S. Ready to Admit World Cocaine Supplies are Vastly Underestimated," *Los Angeles Times*, Saturday, February 17, 1990, p. A20.

JPRS, *Bolivia: DIRECO Reduction Program—1988*, October 20, 1989.

Moore, Mark, *Buy and Bust*, Lexington, Mass.: DC Heath, 1977.

Morales, Edmundo, *Cocaine: White Gold Rush in Peru*, University of Arizona Press, 1989.

National Narcotics Intelligence Consumers Committee, *The NNICC Report 1988*, April 1989.

The Panos Institute, *Beyond Law Enforcement: Narcotics and Development*, February 1990.

The Pompidou Group, "Current Activities and Priorities of the Pompidou Group," December 1990.

Reuter, Peter, and Mark A. Kleiman, "Risks and Prices: An Economic Analysis of Drug Enforcement," *Crime and Justice: An Annual Review*, Vol. 9, 1986, pp. 128–179.

Reuter, Peter, and David Ronfeldt, *Quest for Integrity: The Mexican-U.S. Drug Issue in the 1980s*, Santa Monica, Calif.: RAND, N-3266-USDP, 1992.

Richburg, Keith B., "Reagan Order Defines Drug Trade as Security Threat," *Washington Post*, June 8, 1986.

Sullivan, Louis W., Secretary of Health and Human Services, press conference remarks, summarized in *HHS News*, U.S. Department of Health and Human Services, December 19, 1991.

Treaster, Joseph B., "Drug Bosses Give up Laboratories on Eve of Bush Visit to Colombia," *The New York Times*, February 15, 1990, pp. A1 and A6.

U.S. Congress, House, Committee on the Judiciary, *Posse Comitatus Act, Hearing*, 97th Congress, 1st Session, June 3, 1981.

U.S. Department of Commerce, *Statistical Abstract of the United States 1990*, 1990.

U.S. Department of Health and Human Services, *National Household Survey on Drug Abuse: Population Estimates 1988*, Public Health Service, Alcohol, Drug Abuse, and Mental Health Administration, 1989.

U.S. Department of Justice, Drug Enforcement Administration, *Coca Cultivation and Cocaine Processing: An Overview*, February 1991.

U.S. Department of State, *International Narcotics Control Strategy Report*, Bureau of International Narcotics Matters, United Stated Department of State, March 1989.

U.S. Department of State, *International Narcotics Control Strategy Report*, Bureau of International Narcotics Matters, United States Department of State, March 1990.

U.S. General Accounting Office, *Drug Law Enforcement: Military Assistance for Anti-Drug Agencies*, GAO/GCD-88-27, December 1987, p. 2.

U.S. Office of National Drug Control Policy, *National Drug Control Strategy*, January 1990.