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A System Dynamics Simulation Model of Cocaine Prevalence

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under National Institute of Justice Grant 87-IJ-CX-0042

February, 1990

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Foreword

This report presents a system dynamics simulation model for estimating and projecting the prevalence of cocaine use in the United States. Development of this model was guided by a variety of information sources both numerical and descriptive. Along the way, various plausible hypotheses have been tested and some rejected as being inconsistent with historical evidence. The current model provides a good fit to most national indicator data covering the period 1976-1987 concerning cocaine demand and supply as well as cocaine-related attitudes, morbidity and mortality. It provides user population estimates broken down by product form (powder vs. crack), intensity of use (social vs. compulsive), and recency of use (past month, past year but not past month, ever but not past year). It also provides projections for every model variable through 1992. Sensitivity testing of the model has identified key points of leverage and uncertainty in the "cocaine system", with possible implications for both policymaking and targeted data collection.

It should be recognized that the model presented here is dated May, 1989, and represents the culmination of one phase of a work in progress. Since that time, additional indicator data and studies have become available – including the 1988 National Household Survey – which have spurred yet another round of rethinking, with model refinements and extensions to follow during the coming year. A summary of these more recent thoughts is presented in the "Postscript" section of this report.

Introduction

The system dynamics model of cocaine prevalence presented in this report represents a new application of an established method for analyzing dynamic issues through computer simulation modeling. The basic methodology was developed in the 1950s by computer pioneer Jay Forrester for the purpose of analyzing industrial dynamics (Forrester, 1961). Since then, system dynamics has been used to study a broad spectrum of issues arising in corporate, socioeconomic, psychosocial, biomedical, and ecological systems.

Philosophically, system dynamics occupies a unique place within the management sciences by virtue of its strongly endogenous viewpoint concerning the source of persistent patterns observed over time (Richardson, 1984). That is, system dynamics modeling starts from the assumption that feedback loops among endogenous (dependent) variables are the primary source of such patterns, whereas exogenous (independent) variables serve primarily to "trigger" the system's inherent behavior. This approach is in marked contrast to other popular analytical methods which rely on the movement of exogenous variables to explain observed behavior over time.

The patterns of behavior generated by well-formulated system dynamics models tend to be largely insensitive to the precise numbers used for model calibration and much more sensitive to basic structural assumptions, particularly assumptions affecting a model's representation of feedback loops (Richardson & Pugh, 1981). Consequently, such models typically allow one to gain insight into the functioning of a social system and predict likely future trends without requiring the input of great quantities of raw numerical data. They also allow one to evaluate alternative policies intended to improve a system's performance with the confidence that most numerical uncertainties will have little effect on the findings.

The prevalence of illegal drug use is a complex dynamic issue which calls for and has received attention by modelers applying system dynamics and related methods (Cooley et al., 1978; Gardiner & Shreckengost, 1985, 1987; Levin, Roberts, & Hirsch, 1975; Schlenger, 1973; Shreckengost, 1984a, 1985b). Various categories of users, as well as imports, availability, price, purity, morbidity, mortality, drug-related crime and other factors appear in real life to be tied together in a "seamless web". In order to understand the behavior of such a system, one should carefully investigate the multiple feedback loops of which it is comprised.

The model presented here builds upon previous modeling work but also represents something new. Unlike the well-known "Persistent Poppy" model (Levin, Roberts, & Hirsch, 1975), this model is parsimonious (containing a relatively small number of explanatory variables) and has been tested against actual indicator data. Furthermore, unlike Gardiner and Shreckengost's "Imports" models (Gardiner & Shreckengost, 1985, 1987; Shreckengost, 1984a, 1985b), this model has a large degree of endogenous structure which generates self-propelling "momentum" over time, making it a more useful tool for making projections and anticipating new trends.

System Dynamics Methodology

System dynamics models are developed and tested through a sequence of steps and according to principles intended to maximize their realism and their usefulness. The steps include problem definition, system conceptualization, model formulation, pattern replication ("validation") testing, sensitivity testing, feedback analysis, and policy analysis (Richardson & Pugh, 1981). In a typical system dynamics modeling project, some of these steps may be retraced – and the model refined – as anomalies are discovered and as new information or understanding is obtained.

The procedures and principles of system dynamics modeling are intended largely to systematize and enhance the process by which structural alternatives are screened and validated. Existing hypotheses, including those found in previously developed models, should not be taken at face value, but checked for their soundness and their relevance to the case at hand.

Technically speaking, a system dynamics model is an interconnected set of difference equations which approximates a real-world system operating in continuous time. These equations may be described in shorthand form as follows:

$$L_t = L_{t-dt} + (dt)(R_{t-dt})$$

$$R_t = f(L_t, X_t; C)$$

In this notation, t is the current time, dt is the computation interval, L is a vector of "level" (stock, state) variables, R is a vector of "rate" (flow) variables, f is a vector of functions (often nonlinear) used to compute these rates, X is a vector of exogenous variables (including stochastic inputs), and C is a vector of constants.

In looking at the drug prevalence problem, level variables could include the number of individuals in various specified user states, such as social cocaine sniffers or compulsive crack smokers. Rate variables could include flows into and out of the user states, such as initiation, escalation, quitting, and relapse. Exogenous variables could include the size of the target population and the fraction of imports that are seized. Constants would include delay times and other parameters which modulate behavioral responses, such as the strength of response to changing availability.

By successively computing all equations one small interval (dt) at a time, a system dynamics computer program generates time series data that lie close to the "true solution" one would obtain if the corresponding set of differential equations could be solved in closed form. Although specialized system dynamics software, such as DYNAMO (Richardson & Pugh, 1981), does exist, the basic computations can be programmed using most general programming languages, such as BASIC, FORTRAN and C.

Although system dynamics models are straightforward when viewed as mathematical entities, their proper construction is anything but simple. The functions for computing rate variables – also called decision functions – are typically quite intricate and necessitate the construction of intermediate "auxiliary" variables which make these functions more intuitive and natural. In a model of drug prevalence, auxiliary variables might include such influential factors as availability and perceived health risk. A key principle of system dynamics model building is that all decision functions should have a firm basis in the real world and should respond realistically under all conceivable conditions, including extreme ones.

In general, the principles of system dynamics model formulation are intended to guide the development of realistic models with an endogenous structure rich enough to reproduce observed patterns of behavior and to suggest other possible behaviors. At the same time, these principles guide one to develop models which are simplified enough to be manageable, understandable, and broadly applicable (Forrester, 1961; Forrester & Senge, 1980; Homer, 1987). While a model may include too little detail and ignore elements with important dynamic implications, it may also include too much detail and "miss the forest for the trees". The guiding principles of system dynamics help to ensure that the available data, such as drug abuse indicators, are utilized in a way that avoids both of these undesirable extremes.

Model validation in system dynamics is seen as an ongoing process of building confidence in the realism of the model's structure and behavior. A number of largely qualitative tests have been proposed and used for validation in this broad sense (Forrester & Senge, 1980; Shreckengost, 1985a). For example, confidence in a model's structure is enhanced when all equations have concrete real-life significance, are dimensionally correct, and operate appropriately even under extreme conditions. Likewise, confidence in a model's behavior is enhanced when the model faithfully recreates the dynamic patterns and correlations observed in real life (including periodicities and phasing relationships) or when it brings to light behavior in the real system which has gone unrecognized or unexplained.

Note, however, that point-by-point comparison of simulated and historical data is not considered to be a reliable method for validating feedback models of highly stochastic social systems (Forrester & Senge, 1980). The fact that a model may be able to reproduce accurately the history of one or two variables on a point-by-point basis does not imply that it is necessarily useful for considering future circumstances. Indeed, a truly useful predictive model is likely to score somewhat lower on such a test than an elaborate, but abstract, mathematical function concocted specifically for the purpose of curve fitting. This is not to say that a faithful reproduction of historical patterns is unimportant; indeed, it is often a necessary aspect of building confidence in a model's behavior. Instead, it implies that "fit" should be judged on something other than the amount of variance explained or other similar statistical grounds.

Two Previous Approaches

Two previous approaches to system dynamics modeling of illegal drug use have provided valuable ideas and background information for the present effort. One is the "Persistent Poppy" model developed by Levin, Roberts, and Hirsch (1975) which focused on heroin use. The other is a series of models, which we class together under the name "Imports", developed by Gardiner and Shreckengost (Gardiner & Shreckengost, 1985, 1987; Shreckengost, 1984a, 1985b), which have been used to examine both heroin and cocaine use. Though both the Persistent Poppy and the Imports models have their strengths, they also have limitations as potential tools for estimating and projecting drug use prevalence.

Persistent Poppy is a rather complex model focusing on population flows within an extended urban center (New York City), where heroin users may become addicts and where addicts may move from the street to prison, to drug-free rehabilitation programs, or to methadone maintenance programs – and then back again to the street either as unreformed addicts or as ex-addicts. These flows are affected by a number of factors, many of them part of the model's feedback loop structure. Such endogenous factors include heroin availability and price, the existence of a "drug culture", anti-drug police activity, educational efforts, and the limited capacity of the programs to handle additional people; even the community's socioeconomic status is endogenized in some model simulations. The supply of heroin is depicted as an instantaneously consumed flow (there is no accumulation of inventory) and is assumed to follow the established trend in demand unless disrupted by police action.

The Persistent Poppy was developed for the purpose of policy analysis. Although it is a model rich in real-life detail and endogenous structure, it was developed at a time when the numerical data needed for calibration and validation were lacking. It is a model with many interesting ingredients, indeed probably too many from the standpoint of parsimony. It is not known to what extent its policy findings are sensitive to numerical uncertainties, so that the reliability of the study is open to question.

Much simpler than Persistent Poppy are the Imports models addressing the issue of drug supply and demand on a national level. These models were originally designed to look at heroin (Gardiner & Shreckengost, 1985, 1987; Shreckengost, 1984a) but have also been applied to cocaine (Shreckengost, 1985b). Their main focus is on drug availability or "relative abundance", a comparison of supply with actual or potential demand. (In the heroin model, relative abundance is a comparison of accumulated inventory with consumption, while in the cocaine model it is a comparison of imports with the target population.) Relative abundance determines drug purity and price and the number of users and, in the heroin model, also affects mortality. In both models, imports are an exogenous input while consumption increases with both purity and the number of users.

These relatively small models can be used to estimate numbers of users on a national basis (Shreckengost, 1984a), although they were designed more for the purpose of deriving estimates of imports through a process of curve fitting. Both the heroin and cocaine models have demonstrated an ability to reproduce historical time series over multiple year periods. The cocaine model accurately reproduces available indicator data on the past-year user population, purity and price for the 1975-1984 period.

Although they are parsimonious and have replicated certain historical data, the Imports models fall short as system dynamics models of drug prevalence. They have only minimal feedback structure, and instead are dominated by the exogenous movement of imports over time. The lack of dominant feedback structure means that the Imports models generate little internal "momentum" and thus lack the ability to project future prevalence independently of rather uncertain imports forecasts.

Another weakness of the Imports models for prevalence estimation is their simplistic representation of the user population as a quantity which adjusts with equal speed to increases and decreases in relative abundance. Even when Shreckengost (1984a) breaks the user population into three separate quantities – light, medium, and heavy users – he still assumes that the response to economic conditions is a symmetrical one. That is, he assumes that it takes as long to become a user when the drug becomes abundant as it takes to discontinue use when abundance drops off. Such an assumption obviates the need to model population flows explicitly but is questionable at best when modeling drugs whose use is often as compulsive as with heroin and cocaine. Indeed, in regard to heroin, Shreckengost himself notes (1984b) that the estimated number of heavy users increased both in 1980, when relative abundance increased, and in 1979, when relative abundance fell. A plausible explanation for such asymmetry would seem to be the "momentum" associated with the escalation and dependency process, the modeling of which leads one back to the explicit portrayal of population flows as in the Persistent Poppy.

Model Development

The current model represents the culmination of a nearly two year development process involving numerous avenues of investigation. This process started in 1987 with a review of the relevant literature available at that time. The initial model building strategy, followed through the first half of 1988, was to retain the economic perspective of the Imports models but also to incorporate a population flow structure distinguishing, at a minimum, between compulsive and non-compulsive users. The economic approach was taken because price and availability of supply are generally seen as important variables affecting illegal drug use (Shreckengost, 1985b; Siegel, 1985; Gold, Washton & Dackis, 1985; Grabowski & Dworkin 1985). The population flow approach was taken so as to capture the "momentum" of escalation to compulsive use.

What follows is a brief account of model development, which for the sake of clarity has been divided into sections on population variables, relative abundance and imports, price and purity, sociological variables, and crack. Although these topics are presented sequentially here, they were typically considered in parallel fashion and iteratively during actual model development.

Population Variables

Although the model's depiction of the user population has undergone significant modification during its development, a concern with intensity of use and, in particular, a distinction between compulsive and non-compulsive users has been present from the beginning. Policymakers properly tend to be more concerned about compulsive use than non-compulsive use, largely because compulsive use is much more likely to produce the medical, behavioral, and legal difficulties that are reflected in available indicators (Gawin & Kleber, 1985; Gold, Washton & Dackis, 1985; Siegel, 1984; Siegel, 1985). Also, the volume of cocaine trafficking, with its implications for criminal activity, is closely connected with the number of compulsive users, in large part because compulsive users consume a disproportionately large amount of the drug. For example, Shreckengost (1985b) estimates that, in 1982, daily-to-weekly users of cocaine were responsible for 86% of total consumption though they made up only 19% of total users that year.

In addition to categorizing users according to their intensity of use, the issue of recency of use was also explored from early on, culminating in a decision by mid-1988 to incorporate a population flow structure that reflects the National Household Survey's set of questions regarding past month use, past year use, and lifetime use. This decision was made in part to give the model more points of comparison with the Survey. Also, it allowed the important phenomenon of relapse, both within a year after discontinuation and afterwards, to be explicitly represented.

The final step in modeling the user population – and, indeed, the last major step in model development during early 1989 – was to disaggregate users by product form, in particular distinguishing users of powder cocaine from users of crack. This step was not taken until it had become apparent that the recent history of cocaine could only be explained through explicit recognition of crack (see below). This disaggregation meant replicating in the model the same generic population flow structure for two different sets of users. It additionally allowed for the representation of product switching, from powder to crack and vice versa, among both compulsive and non-compulsive users.

Relative Abundance and Imports

The basic logic of the Imports models is that relative abundance, a measure of supply relative to demand, fully determines demand. Imports are assumed to move independently of demand, and, indeed, to drive demand through the economic effects of abundance or shortage. According to the Imports models, increases in relative abundance draw more people into use and also increase the drug's purity, and both of these effects increase consumption. We reformulated this hypothesis somewhat to focus greater attention on the role of price – specifically retail price per pure gram, a measure which reflects the cost of obtaining a certain level of drug effect (computed by dividing street price by street purity). But even in this reformulation we initially remained faithful to the Imports models in viewing relative abundance as the key to demand.

Continuing to follow the Imports models, we initially posited the level of domestic inventory as a buffer between imports and consumption to explain changes in relative abundance. However, the Drug Enforcement Administration (DEA) estimates that such an inventory may comprise a few weeks' worth of consumption at most, not months as was assumed in the Imports models. For a model with a time horizon of years, this short-term buffer is simply not significant. Domestic inventory was therefore dropped from the model and we assumed, following the DEA, that all imports that are not seized or lost in distribution are rather quickly consumed.

This "tight coupling" of imports and consumption leads to the interesting conclusion that changes in the supply-demand balance must only be reflected in retail purity, and we originally thought that purity itself could serve as an appropriate, measurable indicator of relative abundance. However, since purity can also change for non-economic reasons, such as shifts in fashion or taste, we later concluded that supply-demand imbalances would actually be reflected in <u>unexpected</u> or undesired changes in retail purity. Such changes would cause users to get unexpectedly pure drug during times of excess and unexpectedly impure drug during times of shortage.

Unfortunately, unexpected changes in purity are probably no easier to measure than the original slippery notion of relative abundance.

Considerable thought was given to the explicit modeling of cocaine imports, which had been hypothesized to be the prime driver of relative abundance. If the developing cocaine prevalence model were to have predictive utility, and if imports were to play such an important role, we would want to model them endogenously, as opposed to the exogenous portrayal in the Imports models. Consequently, imports were initially modeled as coming at the end of a supply process – including cultivation, production, transportation, and smuggling – a process which keeps imports rising as long as profitability is high. This "foreign push" model of supply, going all the way back to the coca plantations of South America, was later supplanted by a faster-responding "domestic pull" model in which smuggling increases in direct response to expectations of profitability. The key assumption of the "domestic pull" model (an assumption which available evidence appears to support) is that foreign supplies and production capacity are so plentiful that smugglers can obtain as much drug as they would like at the same low price; that is, that foreign supplies do not constitute a constraint on imports and may be considered infinite for modeling purposes.

Finally, after having explored various theoretical formulations, we obtained the data necessary to test the hypothesis that the rate of change in imports can be explained by the profitability of smuggling. A smuggler's income comes from the difference between the wholesale price he receives and his drug and smuggling costs, and it is reduced to the extent that his supplies are seized or lost (Reuter et al., 1988). Data from DEA's STRIDE data base suggest that inflation-adjusted wholesale price dropped 75% during the 1981-87 period. Although the price of foreign supplies also fell somewhat during this period, the decrease in wholesale prices, combined with a marked increase in the seizure rate (see NNICC, 1987), suggests that the profitability of smuggling probably fell or remained stable during the early-to-mid-1980s. Despite this lack of an increase in profitability per kilogram smuggled, imports by all accounts rose ever faster in the mid-1980s. Consequently, trying to explain the increase in imports solely as a function of profitability simply did not work in our developing model, regardless of the exact formulation used.

We now believe that level of profitability is not currently the main determinant of imports and would play a significant role only if it were to drop precipitously, for example, if the risk of seizure became extremely high. Instead, imports are probably best viewed as responding directly to consumption demands – in effect an even stronger version of the "domestic pull" theory. Thus, as long as the expected profit is large enough – as it appears to have been throughout the 1970s and 1980s – imports will be driven by the quantity demanded by consumers. This conclusion reverses the supply-drives-demand logic of the Imports models and raises yet again the question of why price and purity should change over the years in any systematic way, as they appear to have done.

Price and Purity

Although we parted ways with the Imports models on the modeling of supply, it was still natural to think that the price and purity of cocaine would have some discernible effect on consumption and that these economic variables should be modeled in some way. During Autumn of 1988, an extensive analysis of STRIDE data covering the 1977-87 period provided us with information on price and purity, both retail and wholesale. (After exploring various definitions, a retail buy or seizure was defined as one of less than six grams, while a wholesale buy or seizure was defined as one of more than one hundred grams.)

The average retail pure gram price (in constant 1982 dollars) computed from STRIDE data is bar-graphed in Figure 1, where it can be seen dropping rapidly at first, from about $500 in 1977 to about $250 in 1981, and more slowly thereafter, down to about $150 in 1986. The "street" price of a gram at retail purity may be found by multiplying this pure price by retail purity (see Figure 2), which results in a similar downward sweeping curve but with even less relative decline after 1981 than is seen in the pure price curve.

We were led by economic theory (see, for example, Reuter et al., 1988) to model retail pure price as wholesale pure price plus distribution mark-ups, and wholesale price as an inverse function of relative abundance. The STRIDE data indicate an approximate forty dollar real decline in wholesale price during the 1981-86 period (from $60 to $20 per gram in constant 1982 dollars), which accounts for only part of the hundred dollar decline in retail pure price during that period and implies a sixty dollar decline in real distribution mark-ups. It was not clear how to explain this decline in distribution mark-ups using our economic model, though we speculated that increasingly sophisticated organization and management of the U.S. distribution process (likely aided by the involvement of foreign producers) may have led to greater distributional efficiency and/or reduced distribution risks. Noting the importance of distribution mark-ups and lacking a promising way of modeling them endogenously, we finally decided to model retail pure price itself simply as an exogenous variable.

Average retail purity is graphed in Figure 2, where it can be seen increasing from 0.4 to 0.5 during 1977-82 and from 0.5 to 0.7 during 1982-87. We feel that such a trend is likely to reflect changing tastes rather than consistently unexpected increases in abundance, and conclude that it probably is not essentially a supply-side driven phenomenon. The early, slower increase may represent a "learning curve" among users or an increase in sophistication, resulting in the desire for a purer drug effect. This may also account for some of the increase during the mid-1980s, but the faster increase during this later period strongly suggests to us the growing impact of relatively pure crack.

Purity is not currently included as an explanatory factor in the model. However, even without an explicit representation of purity it is possible to use the current model to test the effects of a severe reduction in drug supply. These effects would include immediate forced reductions in consumption per user and a net outflow of users. Both of these effects can be depicted satisfactorily with appropriate changes in existing model parameters.

Sociological Variables

Even during initial model development we recognized that economic factors might not be sufficient to explain observed trends in cocaine use. We noted, for example, the presence of sociological variables in the Persistent Poppy model as well as discussions in the literature of the potential impact of "cultural aura" on illegal drug use (Grabowski & Dworkin, 1985). We also surmised that the sociological dynamics of "diffusion" which have been shown to apply well to legal medical products (Coleman, Katz & Menzel, 1966; Banta, Behney & Willems, 1983; Fineberg, 1985; Homer, 1987) might prove useful in understanding illegal drugs as well. However, we did not initially expect to have to rely heavily upon sociological variables to explain cocaine prevalence. Instead, we theorized that retail pure price alone would do a good job of explaining observed movements in indicator data.

But the actual data on retail pure price, extracted from STRIDE and graphed in Figure 14, turned out to be incapable in isolation of explaining the trends in users reflected in population surveys. In particular, pure price exhibited a pattern of continuous but slowing decline from 1977 to 1986, which would suggest a pattern of continuous but slowing growth in users. However, both the National Household Survey (Miller, 1983; NIDA, 1987a) and the High School Senior Survey (Johnston, O'Malley & Bachman, 1987) suggest a more complex pattern, one in which the number of current users grew rapidly from 1976 to 1980, but then flattened out and actually declined through 1983, and then grew again in 1984 and 1985 at a moderate rate (see also Adams et al., 1986).

The idea of modeling price endogenously had been abandoned even before the STRIDE analysis was performed, and we were already looking for other variables which might give the model greater predictive power. For evidence of changes in cocaine's "aura" over time, we examined the High School Senior Survey's attitudinal data and found trends there that, unlike the pure price trend, would not suggest a continuous growth in use. In particular, responses to the question of how easy cocaine is to get exhibited the same "grow, decline, and rebound" pattern over time seen for the number of current users. And responses to the question of how risky it is to use cocaine regularly exhibited a clear pattern of increasing wariness over time. Taken together, these two variables of access and perceived risk seemed an acceptable operational definition of the cultural aura surrounding cocaine.

Previous modeling of medical product diffusion (Homer, 1987) suggested how these variables might be modeled endogenously. A diffusion theorist is more likely to think of "access" in terms of social acceptance than as a balance of supply and demand, suggesting that one is more likely to become a user if one's friends or family are users. The increasing perception of risk (or decreasing perception of safety), on the other hand, can be seen as a cognitive response to accumulating reports and experiences that attest to the drug's dangerous effects; we found that data on cocaine-related emergencies from the national Drug Abuse Warning Network (DAWN) served as a suitable proxy for such "bad news" relative to cocaine use (NIDA, 1987b).

A model was constructed in which population flows are affected by the endogenous variables of "relative access to cocaine" and "relative perceived safety" and the exogenous variable of retail pure price. This model proved quite capable of replicating the population survey and DAWN data through 1983, and, surprisingly, did so most ably when price was assumed to have no impact at all. But this model could not satisfactorily explain the resumption of growth from 1983 to 1986.

Crack

At this point we admitted the necessity of modeling explicitly the introduction and spread of crack to explain cocaine prevalence post-1983. Crack, an easily processed and easily transported form of freebase cocaine, was first reported in Southern California and Texas in 1981, spread to New York City in 1984, and was found in urban areas all over the country by 1986 (NNICC, 1987; Johnson et al., 1987). We had hypothesized initially that the spread of crack could be viewed as reflecting a rapid decline in cocaine's price during the 1980s (see Cole (1989) for a similar perspective), and would not have to be modeled explicitly. But the STRIDE data suggest that stories of such a decline are largely exaggerated. Although it is true that crack can be purchased for as little as $10 per vial (NNICC, 1987), we have seen no real evidence that the price per pure gram of crack is less than that of powder.

What is true about crack (and freebase smoking in general), however, is that even a rather small quantity delivers a strong – if short-lived – drug effect, while cocaine powder does not have the same effect. (One might therefore say that crack has a lower price per effective dose, based on some desired peak in the magnitude of effect, even if its price per gram is the same as that of powder.) This aspect of crack, along with its portability, has opened up a whole new market for cocaine among certain groups, especially the urban underclass. Unfortunately, the powerful biochemical effect of crack is also associated with a greater risk of escalation to compulsive use and a greater risk of drug-related morbidity and mortality (Gawin & Ellinwood, 1988).

In order to explain the accelerating spread of crack in the current model, a diffusion process similar to that seen for powder cocaine in the late 1970s was hypothesized. The key to this process is the concept of "availability of crack", similar to "relative access to cocaine" except that whereas the latter reflects cocaine's share of the total drug market, the former reflects crack's share of the cocaine market. This diffusion process results over time in growth in the rate of initiation to cocaine via crack as well as growth in the rate of product switching from powder to crack, followed by rapid escalation to compulsive use.

The development process recapitulated above resulted in a system dynamics model which seemed to capture sufficiently well the spectrum of available information. The structure of this model is described below.

Model Structure and Calibration

The current model has been implemented using the "Professional DYNAMO" software package for IBM PC's and compatibles, a product of Pugh-Roberts Associates, Inc., in Cambridge, Massachusetts. The various computer files used to run and document the model have been assigned the name "COCAPOP", which underscores the model's emphasis on COCAine user POPulation categories and flows. Appendix 1 contains the "Documentor" file, COCAPOP.DOC, which is a numbered and annotated listing of equations followed by an alphabetized dictionary of acronyms. Appendix 2 contains the source file, COCAPOP.DYN, which is the original, unannotated listing of model equations used for all model runs.

An influence diagram summarizing the model's major cause-and-effect relationships is presented in Figure 3. Boxes are drawn around endogenous "output" variables, while no boxes are drawn around exogenous "input" variables. The user population, represented by a single box in Figure 3, is shown in detail in Figure 4 and Figure 5. Figure 4 shows how users are broken down into four major categories (not counting the "never used population") according to product form and intensity of use, and the flows into and out of these categories. Figure 5 shows how each of these four categories is further subdivided into four mutually exclusive levels according to recency of use, and the flows into and out of these levels. The full model thus contains 4 x 4 =16 mutually exclusive user levels plus the one "never used population" level. It also contains a level depicting the continuous accumulation of reported emergencies over time, giving 18 levels in total in COCAPOP.

Summary of Structural Logic

The structural logic of the current model may be summarized as follows:

1. People enter the total at-risk population at the age of 12 and leave when they die. They enter initially as part of the never used population; the model assumes no cocaine use by individuals younger than 12.

2. People who have never used may initiate into "social" (experimental, occasional, or recreational) use, from which they may escalate to compulsive use. Compared with social users, compulsives consume more drug per capita, experience more drug-related emergencies and deaths per capita, continue to use for a longer time, and, unlike social users, are assumed to be relatively unaffected by the drug's changing aura.

3. Consumption, drug-related emergencies and deaths, and access to cocaine are related to the number of "active users", those who have used within the past month. "Transitional users" are those who have used within the past year but not within the past month. "Ex-users" are those who have not used within the past year, some of them (the "immunes") quitting for good, others (the "susceptibles") eventually relapsing.

4. "Once a compulsive user always a compulsive user." Even if a compulsive user were temporarily to retreat to social use, he or she would likely soon reescalate to compulsive use, making it inappropriate to categorize such a person as simply another social user. This might suggest a separate category of "social users formerly

compulsive", but such a category has been left unmodeled for the sake of simplicity and on the grounds that such users are likely to be relatively few in number. Consequently, it is assumed that compulsive users may discontinue using altogether but do not return to social use.

5. Access to cocaine is one aspect of the drug's aura that is directly related to the active cocaine-using fraction of the population. As this user fraction increases, so does access, though at a decreasing rate. (That is, as the number of one's social contacts with users increases, the marginal impact of yet another such contact diminishes.) An increase in access, in turn, tends to increase the number of active social users further due to more initiation and relapse and less inactivation. This concept can also be discussed in peer culture terms.

6. The perceived safety of regular use is the other aspect of aura which has been modeled. It decreases as reported cocaine-related emergencies (a proxy for cocaine's harmful effects in general) accumulate over time, though at a gradually decreasing rate. (As one hears about more cases of harm due to cocaine, the marginal impact of learning about yet another such case diminishes.) A decrease in perceived safety, in turn, tends to reduce the number of active social users due to less initiation and relapse and more inactivation. As previously mentioned, compulsive users are relatively unresponsive to changes in aura.

7. Crack is "introduced" in 1981 by exogenously moving a tiny fraction (0.3%) of social users from powder to crack use during that year. From that time forward, any increases in the number of crack users relative to total users are assumed to lead to greater visibility and availability of crack, which, in turn, lead to even more initiation to crack and product switching from powder to crack.

8. Crack users (both social and compulsive) experience more drug-related emergencies and deaths per capita than powder users do. Also, crack's social users are slower to quit, less sensitive to news of health risks, and much more likely to escalate than are powder's social users.

9. All imports not seized are assumed to be consumed; domestic inventory and distribution loss due to domestic seizures are both assumed insignificant. Consequently, imports are computed in the model as consumption divided by the fraction of imports not seized. (The seized fraction of imports is modeled as an exogenous variable, and appears to have increased significantly in recent years.)

10. The retail sales dollar figure is computed as consumption (in pure kilograms per year) multiplied by retail pure gram price x 1,000. This is the only place where price plays a role in the current model, since the historical impact of price on usage appears

to have been minimal, as explained earlier. This is not to say price will never affect usage but that it would probably have to change dramatically – perhaps as a result of more effective law enforcement – to have such an effect. One might, however, include linkages from price to usage in a future version of the model that is enhanced to be more of a tool for policy analysis than the current model is.

Initialization of Levels

Every level in a dynamic model must be assigned an initial value, which in the case of COCAPOP means assigning eighteen values for the year 1976. The model then produces values for all later years through iterative computation. Eight of the model's levels are crack user subpopulations, each of which is assigned an initial value of zero. The level of cumulative reported emergencies is also set initially to zero, by definition. This leaves the eight powder user levels and the never used population to be initialized. The National Household Survey (NHS) provides information for 1976 on past month users, past year users, lifetime users, and the target population, which translate directly into the model's categories of active (past month) users, transitional (past year minus past month) users, ex- (lifetime minus past year) users, and the never used population (target population minus lifetime users). However, the NHS does not distinguish between social and compulsive users nor does it distinguish between susceptible and immune ex-users. Filling in the gaps on these issues required both educated guesswork and model experimentation.

We looked to a couple of sources for information on the number of compulsive users. NNICC (1987) estimates that of all users in 1981, about 7% were current "heavy users" who use every day or two. Shreckengost (1985b) estimates that of all users in 1982, 4% were current daily users, also representing 10% of all past month users. Applying these percentages to the NHS data for 1976 gives estimates of active compulsive users ranging from 110 thousand to 245 thousand. We chose a value, 200 thousand, near the upper end of this range (and equal to 18% of active users), because the rapid growth in initiation during the late 1970s must have resulted in a decline in the compulsive fraction of active users from its 1976 value.

Model experimentation proved useful for setting initial values for the levels of inactive (transitional and ex-) compulsive users, as well as the breakdown of ex-users into susceptible and immune categories. After reasonable ranges had been found for the various population rate fractions (see below), these remaining levels were adjusted so that (1) none of the population levels declined initially and (2) the pattern of growth seen in the NHS data for 1976-79 was replicated.

Population Rate Formulations

The model's seventeen population levels (the only other model level being cumulative reported emergencies) are associated with an even greater number of population flows or rates, 46 in all. These rates include:

One rate of target population entry;

Seventeen rates of death (from all causes), one for each of the population levels;

Two rates of initiation – one via powder and one via crack;

Two rates of escalation – one via powder and one via crack;

Four rates of product switching – two for social users (powder to crack, crack to powder) and two for compulsive users;

Four rates of inactivation – one for each major user category in Figure 4;

Four rates of successful quits – one per major category;

Four rates of temporary quits – one per major category;

Four rates of transitional user relapse – one per major category; and

Four rates of ex-user relapse – one per major category.

Except for population entry, these rates are all outflows from a level and are mostly formulated in the same basic way, namely, by multiplying the associated level by an annualized outflow fraction; the outflow fraction may itself be variable or may be assumed constant, depending upon the specific rate. The portion of a given level flowing out per model computation equals the outflow fraction multiplied by the computation interval (dt). One may view the annualized outflow fraction as the reciprocal of the average dwell time in the level. Thus, if the annualized outflow fractions exceeds a value of 1 (which is allowed), this means that the average dwell time is less than a year.

The quit rates – successful and temporary – are formulated in a way slightly different from the other outflow rates. Total annual quits are computed first (as Figure 5 suggests) and then split into the two rates according to a "successful quit fraction" (the fraction of quits that are permanent), assigned a value between 0 and 1. Total quits, in turn, consist by definition ("no use past year") of all the transitional users who do not relapse during the year. Thus, for each major user category:

$$TQ = (TU)(1-TURF)$$

where TQ is Total Quits per year, TU is Transitional Users, and TURF is the Transitional User Relapse Fraction per year (constrained to be between 0 and 1.)

The population entry rate is the annual rate of inflow to the 12-and-older population, which includes both the aging of youngsters into this category and the net in-migration of people 12 and older to the U.S. It is computed in the model by multiplying the total target population – that is, the grand sum of all seventeen population levels – by an annual entry fraction which is specified exogenously.

The model contains 41 outflow fractions, eight of which have been modeled as varying over time in response to one or more of the "diffusion" variables – relative access to cocaine (RAC), relative perceived safety (RPS), and availability of crack. We have minimized the number of variable outflow fractions (and thereby reduced the model's complexity) by making a few simplifying assumptions, the most important being that escalation and compulsive user flows are not directly affected by cocaine's general aura (RAC and RPS). The eight rates with variable outflow fractions include the two initiation rates (one for powder, one for crack), the two social user inactivation rates, the two transitional social user relapse rates, and the two powder-to-crack product switching rates (one for social users, one for compulsives).

Each of the eight variable outflow fractions is formulated as a fixed "normal" value multiplied by one or more factors related to the diffusion variables. By definition, the fraction equals its normal value when the relevant diffusion variables have a value of one. (RAC and RPS equal one by definition in the starting year of 1976, while the availability of crack equals one when crack has attained 100% of the current user market.) Each multiplying factor may be expressed as a diffusion variable raised to some constant power – essentially an elasticity of response, which in the model is called the "effect" of the variable on the rate in question. Thus, the initiation to crack fraction (the only outflow fraction affected by all three diffusion variables) is expressed as follows:

$$INKF = (INKFN)(AK)(RPS)^{ESINK}(RAC)^{EAINK}$$

where INKF is Initiation to Crack Fraction, INKFN is Initiation to Crack Fraction Normal, AK is Availability of Crack, ESINK is Effect of Safety on Initiation to Crack, and EAINK is Effect of Access on Initiation to Crack. Note that AK here has an implicit exponent of one, reflecting the fact that availability of crack is operationally defined as the relative impact of the crack fraction of users on initiation, with a range of 0-1.

Calibration of Population Rates

The census provides data on total population and vital statistics, with some breakdown by age, including population projections several years into the future (Census, 1988). From these data and the NHS's own periodic estimates, we calculated the 12-and-older target population for each year from 1976 through 1990, as well as year-to-year net increases. The net increases in population, calculated absolutely and then as a fraction of the population at the start of each year, are explained in the model as population entry less the sum of all deaths. Vital statistics data imply an aggregate death fraction of about 1.1% per year for the 12-and-older population. This 1.1% (assumed constant) was added to the calculated net increase fraction for each year to produce a value for that year's population entry fraction.

Accurate modeling of death fractions for various user categories can be a rather complicated matter, particularly since the ex-user population will be getting older as time goes on. Fortunately, cocaine use was negligible between the 1930s and the late 1960s (Adams et al., 1986), so that there are currently relatively few elderly ex-users. Although the aging of the ex-user population will affect its death fraction in future decades, we decided to ignore these dynamics in a model looking only a few years into the future. For the sake of simplicity, all of the model's death fractions are therefore assumed constant.

In considering user and ex-user deaths, we focused on the age groups of 15-34 and 35-44, which vital statistics suggest have annual death fractions of 0.15-0.2% and 0.25-0.3%, respectively. Based on this information, we assigned active and transitional users a death fraction of 0.2%, susceptible ex-users a death fraction of 0.25%, and immune ex-users (the oldest subpopulation of lifetime users) a death fraction of 0.3%. These fractions were assumed identical for powder and crack users. This left only the never used population death fraction to calculate, which we did by bringing together the relevant NHS population estimates with our assumed user death fractions and the aggregate death fraction of 1.1%. The result was a slight increase over time in the calculated never used population death fraction – due, we believe, to the increase in average age of the never used population as the fraction of lifetime users grows. However, this trend was quite small and justified assigning the never used population death fraction a constant value of 1.2%.

All other population outflow rate parameters – including 24 constant or normal outflow fractions and 12 "effect" exponents – were calibrated through a combination of educated guesswork and model experimentation and "tuning". The first of these parameters to be calibrated were those involving <u>powder</u> users, a task accomplished largely by reference to indicator (and other) data covering the period 1976-82. The first step here was to calibrate the parameters for initiation, so that the model could reproduce the NHS data for 1976-82 on lifetime users. After this, we concentrated on social users, and especially the parameters for inactivation and transitional user relapse, which were the most critical parameters for reproducing the NHS data on past month and past year users. Finally, we moved to the consideration of compulsive users, where we used as an "anchor point" previous estimates of 500 thousand compulsive cocaine users sometime during the 1982-84 period (Clayton, 1985; Shreckengost, 1985b). After making educated guesses regarding the compulsive users' inactivation, quitting, and relapse parameters – and making certain they were in appropriate relation to the corresponding social user parameters – the escalation fraction was adjusted so that the model produced about 500 thousand active compulsive users for 1982.

The next major task was to calibrate the outflow rate parameters involving crack users, including product switching between powder and crack. One way of simplifying this task was to set a given crack parameter with reference to its powder parameter counterpart, and to actually set the two equal wherever there was no good basis to think that they should be significantly different. For example, most of the parameters for compulsive users of crack are set identical to their powder parameter counterparts. But again, model tuning to reproduce historical data proved a very effective way of setting uncertain parameters, including the initiation, inactivation, escalation, and product-switching fractions. This was done by reference to the NHS data for 1985 on past month and past year users, as well as the DAWN emergency data for the 1982-86 period. (The NHS's 1985 figure for lifetime use was deemed unreliable, since it implies virtually no initiation to cocaine between 1982 and 1985 – an impossibility even if one counts only initiates to powder and not to crack.) The tuning process also required using less formal data, such as common knowledge that crack was available in most major urban areas by 1986 but has became even more widely used and available since then. Extensive model testing and tuning made it clear that reproducing the available post-1982 data left rather little room for play in the crack user parameters – a conclusion which was somewhat of a surprise, considering that there were more than just a few "free" parameters available for tuning.

Formulation and Calibration of Aura Variables

The aura variables "relative access to cocaine" (RAC) and "relative perceived safety" (RPS) are formulated endogenously as nonlinear functions of other model variables. In particular, RAC is a function of the active user fraction of the target population (AUFPOP), while RPS is a function of cumulative DAWN emergencies (CDEM). These two functions were calibrated so that their output would correspond to High School Senior Survey (HSS) attitudinal data (Johnston, O'Malley & Bachman, 1987), and so that they would have a 1976 value of one.

RAC was defined with reference to annual HSS data on the percentage of respondents saying cocaine would be "fairly easy" or "very easy" for them to get if they wanted some. The percentages for 1976-86 range from a low of 33.0% in 1977 to a high of 51.5% in 1986. The HSS-based value of RAC for each year was defined as that year's percentage divided by 1977's percentage. RPS was defined by similarly transforming annual HSS data on the percentage of respondents saying they think regular use of cocaine does not pose "great risk" physically or otherwise. The percentages for 1976-86 range from a high of 31.8% in 1977 to a low of 17.8% in 1986. The HSS-based value of RPS for each year was defined as that year's percentage divided by 1977's percentage.

The next step in calibrating the static RAC and RPS functions was to calculate values of their respective inputs, AUFPOP and CDEM, based on available indicator data. AUFPOP was calculated based on NHS data for the years 1976, 1977, 1979, 1982, and 1985. CDEM was calculated by accumulating the DAWN "consistent reporting panel" reports of cocaine-related emergency room visits starting in 1976 and continuing annually through 1986. Having done this, we produced two scatter plots based on indicator data: one of AUFPOP versus HSS-based RAC, and a second of CDEM versus HSS-based RPS. The nonlinear functions to be used in the model were then created by drawing smooth lines through the scatter plots, making certain that the RAC function goes through the point (.006,1), since AUFPOP is about .006 in 1976, and that the RPS function goes through the point (0,1), since CDEM equals zero in 1976.

Miscellaneous Formulations and Calibrations

Total DAWN emergencies (non-fatal) have been modeled as the sum of DAWN emergencies for each of the four major user categories depicted in Figure 4. A category's emergencies, in turn, are found by multiplying the number of active (past-month) users in the category by an annual "emergency fraction" (or risk) for that category, a number which is assumed to be constant. The emergency fractions for powder users were estimated by comparing actual DAWN data with NHS data for 1976-82, and assuming compulsive users of powder numbered about 200 thousand in

1976 and 500 thousand in 1982. This resulted in an estimate of compulsive powder user risk far higher than that for social users. The emergency fractions for crack users were estimated roughly at first by assuming that they would be higher than the corresponding powder values by factors of two to three. These estimates were then adjusted, as part of a broader process of model tuning (discussed above), so that both DAWN emergency values for 1985-86 and NHS population values for 1985 were closely replicated. This adjustment resulted in a value for crack compulsive user risk 2.5 times higher than its powder counterpart, and a value for crack social user risk six times higher than its powder counterpart.

DAWN cocaine-related deaths (excluding New York City, which classifies its medical examiner cases somewhat differently than the rest of the consistent reporting panel does) have been modeled simply as the number of emergencies multiplied by a fixed "death ratio", based on the observation that actual DAWN emergency and death data for 1976-86 are highly correlated with one another. This formulation should not be taken to imply that there is a causal connection between non-fatal emergencies and fatalities, but rather that both are caused, by and large, by the same biochemical mechanisms. This simplification will likely yield to a more explicit recognition of mortality risks in future model versions.

Consumption and imports are both expressed in pure kilograms per year; the computation of imports based on consumption and the seizure fraction was discussed above. Consumption is modeled by summing monthly gram consumption for each of the four major user categories, and then multiplying by 12 months per year and dividing by 1,000 grams per kilogram. A category's monthly gram consumption, in turn, is found by multiplying the number of active users in the category by an average monthly (pure) gram consumption per user. Lacking evidence to the contrary, we assumed for simplicity's sake that these category-specific, per capita consumption rates were fixed over time. We also assumed that, on average, social users of crack consume the same amount per capita as social users of powder, and compulsive users of crack consume the same amount per capita as compulsive users of powder.

The average consumption rates for social and compulsive users were estimated by combining a few different sources of information and focusing on the period 1982-83. First, based on NNICC (1987) estimates for imports and seizures, we assumed an average pure consumption rate during this period of about 6,000 kilograms (six metric tons) per month. Second, based on estimates from NNICC and Shreckengost (1985b), we assumed that compulsive users were responsible for about 65% of monthly cocaine consumption, and social users for the remaining 35%. Third, we used the NHS 1982 estimate of 4.3 million past month users, and the informal estimate that 500 thousand of these were compulsives. Taken together, these estimates imply monthly pure consumption rates of about eight grams per compulsive user and about one-half gram per social user.

Base Run Results

The current model, with its derived constants and the table functions assigned their baseline values (see Appendices 1 and 2 for baseline model listings), is initialized for 1976 and has been used to generate output results through 1992. These base run results – with variables identified by their model acronyms – are documented numerically in the upper portion of Table 1 and in the form of line graphs in Figures 6 to 14 (which allow comparisons to indicator data) and Figures 16 to 24. (See Appendix 1 for a listing of model acronyms and their definitions.) In addition, the assumed input values of retail pure gram price and the seized fraction of imports are graphed in Figures 1 and 15, respectively.

The lower portion of Table 1 presents national indicator data for 1976-1987 taken directly or derived from the National Household Survey (NHS), the High School Senior Survey (HSS), DAWN, the NNICC Report, STRIDE, and the Consumer Price Index (Census, 1988). These data are also presented in the form of bar graphs in Figures 1-2 and 6-15.

Comparison of Base Run Results with Indicator Data

Comparison of the model's base run results with indicator data will be left primarily to the reader and should in most cases confirm the model's ability to replicate historical trends and to approximate actual recorded values. There are a few notable exceptions or "mismatches", however. One involves the 1985 value for the ever used (lifetime user) population (see Figure 6), where the model produces a value about 30% above the NHS estimate. We feel that the NHS value in this instance is manifestly unreliable, because it suggests virtually no initiation from 1982-85, and that the value produced by the model is more in line with other indicator data available.

A second mismatch involves the 1976 value for relative perceived safety (see Figure 10), which is reported in the HSS as being much lower than in 1977, at a level of wariness not seen again in the HSS until 1982. HSS data for 1975 (not presented here) also suggest a period of lower perceived safety prior to 1977, combined, surprisingly, with greater access to cocaine. We have found nothing in other data or literature to support the idea that perceived safety increased (while access decreased) from 1975 to 1977. Lacking such corroborating data, we have chosen to maintain the hypothesis that relative perceived safety declines inexorably over time as "bad news" accumulates.

A third mismatch involves 1983-84 DAWN emergencies and deaths (see Figures 11 and 12), where the model produces values considerably lower than DAWN actually reported. The model explains the general upsurge in medical side effects in the mid-1980s as a function of the spread of crack, but suggests that this spread did not lead to a large upsurge until 1985. Perhaps part of the recorded upsurge during 1983-84 corresponds to something not depicted in the model, namely, the increasing popularity among compulsive users of more dangerous modes of administration – particularly the smoking of traditional freebase – even prior to the widespread use of crack (see Adams et al., 1986). We surmise that most of these freebase smokers (excluding some freebase "elitists") soon switched to crack – a more marketable form of freebase – when it became available to them, so that the model's apparent distortion of reality applies only to the transitional 1983-84 period.

Total User Time-Paths and their Causes

Simulated time-paths for the total number of users – active, past year, and ever used – are graphed in Figures 6, 7, and 8. ("Total" in this case refers to the aggregate of social and compulsive users.) With regard to active users, the model depicts rapid growth during 1976-80, a leveling off and decline during 1981-83, resumed growth due to crack from 1984-87, and finally a gradual decline starting in 1988. Past year users grow until 1981, level off through 1984, grow through 1987, and then decline. The ever used population grows continuously, with a brief period of slowdown in the early 1980s followed by resumed rapid growth, but followed, starting in 1988, by a more significant and lasting slowdown in growth.

Figure 16 shows the number of active users broken down by product type (cocaine powder vs. crack). The complex rise-decline-rise-decline pattern seen in Figure 4 is explained here as the superimposition of two simpler patterns: Powder users rise through 1980 and then decline continuously starting in 1982, while crack users grow rapidly during 1984-87 and then level off. Figure 17 shows that crack users grow to comprise about 80% of all active users by 1988-92. This figure also shows similar patterns of growth for the proportions of total consumption and emergencies for which crack users are responsible, as well as growth in the availability of crack.

To a large extent, changes in the total number of users may be seen as reflecting the rate of initiation, graphed in Figure 20. Total (powder plus crack) initiation rises during 1976-79, declines during 1980-82, rises sharply during 1984-85, then reverses direction and declines continuously. Figure 20 also shows initiation via crack, which is responsible for the sharp rise in total initiation during 1984-85 and for some of its decline thereafter. The difference between the total initiation and crack initiation curves gives initiation via powder, which (being identical with total initiation during 1976-81) rises through 1979 and falls steadily thereafter.

The rise and decline of powder users is largely driven by a rise and decline in initiation to powder, it is true, but is also driven by a corresponding rise and decline in the duration of social use before quitting – a function of the social users' inactivation and transitional relapse fractions. Behind these population rate changes, in turn, lie changes in the aura variables, relative access to cocaine (RAC, graphed in Figure 9) and relative perceived safety (RPS, graphed in Figure 10.) Access, it will be recalled, rises as the number of active users rises, and as it does so, causes initiation and the duration of use to rise further. This self-reinforcing cycle is responsible for the accelerating growth in users in the late 1970s.

But as use increases, so does the number of reported emergencies (see Figure 11), whose accumulation causes perceived safety to begin its downward slide. By 1981, perceived safety has fallen enough to halt the growth in active users; then, as perceived safety continues to fall through 1992, so does the number of powder users. In sum, the growth in use has led to its own reversal by permitting the dangers of cocaine to be exposed. Both the self-reinforcing feedback loop involving access and this self-correcting feedback loop involving perceived safety may be seen in Figure 3.

The rise and leveling off of crack users is driven by a diffusion process similar to that of cocaine powder, but with the additional factor of "availability of crack" being necessary to explain the rapid rise of crack soon after its introduction in 1981. In the early 1980s, cocaine was a product whose general aura was on a steady downhill slide from which it would not recover. Crack's introduction created the potential for a new class of users who would be attracted by its more powerful drug effect or lower price per dose (as described previously.) This potential would be realized to the extent that crack's attractiveness could "shake off" cocaine's generally declining aura – or attract a market that ignores aura – and gain enough of a following to attract even more users. Such a self-reinforcing feedback loop involving crack availability is pictured in Figure 3 and illustrated dynamically in Figure 17.

Eventually, the self-correcting loop involving perceived safety eventually reasserts itself again in the base run. As crack spreads quickly in the mid-1980s, reported emergencies increase more rapidly than ever, causing perceived safety to decline faster and further than it had previously. By 1987, the decline in perceived safety is enough to reverse the growth in crack initiation, which causes the number of crack users to level off for several years. The base run shows the number of crack users actually starting to decline in 1991, as accumulating "bad news" causes crack initiation to continue to decline (see Figure 20.)

The Compulsive User Time-Path and its Causes and Consequences

Figure 18 presents the time-path for active compulsive users, broken down by product type. The number of compulsives (all classified as powder users prior to the introduction of crack) rises gradually during 1976-83, from 200 thousand to about 500 thousand. The number of powder-using compulsives in the base run remains remarkably steady within the 450 to 470 thousand range from 1982 to 1992. The number of crack-using compulsives starts its lift-off in 1984 and grows in S-shaped fashion thereafter – accelerating in rate through 1987 and then decelerating. Since the number of powder-using compulsives is roughly constant during this period, the S-shaped pattern for crack compulsives is directly reflected in the total number of compulsives during 1984-92. The base run produces a total of about 1.6 active compulsive users by 1988 (70% using crack), and about 2.3 million by 1992 (80% using crack.)

Changes over time in the number of compulsive users essentially represent an accumulation of the escalation rate, graphed in Figure 21. Since the escalation rate is a function of the number of active social users, the general pattern of rise-decline-rise-decline seen in Figures 6 and 16 is again observed, with peaks in 1980 and 1987. But the 1987 peak is more than four times greater than the 1980 peak, a dramatic reflection of the shift in use from powder to much more addictive crack. (The base run assumes an annual escalation fraction of 15% for crack, compared with 2.5% for powder.)

The pattern of growth in compulsive users seen in Figure 18 is primarily responsible for similar time-paths for DAWN emergencies (Figure 11), DAWN deaths (Figure 12), imports (Figure 13), seizures (Figure 14), consumption (Figure 22), and even retail dollar sales (Figure 23). (But note that retail sales – price x consumption – show a decline in the early 1980s, reflecting the price decline seen in Figure 1 combined with a leveling off in consumption during those years.) Seeing the same pattern repeated for several key indicators serves to underscore the policy significance of compulsive use.

Although policymakers are aware that compulsive use is important, it is hard to quantify this importance and measure its change over time. Figure 19 presents three graphs describing how compulsive use accounts for changing proportions of the total cocaine picture over time – in terms of users, consumption, and emergencies. In 1976, compulsives account for about 20% of active users, 80% of consumption, and 90% of emergencies. The compulsive fractions all decline significantly during 1976-80 due to a rapid influx of social users. They then rise again during the social use slowdown of 1981-83, stabilize during the 1984-85 period of rapid initiation, and then grow steadily thereafter. The base run suggests that by 1992, 40% of active users will be compulsives and they will account for 90-95% of consumption and emergencies.

These 1992 proportions are, in the case of users and consumption, significantly higher than their 1976 counterparts, directly reflecting the much greater rate of escalation associated with crack compared with powder. The reason that this growth does not also apply as well to the compulsives' fraction of emergencies – despite a doubling in the fraction of compulsive users – is that crack, relative to powder, is assumed to increase the risk of emergencies for social users even more than it does for compulsive users. Our experiments in model tuning suggest that the social use of crack is risky enough to have a noticeable impact on cocaine-related emergencies and deaths – though still much less risky than the compulsive use of either powder or crack. Crack in this respect appears to be unlike cocaine powder, which rarely produces acute complications when used in small quantities (Gawin & Ellinwood, 1988).

Summary of Base Run Results

The base run tells a story for the sixteen-year period from 1976 to 1992 that is internally consistent and consistent with most indicator data and other information to which we have had access. This story starts with rapid growth in the social use of cocaine powder during 1976-80, along with gradual growth in compulsive use. The rapid growth in social use is the result of a self-reinforcing feedback loop – a loop in which increasing use leads to increasing access, in turn attracting still more new users and extending the average duration of use. As escalation draws an increasing number of users into compulsive use, the number of reported emergencies also rises, and the accumulation of such emergencies causes the perceived safety of cocaine to decline. By 1981, it has declined enough to halt the growth in cocaine powder use, and its continued decline thereafter causes powder use also to decline continuously through 1992.

The second aspect of the cocaine story begins with crack's introduction in 1981. The new product gains momentum, again through the self-reinforcing cycle of use and availability, and really starts to take off in 1984. The model suggests that the decline of powder use actually helps crack gain this momentum by increasing crack's share of the market. As a result, both new initiates and current users are essentially steered toward crack by virtue of its increasing availability relative to powder. Crack soon builds its own population of users, whose duration of use and risk of escalation and medical complications are greater than those for powder users. Consequently, the number of compulsive users grows rapidly through 1987, as does the number of reported emergencies, causing cocaine's perceived safety to decline further.

This further decline in aura is finally enough in 1987 to suppress the rate of crack initiation, and the number of social crack users thereafter declines. But the legacy of crack's rapid growth casts a long shadow, being reflected in continued increases in the number of compulsive users into the early 1990s. Consequently, such key indicators as emergencies, fatalities, and seizures also continue to increase, though at a slowing rate. Although the rate of crack escalation peaks along with the number of social crack users in 1987, it does not decline fast enough thereafter to prevent the continued growth in compulsive use and its consequences. Since it takes some period of time for compulsive users to quit successfully – five or six years on average given the model's baseline parameter values – the number of compulsive users continues to increase for several years even as the rate of escalation is declining.

Sensitivity Analysis

Sensitivity testing and analysis is an important stage in the system dynamics modeling process and serves to focus attention on those structural elements in a model most responsible for the model's patterns of behavior. It consists of testing a model by altering the values of exogenous parameters (constants and table look-up functions), and analyzing the results from modeling and real-world standpoints.

If such testing uncovers a parameter that has a major effect on the time-paths of output variables, three possible interpretations exist (Richardson & Pugh, 1981). One interpretation is that the sensitivity is due to the model's artificial simplification of reality, and that the pertinent structure should be modeled in greater detail to remove such unrealistic sensitivity. A second interpretation is that the model's structure is adequate but that the sensitivity indicates a need for more careful estimation of the parameter in question. This revealed need may serve to target key areas for further empirical data collection, so that more confidence may be placed in the model's conclusions. The third possible response is to interpret the sensitivity from a policy standpoint as a potential point of leverage in the real system, assuming that the baseline model adequately represents the system's logical structure and parameter values under existing policy. However, even when sensitivity testing reveals a potential leverage point, thereby holding out the promise of effective intervention, it can not answer the question of whether the indicated type and magnitude of policy change is actually achievable in the real world (Richardson & Pugh, 1981).

Sensitivity Tests Performed

The COCAPOP model contains 87 numerical assignments, including 18 initial values, 52 defined constants and table look-up functions, and 17 death fractions (not defined separately.) Of these, 44 of the defined constants and three of the table functions were determined both to be somewhat uncertain in magnitude and to have some conceivable effect on the model's 1976-92 results regarding the numbers of active users in the four major categories shown in Figure 4. Sensitivity testing consisted of changing a single parameter from its baseline value while holding all other parameters at their baseline values. For each of the 47 parameters tested, two such tests were performed – giving 94 sensitivity tests in all.

Each of the 44 constants (listed as parameters 1-44) was tested in the same way: First, the constant was increased from its baseline value by 20%, producing the so-called "high" or "H" test value; second, the constant was decreased from its baseline value by 20%, producing the so-called "low" or "L" test value.

The three table functions (listed as parameters 45, 46, and 47) were tested in a way that corresponds to increasing and decreasing a parameter value by 20%. Parameters 45 and 46 are the table functions for relative access to cocaine (RAC, a function of the active user fraction of the population, AUFPOP) and relative perceived safety (RPS, a function of cumulative DAWN emergencies, CDEM), respectively. Both RAC and RPS go through the normal value of 1, but while the RAC function has a positive slope, the RPS function has a negative slope. In both of these cases, the "H" or "steeper function" test consisted of magnifying by 20% the difference between each output value along the baseline function and the normal value of 1. The "L" or "shallower function" test consisted of shrinking by 20% these same differences.

Parameter 47 is the table function for availability of crack (AK, a function of the crack fraction of active users, KFAU), which goes through the points (0,0) and (1,1), and rises above the diagonal between them in convex fashion. The "H" test consisted of increasing each value along the baseline function by 20%, but without exceeding the ceiling value of 1. The "L" test consisted of decreasing each value by 20% within the lower half of the function, and then assuming a nearly linear continuation in the upper half of the function so that the point (1,1) was approached smoothly. (The AK function values used for test 47L are: 0/.16/.28/.38/.48/.58/.68/.78/.88/.95/1, compared with baseline values of: 0/.2/.35/.48/.6/.7/.8/.88/.95/.99/1.)

Sensitivity Test Results

Results from each of the 94 sensitivity tests performed were examined to ascertain the degree of effect on numbers of users, relative to the base run, at regular time intervals along the sixteen-year simulation. In particular, the total number of active users (AU) and the number of active compulsive users (ACU) were compared with their base run values at years 1980, 1984, 1988, and 1992. A parameter was judged to have a significant effect if its 20% change, in either the "H" test or the "L" test, resulted in a change relative to the base run of at least 10% in AU or ACU at any one of the comparison points. Only nine of the 47 parameters tested were judged significant in this sense, including all of the three table functions tested.

Table 2 presents results – focusing on the variables AU and ACU – for 24 selected sensitivity tests, corresponding to twelve different parameters. (For each of the selected parameters, results for both the "H" test and the "L" test are presented.) The twelve selected parameters include the nine "significant" parameters, as well as an additional three parameters whose "non-significance" is of special interest. Each column of test output in this table contains a two-line heading which describes the output variable (AU or ACU), the test number (such as 1H or 47L), the acronym of the changed parameter (such as CUKIF or TAK), and the direction of change in that parameter (where "/ "signifies an increased constant, "\" signifies a decreased constant, "|" signifies a steeper table function, and "-" signifies a shallower table function.) Annual output values are presented for the complete 1976-92 period, as well as percentage changes relative to the base run for the years 1980, 1984, 1988, and 1992. These results are also presented graphically in Figures 24 to 39.

The increasing and decreasing of a given parameter has been found, on the whole, to create essentially symmetrical changes around the base run's time-paths for AU and ACU. In the following discussion, such symmetry will be assumed for the sake of a simpler presentation. The focus will be on only one of the two tests for each parameter (either "H" or "L"), with the selection in each case corresponding to the direction in which a policymaker – with a short-term orientation – might naturally tend to want to see the parameter be changed.

Figures 24 and 25 show the results of changes in the initiation fraction normals for powder (INPFN, #26) and for crack (INKFN, #25), both of which were judged significant. A reduction in the initiation to powder parameter (test 26L) results in slower growth initially but also much less of a decline through 1983. Because the initial self-reinforcing growth process has been slowed, there is less accumulation of reported emergencies, thereby delaying the decline in cocaine's perceived safety. This higher level of perceived safety relative to the base run significantly speeds the spread of crack in the mid-1980s and causes the number of users, particularly compulsives, to be somewhat higher than in the base run during the second half of the simulation. But this difference declines going into the 1990s, as the levels of perceived safety in the two runs converge. In sum, a parameter change which reduces use prior to crack actually increases use during the first several years of the crack era, due to the self-correcting feedback involving perceived safety.

A reduction in the initiation to crack parameter (test 25L) has the effect of delaying the spread of crack somewhat but more importantly reducing its magnitude. Because fewer people are initiated into crack use, the rate of escalation declines considerably, leading to a significant reduction in compulsive use into the 1990s.

Figures 26 and 27 show the results of changes in the social user inactivation fraction normals for powder (SUPIFN, #34) and crack (SUKIFN, #31), both of which were judged significant. An increase in the powder inactivation parameter (test 34H) causes the average duration of social powder use to decrease, with an effect quite similar to that of a decrease in initiation to powder. One again sees the slower initial growth unexpectedly leading later to a more rapid spread of crack and, consequently, more compulsive use in the late 1980s and early 1990s.

An increase in the crack inactivation parameter (test 31H) causes the average duration of social crack use to decrease. The effect is in the same desired direction as seen with a reduction in initiation, but does not set in as soon nor with nearly the same magnitude as in test 25L. Since inactivation is a process that occurs after initiation, the effects of crack inactivation do not become evident until a significant number of people have already initiated crack use.

Figures 28 and 29 show the results of changes in the escalation fractions for powder (ESCPF, #18) and crack (ESCKF, #17), both of which were judged significant. A decrease in the powder escalation fraction (test 18L) has the initial effect of reducing compulsive use and, consequently, the number of reported emergencies. This delays the decline in cocaine's perceived safety and causes social use to be greater during the 1980s and early 1990s than it is in the base run. This increase in social use (which diminishes over time) compensates fully for the reduced likelihood of escalation, resulting in virtually no change in compulsive use relative to the base run in the latter half of the simulation.

A decrease in the crack escalation fraction (test 17L) leads to increasingly less compulsive use relative to the base run. But by reducing the number of emergencies, this slows the decline in cocaine's aura, leading to a compensating relative increase in social use from 1986 onward.

Figures 30 and 31 show the results of changes in the compulsive user inactivation fractions for powder (CUPIF, #4) and crack (CUKIF, #1), neither of which was judged significant. These parameters were of special interest because their increase could be interpreted from a policy standpoint as an expansion of the number of treatment slots available. Recall that an increase in the rate of inactivation causes the average duration of use (in this case, compulsive use) to decrease. For both powder (test 4H) and crack (test 1H), the effects of this change are similar to those of a decrease in escalation, but with the magnitudes reduced somewhat. In the case of increased powder, this means a bit less compulsive use initially, followed by a compensating increase in social use. In the case of crack, this means increasingly less compulsive use relative to the base run but a compensating increase in social use.

Figures 32 and 33 show the results of changes in the social users of powder switch-to-crack fraction normal (SUPSKFN, #35), a parameter which was judged not to be significant. This parameter was of special interest because it controls the second major route into crack use after direct initiation. Although a reduction in this parameter (test 35L) has the desired effect of reducing both social and compulsive users, it does so to an unexpectedly small extent – in particular, to a much smaller extent than does a reduction in crack initiation (see test 25L.) The reason for this result is that the product switching in question pulls from a pool of users – the social users of powder – which shrinks continuously during the 1980s. Such product switching is therefore of diminishing importance as time goes on.

Figures 34 and 35 show the results of changes in the table for relative perceived safety (TRPS, #45), a function which was judged to be significant – in fact, so significant that the results are graphed here using expanded output scales. This function directly affects social users of both powder and cocaine through their rates of initiation, inactivation, and transitional relapse. The results are uniformly in the expected direction, becoming increasingly strong as time goes on and particularly after the take-off of crack. Until about 1980, the accumulation of "bad news" is slow enough to have little effect on cocaine's aura, and so it matters little how people respond to that news. But after that, the strength of response becomes increasingly important, initially affecting social use and then affecting compulsive use as a delayed reflection – via escalation – of the changes in social use. The "steeper function" test (45H) not only results in the total number of users declining earlier (by a year) and faster than in the base run, but it also results in a virtual leveling off in compulsive use by 1990.

Figures 36 and 37 show the results of changes in the table for relative access to cocaine (TRAC, #46), a function which was judged to be significant. This function affects social users through rates of initiation, inactivation, and transitional relapse – as the perceived safety function does. Although the results are again in the expected direction, they are considerably different than those of perceived safety, with more impact occurring early in the simulation and less impact later. The effect of a shallower access function (test 46L) is initially to slow the self-reinforcing growth in use relative to the base run, which it does quite effectively through 1980. But this leads to a slower accumulation of reported emergencies, so that the decline through 1983 is also slower than in the base run. This relative reduction in "bad news" also lays the groundwork for a more rapid spread of crack, compensating for relatively lower access through greater perceived safety, and erasing the differences between the simulations during 1984-85. Because of this temporary state of near-equality, the "bad news" increases at a rate equal to or greater than that of the base run from 1984-87. Having "caught up" in perceived safety, however, lower access once again leads to lower aura starting in the late 1980s. This results in a gradual decline in total use that parallels that of the base run but at a lower level, and a growth in compulsive use which decelerates more than that of the base run.

Figures 38 and 39 show the results of changes in the table for availability of crack (AK, #47), a function which was judged to be significant. The results of changing this parameter are negligible until 1984, but become significant soon after that as crack spreads more rapidly. A reduction in crack availability relative to the base run (test 47L) leads to a year's delay in this spread, which occurs at a slower rate than in the base run. With this delayed and slower spread of crack comes a slower increase in compulsive use, and so fewer reported emergencies. As a result, perceived safety does not decline as quickly as in the base run and the total number of users stays relatively constant during 1988-92, instead of declining. However, the legacy of a slower spread of crack continues to affect the amount of compulsive use during 1988-92, resulting in a growth path parallel to but significantly lower than that of the base run.

Implications of Sensitivity Test Results for Policymaking and Data Collection

The sensitivity test results make apparent certain key aspects of the current model, lessons which may carry over to the real world and have significance there for policymaking and targeted data collection.

Perceived safety emerges as the single most important factor in the model, even more important than access or availability, because of its role in halting a growth in use and turning it into a decline. This result suggests that to the extent the health risks of cocaine are communicated effectively to both potential initiates and current social users, the decline in social use will be accelerated and the growth in compulsive use slowed.

Furthermore, enhancing the attitudinal impact of medical side effects – through the parameter of perceived safety – is the only kind of policy-related change in the model that can weaken a feedback mechanism tending to reduce the impact of all other parameter changes. This refers to the self-correcting loop that says that an initial reduction in use leads to fewer reported emergencies, which leads to less decline in perceived safety, resulting in less reduction in use. Compensation of this sort is seen most dramatically in those sensitivity tests which reduce the growth of use in the late 1970s, only to set the stage for increased growth in the mid-1980s following the advent of crack.

A second key point that emerges is that we are now well into the era of crack, and that prevalence reduction efforts that focus on that form of cocaine are likely to be more effective than those that do not. The growth of compulsive use we are seeing now and will continue to see for at least a few more years reflects the spread of crack in the mid-1980s, a time during which powder use overall has fallen and even the compulsive use of powder has remained relatively stable.

Thirdly, sensitivity testing suggests that slowing the growth in compulsive use is more effectively achieved by focusing on reducing the number of social users – tomorrow's compulsive users – rather than by focusing on reducing the number of today's compulsive users through treatment or incarceration. (A multiyear policy that directly reduces the number of compulsive users would do more to reduce the "steady-state" level of compulsive use several years into the future than it would to slow current growth. This is not to say, however, that such a policy should not be pursued.) In the model, a reduction in social users is best accomplished by reducing initiation or by increasing social users' inactivation. And of these two, reducing the rate of initiation – that is, prevention – appears to be the more effective way to go. The general message seems to be that policy efforts are likely to become more effective the more they focus on potential or early users, rather than longer-term users.

A reduction in social users is precisely what an attack on the "diffusion" variables of perceived safety and access/availability serves to accomplish. As noted above, the effective communication of health risks would seem to be the more robust tool in this regard. But that certainly does not rule out a simultaneous pursuit of enforcement policies that effectively reduce access to the drug by making it legally more risky to purchase and possess, or that limit its supply so much that high price blunts the "access" effect of having friends who are users. On the other hand, aggressive enforcement policies may have their own side effects and civil liberties implications which need to be considered carefully.

Turning to the implications of sensitivity testing results for data collection, two major areas of uncertainty stand out as requiring greater attention so as to improve the model's ability to forecast trends and explore policy implications. One area is crack – specifically, its prevalence, health risks, and escalation risk, information which would be acceptable even if expressed only by way of comparison with powder. The model's portrayal of the evolution of use in the late 1980s and early 1990s is based largely on educated guesses regarding crack and inferences based on model tuning, which leave enough room for error to be of concern. The second major area for targeted data collection would be in the area of attitudes and the connection between attitudes and behavior. It would be particularly useful to know how receptive or non-receptive different demographic population groups are to various sources of information regarding the dangers of drug use. Such information might, in particular, help us to understand how quickly and how far perceived safety will decline in the future – information to which the model's projections are particularly sensitive.

Conclusion

This report has presented a system dynamics model of cocaine prevalence which connects through feedback loops a detailed population flow structure – depicting several categories of users – with such "diffusion" variables as access and perceived safety. The model – called COCAPOP – is rich enough to replicate a variety of indicator data, but not so complex as to make it unreliable for projection or impossible to understand. It evolved through a process of development that involved testing new hypotheses when the old ones proved inadequate to explain historical trends. Starting with an orientation that was largely economic and supply-side in nature, we turned increasingly to sociological, demand-side variables, until price was finally abandoned as a factor for explaining historical trends and supply was viewed as being driven directly by demand during the historical period.

Among the many endogenous "output" variables of the dynamic model are the numbers of compulsive users and users of crack, both of which are difficult to estimate through surveys and other simple statistical tools which have few built-in checks for consistency. COCAPOP, by virtue of its having a dynamic structure that accounts for a wide variety of indicator data, not only allows one to check for consistency across variables at any one point in time, but also allows one to determine whether the estimates remain internally consistent over the full time span of available data. Furthermore, one can use the same model to project into the near future and perform "what-if" analysis of changes in those parameters that may be affected by proposed policies. For example, sensitivity testing of the model has suggested that policies which focus on early prevention of use are likely to be more effective in reducing the current growth rate of compulsive cocaine use than are policies which focus on treatment or incarceration of today's compulsive users.

This should not be taken to suggest that the current model is appropriate for addressing the entire range of policy issues relative to cocaine. It does not contain any variables related to drug-related crime, which is a major policy concern. Also, it does not allow one realistically to evaluate the impact of an unprecedented cut-off of supply, nor of a hypothetical policy of legalization. Indeed, the current model was constructed not primarily for policy analysis but for the purposes of estimation and relatively short-term projection of cocaine prevalence. We believe, however, that having established that the model is useful for these purposes, the next step is to build upon this foundation and enhance the model so that it is capable of performing a wide range of policy analysis.

Postscript

Since the writing of this report, additional data have been released or come to our attention, causing us to go back and ask some basic questions which will surely lead to further refinement of the model.

The new data include the following highlights:

- The 1988 National Household Survey (NHS) suggests a dramatic decline since 1985 in both past-month and past-year use of cocaine, while weekly use as measured by the NHS has increased moderately. Large decreases in marijuana use were also indicated by the NHS.

- The annual High School Senior Survey (HSSS) similarly indicates a very sizable decline in the use of both cocaine and marijuana, with 1987 appearing to be a watershed year for cocaine and marijuana declining steadily starting in 1986.
- In 1988, 40% of the NHS past-month users of cocaine also reported past-month use of crack; this 1988 crack fraction among HSSS high school seniors was nearly 50%, but among high school graduates aged 19-28 was only about 20%.
- While high school seniors indicate a growing perception of cocaine's health risks, and say increasingly that their peers do not use the drug, they also say that cocaine (in both its powder and crack forms) has become steadily easier to obtain should they want it.
- DAWN emergency room mentions and medical examiner mentions have grown dramatically in recent years, ER mentions actually quadrupling from 1985-88. The ER data show steady increases, starting in 1985, in both the proportion of blacks and the proportion of smoking-related incidents, which might suggest crack as the prime suspect. However, sniffing-related and injection-related ER mentions have also increased steadily in number, though their proportions of the total have declined.
- The exponential growth seen in the DAWN data is also seen in data from the FBI's Uniform Crime Reports (UCR), which show arrests for both possession and sales of cocaine and opiates more than doubling during 1984-87.
- Recent (1987-88) data from NIJ's Drug Use Forecasting (DUF) program show rates of self-reported cocaine use among arrestees many times higher than those reflected in general population surveys, with urine testing results suggesting even higher actual rates of current use. Within this population (and based on the self-report data), the fraction of current cocaine users who use crack has grown to over 50%. Over 80% of the arrestees who have ever tried crack have also tried powder cocaine; and over 40% of the arrestees who currently use crack also currently use powder.

The existing model, in a nutshell, projects a continued decline in the use of cocaine powder and simultaneous growth in the use of crack during the late 1980s and early 1990s. At the risk of some simplification, one may think of the NHS and HSSS as reasonable indicators of social use, and think of DAWN, UCR, and DUF as reasonable indicators of compulsive use. From this perspective, the existing model does – perhaps with one exception – at least generate trends which move in the same direction as the indicators have during the last few years. The one exception is that compulsive use of powder appears (from DAWN) to have increased along with that of crack, though not quite as quickly. However, one may hypothesize that this growth has occurred primarily within a population that first became dependent on crack – and may therefore be considered compulsive users of crack first and foremost – and now use cocaine in whatever form they can get it. Further analysis of the DUF data may help to sort out this issue.

However, even if one allows that the existing model has gotten the general trends right, it appears (based on the indicators) to have fallen significantly short of the mark in projecting the rapidity of decline in social use (when compared with the NHS and HSSS figures), as well as the rapidity of growth in cocaine-related morbidity and mortality (when compared with the DAWN figures). Also, the model's projection of crack fractions in the neighborhood of 80% by 1988-90 appears to be excessive, based on recent data from NHS, HSSS, and DUF.

When faced with such discrepancies between model and data, there are essentially three ways to proceed:

- First, one may question the validity of the indicators and stick with the existing model. A prime candidate for questioning in this regard is the National Household Survey, which has been criticized on various grounds, but most importantly for under- or non-representation of key drug-using segments of the population, such as prison inmates.
- Second, one may question the model and accept the indicators (at least selectively) as valid reflections of actual trends. Thus, one might say the the NHS and HSSS reflect actual trends in social use, even if one discounts their findings regarding compulsive use. This would indicate that the model should be adjusted in some way.
- Third, one may question both the indicator data and the model, and attempt to make adjustments to both.

Although adjustments to the NHS may eventually be made as part of our study, our current approach has been to accept the trends in available indicators as valid, at least selectively (for example, we tend to discount the NHS data on weekly use), and center our efforts on those adjustments that might be made to the model to improve the fit with the indicators. In some cases, these adjustments may involve little more than changes in parameter values. For example, it may be that simply by increasing the assumed health risks of crack, the model's ability to reproduce both the ER/ME data and the crack fraction data may be improved significantly. But in other cases, the improved fit may be achieved only with the actual alteration of model structure. For example, we have been examining the utility of including marijuana use prevalence as a variable that modulates initiation to cocaine use (looking at it either as a "gateway drug" or as an indicator of general orientation toward illicit drug use), and which may be of particular help in explaining the recent rapid decline in social use of cocaine.

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Appendix 1: COCAPOP Documentor Listing

The following pages were produced by Professional DYNAMO's "Documentor" tool and are saved as the file COCAPOP.DOC. The Documentor assigns consecutive equation numbers to the source code and merges with the equations a separately created file of acronym definitions, COCAPOP.DEF. Each dynamic variable equation (types L, R, A) is assigned a whole number, while each static initial value, constant and table look-up function (types N, C, T) is assigned a number with one decimal place. The COCAPOP model contains 131 dynamic equations and 70 static equations. The Documentor also generates an alphabetized dictionary of acronyms – the "List of Variables" – which shows the equation type, number, and definition for each acronym in the model.

```
     COCAPOP, BY JB HOMER, MAY 1989

     POPULATION LEVELS

     NEVER USED POPULATION
NUPOP.K=NUPOP.J+DT*(POPE.JK-NUPOPD.JK-INP.JK-INK.JK)             L,1
NUPOP=169.4E6                                                    N,1.1
     NUPOP  - NEVER USED POPULATION (PEOPLE) <1>
     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     POPE   - POPULATION ENTRY (PEOPLE/YR) <18>
     NUPOPD - NEVER USED POPULATION DEATH (PEOPLE/YR) <58>
     INP    - INITIATION TO POWDER (PEOPLE/YR) <20>
     INK    - INITIATION TO CRACK (PEOPLE/YR) <22>

     SOCIAL USERS
ASUP.K=ASUP.J+DT*(INP.JK-SUPI.JK+XSUPR.JK-ASUPD.JK-ESCP.JK+      L,2
 TSUPR.JK+SUKSP.JK-SUPSK.JK)
ASUP=0.9E6                                                       N,2.1
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     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     INP    - INITIATION TO POWDER (PEOPLE/YR) <20>
     SUPI   - S.U. OF POWDER INACTIVATION (PEOPLE/YR) <28>
     XSUPR  - EX-S.U. OF POWDER RELAPSE (PEOPLE/YR) <42>
     ASUPD  - ACTIVE S.U. OF POWDER DEATH (PEOPLE/YR) <59>
     ESCP   - ESCALATION VIA POWDER (PEOPLE/YR) <24>
     TSUPR  - TRANSITIONAL S.U. OF POWDER RELAPSE (PEOPLE/YR)
               <38>
     SUKSP  - S.U. OF CRACK SWITCH TO POWDER (PEOPLE/YR) <27>
     SUPSK  - S.U. OF POWDER SWITCH TO CRACK (PEOPLE/YR) <26>

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 TSUKR.JK+SUPSK.JK-SUKSP.JK)
ASUK=0                                                           N,3.1
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     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     INK    - INITIATION TO CRACK (PEOPLE/YR) <22>
     SUKI   - S.U. OF CRACK INACTIVATION (PEOPLE/YR) <30>
     XSUKR  - EX-S.U. OF CRACK RELAPSE (PEOPLE/YR) <43>
     ASUKD  - ACTIVE S.U. OF CRACK DEATH (PEOPLE/YR) <60>
     ESCK   - ESCALATION VIA CRACK (PEOPLE/YR) <25>
     TSUKR  - TRANSITIONAL S.U. OF CRACK RELAPSE (PEOPLE/YR)
               <40>
     SUPSK  - S.U. OF POWDER SWITCH TO CRACK (PEOPLE/YR) <26>
     SUKSP  - S.U. OF CRACK SWITCH TO POWDER (PEOPLE/YR) <27>

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TSUP=2.3E6                                                       N,4.1
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     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     SUPI   - S.U. OF POWDER INACTIVATION (PEOPLE/YR) <28>
     SUPTQ  - S.U. OF POWDER TEMPORARY QUITS (PEOPLE/YR) <34>
     SUPSQ  - S.U. OF POWDER SUCCESSFUL QUITS (PEOPLE/YR) <32>
     TSUPD  - TRANSITIONAL S.U. OF POWDER DEATH (PEOPLE/YR)
               <61>
     TSUPR  - TRANSITIONAL S.U. OF POWDER RELAPSE (PEOPLE/YR)
               <38>
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TSUK=0                                                         N,5.1
     TSUK   - TRANSITIONAL SOCIAL USERS OF CRACK (PEOPLE) <5>
     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     SUKI   - S.U. OF CRACK INACTIVATION (PEOPLE/YR) <30>
     SUKTQ  - S.U. OF CRACK TEMPORARY QUITS (PEOPLE/YR) <37>
     SUKSQ  - S.U. OF CRACK SUCCESSFUL QUITS (PEOPLE/YR) <35>
     TSUKD  - TRANSITIONAL S.U. OF CRACK DEATH (PEOPLE/YR) <62>
     TSUKR  - TRANSITIONAL S.U. OF CRACK RELAPSE (PEOPLE/YR)
               <40>

SXSUP.K=SXSUP.J+DT*(SUPTQ.JK-XSUPR.JK-SXSUPD.JK)               L,6
SXSUP=0.7E6                                                    N,6.1
     SXSUP  - SUSCEPTIBLE EX-SOCIAL USERS OF POWDER (PEOPLE)
               <6>
     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     SUPTQ  - S.U. OF POWDER TEMPORARY QUITS (PEOPLE/YR) <34>
     XSUPR  - EX-S.U. OF POWDER RELAPSE (PEOPLE/YR) <42>
     SXSUPD - SUSCEPTIBLE EX-S.U. OF POWDER DEATH (PEOPLE/YR)
               <63>

SXSUK.K=SXSUK.J+DT*(SUKTQ.JK-XSUKR.JK-SXSUKD.JK)               L,7
SXSUK=0                                                        N,7.1
     SXSUK  - SUSCEPTIBLE EX-SOCIAL USERS OF CRACK (PEOPLE) <7>
     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     SUKTQ  - S.U. OF CRACK TEMPORARY QUITS (PEOPLE/YR) <37>
     XSUKR  - EX-S.U. OF CRACK RELAPSE (PEOPLE/YR) <43>
     SXSUKD - SUSCEPTIBLE EX-S.U. OF CRACK DEATH (PEOPLE/YR)
               <64>

IXSUP.K=IXSUP.J+DT*(SUPSQ.JK-IXSUPD.JK)                        L,8
IXSUP=2.4E6                                                    N,8.1
     IXSUP  - IMMUNE EX-SOCIAL USERS OF POWDER (PEOPLE) <8>
     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     SUPSQ  - S.U. OF POWDER SUCCESSFUL QUITS (PEOPLE/YR) <32>
     IXSUPD - IMMUNE EX-S.U. OF POWDER DEATH (PEOPLE/YR) <65>

IXSUK.K=IXSUK.J+DT*(SUKSQ.JK-IXSUKD.JK)                        L,9
IXSUK=0                                                        N,9.1
     IXSUK  - IMMUNE EX-SOCIAL USERS OF CRACK (PEOPLE) <9>
     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     SUKSQ  - S.U. OF CRACK SUCCESSFUL QUITS (PEOPLE/YR) <35>
     IXSUKD - IMMUNE EX-S.U. OF CRACK DEATH (PEOPLE/YR) <66>

     COMPULSIVE USERS
ACUP.K=ACUP.J+DT*(ESCP.JK-CUPI.JK+XCUPR.JK-ACUPD.JK+TCUPR.JK+  L,10
 CUKSP.JK-CUPSK.JK)
ACUP=0.2E6                                                     N,10.1
     ACUP   - ACTIVE COMPULSIVE USERS OF POWDER (PEOPLE) <10>
     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     ESCP   - ESCALATION VIA POWDER (PEOPLE/YR) <24>
     CUPI   - C.U. OF POWDER INACTIVATION (PEOPLE/YR) <46>
     XCUPR  - EX-C.U. OF POWDER RELAPSE (PEOPLE/YR) <56>
     ACUPD  - ACTIVE C.U. OF POWDER DEATH (PEOPLE/YR) <67>
     TCUPR  - TRANSITIONAL C.U. OF POWDER RELAPSE (PEOPLE/YR)
               <54>
     CUKSP  - C.U. OF CRACK SWITCH TO POWDER (PEOPLE/YR) <45>
     CUPSK  - C.U. OF POWDER SWITCH TO CRACK (PEOPLE/YR) <44>
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ACUK.K=ACUK.J+DT*(ESCK.JK-CUKI.JK+XCUKR.JK-ACUKD.JK+TCUKR.JK+  L,11
 CUPSK.JK-CUKSP.JK)
ACUK=0                                                          N,11.1
     ACUK   - ACTIVE COMPULSIVE USERS OF CRACK (PEOPLE) <11>
     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     ESCK   - ESCALATION VIA CRACK (PEOPLE/YR) <25>
     CUKI   - C.U. OF CRACK INACTIVATION (PEOPLE/YR) <47>
     XCUKR  - EX-C.U. OF CRACK RELAPSE (PEOPLE/YR) <57>
     ACUKD  - ACTIVE C.U. OF CRACK DEATH (PEOPLE/YR) <68>
     TCUKR  - TRANSITIONAL C.U. OF CRACK RELAPSE (PEOPLE/YR)
               <55>
     CUPSK  - C.U. OF POWDER SWITCH TO CRACK (PEOPLE/YR) <44>
     CUKSP  - C.U. OF CRACK SWITCH TO POWDER (PEOPLE/YR) <45>

TCUP.K=TCUP.J+DT*(CUPI.JK-CUPTQ.JK-CUPSQ.JK-TCUPD.JK-TCUPR.JK) L,12
TCUP=0.1E6                                                      N,12.1
     TCUP   - TRANSITIONAL COMPULSIVE USERS OF POWDER (PEOPLE)
               <12>
     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     CUPI   - C.U. OF POWDER INACTIVATION (PEOPLE/YR) <46>
     CUPTQ  - C.U. OF POWDER TEMPORARY QUITS (PEOPLE/YR) <50>
     CUPSQ  - C.U. OF POWDER SUCCESSFUL QUITS (PEOPLE/YR) <48>
     TCUPD  - TRANSITIONAL C.U. OF POWDER DEATH (PEOPLE/YR)
               <69>
     TCUPR  - TRANSITIONAL C.U. OF POWDER RELAPSE (PEOPLE/YR)
               <54>

TCUK.K=TCUK.J+DT*(CUKI.JK-CUKTQ.JK-CUKSQ.JK-TCUKD.JK-TCUKR.JK) L,13
TCUK=0                                                          N,13.1
     TCUK   - TRANSITIONAL COMPULSIVE USERS OF CRACK (PEOPLE)
               <13>
     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     CUKI   - C.U. OF CRACK INACTIVATION (PEOPLE/YR) <47>
     CUKTQ  - C.U. OF CRACK TEMPORARY QUITS (PEOPLE/YR) <53>
     CUKSQ  - C.U. OF CRACK SUCCESSFUL QUITS (PEOPLE/YR) <51>
     TCUKD  - TRANSITIONAL C.U. OF CRACK DEATH (PEOPLE/YR) <70>
     TCUKR  - TRANSITIONAL C.U. OF CRACK RELAPSE (PEOPLE/YR)
               <55>

SXCUP.K=SXCUP.J+DT*(CUPTQ.JK-SXCUPD.JK-XCUPR.JK)               L,14
SXCUP=.05E6                                                     N,14.1
     SXCUP  - SUSCEPTIBLE EX-COMPULSIVE USERS OF POWDER (PEOPLE
               ) <14>
     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     CUPTQ  - C.U. OF POWDER TEMPORARY QUITS (PEOPLE/YR) <50>
     SXCUPD - SUSCEPTIBLE EX-C.U. OF POWDER DEATH (PEOPLE/YR)
               <71>
     XCUPR  - EX-C.U. OF POWDER RELAPSE (PEOPLE/YR) <56>

SXCUK.K=SXCUK.J+DT*(CUKTQ.JK-SXCUKD.JK-XCUKR.JK)               L,15
SXCUK=0                                                         N,15.1
     SXCUK  - SUSCEPTIBLE EX-COMPULSIVE USERS OF CRACK (PEOPLE)
               <15>
     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     CUKTQ  - C.U. OF CRACK TEMPORARY QUITS (PEOPLE/YR) <53>
     SXCUKD - SUSCEPTIBLE EX-C.U. OF CRACK DEATH (PEOPLE/YR)
               <72>
     XCUKR  - EX-C.U. OF CRACK RELAPSE (PEOPLE/YR) <57>
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IXCUP.K=IXCUP.J+DT*(CUPSQ.JK-IXCUPD.JK)                       L,16
IXCUP=0.35E6                                                  N,16.1
     IXCUP  - IMMUNE EX-COMPULSIVE USERS OF POWDER (PEOPLE)
               <16>
     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     CUPSQ  - C.U. OF POWDER SUCCESSFUL QUITS (PEOPLE/YR) <48>
     IXCUPD - IMMUNE EX-C.U. OF POWDER DEATH (PEOPLE/YR) <73>

IXCUK.K=IXCUK.J+DT*(CUKSQ.JK-IXCUKD.JK)                       L,17
IXCUK=0                                                       N,17.1
     IXCUK  - IMMUNE EX-COMPULSIVE USERS OF CRACK (PEOPLE) <17>
     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     CUKSQ  - C.U. OF CRACK SUCCESSFUL QUITS (PEOPLE/YR) <51>
     IXCUKD - IMMUNE EX-C.U. OF CRACK DEATH (PEOPLE/YR) <74>

     POPULATION FLOWS

     POPULATION ENTRY
POPE.KL=POP.K*POPEF.K                                         R,18
     POPE   - POPULATION ENTRY (PEOPLE/YR) <18>
     POP    - POPULATION (PEOPLE) <75>
     POPEF  - POPULATION ENTRY FRACTION (1/YR) <19>

POPEF.K=TABHL(TPOPEF,TIME.K,1976,1988,1)                      A,19
TPOPEF=.026/.027/.025/.025/.023/.021/.022/.022/.022/.021/.02/ T,19.1
 .021/.02
     POPEF  - POPULATION ENTRY FRACTION (1/YR) <19>
     TABHL  - DYNAMO TABLE FUNCTION (WITH HORIZONTAL
               EXTRAPOLATION)
     TPOPEF - TABLE FOR POPULATION ENTRY FRACTION <19>
     TIME   - SIMULATION CURRENT TIME (YEAR) <132>

     INITIATION AND ESCALATION
INP.KL=NUPOP.K*INPF.K                                         R,20
     INP    - INITIATION TO POWDER (PEOPLE/YR) <20>
     NUPOP  - NEVER USED POPULATION (PEOPLE) <1>
     INPF   - INITIATION TO POWDER FRACTION (1/YR) <21>

INPF.K=INPFN*(RPS.K**ESINP)*(RAC.K**EAINP)                    A,21
INPFN=.014                                                    C,21.1
ESINP=2.8                                                     C,21.2
EAINP=1                                                       C,21.3
     INPF   - INITIATION TO POWDER FRACTION (1/YR) <21>
     INPFN  - INITIATION TO POWDER FRACTION NORMAL (1/YR) <21>
     RPS    - RELATIVE PERCEIVED SAFETY (INDEX) <110>
     ESINP  - EFFECT OF SAFETY ON INITIATION TO POWDER <21>
     RAC    - RELATIVE ACCESS TO COCAINE (INDEX) <112>
     EAINP  - EFFECT OF ACCESS ON INITIATION TO POWDER <21>

INK.KL=NUPOP.K*INKF.K                                         R,22
     INK    - INITIATION TO CRACK (PEOPLE/YR) <22>
     NUPOP  - NEVER USED POPULATION (PEOPLE) <1>
     INKF   - INITIATION TO CRACK FRACTION (1/YR) <23>
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INKF.K=INKFN*AK.K*(RPS.K**ESINK)*(RAC.K**EAINK)                     A,23
INKFN=.027                                                          C,23.1
ESINK=1.5                                                           C,23.2
EAINK=1                                                             C,23.3
     INKF    - INITIATION TO CRACK FRACTION (1/YR) <23>
     INKFN   - INITIATION TO CRACK FRACTION NORMAL (1/YR) <23>
     AK      - AVAILABILITY OF CRACK (0-1) <113>
     RPS     - RELATIVE PERCEIVED SAFETY (INDEX) <110>
     ESINK   - EFFECT OF SAFETY ON INITIATION TO CRACK <23>
     RAC     - RELATIVE ACCESS TO COCAINE (INDEX) <112>
     EAINK   - EFFECT OF ACCESS ON INITIATION TO CRACK <23>

ESCP.KL=ASUP.K*ESCPF                                                R,24
ESCPF=.025                                                          C,24.1
     ESCP    - ESCALATION VIA POWDER (PEOPLE/YR) <24>
     ASUP    - ACTIVE SOCIAL USERS OF POWDER (PEOPLE) <2>
     ESCPF   - ESCALATION VIA POWDER FRACTION (1/YR) <24>

ESCK.KL=ASUK.K*ESCKF                                                R,25
ESCKF=.15                                                           C,25.1
     ESCK    - ESCALATION VIA CRACK (PEOPLE/YR) <25>
     ASUK    - ACTIVE SOCIAL USERS OF CRACK (PEOPLE) <3>
     ESCKF   - ESCALATION VIA CRACK FRACTION (1/YR) <25>

     SOCIAL USERS PRODUCT-SWITCHING
SUPSK.KL=ASUP.K*SUPSKFN*MAX(AK.K,STEP(.01,1981))                    R,26
SUPSKFN=.3                                                          C,26.1
     SUPSK   - S.U. OF POWDER SWITCH TO CRACK (PEOPLE/YR) <26>
     ASUP    - ACTIVE SOCIAL USERS OF POWDER (PEOPLE) <2>
     SUPSKFN- S.U. OF POWDER SWITCH TO CRACK FRACTION NORMAL (1
               /YR) <26>
     MAX     - DYNAMO MAXIMUM FUNCTION
     AK      - AVAILABILITY OF CRACK (0-1) <113>
     STEP    - DYNAMO STEP-CHANGE FUNCTION

SUKSP.KL=ASUK.K*SUKSPF                                              R,27
SUKSPF=.1                                                           C,27.1
     SUKSP   - S.U. OF CRACK SWITCH TO POWDER (PEOPLE/YR) <27>
     ASUK    - ACTIVE SOCIAL USERS OF CRACK (PEOPLE) <3>
     SUKSPF  - S.U. OF CRACK SWITCH TO POWDER FRACTION (1/YR)
               <27>

     SOCIAL USERS INACTIVATION AND QUITTING
SUPI.KL=ASUP.K*SUPIF.K                                              R,28
     SUPI    - S.U. OF POWDER INACTIVATION (PEOPLE/YR) <28>
     ASUP    - ACTIVE SOCIAL USERS OF POWDER (PEOPLE) <2>
     SUPIF   - S.U. OF POWDER INACTIVATION FRACTION (1/YR) <29>
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SUPIF.K=SUPIFN*((1/RPS.K)**ESSUPI)*((1/RAC.K)**EASUPI)         A,29
SUPIFN=3.1                                                      C,29.1
ESSUPI=1.8                                                      C,29.2
EASUPI=2.5                                                      C,29.3
     SUPIF  - S.U. OF POWDER INACTIVATION FRACTION (1/YR) <29>
     SUPIFN - S.U. OF POWDER INACTIVATION FRACTION NORMAL (1/YR
               ) <29>
     RPS    - RELATIVE PERCEIVED SAFETY (INDEX) <110>
     ESSUPI - EFFECT OF SAFETY ON S.U. OF POWDER INACTIVATION
               <29>
     RAC    - RELATIVE ACCESS TO COCAINE (INDEX) <112>
     EASUPI - EFFECT OF ACCESS ON S.U. OF POWDER INACTIVATION
               <29>

SUKI.KL=ASUK.K*SUKIF.K                                          R,30
     SUKI   - S.U. OF CRACK INACTIVATION (PEOPLE/YR) <30>
     ASUK   - ACTIVE SOCIAL USERS OF CRACK (PEOPLE) <3>
     SUKIF  - S.U. OF CRACK INACTIVATION FRACTION (1/YR) <31>

SUKIF.K=SUKIFN*((1/RPS.K)**ESSUKI)*((1/RAC.K)**EASUKI)         A,31
SUKIFN=1                                                        C,31.1
ESSUKI=1                                                        C,31.2
EASUKI=2.5                                                      C,31.3
     SUKIF  - S.U. OF CRACK INACTIVATION FRACTION (1/YR) <31>
     SUKIFN - S.U. OF CRACK INACTIVATION FRACTION NORMAL (1/YR)
               <31>
     RPS    - RELATIVE PERCEIVED SAFETY (INDEX) <110>
     ESSUKI - EFFECT OF SAFETY ON S.U. OF CRACK INACTIVATION
               <31>
     RAC    - RELATIVE ACCESS TO COCAINE (INDEX) <112>
     EASUKI - EFFECT OF ACCESS ON S.U. OF CRACK INACTIVATION
               <31>

SUPSQ.KL=SUPQ.K*SUPSQF                                          R,32
SUPSQF=.25                                                      C,32.1
     SUPSQ  - S.U. OF POWDER SUCCESSFUL QUITS (PEOPLE/YR) <32>
     SUPQ   - S.U. OF POWDER QUITS (PEOPLE/YR) <33>
     SUPSQF - S.U. OF POWDER SUCCESSFUL QUIT FRACTION (0-1)
               <32>

SUPQ.K=TSUP.K*(1-TSUPRF.K)                                      A,33
     SUPQ   - S.U. OF POWDER QUITS (PEOPLE/YR) <33>
     TSUP   - TRANSITIONAL SOCIAL USERS OF POWDER (PEOPLE) <4>
     TSUPRF - TRANSITIONAL S.U. OF POWDER RELAPSE FRACTION (1/
               YR) <39>

SUPTQ.KL=SUPQ.K-SUPSQ.KL                                        R,34
     SUPTQ  - S.U. OF POWDER TEMPORARY QUITS (PEOPLE/YR) <34>
     SUPQ   - S.U. OF POWDER QUITS (PEOPLE/YR) <33>
     SUPSQ  - S.U. OF POWDER SUCCESSFUL QUITS (PEOPLE/YR) <32>

SUKSQ.KL=SUKQ.K*SUKSQF                                          R,35
SUKSQF=.25                                                      C,35.1
     SUKSQ  - S.U. OF CRACK SUCCESSFUL QUITS (PEOPLE/YR) <35>
     SUKQ   - S.U. OF CRACK QUITS (PEOPLE/YR) <36>
     SUKSQF - S.U. OF CRACK SUCCESSFUL QUIT FRACTION (0-1) <35>
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SUKQ.K=TSUK.K*(1-TSUKRF.K)                                        A,36
     SUKQ    - S.U. OF CRACK QUITS (PEOPLE/YR) <36>
     TSUK    - TRANSITIONAL SOCIAL USERS OF CRACK (PEOPLE) <5>
     TSUKRF  - TRANSITIONAL S.U. OF CRACK RELAPSE FRACTION (1/YR
               ) <41>

SUKTQ.KL=SUKQ.K-SUKSQ.KL                                          R,37
     SUKTQ   - S.U. OF CRACK TEMPORARY QUITS (PEOPLE/YR) <37>
     SUKQ    - S.U. OF CRACK QUITS (PEOPLE/YR) <36>
     SUKSQ   - S.U. OF CRACK SUCCESSFUL QUITS (PEOPLE/YR) <35>

     SOCIAL USERS RELAPSE
TSUPR.KL=TSUP.K*TSUPRF.K                                          R,38
     TSUPR   - TRANSITIONAL S.U. OF POWDER RELAPSE (PEOPLE/YR)
               <38>
     TSUP    - TRANSITIONAL SOCIAL USERS OF POWDER (PEOPLE) <4>
     TSUPRF  - TRANSITIONAL S.U. OF POWDER RELAPSE FRACTION (1/
               YR) <39>

TSUPRF.K=TSUPRFN*(RPS.K**ESTSUPR)*(RAC.K**EATSUPR)                A,39
TSUPRFN=.4                                                        C,39.1
ESTSUPR=2.5                                                       C,39.2
EATSUPR=1.5                                                       C,39.3
     TSUPRF  - TRANSITIONAL S.U. OF POWDER RELAPSE FRACTION (1/
               YR) <39>
     TSUPRFN- TRANSITIONAL S.U. OF POWDER RELAPSE FRACTION
               NORMAL (1/YR) <39>
     RPS     - RELATIVE PERCEIVED SAFETY (INDEX) <110>
     ESTSUPR- EFFECT OF SAFETY ON TRANSITIONAL S.U. OF POWDER
               RELAPSE <39>
     RAC     - RELATIVE ACCESS TO COCAINE (INDEX) <112>
     EATSUPR- EFFECT OF ACCESS ON TRANSITIONAL S.U. OF POWDER
               RELAPSE <39>

TSUKR.KL=TSUK.K*TSUKRF.K                                          R,40
     TSUKR   - TRANSITIONAL S.U. OF CRACK RELAPSE (PEOPLE/YR)
               <40>
     TSUK    - TRANSITIONAL SOCIAL USERS OF CRACK (PEOPLE) <5>
     TSUKRF  - TRANSITIONAL S.U. OF CRACK RELAPSE FRACTION (1/YR
               ) <41>

TSUKRF.K=TSUKRFN*(RPS.K**ESTSUKR)*(RAC.K**EATSUKR)                A,41
TSUKRFN=.4                                                        C,41.1
ESTSUKR=1.5                                                       C,41.2
EATSUKR=1.5                                                       C,41.3
     TSUKRF  - TRANSITIONAL S.U. OF CRACK RELAPSE FRACTION (1/YR
               ) <41>
     TSUKRFN- TRANSITIONAL S.U. OF CRACK RELAPSE FRACTION
               NORMAL (1/YR) <41>
     RPS     - RELATIVE PERCEIVED SAFETY (INDEX) <110>
     ESTSUKR- EFFECT OF SAFETY ON TRANSITIONAL S.U. OF CRACK
               RELAPSE <41>
     RAC     - RELATIVE ACCESS TO COCAINE (INDEX) <112>
     EATSUKR- EFFECT OF ACCESS ON TRANSITIONAL S.U. OF CRACK
               RELAPSE <41>
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XSUPR.KL=SXSUP.K*XSUPRF                                         R,42
XSUPRF=0.7                                                      C,42.1
     XSUPR  - EX-S.U. OF POWDER RELAPSE (PEOPLE/YR) <42>
     SXSUP  - SUSCEPTIBLE EX-SOCIAL USERS OF POWDER (PEOPLE)
               <6>
     XSUPRF - EX-S.U. OF POWDER RELAPSE FRACTION (1/YR) <42>

XSUKR.KL=SXSUK.K*XSUKRF                                         R,43
XSUKRF=0.7                                                      C,43.1
     XSUKR  - EX-S.U. OF CRACK RELAPSE (PEOPLE/YR) <43>
     SXSUK  - SUSCEPTIBLE EX-SOCIAL USERS OF CRACK (PEOPLE) <7>
     XSUKRF - EX-S.U. OF CRACK RELAPSE FRACTION (1/YR) <43>

     COMPULSIVE USERS PRODUCT-SWITCHING
CUPSK.KL=ACUP.K*CUPSKFN*AK.K                                    R,44
CUPSKFN=.10                                                     C,44.1
     CUPSK  - C.U. OF POWDER SWITCH TO CRACK (PEOPLE/YR) <44>
     ACUP   - ACTIVE COMPULSIVE USERS OF POWDER (PEOPLE) <10>
     CUPSKFN- C.U. OF POWDER SWITCH TO CRACK FRACTION NORMAL (1
               /YR) <44>
     AK     - AVAILABILITY OF CRACK (0-1) <113>

CUKSP.KL=ACUK.K*CUKSPF                                          R,45
CUKSPF=.05                                                      C,45.1
     CUKSP  - C.U. OF CRACK SWITCH TO POWDER (PEOPLE/YR) <45>
     ACUK   - ACTIVE COMPULSIVE USERS OF CRACK (PEOPLE) <11>
     CUKSPF - C.U. OF CRACK SWITCH TO POWDER FRACTION (1/YR)
               <45>

     COMPULSIVE USERS INACTIVATION AND QUITTING
CUPI.KL=ACUP.K*CUPIF                                            R,46
CUPIF=.5                                                        C,46.1
     CUPI   - C.U. OF POWDER INACTIVATION (PEOPLE/YR) <46>
     ACUP   - ACTIVE COMPULSIVE USERS OF POWDER (PEOPLE) <10>
     CUPIF  - C.U. OF POWDER INACTIVATION FRACTION (1/YR) <46>

CUKI.KL=ACUK.K*CUKIF                                            R,47
CUKIF=.5                                                        C,47.1
     CUKI   - C.U. OF CRACK INACTIVATION (PEOPLE/YR) <47>
     ACUK   - ACTIVE COMPULSIVE USERS OF CRACK (PEOPLE) <11>
     CUKIF  - C.U. OF CRACK INACTIVATION FRACTION (1/YR) <47>

CUPSQ.KL=CUPQ.K*CUPSQF                                          R,48
CUPSQF=.4                                                       C,48.1
     CUPSQ  - C.U. OF POWDER SUCCESSFUL QUITS (PEOPLE/YR) <48>
     CUPQ   - C.U. OF POWDER QUITS (PEOPLE/YR) <49>
     CUPSQF - C.U. OF POWDER SUCCESSFUL QUIT FRACTION (0-1)
               <48>

CUPQ.K=TCUP.K*(1-TCUPRF)                                        A,49
     CUPQ   - C.U. OF POWDER QUITS (PEOPLE/YR) <49>
     TCUP   - TRANSITIONAL COMPULSIVE USERS OF POWDER (PEOPLE)
               <12>
     TCUPRF - TRANSITIONAL C.U. OF POWDER RELAPSE FRACTION (1/
               YR) <54>
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CUPTQ.KL=CUPQ.K-CUPSQ.KL                                      R,50
     CUPTQ  - C.U. OF POWDER TEMPORARY QUITS (PEOPLE/YR) <50>
     CUPQ   - C.U. OF POWDER QUITS (PEOPLE/YR) <49>
     CUPSQ  - C.U. OF POWDER SUCCESSFUL QUITS (PEOPLE/YR) <48>

CUKSQ.KL=CUKQ.K*CUKSQF                                        R,51
CUKSQF=.4                                                     C,51.1
     CUKSQ  - C.U. OF CRACK SUCCESSFUL QUITS (PEOPLE/YR) <51>
     CUKQ   - C.U. OF CRACK QUITS (PEOPLE/YR) <52>
     CUKSQF - C.U. OF CRACK SUCCESSFUL QUIT FRACTION (0-1) <51>

CUKQ.K=TCUK.K*(1-TCUKRF)                                      A,52
     CUKQ   - C.U. OF CRACK QUITS (PEOPLE/YR) <52>
     TCUK   - TRANSITIONAL COMPULSIVE USERS OF CRACK (PEOPLE)
               <13>
     TCUKRF - TRANSITIONAL C.U. OF CRACK RELAPSE FRACTION (1/YR
               ) <55>

CUKTQ.KL=CUKQ.K-CUKSQ.KL                                      R,53
     CUKTQ  - C.U. OF CRACK TEMPORARY QUITS (PEOPLE/YR) <53>
     CUKQ   - C.U. OF CRACK QUITS (PEOPLE/YR) <52>
     CUKSQ  - C.U. OF CRACK SUCCESSFUL QUITS (PEOPLE/YR) <51>

     COMPULSIVE USERS RELAPSE
TCUPR.KL=TCUP.K*TCUPRF                                        R,54
TCUPRF=.5                                                     C,54.1
     TCUPR  - TRANSITIONAL C.U. OF POWDER RELAPSE (PEOPLE/YR)
               <54>
     TCUP   - TRANSITIONAL COMPULSIVE USERS OF POWDER (PEOPLE)
               <12>
     TCUPRF - TRANSITIONAL C.U. OF POWDER RELAPSE FRACTION (1/
               YR) <54>

TCUKR.KL=TCUK.K*TCUKRF                                        R,55
TCUKRF=.5                                                     C,55.1
     TCUKR  - TRANSITIONAL C.U. OF CRACK RELAPSE (PEOPLE/YR)
               <55>
     TCUK   - TRANSITIONAL COMPULSIVE USERS OF CRACK (PEOPLE)
               <13>
     TCUKRF - TRANSITIONAL C.U. OF CRACK RELAPSE FRACTION (1/YR
               ) <55>

XCUPR.KL=SXCUP.K*XCUPRF                                       R,56
XCUPRF=.7                                                     C,56.1
     XCUPR  - EX-C.U. OF POWDER RELAPSE (PEOPLE/YR) <56>
     SXCUP  - SUSCEPTIBLE EX-COMPULSIVE USERS OF POWDER (PEOPLE
               ) <14>
     XCUPRF - EX-C.U. OF POWDER RELAPSE FRACTION (1/YR) <56>

XCUKR.KL=SXCUK.K*XCUKRF                                       R,57
XCUKRF=.7                                                     C,57.1
     XCUKR  - EX-C.U. OF CRACK RELAPSE (PEOPLE/YR) <57>
     SXCUK  - SUSCEPTIBLE EX-COMPULSIVE USERS OF CRACK (PEOPLE)
               <15>
     XCUKRF - EX-C.U. OF CRACK RELAPSE FRACTION (1/YR) <57>
```

```
     DEATH FROM ALL CAUSES
NUPOPD.KL=NUPOP.K*.012                                       R,58
     NUPOPD - NEVER USED POPULATION DEATH (PEOPLE/YR) <58>
     NUPOP  - NEVER USED POPULATION (PEOPLE) <1>

ASUPD.KL=ASUP.K*.002                                         R,59
     ASUPD  - ACTIVE S.U. OF POWDER DEATH (PEOPLE/YR) <59>
     ASUP   - ACTIVE SOCIAL USERS OF POWDER (PEOPLE) <2>

ASUKD.KL=ASUK.K*.002                                         R,60
     ASUKD  - ACTIVE S.U. OF CRACK DEATH (PEOPLE/YR) <60>
     ASUK   - ACTIVE SOCIAL USERS OF CRACK (PEOPLE) <3>

TSUPD.KL=TSUP.K*.002                                         R,61
     TSUPD  - TRANSITIONAL S.U. OF POWDER DEATH (PEOPLE/YR)
               <61>
     TSUP   - TRANSITIONAL SOCIAL USERS OF POWDER (PEOPLE) <4>

TSUKD.KL=TSUK.K*.002                                         R,62
     TSUKD  - TRANSITIONAL S.U. OF CRACK DEATH (PEOPLE/YR) <62>
     TSUK   - TRANSITIONAL SOCIAL USERS OF CRACK (PEOPLE) <5>

SXSUPD.KL=SXSUP.K*.0025                                      R,63
     SXSUPD - SUSCEPTIBLE EX-S.U. OF POWDER DEATH (PEOPLE/YR)
               <63>
     SXSUP  - SUSCEPTIBLE EX-SOCIAL USERS OF POWDER (PEOPLE)
               <6>

SXSUKD.KL=SXSUK.K*.0025                                      R,64
     SXSUKD - SUSCEPTIBLE EX-S.U. OF CRACK DEATH (PEOPLE/YR)
               <64>
     SXSUK  - SUSCEPTIBLE EX-SOCIAL USERS OF CRACK (PEOPLE) <7>

IXSUPD.KL=IXSUP.K*.003                                       R,65
     IXSUPD - IMMUNE EX-S.U. OF POWDER DEATH (PEOPLE/YR) <65>
     IXSUP  - IMMUNE EX-SOCIAL USERS OF POWDER (PEOPLE) <8>

IXSUKD.KL=IXSUK.K*.003                                       R,66
     IXSUKD - IMMUNE EX-S.U. OF CRACK DEATH (PEOPLE/YR) <66>
     IXSUK  - IMMUNE EX-SOCIAL USERS OF CRACK (PEOPLE) <9>

ACUPD.KL=ACUP.K*.002                                         R,67
     ACUPD  - ACTIVE C.U. OF POWDER DEATH (PEOPLE/YR) <67>
     ACUP   - ACTIVE COMPULSIVE USERS OF POWDER (PEOPLE) <10>

ACUKD.KL=ACUK.K*.002                                         R,68
     ACUKD  - ACTIVE C.U. OF CRACK DEATH (PEOPLE/YR) <68>
     ACUK   - ACTIVE COMPULSIVE USERS OF CRACK (PEOPLE) <11>

TCUPD.KL=TCUP.K*.002                                         R,69
     TCUPD  - TRANSITIONAL C.U. OF POWDER DEATH (PEOPLE/YR)
               <69>
     TCUP   - TRANSITIONAL COMPULSIVE USERS OF POWDER (PEOPLE)
               <12>
```

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TCUKD.KL=TCUK.K*.002                                            R,70
     TCUKD  - TRANSITIONAL C.U. OF CRACK DEATH (PEOPLE/YR) <70>
     TCUK   - TRANSITIONAL COMPULSIVE USERS OF CRACK (PEOPLE)
               <13>

SXCUPD.KL=SXCUP.K*.0025                                         R,71
     SXCUPD - SUSCEPTIBLE EX-C.U. OF POWDER DEATH (PEOPLE/YR)
               <71>
     SXCUP  - SUSCEPTIBLE EX-COMPULSIVE USERS OF POWDER (PEOPLE
               ) <14>

SXCUKD.KL=SXCUK.K*.0025                                         R,72
     SXCUKD - SUSCEPTIBLE EX-C.U. OF CRACK DEATH (PEOPLE/YR)
               <72>
     SXCUK  - SUSCEPTIBLE EX-COMPULSIVE USERS OF CRACK (PEOPLE)
               <15>

IXCUPD.KL=IXCUP.K*.003                                          R,73
     IXCUPD - IMMUNE EX-C.U. OF POWDER DEATH (PEOPLE/YR) <73>
     IXCUP  - IMMUNE EX-COMPULSIVE USERS OF POWDER (PEOPLE)
               <16>

IXCUKD.KL=IXCUK.K*.003                                          R,74
     IXCUKD - IMMUNE EX-C.U. OF CRACK DEATH (PEOPLE/YR) <74>
     IXCUK  - IMMUNE EX-COMPULSIVE USERS OF CRACK (PEOPLE) <17>

     POPULATION AUXILIARIES

     POPULATION LEVEL AGGREGATES
POP.K=NUPOP.K+EUPOP.K                                           A,75
     POP    - POPULATION (PEOPLE) <75>
     NUPOP  - NEVER USED POPULATION (PEOPLE) <1>
     EUPOP  - EVER USED POPULATION (PEOPLE) <76>

EUPOP.K=PYU.K+XU.K                                              A,76
     EUPOP  - EVER USED POPULATION (PEOPLE) <76>
     PYU    - PAST YEAR USERS (PEOPLE) <77>
     XU     - EX-USERS (PEOPLE) <92>

PYU.K=AU.K+TU.K                                                 A,77
     PYU    - PAST YEAR USERS (PEOPLE) <77>
     AU     - ACTIVE USERS (PEOPLE) <82>
     TU     - TRANSITIONAL USERS (PEOPLE) <87>

PYSU.K=ASU.K+TSU.K                                              A,78
     PYSU   - PAST YEAR SOCIAL USERS (PEOPLE) <78>
     ASU    - ACTIVE SOCIAL USERS (PEOPLE) <83>
     TSU    - TRANSITIONAL SOCIAL USERS (PEOPLE) <88>

PYCU.K=ACU.K+TCU.K                                              A,79
     PYCU   - PAST YEAR COMPULSIVE USERS (PEOPLE) <79>
     ACU    - ACTIVE COMPULSIVE USERS (PEOPLE) <84>
     TCU    - TRANSITIONAL COMPULSIVE USERS (PEOPLE) <89>

PYUP.K=AUP.K+TUP.K                                              A,80
     PYUP   - PAST YEAR USERS OF POWDER (PEOPLE) <80>
     AUP    - ACTIVE USERS OF POWDER (PEOPLE) <85>
     TUP    - TRANSITIONAL USERS OF POWDER (PEOPLE) <90>
```

```
PYUK.K=AUK.K+TUK.K                                                  A,81
     PYUK    - PAST YEAR USERS OF CRACK (PEOPLE) <81>
     AUK     - ACTIVE USERS OF CRACK (PEOPLE) <86>
     TUK     - TRANSITIONAL USERS OF CRACK (PEOPLE) <91>

AU.K=ASU.K+ACU.K                                                    A,82
     AU      - ACTIVE USERS (PEOPLE) <82>
     ASU     - ACTIVE SOCIAL USERS (PEOPLE) <83>
     ACU     - ACTIVE COMPULSIVE USERS (PEOPLE) <84>

ASU.K=ASUP.K+ASUK.K                                                 A,83
     ASU     - ACTIVE SOCIAL USERS (PEOPLE) <83>
     ASUP    - ACTIVE SOCIAL USERS OF POWDER (PEOPLE) <2>
     ASUK    - ACTIVE SOCIAL USERS OF CRACK (PEOPLE) <3>

ACU.K=ACUP.K+ACUK.K                                                 A,84
     ACU     - ACTIVE COMPULSIVE USERS (PEOPLE) <84>
     ACUP    - ACTIVE COMPULSIVE USERS OF POWDER (PEOPLE) <10>
     ACUK    - ACTIVE COMPULSIVE USERS OF CRACK (PEOPLE) <11>

AUP.K=ASUP.K+ACUP.K                                                 A,85
     AUP     - ACTIVE USERS OF POWDER (PEOPLE) <85>
     ASUP    - ACTIVE SOCIAL USERS OF POWDER (PEOPLE) <2>
     ACUP    - ACTIVE COMPULSIVE USERS OF POWDER (PEOPLE) <10>

AUK.K=ASUK.K+ACUK.K                                                 A,86
     AUK     - ACTIVE USERS OF CRACK (PEOPLE) <86>
     ASUK    - ACTIVE SOCIAL USERS OF CRACK (PEOPLE) <3>
     ACUK    - ACTIVE COMPULSIVE USERS OF CRACK (PEOPLE) <11>

TU.K=TSU.K+TCU.K                                                    A,87
     TU      - TRANSITIONAL USERS (PEOPLE) <87>
     TSU     - TRANSITIONAL SOCIAL USERS (PEOPLE) <88>
     TCU     - TRANSITIONAL COMPULSIVE USERS (PEOPLE) <89>

TSU.K=TSUP.K+TSUK.K                                                 A,88
     TSU     - TRANSITIONAL SOCIAL USERS (PEOPLE) <88>
     TSUP    - TRANSITIONAL SOCIAL USERS OF POWDER (PEOPLE) <4>
     TSUK    - TRANSITIONAL SOCIAL USERS OF CRACK (PEOPLE) <5>

TCU.K=TCUP.K+TCUK.K                                                 A,89
     TCU     - TRANSITIONAL COMPULSIVE USERS (PEOPLE) <89>
     TCUP    - TRANSITIONAL COMPULSIVE USERS OF POWDER (PEOPLE)
                <12>
     TCUK    - TRANSITIONAL COMPULSIVE USERS OF CRACK (PEOPLE)
                <13>

TUP.K=TSUP.K+TCUP.K                                                 A,90
     TUP     - TRANSITIONAL USERS OF POWDER (PEOPLE) <90>
     TSUP    - TRANSITIONAL SOCIAL USERS OF POWDER (PEOPLE) <4>
     TCUP    - TRANSITIONAL COMPULSIVE USERS OF POWDER (PEOPLE)
                <12>

TUK.K=TSUK.K+TCUK.K                                                 A,91
     TUK     - TRANSITIONAL USERS OF CRACK (PEOPLE) <91>
     TSUK    - TRANSITIONAL SOCIAL USERS OF CRACK (PEOPLE) <5>
     TCUK    - TRANSITIONAL COMPULSIVE USERS OF CRACK (PEOPLE)
                <13>
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XU.K=XSU.K+XCU.K                                           A,92
     XU      - EX-USERS (PEOPLE) <92>
     XSU     - EX-SOCIAL USERS (PEOPLE) <93>
     XCU     - EX-COMPULSIVE USERS (PEOPLE) <94>

XSU.K=SXSUP.K+IXSUP.K+SXSUK.K+IXSUK.K                      A,93
     XSU     - EX-SOCIAL USERS (PEOPLE) <93>
     SXSUP   - SUSCEPTIBLE EX-SOCIAL USERS OF POWDER (PEOPLE)
               <6>
     IXSUP   - IMMUNE EX-SOCIAL USERS OF POWDER (PEOPLE) <8>
     SXSUK   - SUSCEPTIBLE EX-SOCIAL USERS OF CRACK (PEOPLE) <7>
     IXSUK   - IMMUNE EX-SOCIAL USERS OF CRACK (PEOPLE) <9>

XCU.K=SXCUP.K+IXCUP.K+SXCUK.K+IXCUK.K                      A,94
     XCU     - EX-COMPULSIVE USERS (PEOPLE) <94>
     SXCUP   - SUSCEPTIBLE EX-COMPULSIVE USERS OF POWDER (PEOPLE
               ) <14>
     IXCUP   - IMMUNE EX-COMPULSIVE USERS OF POWDER (PEOPLE)
               <16>
     SXCUK   - SUSCEPTIBLE EX-COMPULSIVE USERS OF CRACK (PEOPLE)
               <15>
     IXCUK   - IMMUNE EX-COMPULSIVE USERS OF CRACK (PEOPLE) <17>

XUP.K=SXSUP.K+IXSUP.K+SXCUP.K+IXCUP.K                      A,95
     XUP     - EX-USERS OF POWDER (PEOPLE) <95>
     SXSUP   - SUSCEPTIBLE EX-SOCIAL USERS OF POWDER (PEOPLE)
               <6>
     IXSUP   - IMMUNE EX-SOCIAL USERS OF POWDER (PEOPLE) <8>
     SXCUP   - SUSCEPTIBLE EX-COMPULSIVE USERS OF POWDER (PEOPLE
               ) <14>
     IXCUP   - IMMUNE EX-COMPULSIVE USERS OF POWDER (PEOPLE)
               <16>

XUK.K=SXSUK.K+IXSUK.K+SXCUK.K+IXCUK.K                      A,96
     XUK     - EX-USERS OF CRACK (PEOPLE) <96>
     SXSUK   - SUSCEPTIBLE EX-SOCIAL USERS OF CRACK (PEOPLE) <7>
     IXSUK   - IMMUNE EX-SOCIAL USERS OF CRACK (PEOPLE) <9>
     SXCUK   - SUSCEPTIBLE EX-COMPULSIVE USERS OF CRACK (PEOPLE)
               <15>
     IXCUK   - IMMUNE EX-COMPULSIVE USERS OF CRACK (PEOPLE) <17>

     POPULATION LEVEL FRACTIONS
AUFPOP.K=AU.K/POP.K                                        A,97
     AUFPOP  - ACTIVE USER FRACTION OF POPULATION (0-1) <97>
     AU      - ACTIVE USERS (PEOPLE) <82>
     POP     - POPULATION (PEOPLE) <75>

CFAU.K=ACU.K/AU.K                                          A,98
     CFAU    - COMPULSIVE FRACTION OF ACTIVE USERS (0-1) <98>
     ACU     - ACTIVE COMPULSIVE USERS (PEOPLE) <84>
     AU      - ACTIVE USERS (PEOPLE) <82>

CFPYU.K=PYCU.K/PYU.K                                       A,99
     CFPYU   - COMPULSIVE FRACTION OF PAST YEAR USERS (0-1) <99>
     PYCU    - PAST YEAR COMPULSIVE USERS (PEOPLE) <79>
     PYU     - PAST YEAR USERS (PEOPLE) <77>
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KFPYU.K=PYUK.K/PYU.K                                              A,100
     KFPYU   - CRACK-USER FRACTION OF PAST YEAR USERS (0-1)
                <100>
     PYUK    - PAST YEAR USERS OF CRACK (PEOPLE) <81>
     PYU     - PAST YEAR USERS (PEOPLE) <77>

KFAU.K=AUK.K/AU.K                                                 A,101
     KFAU    - CRACK-USER FRACTION OF ACTIVE USERS (0-1) <101>
     AUK     - ACTIVE USERS OF CRACK (PEOPLE) <86>
     AU      - ACTIVE USERS (PEOPLE) <82>

     POPULATION FLOW AGGREGATES
IN.K=INP.KL+INK.KL                                                A,102
     IN      - INITIATION (PEOPLE/YR) <102>
     INP     - INITIATION TO POWDER (PEOPLE/YR) <20>
     INK     - INITIATION TO CRACK (PEOPLE/YR) <22>

KFIN.K=INK.KL/IN.K                                                A,103
     KFIN    - CRACK-USER FRACTION OF INITIATION (0-1) <103>
     INK     - INITIATION TO CRACK (PEOPLE/YR) <22>
     IN      - INITIATION (PEOPLE/YR) <102>

ESC.K=ESCP.KL+ESCK.KL                                             A,104
     ESC     - ESCALATION (PEOPLE/YR) <104>
     ESCP    - ESCALATION VIA POWDER (PEOPLE/YR) <24>
     ESCK    - ESCALATION VIA CRACK (PEOPLE/YR) <25>

KFESC.K=ESCK.KL/ESC.K                                             A,105
     KFESC   - CRACK-USER FRACTION OF ESCALATION (0-1) <105>
     ESCK    - ESCALATION VIA CRACK (PEOPLE/YR) <25>
     ESC     - ESCALATION (PEOPLE/YR) <104>

SQ.K=SQP.K+SQK.K                                                  A,106
     SQ      - SUCCESSFUL QUITS (PEOPLE/YR) <106>
     SQP     - SUCCESSFUL QUITS FROM POWDER (PEOPLE/YR) <107>
     SQK     - SUCCESSFUL QUITS FROM CRACK (PEOPLE/YR) <108>

SQP.K=SUPSQ.KL+CUPSQ.KL                                           A,107
     SQP     - SUCCESSFUL QUITS FROM POWDER (PEOPLE/YR) <107>
     SUPSQ   - S.U. OF POWDER SUCCESSFUL QUITS (PEOPLE/YR) <32>
     CUPSQ   - C.U. OF POWDER SUCCESSFUL QUITS (PEOPLE/YR) <48>

SQK.K=SUKSQ.KL+CUKSQ.KL                                           A,108
     SQK     - SUCCESSFUL QUITS FROM CRACK (PEOPLE/YR) <108>
     SUKSQ   - S.U. OF CRACK SUCCESSFUL QUITS (PEOPLE/YR) <35>
     CUKSQ   - C.U. OF CRACK SUCCESSFUL QUITS (PEOPLE/YR) <51>

KFSQ.K=SQK.K/SQ.K                                                 A,109
     KFSQ    - CRACK-USER FRACTION OF SUCCESSFUL QUITS (0-1)
                <109>
     SQK     - SUCCESSFUL QUITS FROM CRACK (PEOPLE/YR) <108>
     SQ      - SUCCESSFUL QUITS (PEOPLE/YR) <106>
```

PERCEIVED SAFETY AND ACCESS TO COCAINE, AND AVAILABILITY OF CRACK

```
RPS.K=MAX(TABXT(TRPS,CDEM.K,0,80000,5000),MINRPS)                A,110
TRPS=1/.97/.86/.78/.72/.66/.62/.59/.57/.55/.53/.51/.49/.47/      T,110.1
 .46/.45/.445
MINRPS=.25                                                       C,110.2
     RPS    - RELATIVE PERCEIVED SAFETY (INDEX) <110>
     MAX    - DYNAMO MAXIMUM FUNCTION
     TABXT  - DYNAMO TABLE FUNCTION (WITH LINEAR EXTRAPOLATION)
     TRPS   - TABLE FOR RELATIVE PERCEIVED SAFETY <110>
     CDEM   - CUMULATIVE DAWN EMERGENCIES (PEOPLE) <111>
     MINRPS - MINIMUM RELATIVE PERCEIVED SAFETY (INDEX) <110>

CDEM.K=CDEM.J+DT*DEM.J                                           L,111
CDEM=0                                                           N,111.1
     CDEM   - CUMULATIVE DAWN EMERGENCIES (PEOPLE) <111>
     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     DEM    - DAWN EMERGENCIES (E.R. VISITS/YR) <114>

RAC.K=TABHL(TRAC,AUFPOP.K,.003,.042,.003)                        A,112
TRAC=.8/1/1.09/1.17/1.24/1.30/1.36/1.41/1.45/1.48/1.5/1.52/      T,112.1
 1.53/1.54
     RAC    - RELATIVE ACCESS TO COCAINE (INDEX) <112>
     TABHL  - DYNAMO TABLE FUNCTION (WITH HORIZONTAL
               EXTRAPOLATION)
     TRAC   - TABLE FOR RELATIVE ACCESS TO COCAINE <112>
     AUFPOP - ACTIVE USER FRACTION OF POPULATION (0-1) <97>

AK.K=TABHL(TAK,KFAU.K,0,1,.1)                                    A,113
TAK=0/.2/.35/.48/.6/.7/.8/.88/.95/.99/1                          T,113.1
     AK     - AVAILABILITY OF CRACK (0-1) <113>
     TABHL  - DYNAMO TABLE FUNCTION (WITH HORIZONTAL
               EXTRAPOLATION)
     TAK    - TABLE FOR AVAILABILITY OF CRACK <113>
     KFAU   - CRACK-USER FRACTION OF ACTIVE USERS (0-1) <101>
```

DAWN EMERGENCIES AND DAWN DEATHS

```
DEM.K=DEMSU.K+DEMCU.K                                            A,114
     DEM    - DAWN EMERGENCIES (E.R. VISITS/YR) <114>
     DEMSU  - DAWN EMERGENCIES AMONG S.U. (E.R. VISITS/YR)
               <115>
     DEMCU  - DAWN EMERGENCIES AMONG C.U. (E.R. VISITS/YR)
               <116>

DEMSU.K=EMFSUP*ASUP.K+EMFSUK*ASUK.K                              A,115
EMFSUP=.0001                                                     C,115.1
EMFSUK=.0006                                                     C,115.2
     DEMSU  - DAWN EMERGENCIES AMONG S.U. (E.R. VISITS/YR)
               <115>
     EMFSUP - EMERGENCY FRACTION FOR S.U. OF POWDER (E.R.
               VISITS/PERSON/YR) <115>
     ASUP   - ACTIVE SOCIAL USERS OF POWDER (PEOPLE) <2>
     EMFSUK - EMERGENCY FRACTION FOR S.U. OF CRACK (E.R. VISITS
               /PERSON/YR) <115>
     ASUK   - ACTIVE SOCIAL USERS OF CRACK (PEOPLE) <3>
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DEMCU.K=EMFCUP*ACUP.K+EMFCUK*ACUK.K                                  A,116
EMFCUP=.0060                                                         C,116.1
EMFCUK=.0150                                                         C,116.2
     DEMCU  - DAWN EMERGENCIES AMONG C.U. (E.R. VISITS/YR)
               <116>
     EMFCUP - EMERGENCY FRACTION FOR C.U. OF POWDER (E.R.
               VISITS/PERSON/YR) <116>
     ACUP   - ACTIVE COMPULSIVE USERS OF POWDER (PEOPLE) <10>
     EMFCUK - EMERGENCY FRACTION FOR C.U. OF CRACK (E.R. VISITS
               /PERSON/YR) <116>
     ACUK   - ACTIVE COMPULSIVE USERS OF CRACK (PEOPLE) <11>

CUFEM.K=DEMCU.K/DEM.K                                                A,117
     CUFEM  - COMPULSIVE USERS' FRACTION OF EMERGENCIES (0-1)
               <117>
     DEMCU  - DAWN EMERGENCIES AMONG C.U. (E.R. VISITS/YR)
               <116>
     DEM    - DAWN EMERGENCIES (E.R. VISITS/YR) <114>

KUFEM.K=DEMUK.K/DEM.K                                                A,118
     KUFEM  - CRACK USERS' FRACTION OF EMERGENCIES (0-1) <118>
     DEMUK  - DAWN EMERGENCIES AMONG USERS OF CRACK (E.R.
               VISITS/YR) <119>
     DEM    - DAWN EMERGENCIES (E.R. VISITS/YR) <114>

DEMUK.K=EMFSUK*ASUK.K+EMFCUK*ACUK.K                                  A,119
     DEMUK  - DAWN EMERGENCIES AMONG USERS OF CRACK (E.R.
               VISITS/YR) <119>
     EMFSUK - EMERGENCY FRACTION FOR S.U. OF CRACK (E.R. VISITS
               /PERSON/YR) <115>
     ASUK   - ACTIVE SOCIAL USERS OF CRACK (PEOPLE) <3>
     EMFCUK - EMERGENCY FRACTION FOR C.U. OF CRACK (E.R. VISITS
               /PERSON/YR) <116>
     ACUK   - ACTIVE COMPULSIVE USERS OF CRACK (PEOPLE) <11>

DD.K=DDR*DEM.K                                                       A,120
DDR=.055                                                             C,120.1
     DD     - DAWN DEATHS (PEOPLE/YR) <120>
     DDR    - DAWN DEATH RATIO (DEATHS/E.R. VISIT) <120>
     DEM    - DAWN EMERGENCIES (E.R. VISITS/YR) <114>

     RETAIL SALES, CONSUMPTION, IMPORTS, SEIZURES

RSALES.K=RGPRIC.K*1000*CON.K                                         A,121
     RSALES - RETAIL SALES (1982 DOLLARS/YR) <121>
     RGPRIC - RETAIL GRAM PRICE (1982 DOLLARS/PURE GM) <122>
     CON    - CONSUMPTION (KG/YR) <123>

RGPRIC.K=TABHL(TRGPRIC,TIME.K,1976,1990,1)                           A,122
TRGPRIC=555/524/462/396/335/285/246/212/195/178/168/161/158/         T,122.1
 156/155
     RGPRIC - RETAIL GRAM PRICE (1982 DOLLARS/PURE GM) <122>
     TABHL  - DYNAMO TABLE FUNCTION (WITH HORIZONTAL
               EXTRAPOLATION)
     TRGPRIC- TABLE FOR RETAIL GRAM PRICE <122>
     TIME   - SIMULATION CURRENT TIME (YEAR) <132>
```

```
CON.K=CONSU.K+CONCU.K                                          A,123
     CON     - CONSUMPTION (KG/YR) <123>
     CONSU   - CONSUMPTION BY SOCIAL USERS (KG/YR) <124>
     CONCU   - CONSUMPTION BY COMPULSIVE USERS (KG/YR) <125>

CONSU.K=(ASUP.K*MGCSUP+ASUK.K*MGCSUK)*(12/1000)                A,124
MGCSUP=0.5                                                     C,124.1
MGCSUK=0.5                                                     C,124.2
     CONSU   - CONSUMPTION BY SOCIAL USERS (KG/YR) <124>
     ASUP    - ACTIVE SOCIAL USERS OF POWDER (PEOPLE) <2>
     MGCSUP  - MONTHLY GRAM CONSUMPTION PER S.U. OF POWDER (PURE
                GM/PERSON/MO) <124>
     ASUK    - ACTIVE SOCIAL USERS OF CRACK (PEOPLE) <3>
     MGCSUK  - MONTHLY GRAM CONSUMPTION PER S.U. OF CRACK (PURE
                GM/PERSON/MO) <124>

CONCU.K=(ACUP.K*MGCCUP+ACUK.K*MGCCUK)*(12/1000)                A,125
MGCCUP=8                                                       C,125.1
MGCCUK=8                                                       C,125.2
     CONCU   - CONSUMPTION BY COMPULSIVE USERS (KG/YR) <125>
     ACUP    - ACTIVE COMPULSIVE USERS OF POWDER (PEOPLE) <10>
     MGCCUP  - MONTHLY GRAM CONSUMPTION PER C.U. OF POWDER (PURE
                GM/PERSON/MO) <125>
     ACUK    - ACTIVE COMPULSIVE USERS OF CRACK (PEOPLE) <11>
     MGCCUK  - MONTHLY GRAM CONSUMPTION PER C.U. OF CRACK (PURE
                GM/PERSON/MO) <125>

CUFCON.K=CONCU.K/CON.K                                         A,126
     CUFCON  - COMPULSIVE USERS' FRACTION OF CONSUMPTION (0-1)
                <126>
     CONCU   - CONSUMPTION BY COMPULSIVE USERS (KG/YR) <125>
     CON     - CONSUMPTION (KG/YR) <123>

KUFCON.K=CONUK.K/CON.K                                         A,127
     KUFCON  - CRACK USERS' FRACTION OF CONSUMPTION (0-1) <127>
     CONUK   - CONSUMPTION BY USERS OF CRACK (KG/YR) <128>
     CON     - CONSUMPTION (KG/YR) <123>

CONUK.K=(ASUK.K*MGCSUK+ACUK.K*MGCCUK)*(12/1000)                A,128
     CONUK   - CONSUMPTION BY USERS OF CRACK (KG/YR) <128>
     ASUK    - ACTIVE SOCIAL USERS OF CRACK (PEOPLE) <3>
     MGCSUK  - MONTHLY GRAM CONSUMPTION PER S.U. OF CRACK (PURE
                GM/PERSON/MO) <124>
     ACUK    - ACTIVE COMPULSIVE USERS OF CRACK (PEOPLE) <11>
     MGCCUK  - MONTHLY GRAM CONSUMPTION PER C.U. OF CRACK (PURE
                GM/PERSON/MO) <125>

IMP.K=CON.K/(1-SEIZF.K)                                        A,129
     IMP     - IMPORTS (KG/YR) <129>
     CON     - CONSUMPTION (KG/YR) <123>
     SEIZF   - SEIZURE FRACTION (0-1) <130>
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SEIZF.K=TABHL(TSEIZF,TIME.K,1978,1988,1)                     A,130
TSEIZF=.02/.02/.04/.05/.07/.10/.13/.15/.17/.19/.2            T,130.1
     SEIZF  - SEIZURE FRACTION (0-1) <130>
     TABHL  - DYNAMO TABLE FUNCTION (WITH HORIZONTAL
               EXTRAPOLATION)
     TSEIZF - TABLE FOR SEIZURE FRACTION <130>
     TIME   - SIMULATION CURRENT TIME (YEAR) <132>

SEIZ.K=IMP.K*SEIZF.K                                         A,131
     SEIZ   - SEIZURE (KG/YR) <131>
     IMP    - IMPORTS (KG/YR) <129>
     SEIZF  - SEIZURE FRACTION (0-1) <130>

     RUN SPECIFICATIONS

SPEC  DT=.2/LENGTH=1992/SAVPER=.2/REL_ERR=1                    132
TIME=1976                                                    N,132.1
     DT     - SIMULATION COMPUTATION INTERVAL (YEARS) <132>
     LENGTH - SIMULATION END TIME (YEAR) <132>
     SAVPER - SIMULATION OUTPUT SAVE INTERVAL (YEARS) <132>
     REL_ERR- RELATIVE ERROR (RUNGE-KUTTA INTEGRATION CONSTANT)
               <132>
     TIME   - SIMULATION CURRENT TIME (YEAR) <132>
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SAVE  POP,EUPOP,AU,ASU,ASUP,ASUK,ACU,ACUP,ACUK,AUP,AUK,TU,PYU,     133
 PYSU,PYCU,PYUP,PYUK,XU,XCU,XUP,XUK,AUFPOP,CFAU,CFPYU,KFAU,
 KFPYU,IN,INK,KFIN,ESC,ESCK,KFESC,SQ,SQK,KFSQ,RPS,RAC,AK,CDEM,
 DEM,DEMCU,DEMUK,CUFEM,KUFEM,DD,RSALES,RGPRIC,CON,CONCU,CONUK,
 CUFCON,KUFCON,IMP,SEIZF,SEIZ
     POP    - POPULATION (PEOPLE) <75>
     EUPOP  - EVER USED POPULATION (PEOPLE) <76>
     AU     - ACTIVE USERS (PEOPLE) <82>
     ASU    - ACTIVE SOCIAL USERS (PEOPLE) <83>
     ASUP   - ACTIVE SOCIAL USERS OF POWDER (PEOPLE) <2>
     ASUK   - ACTIVE SOCIAL USERS OF CRACK (PEOPLE) <3>
     ACU    - ACTIVE COMPULSIVE USERS (PEOPLE) <84>
     ACUP   - ACTIVE COMPULSIVE USERS OF POWDER (PEOPLE) <10>
     ACUK   - ACTIVE COMPULSIVE USERS OF CRACK (PEOPLE) <11>
     AUP    - ACTIVE USERS OF POWDER (PEOPLE) <85>
     AUK    - ACTIVE USERS OF CRACK (PEOPLE) <86>
     TU     - TRANSITIONAL USERS (PEOPLE) <87>
     PYU    - PAST YEAR USERS (PEOPLE) <77>
     PYSU   - PAST YEAR SOCIAL USERS (PEOPLE) <78>
     PYCU   - PAST YEAR COMPULSIVE USERS (PEOPLE) <79>
     PYUP   - PAST YEAR USERS OF POWDER (PEOPLE) <80>
     PYUK   - PAST YEAR USERS OF CRACK (PEOPLE) <81>
     XU     - EX-USERS (PEOPLE) <92>
     XCU    - EX-COMPULSIVE USERS (PEOPLE) <94>
     XUP    - EX-USERS OF POWDER (PEOPLE) <95>
     XUK    - EX-USERS OF CRACK (PEOPLE) <96>
     AUFPOP - ACTIVE USER FRACTION OF POPULATION (0-1) <97>
     CFAU   - COMPULSIVE FRACTION OF ACTIVE USERS (0-1) <98>
     CFPYU  - COMPULSIVE FRACTION OF PAST YEAR USERS (0-1) <99>
     KFAU   - CRACK-USER FRACTION OF ACTIVE USERS (0-1) <101>
     KFPYU  - CRACK-USER FRACTION OF PAST YEAR USERS (0-1)
               <100>
     IN     - INITIATION (PEOPLE/YR) <102>
     INK    - INITIATION TO CRACK (PEOPLE/YR) <22>
     KFIN   - CRACK-USER FRACTION OF INITIATION (0-1) <103>
     ESC    - ESCALATION (PEOPLE/YR) <104>
     ESCK   - ESCALATION VIA CRACK (PEOPLE/YR) <25>
     KFESC  - CRACK-USER FRACTION OF ESCALATION (0-1) <105>
     SQ     - SUCCESSFUL QUITS (PEOPLE/YR) <106>
     SQK    - SUCCESSFUL QUITS FROM CRACK (PEOPLE/YR) <108>
     KFSQ   - CRACK-USER FRACTION OF SUCCESSFUL QUITS (0-1)
               <109>
     RPS    - RELATIVE PERCEIVED SAFETY (INDEX) <110>
     RAC    - RELATIVE ACCESS TO COCAINE (INDEX) <112>
     AK     - AVAILABILITY OF CRACK (0-1) <113>
     CDEM   - CUMULATIVE DAWN EMERGENCIES (PEOPLE) <111>
     DEM    - DAWN EMERGENCIES (E.R. VISITS/YR) <114>
     DEMCU  - DAWN EMERGENCIES AMONG C.U. (E.R. VISITS/YR)
               <116>
     DEMUK  - DAWN EMERGENCIES AMONG USERS OF CRACK (E.R.
               VISITS/YR) <119>
     CUFEM  - COMPULSIVE USERS' FRACTION OF EMERGENCIES (0-1)
               <117>
     KUFEM  - CRACK USERS' FRACTION OF EMERGENCIES (0-1) <118>
     DD     - DAWN DEATHS (PEOPLE/YR) <120>
     RSALES - RETAIL SALES (1982 DOLLARS/YR) <121>
     RGPRIC - RETAIL GRAM PRICE (1982 DOLLARS/PURE GM) <122>
     CON    - CONSUMPTION (KG/YR) <123>
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CONCU - CONSUMPTION BY COMPULSIVE USERS (KG/YR) <125>
CONUK - CONSUMPTION BY USERS OF CRACK (KG/YR) <128>
CUFCON - COMPULSIVE USERS' FRACTION OF CONSUMPTION (0-1) <126>
KUFCON - CRACK USERS' FRACTION OF CONSUMPTION (0-1) <127>
IMP - IMPORTS (KG/YR) <129>
SEIZF - SEIZURE FRACTION (0-1) <130>
SEIZ - SEIZURE (KG/YR) <131>

LIST OF VARIABLES

SYMBOL	T	WHR-CMP	DEFINITION
ACU	A	84	ACTIVE COMPULSIVE USERS (PEOPLE) <84>
ACUK	L	11	ACTIVE COMPULSIVE USERS OF CRACK (PEOPLE) <11>
	N	11.1	
ACUKD	R	68	ACTIVE C.U. OF CRACK DEATH (PEOPLE/YR) <68>
ACUP	L	10	ACTIVE COMPULSIVE USERS OF POWDER (PEOPLE) <10>
	N	10.1	
ACUPD	R	67	ACTIVE C.U. OF POWDER DEATH (PEOPLE/YR) <67>
AK	A	113	AVAILABILITY OF CRACK (0-1) <113>
ASU	A	83	ACTIVE SOCIAL USERS (PEOPLE) <83>
ASUK	L	3	ACTIVE SOCIAL USERS OF CRACK (PEOPLE) <3>
	N	3.1	
ASUKD	R	60	ACTIVE S.U. OF CRACK DEATH (PEOPLE/YR) <60>
ASUP	L	2	ACTIVE SOCIAL USERS OF POWDER (PEOPLE) <2>
	N	2.1	
ASUPD	R	59	ACTIVE S.U. OF POWDER DEATH (PEOPLE/YR) <59>
AU	A	82	ACTIVE USERS (PEOPLE) <82>
AUFPOP	A	97	ACTIVE USER FRACTION OF POPULATION (0-1) <97>
AUK	A	86	ACTIVE USERS OF CRACK (PEOPLE) <86>
AUP	A	85	ACTIVE USERS OF POWDER (PEOPLE) <85>
CDEM	L	111	CUMULATIVE DAWN EMERGENCIES (PEOPLE) <111>
	N	111.1	
CFAU	A	98	COMPULSIVE FRACTION OF ACTIVE USERS (0-1) <98>
CFPYU	A	99	COMPULSIVE FRACTION OF PAST YEAR USERS (0-1) <99>
CON	A	123	CONSUMPTION (KG/YR) <123>
CONCU	A	125	CONSUMPTION BY COMPULSIVE USERS (KG/YR) <125>
CONSU	A	124	CONSUMPTION BY SOCIAL USERS (KG/YR) <124>
CONUK	A	128	CONSUMPTION BY USERS OF CRACK (KG/YR) <128>
CUFCON	A	126	COMPULSIVE USERS' FRACTION OF CONSUMPTION (0-1) <126>
CUFEM	A	117	COMPULSIVE USERS' FRACTION OF EMERGENCIES (0-1) <117>
CUKI	R	47	C.U. OF CRACK INACTIVATION (PEOPLE/YR) <47>
CUKIF	C	47.1	C.U. OF CRACK INACTIVATION FRACTION (1/YR) <47>
CUKQ	A	52	C.U. OF CRACK QUITS (PEOPLE/YR) <52>
CUKSP	R	45	C.U. OF CRACK SWITCH TO POWDER (PEOPLE/YR) <45>
CUKSPF	C	45.1	C.U. OF CRACK SWITCH TO POWDER FRACTION (1/YR) <45>
CUKSQ	R	51	C.U. OF CRACK SUCCESSFUL QUITS (PEOPLE/YR) <51>
CUKSQF	C	51.1	C.U. OF CRACK SUCCESSFUL QUIT FRACTION (0-1) <51>
CUKTQ	R	53	C.U. OF CRACK TEMPORARY QUITS (PEOPLE/YR) <53>
CUPI	R	46	C.U. OF POWDER INACTIVATION (PEOPLE/YR) <46>
CUPIF	C	46.1	C.U. OF POWDER INACTIVATION FRACTION (1/YR) <46>
CUPQ	A	49	C.U. OF POWDER QUITS (PEOPLE/YR) <49>
CUPSK	R	44	C.U. OF POWDER SWITCH TO CRACK (PEOPLE/YR) <44>
CUPSKFN	C	44.1	C.U. OF POWDER SWITCH TO CRACK FRACTION NORMAL (1 /YR) <44>
CUPSQ	R	48	C.U. OF POWDER SUCCESSFUL QUITS (PEOPLE/YR) <48>
CUPSQF	C	48.1	C.U. OF POWDER SUCCESSFUL QUIT FRACTION (0-1) <48>
CUPTQ	R	50	C.U. OF POWDER TEMPORARY QUITS (PEOPLE/YR) <50>
DD	A	120	DAWN DEATHS (PEOPLE/YR) <120>
DDR	C	120.1	DAWN DEATH RATIO (DEATHS/E.R. VISIT) <120>
DEM	A	114	DAWN EMERGENCIES (E.R. VISITS/YR) <114>

DEMCU	A	116	DAWN EMERGENCIES AMONG C.U. (E.R. VISITS/YR) <116>
DEMSU	A	115	DAWN EMERGENCIES AMONG S.U. (E.R. VISITS/YR) <115>
DEMUK	A	119	DAWN EMERGENCIES AMONG USERS OF CRACK (E.R. VISITS/YR) <119>
DT	C	132	SIMULATION COMPUTATION INTERVAL (YEARS) <132>
EAINK	C	23.3	EFFECT OF ACCESS ON INITIATION TO CRACK <23>
EAINP	C	21.3	EFFECT OF ACCESS ON INITIATION TO POWDER <21>
EASUKI	C	31.3	EFFECT OF ACCESS ON S.U. OF CRACK INACTIVATION <31>
EASUPI	C	29.3	EFFECT OF ACCESS ON S.U. OF POWDER INACTIVATION <29>
EATSUKR	C	41.3	EFFECT OF ACCESS ON TRANSITIONAL S.U. OF CRACK RELAPSE <41>
EATSUPR	C	39.3	EFFECT OF ACCESS ON TRANSITIONAL S.U. OF POWDER RELAPSE <39>
EMFCUK	C	116.2	EMERGENCY FRACTION FOR C.U. OF CRACK (E.R. VISITS /PERSON/YR) <116>
EMFCUP	C	116.1	EMERGENCY FRACTION FOR C.U. OF POWDER (E.R. VISITS/PERSON/YR) <116>
EMFSUK	C	115.2	EMERGENCY FRACTION FOR S.U. OF CRACK (E.R. VISITS /PERSON/YR) <115>
EMFSUP	C	115.1	EMERGENCY FRACTION FOR S.U. OF POWDER (E.R. VISITS/PERSON/YR) <115>
ESC	A	104	ESCALATION (PEOPLE/YR) <104>
ESCK	R	25	ESCALATION VIA CRACK (PEOPLE/YR) <25>
ESCKF	C	25.1	ESCALATION VIA CRACK FRACTION (1/YR) <25>
ESCP	R	24	ESCALATION VIA POWDER (PEOPLE/YR) <24>
ESCPF	C	24.1	ESCALATION VIA POWDER FRACTION (1/YR) <24>
ESINK	C	23.2	EFFECT OF SAFETY ON INITIATION TO CRACK <23>
ESINP	C	21.2	EFFECT OF SAFETY ON INITIATION TO POWDER <21>
ESSUKI	C	31.2	EFFECT OF SAFETY ON S.U. OF CRACK INACTIVATION <31>
ESSUPI	C	29.2	EFFECT OF SAFETY ON S.U. OF POWDER INACTIVATION <29>
ESTSUKR	C	41.2	EFFECT OF SAFETY ON TRANSITIONAL S.U. OF CRACK RELAPSE <41>
ESTSUPR	C	39.2	EFFECT OF SAFETY ON TRANSITIONAL S.U. OF POWDER RELAPSE <39>
EUPOP	A	76	EVER USED POPULATION (PEOPLE) <76>
IMP	A	129	IMPORTS (KG/YR) <129>
IN	A	102	INITIATION (PEOPLE/YR) <102>
INK	R	22	INITIATION TO CRACK (PEOPLE/YR) <22>
INKF	A	23	INITIATION TO CRACK FRACTION (1/YR) <23>
INKFN	C	23.1	INITIATION TO CRACK FRACTION NORMAL (1/YR) <23>
INP	R	20	INITIATION TO POWDER (PEOPLE/YR) <20>
INPF	A	21	INITIATION TO POWDER FRACTION (1/YR) <21>
INPFN	C	21.1	INITIATION TO POWDER FRACTION NORMAL (1/YR) <21>
IXCUK	L	17	IMMUNE EX-COMPULSIVE USERS OF CRACK (PEOPLE) <17>
	N	17.1	
IXCUKD	R	74	IMMUNE EX-C.U. OF CRACK DEATH (PEOPLE/YR) <74>
IXCUP	L	16	IMMUNE EX-COMPULSIVE USERS OF POWDER (PEOPLE) <16>
	N	16.1	
IXCUPD	R	73	IMMUNE EX-C.U. OF POWDER DEATH (PEOPLE/YR) <73>
IXSUK	L	9	IMMUNE EX-SOCIAL USERS OF CRACK (PEOPLE) <9>
	N	9.1	
IXSUKD	R	66	IMMUNE EX-S.U. OF CRACK DEATH (PEOPLE/YR) <66>

IXSUP	L	8	IMMUNE EX-SOCIAL USERS OF POWDER (PEOPLE) <8>
	N	8.1	
IXSUPD	R	65	IMMUNE EX-S.U. OF POWDER DEATH (PEOPLE/YR) <65>
KFAU	A	101	CRACK-USER FRACTION OF ACTIVE USERS (0-1) <101>
KFESC	A	105	CRACK-USER FRACTION OF ESCALATION (0-1) <105>
KFIN	A	103	CRACK-USER FRACTION OF INITIATION (0-1) <103>
KFPYU	A	100	CRACK-USER FRACTION OF PAST YEAR USERS (0-1) <100>
KFSQ	A	109	CRACK-USER FRACTION OF SUCCESSFUL QUITS (0-1) <109>
KUFCON	A	127	CRACK USERS' FRACTION OF CONSUMPTION (0-1) <127>
KUFEM	A	118	CRACK USERS' FRACTION OF EMERGENCIES (0-1) <118>
LENGTH	C	132	SIMULATION END TIME (YEAR) <132>
MAX			DYNAMO MAXIMUM FUNCTION
MGCCUK	C	125.2	MONTHLY GRAM CONSUMPTION PER C.U. OF CRACK (PURE GM/PERSON/MO) <125>
MGCCUP	C	125.1	MONTHLY GRAM CONSUMPTION PER C.U. OF POWDER (PURE GM/PERSON/MO) <125>
MGCSUK	C	124.2	MONTHLY GRAM CONSUMPTION PER S.U. OF CRACK (PURE GM/PERSON/MO) <124>
MGCSUP	C	124.1	MONTHLY GRAM CONSUMPTION PER S.U. OF POWDER (PURE GM/PERSON/MO) <124>
MINRPS	C	110.2	MINIMUM RELATIVE PERCEIVED SAFETY (INDEX) <110>
NUPOP	L	1	NEVER USED POPULATION (PEOPLE) <1>
	N	1.1	
NUPOPD	R	58	NEVER USED POPULATION DEATH (PEOPLE/YR) <58>
POP	A	75	POPULATION (PEOPLE) <75>
POPE	R	18	POPULATION ENTRY (PEOPLE/YR) <18>
POPEF	A	19	POPULATION ENTRY FRACTION (1/YR) <19>
PYCU	A	79	PAST YEAR COMPULSIVE USERS (PEOPLE) <79>
PYSU	A	78	PAST YEAR SOCIAL USERS (PEOPLE) <78>
PYU	A	77	PAST YEAR USERS (PEOPLE) <77>
PYUK	A	81	PAST YEAR USERS OF CRACK (PEOPLE) <81>
PYUP	A	80	PAST YEAR USERS OF POWDER (PEOPLE) <80>
RAC	A	112	RELATIVE ACCESS TO COCAINE (INDEX) <112>
REL_ERR	C	132	RELATIVE ERROR (RUNGE-KUTTA INTEGRATION CONSTANT) <132>
RGPRIC	A	122	RETAIL GRAM PRICE (1982 DOLLARS/PURE GM) <122>
RPS	A	110	RELATIVE PERCEIVED SAFETY (INDEX) <110>
RSALES	A	121	RETAIL SALES (1982 DOLLARS/YR) <121>
SAVPER	C	132	SIMULATION OUTPUT SAVE INTERVAL (YEARS) <132>
SEIZ	A	131	SEIZURE (KG/YR) <131>
SEIZF	A	130	SEIZURE FRACTION (0-1) <130>
SQ	A	106	SUCCESSFUL QUITS (PEOPLE/YR) <106>
SQK	A	108	SUCCESSFUL QUITS FROM CRACK (PEOPLE/YR) <108>
SQP	A	107	SUCCESSFUL QUITS FROM POWDER (PEOPLE/YR) <107>
STEP			DYNAMO STEP-CHANGE FUNCTION
SUKI	R	30	S.U. OF CRACK INACTIVATION (PEOPLE/YR) <30>
SUKIF	A	31	S.U. OF CRACK INACTIVATION FRACTION (1/YR) <31>
SUKIFN	C	31.1	S.U. OF CRACK INACTIVATION FRACTION NORMAL (1/YR) <31>
SUKQ	A	36	S.U. OF CRACK QUITS (PEOPLE/YR) <36>
SUKSP	R	27	S.U. OF CRACK SWITCH TO POWDER (PEOPLE/YR) <27>
SUKSPF	C	27.1	S.U. OF CRACK SWITCH TO POWDER FRACTION (1/YR) <27>
SUKSQ	R	35	S.U. OF CRACK SUCCESSFUL QUITS (PEOPLE/YR) <35>
SUKSQF	C	35.1	S.U. OF CRACK SUCCESSFUL QUIT FRACTION (0-1) <35>

SUKTQ	R	37	S.U. OF CRACK TEMPORARY QUITS (PEOPLE/YR) <37>
SUPI	R	28	S.U. OF POWDER INACTIVATION (PEOPLE/YR) <28>
SUPIF	A	29	S.U. OF POWDER INACTIVATION FRACTION (1/YR) <29>
SUPIFN	C	29.1	S.U. OF POWDER INACTIVATION FRACTION NORMAL (1/YR) <29>
SUPQ	A	33	S.U. OF POWDER QUITS (PEOPLE/YR) <33>
SUPSK	R	26	S.U. OF POWDER SWITCH TO CRACK (PEOPLE/YR) <26>
SUPSKFN	C	26.1	S.U. OF POWDER SWITCH TO CRACK FRACTION NORMAL (1 /YR) <26>
SUPSQ	R	32	S.U. OF POWDER SUCCESSFUL QUITS (PEOPLE/YR) <32>
SUPSQF	C	32.1	S.U. OF POWDER SUCCESSFUL QUIT FRACTION (0-1) <32>
SUPTQ	R	34	S.U. OF POWDER TEMPORARY QUITS (PEOPLE/YR) <34>
SXCUK	L	15	SUSCEPTIBLE EX-COMPULSIVE USERS OF CRACK (PEOPLE)
	N	15.1	<15>
SXCUKD	R	72	SUSCEPTIBLE EX-C.U. OF CRACK DEATH (PEOPLE/YR) <72>
SXCUP	L	14	SUSCEPTIBLE EX-COMPULSIVE USERS OF POWDER (PEOPLE
	N	14.1	) <14>
SXCUPD	R	71	SUSCEPTIBLE EX-C.U. OF POWDER DEATH (PEOPLE/YR) <71>
SXSUK	L	7	SUSCEPTIBLE EX-SOCIAL USERS OF CRACK (PEOPLE) <7>
	N	7.1	
SXSUKD	R	64	SUSCEPTIBLE EX-S.U. OF CRACK DEATH (PEOPLE/YR) <64>
SXSUP	L	6	SUSCEPTIBLE EX-SOCIAL USERS OF POWDER (PEOPLE) <6>
	N	6.1	
SXSUPD	R	63	SUSCEPTIBLE EX-S.U. OF POWDER DEATH (PEOPLE/YR) <63>
TABHL			DYNAMO TABLE FUNCTION (WITH HORIZONTAL EXTRAPOLATION)
TABXT			DYNAMO TABLE FUNCTION (WITH LINEAR EXTRAPOLATION)
TAK	T	113.1	TABLE FOR AVAILABILITY OF CRACK <113>
TCU	A	89	TRANSITIONAL COMPULSIVE USERS (PEOPLE) <89>
TCUK	L	13	TRANSITIONAL COMPULSIVE USERS OF CRACK (PEOPLE)
	N	13.1	<13>
TCUKD	R	70	TRANSITIONAL C.U. OF CRACK DEATH (PEOPLE/YR) <70>
TCUKR	R	55	TRANSITIONAL C.U. OF CRACK RELAPSE (PEOPLE/YR) <55>
TCUKRF	C	55.1	TRANSITIONAL C.U. OF CRACK RELAPSE FRACTION (1/YR) <55>
TCUP	L	12	TRANSITIONAL COMPULSIVE USERS OF POWDER (PEOPLE)
	N	12.1	<12>
TCUPD	R	69	TRANSITIONAL C.U. OF POWDER DEATH (PEOPLE/YR) <69>
TCUPR	R	54	TRANSITIONAL C.U. OF POWDER RELAPSE (PEOPLE/YR) <54>
TCUPRF	C	54.1	TRANSITIONAL C.U. OF POWDER RELAPSE FRACTION (1/ YR) <54>
TIME	N	132.1	SIMULATION CURRENT TIME (YEAR) <132>
TPOPEF	T	19.1	TABLE FOR POPULATION ENTRY FRACTION <19>
TRAC	T	112.1	TABLE FOR RELATIVE ACCESS TO COCAINE <112>
TRGPRIC	T	122.1	TABLE FOR RETAIL GRAM PRICE <122>
TRPS	T	110.1	TABLE FOR RELATIVE PERCEIVED SAFETY <110>
TSEIZF	T	130.1	TABLE FOR SEIZURE FRACTION <130>
TSU	A	88	TRANSITIONAL SOCIAL USERS (PEOPLE) <88>
TSUK	L	5	TRANSITIONAL SOCIAL USERS OF CRACK (PEOPLE) <5>
	N	5.1	

TSUKD	R	62	TRANSITIONAL S.U. OF CRACK DEATH (PEOPLE/YR) <62>
TSUKR	R	40	TRANSITIONAL S.U. OF CRACK RELAPSE (PEOPLE/YR) <40>
TSUKRF	A	41	TRANSITIONAL S.U. OF CRACK RELAPSE FRACTION (1/YR) <41>
TSUKRFN	C	41.1	TRANSITIONAL S.U. OF CRACK RELAPSE FRACTION NORMAL (1/YR) <41>
TSUP	L	4	TRANSITIONAL SOCIAL USERS OF POWDER (PEOPLE) <4>
	N	4.1	
TSUPD	R	61	TRANSITIONAL S.U. OF POWDER DEATH (PEOPLE/YR) <61>
TSUPR	R	38	TRANSITIONAL S.U. OF POWDER RELAPSE (PEOPLE/YR) <38>
TSUPRF	A	39	TRANSITIONAL S.U. OF POWDER RELAPSE FRACTION (1/ YR) <39>
TSUPRFN	C	39.1	TRANSITIONAL S.U. OF POWDER RELAPSE FRACTION NORMAL (1/YR) <39>
TU	A	87	TRANSITIONAL USERS (PEOPLE) <87>
TUK	A	91	TRANSITIONAL USERS OF CRACK (PEOPLE) <91>
TUP	A	90	TRANSITIONAL USERS OF POWDER (PEOPLE) <90>
XCU	A	94	EX-COMPULSIVE USERS (PEOPLE) <94>
XCUKR	R	57	EX-C.U. OF CRACK RELAPSE (PEOPLE/YR) <57>
XCUKRF	C	57.1	EX-C.U. OF CRACK RELAPSE FRACTION (1/YR) <57>
XCUPR	R	56	EX-C.U. OF POWDER RELAPSE (PEOPLE/YR) <56>
XCUPRF	C	56.1	EX-C.U. OF POWDER RELAPSE FRACTION (1/YR) <56>
XSU	A	93	EX-SOCIAL USERS (PEOPLE) <93>
XSUKR	R	43	EX-S.U. OF CRACK RELAPSE (PEOPLE/YR) <43>
XSUKRF	C	43.1	EX-S.U. OF CRACK RELAPSE FRACTION (1/YR) <43>
XSUPR	R	42	EX-S.U. OF POWDER RELAPSE (PEOPLE/YR) <42>
XSUPRF	C	42.1	EX-S.U. OF POWDER RELAPSE FRACTION (1/YR) <42>
XU	A	92	EX-USERS (PEOPLE) <92>
XUK	A	96	EX-USERS OF CRACK (PEOPLE) <96>
XUP	A	95	EX-USERS OF POWDER (PEOPLE) <95>

Number of symbol table entries - 192

Appendix 2: COCAPOP Source Code

The following pages contain the complete, editable listing of model equations, saved as the file COCAPOP.DYN. The compiled version of this file, called COCAPOP.SMT, is used for performing model simulations.

```
*  A DYNAMIC MODEL OF COCAINE PREVALENCE
NOTE  COCAPOP, BY JB HOMER, MAY 1989

NOTE  POPULATION LEVELS

NOTE  NEVER USED POPULATION
L  NUPOP.K=NUPOP.J+DT*(POPE.JK-NUPOPD.JK-INP.JK-INK.JK)
N  NUPOP=169.4E6

NOTE  SOCIAL USERS
L  ASUP.K=ASUP.J+DT*(INP.JK-SUPI.JK+XSUPR.JK-ASUPD.JK-ESCP.JK+TSUPR.JK ^
   +SUKSP.JK-SUPSK.JK)
N  ASUP=0.9E6
L  ASUK.K=ASUK.J+DT*(INK.JK-SUKI.JK+XSUKR.JK-ASUKD.JK-ESCK.JK+TSUKR.JK ^
   +SUPSK.JK-SUKSP.JK)
N  ASUK=0
L  TSUP.K=TSUP.J+DT*(SUPI.JK-SUPTQ.JK-SUPSQ.JK-TSUPD.JK-TSUPR.JK)
N  TSUP=2.3E6
L  TSUK.K=TSUK.J+DT*(SUKI.JK-SUKTQ.JK-SUKSQ.JK-TSUKD.JK-TSUKR.JK)
N  TSUK=0
L  SXSUP.K=SXSUP.J+DT*(SUPTQ.JK-XSUPR.JK-SXSUPD.JK)
N  SXSUP=0.7E6
L  SXSUK.K=SXSUK.J+DT*(SUKTQ.JK-XSUKR.JK-SXSUKD.JK)
N  SXSUK=0
L  IXSUP.K=IXSUP.J+DT*(SUPSQ.JK-IXSUPD.JK)
N  IXSUP=2.4E6
L  IXSUK.K=IXSUK.J+DT*(SUKSQ.JK-IXSUKD.JK)
N  IXSUK=0

NOTE  COMPULSIVE USERS
L  ACUP.K=ACUP.J+DT*(ESCP.JK-CUPI.JK+XCUPR.JK-ACUPD.JK+TCUPR.JK ^
   +CUKSP.JK-CUPSK.JK)
N  ACUP=0.2E6
L  ACUK.K=ACUK.J+DT*(ESCK.JK-CUKI.JK+XCUKR.JK-ACUKD.JK+TCUKR.JK ^
   +CUPSK.JK-CUKSP.JK)
N  ACUK=0
L  TCUP.K=TCUP.J+DT*(CUPI.JK-CUPTQ.JK-CUPSQ.JK-TCUPD.JK-TCUPR.JK)
N  TCUP=0.1E6
L  TCUK.K=TCUK.J+DT*(CUKI.JK-CUKTQ.JK-CUKSQ.JK-TCUKD.JK-TCUKR.JK)
N  TCUK=0
L  SXCUP.K=SXCUP.J+DT*(CUPTQ.JK-SXCUPD.JK-XCUPR.JK)
N  SXCUP=.05E6
L  SXCUK.K=SXCUK.J+DT*(CUKTQ.JK-SXCUKD.JK-XCUKR.JK)
N  SXCUK=0
L  IXCUP.K=IXCUP.J+DT*(CUPSQ.JK-IXCUPD.JK)
N  IXCUP=0.35E6
L  IXCUK.K=IXCUK.J+DT*(CUKSQ.JK-IXCUKD.JK)
N  IXCUK=0

NOTE  POPULATION FLOWS

NOTE  POPULATION ENTRY
R  POPE.KL=POP.K*POPEF.K
A  POPEF.K=TABHL(TPOPEF,TIME.K,1976,1988,1)
   TPOPEF=.026/.027/.025/.025/.023/.021/.022/.022/.022/.021/.02/^
    .021/.02

NOTE  INITIATION AND ESCALATION
R  INP.KL=NUPOP.K*INPF.K
A  INPF.K=INPFN*(RPS.K**ESINP)*(RAC.K**EAINP)
```

```
C   INPFN=.014
C   ESINP=2.8
C   EAINP=1
R   INK.KL=NUPOP.K*INKF.K
A   INKF.K=INKFN*AK.K*(RPS.K**ESINK)*(RAC.K**EAINK)
C   INKFN=.027
C   ESINK=1.5
C   EAINK=1
R   ESCP.KL=ASUP.K*ESCPF
C   ESCPF=.025
R   ESCK.KL=ASUK.K*ESCKF
C   ESCKF=.15

NOTE   SOCIAL USERS PRODUCT-SWITCHING
R   SUPSK.KL=ASUP.K*SUPSKFN*MAX(AK.K,STEP(.01,1981))
C   SUPSKFN=.3
R   SUKSP.KL=ASUK.K*SUKSPF
C   SUKSPF=.1

NOTE   SOCIAL USERS INACTIVATION AND QUITTING
R   SUPI.KL=ASUP.K*SUPIF.K
A   SUPIF.K=SUPIFN*((1/RPS.K)**ESSUPI)*((1/RAC.K)**EASUPI)
C   SUPIFN=3.1
C   ESSUPI=1.8
C   EASUPI=2.5
R   SUKI.KL=ASUK.K*SUKIF.K
A   SUKIF.K=SUKIFN*((1/RPS.K)**ESSUKI)*((1/RAC.K)**EASUKI)
C   SUKIFN=1
C   ESSUKI=1
C   EASUKI=2.5
R   SUPSQ.KL=SUPQ.K*SUPSQF
C   SUPSQF=.25
A   SUPQ.K=TSUP.K*(1-TSUPRF.K)
R   SUPTQ.KL=SUPQ.K-SUPSQ.KL
R   SUKSQ.KL=SUKQ.K*SUKSQF
C   SUKSQF=.25
A   SUKQ.K=TSUK.K*(1-TSUKRF.K)
R   SUKTQ.KL=SUKQ.K-SUKSQ.KL

NOTE   SOCIAL USERS RELAPSE
R   TSUPR.KL=TSUP.K*TSUPRF.K
A   TSUPRF.K=TSUPRFN*(RPS.K**ESTSUPR)*(RAC.K**EATSUPR)
C   TSUPRFN=.4
C   ESTSUPR=2.5
C   EATSUPR=1.5
R   TSUKR.KL=TSUK.K*TSUKRF.K
A   TSUKRF.K=TSUKRFN*(RPS.K**ESTSUKR)*(RAC.K**EATSUKR)
C   TSUKRFN=.4
C   ESTSUKR=1.5
C   EATSUKR=1.5
R   XSUPR.KL=SXSUP.K*XSUPRF
C   XSUPRF=0.7
R   XSUKR.KL=SXSUK.K*XSUKRF
C   XSUKRF=0.7

NOTE   COMPULSIVE USERS PRODUCT-SWITCHING
R   CUPSK.KL=ACUP.K*CUPSKFN*AK.K
C   CUPSKFN=.10
R   CUKSP.KL=ACUK.K*CUKSPF
C   CUKSPF=.05
```

```
NOTE  COMPULSIVE USERS INACTIVATION AND QUITTING
R   CUPI.KL=ACUP.K*CUPIF
C   CUPIF=.5
R   CUKI.KL=ACUK.K*CUKIF
C   CUKIF=.5
R   CUPSQ.KL=CUPQ.K*CUPSQF
C   CUPSQF=.4
A   CUPQ.K=TCUP.K*(1-TCUPRF)
R   CUPTQ.KL=CUPQ.K-CUPSQ.KL
R   CUKSQ.KL=CUKQ.K*CUKSQF
C   CUKSQF=.4
A   CUKQ.K=TCUK.K*(1-TCUKRF)
R   CUKTQ.KL=CUKQ.K-CUKSQ.KL

NOTE  COMPULSIVE USERS RELAPSE
R   TCUPR.KL=TCUP.K*TCUPRF
C   TCUPRF=.5
R   TCUKR.KL=TCUK.K*TCUKRF
C   TCUKRF=.5
R   XCUPR.KL=SXCUP.K*XCUPRF
C   XCUPRF=.7
R   XCUKR.KL=SXCUK.K*XCUKRF
C   XCUKRF=.7

NOTE  DEATH FROM ALL CAUSES
R   NUPOPD.KL=NUPOP.K*.012
R   ASUPD.KL=ASUP.K*.002
R   ASUKD.KL=ASUK.K*.002
R   TSUPD.KL=TSUP.K*.002
R   TSUKD.KL=TSUK.K*.002
R   SXSUPD.KL=SXSUP.K*.0025
R   SXSUKD.KL=SXSUK.K*.0025
R   IXSUPD.KL=IXSUP.K*.003
R   IXSUKD.KL=IXSUK.K*.003
R   ACUPD.KL=ACUP.K*.002
R   ACUKD.KL=ACUK.K*.002
R   TCUPD.KL=TCUP.K*.002
R   TCUKD.KL=TCUK.K*.002
R   SXCUPD.KL=SXCUP.K*.0025
R   SXCUKD.KL=SXCUK.K*.0025
R   IXCUPD.KL=IXCUP.K*.003
R   IXCUKD.KL=IXCUK.K*.003

NOTE  POPULATION AUXILIARIES

NOTE  POPULATION LEVEL AGGREGATES
A   POP.K=NUPOP.K+EUPOP.K
A   EUPOP.K=PYU.K+XU.K
A   PYU.K=AU.K+TU.K
A   PYSU.K=ASU.K+TSU.K
A   PYCU.K=ACU.K+TCU.K
A   PYUP.K=AUP.K+TUP.K
A   PYUK.K=AUK.K+TUK.K
A   AU.K=ASU.K+ACU.K
A   ASU.K=ASUP.K+ASUK.K
A   ACU.K=ACUP.K+ACUK.K
A   AUP.K=ASUP.K+ACUP.K
A   AUK.K=ASUK.K+ACUK.K
A   TU.K=TSU.K+TCU.K
```

```
A   TSU.K=TSUP.K+TSUK.K
A   TCU.K=TCUP.K+TCUK.K
A   TUP.K=TSUP.K+TCUP.K
A   TUK.K=TSUK.K+TCUK.K
A   XU.K=XSU.K+XCU.K
A   XSU.K=SXSUP.K+IXSUP.K+SXSUK.K+IXSUK.K
A   XCU.K=SXCUP.K+IXCUP.K+SXCUK.K+IXCUK.K
A   XUP.K=SXSUP.K+IXSUP.K+SXCUP.K+IXCUP.K
A   XUK.K=SXSUK.K+IXSUK.K+SXCUK.K+IXCUK.K

NOTE  POPULATION LEVEL FRACTIONS
A   AUFPOP.K=AU.K/POP.K
A   CFAU.K=ACU.K/AU.K
A   CFPYU.K=PYCU.K/PYU.K
A   KFPYU.K=PYUK.K/PYU.K
A   KFAU.K=AUK.K/AU.K

NOTE  POPULATION FLOW AGGREGATES
A   IN.K=INP.KL+INK.KL
A   KFIN.K=INK.KL/IN.K
A   ESC.K=ESCP.KL+ESCK.KL
A   KFESC.K=ESCK.KL/ESC.K
A   SQ.K=SQP.K+SQK.K
A   SQP.K=SUPSQ.KL+CUPSQ.KL
A   SQK.K=SUKSQ.KL+CUKSQ.KL
A   KFSQ.K=SQK.K/SQ.K

NOTE  PERCEIVED SAFETY AND ACCESS TO COCAINE, AND AVAILABILITY OF CRACK

A   RPS.K=MAX(TABXT(TRPS,CDEM.K,0,80000,5000),MINRPS)
T   TRPS=1/.97/.86/.78/.72/.66/.62/.59/.57/.55/.53/.51/.49/.47/.46/.45/.445
C   MINRPS=.25
L   CDEM.K=CDEM.J+DT*DEM.J
N   CDEM=0
A   RAC.K=TABHL(TRAC,AUFPOP.K,.003,.042,.003)
T   TRAC=.8/1/1.09/1.17/1.24/1.30/1.36/1.41/1.45/1.48/1.5/1.52/1.53/1.54
A   AK.K=TABHL(TAK,KFAU.K,0,1,.1)
T   TAK=0/.2/.35/.48/.6/.7/.8/.88/.95/.99/1

NOTE  DAWN EMERGENCIES AND DAWN DEATHS

A   DEM.K=DEMSU.K+DEMCU.K
A   DEMSU.K=EMFSUP*ASUP.K+EMFSUK*ASUK.K
C   EMFSUP=.0001
C   EMFSUK=.0006
A   DEMCU.K=EMFCUP*ACUP.K+EMFCUK*ACUK.K
C   EMFCUP=.0060
C   EMFCUK=.0150
A   CUFEM.K=DEMCU.K/DEM.K
A   KUFEM.K=DEMUK.K/DEM.K
A   DEMUK.K=EMFSUK*ASUK.K+EMFCUK*ACUK.K
A   DD.K=DDR*DEM.K
C   DDR=.055

NOTE  RETAIL SALES, CONSUMPTION, IMPORTS, SEIZURES

A   RSALES.K=RGPRIC.K*1000*CON.K
A   RGPRIC.K=TABHL(TRGPRIC,TIME.K,1976,1990,1)
T   TRGPRIC=555/524/462/396/335/285/246/212/195/178/168/161/158/^
     156/155
```

```
A   CON.K=CONSU.K+CONCU.K
A   CONSU.K=(ASUP.K*MGCSUP+ASUK.K*MGCSUK)*(12/1000)
C   MGCSUP=0.5
C   MGCSUK=0.5
A   CONCU.K=(ACUP.K*MGCCUP+ACUK.K*MGCCUK)*(12/1000)
C   MGCCUP=8
C   MGCCUK=8
A   CUFCON.K=CONCU.K/CON.K
A   KUFCON.K=CONUK.K/CON.K
A   CONUK.K=(ASUK.K*MGCSUK+ACUK.K*MGCCUK)*(12/1000)
A   IMP.K=CON.K/(1-SEIZF.K)
A   SEIZF.K=TABHL(TSEIZF,TIME.K,1978,1988,1)
T   TSEIZF=.02/.02/.04/.05/.07/.10/.13/.15/.17/.19/.2
A   SEIZ.K=IMP.K*SEIZF.K

NOTE  RUN SPECIFICATIONS

SPEC  DT=.2/LENGTH=1992/SAVPER=.2/REL_ERR=1
N   TIME=1976
SAVE  POP,EUPOP,AU,ASU,ASUP,ASUK,ACU,ACUP,ACUK,AUP,AUK,TU,PYU,PYSU,PYCU,^
 PYUP,PYUK,XU,XCU,XUP,XUK,AUFPOP,CFAU,CFPYU,KFAU,KFPYU,IN,INK,KFIN,^
 ESC,ESCK,KFESC,SQ,SQK,KFSQ,RPS,RAC,AK,CDEM,DEM,DEMCU,DEMUK,CUFEM,KUFEM,^
 DD,RSALES,RGPRIC,CON,CONCU,CONUK,CUFCON,KUFCON,IMP,SEIZF,SEIZ
```

Tables and Figures

The following pages contain all of the tables and figures referenced in the body of this report, as listed below. Figures 3-5 are diagrams of model structure. Figures 1-2 and Figures 6-23 are graphs over time of base run results and indicator data, based on Table 1. Figures 24-39 are graphs over time of selected sensitivity testing results, based on Table 2.

(Tables and Figures, continued)

COCAPOP Base Run 1976-1992 vs. Indicators

MODEL BASE RUN RESULTS, p. 1														
TIME	AU	AUP	AUK	KFAU	ACU	CFAU	ACUP	ACUK	PYU	EUPOP	IN	INK	ESC	ESCK
	(mill)	(mill)	(mill)		(mill)		(mill)	(mill)	(mill)	(mill)	(mill/yr)	(mill/yr)	(mill/yr)	(mill/yr)
1976	1.10	1.10	.00	.00	.20	.18	0.20	.00	3.50	7.00	2.39	0.00	0.02	0.00
1977	2.02	2.02	.00	.00	.21	.11	0.21	.00	5.20	9.52	2.67	0.00	0.05	0.00
1978	3.08	3.08	.00	.00	.24	.08	0.24	.00	7.18	12.27	2.88	0.00	0.07	0.00
1979	4.44	4.44	.00	.00	.29	.07	0.29	.00	9.43	15.22	3.07	0.00	0.10	0.00
1980	5.47	5.47	.00	.00	.35	.06	0.35	.00	11.50	18.12	2.75	0.00	0.13	0.00
1981	5.46	5.46	.00	.00	.41	.08	0.41	.00	12.56	20.59	2.26	0.00	0.13	0.00
1982	4.85	4.82	.03	.01	.45	.09	0.45	.00	12.66	22.62	1.93	0.06	0.11	0.00
1983	4.11	3.88	.23	.06	.49	.12	0.47	.02	12.27	24.44	1.97	0.46	0.12	0.03
1984	4.40	3.25	1.15	.26	.57	.13	0.47	.09	12.48	26.79	2.89	1.63	0.23	0.16
1985	5.52	2.89	2.64	.48	.76	.14	0.47	.30	13.62	29.88	3.27	2.29	0.41	0.35
1986	6.32	2.42	3.90	.62	1.05	.17	0.46	.59	14.70	33.00	3.11	2.37	0.54	0.50
1987	6.63	1.97	4.66	.70	1.36	.21	0.46	.91	15.34	35.83	2.67	2.15	0.60	0.56
1988	6.34	1.52	4.83	.76	1.64	.26	0.45	1.18	15.29	38.13	2.21	1.84	0.57	0.55
1989	6.26	1.34	4.92	.79	1.86	.30	0.45	1.40	15.12	40.16	2.03	1.72	0.55	0.53
1990	6.17	1.19	4.99	.81	2.05	.33	0.46	1.60	14.95	41.99	1.83	1.57	0.53	0.51
1991	5.96	1.04	4.92	.83	2.22	.37	0.47	1.75	14.64	43.60	1.61	1.40	0.49	0.47
1992	5.61	0.91	4.70	.84	2.34	.42	0.47	1.87	14.15	44.97	1.38	1.22	0.44	0.43
INDICATOR DATA, p. 1														
TIME	AU								PYU	EUPOP				
	NHS								NHS	NHS				
1976	1.1								3.5	7.0				
1977	1.7								5.1	10.4				
1978														
1979	4.7								10.1	16.0				
1980														
1981														
1982	4.3								12.5	22.6				
1983														
1984														
1985	5.8								12.3	22.9				
1986														
1987														

Table 1. Model Base Run Results and Indicator Data

COCAPOP Base Run 1976-1992 vs. indicators

MODEL BASE RUN RESULTS, p. 2															
TIME	RAC	RPS	AK	DEM	CUFEM	KUFEM	DD	CON	CUFCON	KUFCON	IMP	RSALES	RGPRIC	SEIZ	SEIZF
								(MT/yr)			(MT/yr)	($'82 Bill.)	($'82/gm)	(MT/yr)	
1976	1.01	1.00	0.00	1290	.93	.00	71	24.6	.78	.00	25.1	13.65	555	0.0	.02
1977	1.15	0.99	0.00	1467	.88	.00	81	31.4	.66	.00	32.0	16.45	524	0.6	.02
1978	1.28	0.98	0.00	1740	.84	.00	96	40.3	.58	.00	41.1	18.62	462	0.8	.02
1979	1.41	0.97	0.00	2143	.81	.00	118	52.5	.53	.00	53.6	20.80	396	1.1	.02
1980	1.47	0.92	0.00	2609	.80	.00	144	64.3	.52	.00	67.0	21.53	335	2.7	.04
1981	1.47	0.86	0.00	2957	.83	.00	163	69.5	.56	.00	73.2	19.82	285	3.7	.05
1982	1.43	0.81	0.01	3191	.86	.01	175	69.9	.62	.01	75.2	17.20	246	5.3	.07
1983	1.37	0.76	0.11	3540	.87	.10	195	68.7	.68	.04	76.3	14.56	212	7.6	.10
1984	1.39	0.71	0.43	5156	.82	.39	284	77.5	.70	.20	89.0	15.11	195	11.6	.13
1985	1.46	0.64	0.68	8896	.82	.66	489	101.8	.72	.42	119.8	18.13	178	18.0	.15
1986	1.49	0.58	0.81	13800	.84	.79	759	132.4	.76	.58	159.5	22.25	168	27.1	.17
1987	1.50	0.51	0.88	18720	.87	.85	1030	162.3	.81	.68	200.3	26.13	161	38.1	.19
1988	1.49	0.45	0.92	22740	.90	.88	1251	185.2	.85	.73	231.5	29.26	158	46.3	.20
1989	1.48	0.43	0.94	25980	.92	.89	1429	204.8	.87	.76	256.0	31.95	156	51.2	.20
1990	1.48	0.40	0.95	28780	.93	.90	1583	221.8	.89	.78	277.3	34.38	155	55.5	.20
1991	1.47	0.37	0.96	31010	.94	.91	1706	235.2	.91	.80	294.0	36.45	155	58.8	.20
1992	1.44	0.34	0.97	32560	.95	.91	1791	244.0	.92	.80	305.1	37.83	155	61.0	.20

INDICATOR DATA, p. 2															
TIME	RAC	RPS		DEM			DD				IMP	RPUR	RGPRIC	SEIZ	SEIZ/IMP
	HSS	HSS		DAWN			DAWN				NNICC	STRIDE	STRIDE	NNICC	NNICC
1976	1.03	0.87		1015			53								
1977	1.00	1.00		1145			48					0.38	512	0.6	
1978	1.15	1.00		1370			69					0.37	477	0.8	
1979	1.38	0.96		1931			99					0.38	420	1.2	
1980	1.45	0.97		2777			166					0.44	315	3.5	
1981	1.44	0.91		3095			193				53	0.48	264	2.0	0.037
1982	1.44	0.85		4233			217				62.5	0.48		4.9	0.079
1983	1.31	0.81		4903			313				86	0.54	217	7.6	0.088
1984	1.36	0.67		7898			566				144	0.57		11.8	0.082
1985	1.48	0.66		9403			615				132	0.55	196	24.6	0.187
1986	1.56	0.56		13938			734					0.66	163	27.2	
1987												0.72		36.0	

Table 1. Model Base Run Results and Indicator Data

SELECTED SENSITIVITY TEST RESULTS, p. 1 [Active Users-AU]													
	AU0	AU1H	AU1L	AU4H	AU4L	AU17H	AU17L	AU18H	AU18L	AU25H	AU25L	AU26H	AU26L
TIME	Base Run	CUKIF/	CUKIF\	CUPIF/	CUPIF\	ESCKF/	ESCKF\	ESCPF/	ESCPF\	INKFN/	INKFN\	INPFN/	INPFN\
1976	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100
1977	2.016	2.016	2.016	1.994	2.040	2.016	2.016	2.020	2.013	2.016	2.016	2.464	1.624
1978	3.076	3.076	3.076	3.039	3.116	3.076	3.076	3.083	3.068	3.076	3.076	4.132	2.211
1979	4.435	4.435	4.435	4.397	4.475	4.435	4.435	4.438	4.432	4.435	4.435	6.071	2.924
1980	5.469	5.468	5.469	5.572	5.345	5.469	5.469	5.358	5.580	5.469	5.469	6.886	3.575
1981	5.455	5.455	5.455	5.708	5.172	5.455	5.455	5.202	5.717	5.455	5.455	6.473	3.713
1982	4.853	4.853	4.853	5.184	4.478	4.853	4.854	4.494	5.228	4.865	4.845	5.596	3.340
1983	4.113	4.111	4.115	4.516	3.687	4.111	4.115	3.681	4.609	4.353	3.979	4.668	3.313
1984	4.402	4.391	4.413	4.748	4.025	4.389	4.416	3.998	4.866	5.525	3.557	4.231	5.021
1985	5.522	5.504	5.541	5.814	5.190	5.463	5.585	5.152	5.941	6.962	3.980	4.776	6.699
1986	6.316	6.292	6.344	6.520	6.073	6.215	6.432	6.038	6.618	7.694	4.622	5.603	7.234
1987	6.625	6.610	6.642	6.801	6.419	6.437	6.834	6.388	6.889	7.576	5.106	6.110	7.140
1988	6.342	6.323	6.381	6.473	6.196	6.167	6.597	6.169	6.545	7.380	5.226	5.995	6.742
1989	6.257	6.193	6.337	6.344	6.154	6.126	6.431	6.128	6.401	7.283	4.972	5.920	6.580
1990	6.172	6.098	6.258	6.238	6.090	6.022	6.350	6.062	6.287	7.025	4.885	5.905	6.359
1991	5.955	5.888	6.038	6.006	5.896	5.781	6.174	5.866	6.054	6.597	4.817	5.788	6.016
1992	5.607	5.554	5.675	5.640	5.570	5.406	5.859	5.539	5.685	6.037	4.678	5.539	5.544
1980 Δ		0.0%	0.0%	1.9%	-2.3%	0.0%	0.0%	-2.0%	2.0%	0.0%	0.0%	25.9%	-34.6%
1984 Δ		-0.2%	0.2%	7.9%	-8.6%	-0.3%	0.3%	-9.2%	10.5%	25.5%	-19.2%	-3.9%	14.1%
1988 Δ		-0.3%	0.6%	2.1%	-2.3%	-2.8%	4.0%	-2.7%	3.2%	16.4%	-17.6%	-5.5%	6.3%
1992 Δ		-0.9%	1.2%	0.6%	-0.7%	-3.6%	4.5%	-1.2%	1.4%	7.7%	-16.6%	-1.2%	-1.1%
Note: Δ's computed relative to Base Run													

Table 2. Selected Sensitivity Testing Results

SELECTED SENSITIVITY TEST RESULTS, p. 2 [Active Users-AU]												
	AU31H	AU31L	AU34H	AU34L	AU35H	AU35L	AU45H	AU45L	AU46H	AU46L	AU47H	AU47L
TIME	SUKIFN/	SUKIFN\	SUPIFN/	SUPIFN\	SUPSKFN/	SUPSKFN\	TRPS |	TRPS -	TRAC |	TRAC -	TAK |	TAK -
1976	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100
1977	2.016	2.016	1.607	2.532	2.016	2.016	1.998	2.035	2.187	1.870	2.016	2.016
1978	3.076	3.076	2.258	4.148	3.076	3.076	2.987	3.166	3.755	2.602	3.076	3.076
1979	4.435	4.435	3.108	5.941	4.435	4.435	4.187	4.687	5.877	3.364	4.435	4.435
1980	5.469	5.469	3.940	6.803	5.469	5.469	5.019	5.919	7.071	3.970	5.469	5.469
1981	5.455	5.455	4.114	6.574	5.455	5.455	4.732	6.165	6.953	3.914	5.455	5.455
1982	4.851	4.856	3.619	5.849	4.860	4.847	3.782	5.866	6.200	3.379	4.865	4.845
1983	4.077	4.154	3.331	5.049	4.197	4.040	2.931	5.455	5.365	3.112	4.407	3.969
1984	4.175	4.647	4.778	4.610	4.756	4.040	3.440	5.828	4.993	4.131	5.761	3.459
1985	5.088	5.968	6.385	5.008	5.946	5.038	4.349	6.919	5.682	5.450	7.231	3.740
1986	5.781	6.875	6.945	5.779	6.672	5.902	4.651	8.101	6.661	5.912	7.812	4.318
1987	6.097	7.219	6.948	6.280	6.836	6.358	4.540	8.801	7.131	5.985	7.446	4.886
1988	5.805	7.016	6.553	6.162	6.523	6.180	3.897	9.061	7.001	5.599	7.144	5.210
1989	5.609	6.984	6.408	6.103	6.441	6.052	3.311	9.315	7.039	5.424	6.925	5.112
1990	5.526	6.859	6.223	6.092	6.306	5.998	3.084	9.341	6.985	5.310	6.597	5.099
1991	5.354	6.582	5.912	5.966	6.036	5.845	2.910	9.122	6.762	5.124	6.148	5.134
1992	5.069	6.164	5.479	5.705	5.630	5.562	2.735	8.674	6.377	4.846	5.583	5.088
1980 Δ	0.0%	0.0%	-28.0%	24.4%	0.0%	0.0%	-8.2%	8.2%	29.3%	-27.4%	0.0%	0.0%
1984 Δ	-5.2%	5.6%	8.5%	4.7%	8.0%	-8.2%	-21.9%	32.4%	13.4%	-6.2%	30.9%	-21.4%
1988 Δ	-8.5%	10.6%	3.3%	-2.8%	2.9%	-2.6%	-38.6%	42.9%	10.4%	-11.7%	12.6%	-17.8%
1992 Δ	-9.6%	9.9%	-2.3%	1.7%	0.4%	-0.8%	-51.2%	54.7%	13.7%	-13.6%	-0.4%	-9.3%
Note: Δ's computed relative to Base Run												

Table 2. Selected Sensitivity Testing Results

SELECTED SENSITIVITY TEST RESULTS, p. 3 [Active Compulsive Users-ACU]													
	ACU0	ACU1H	ACU1L	ACU4H	ACU4L	ACU17H	ACU17L	ACU18H	ACU18L	ACU25H	ACU25L	ACU26H	ACU26L
TIME	Base Run	CUKIF/	CUKIF\	CUPIF/	CUPIF\	ESCKF/	ESCKF\	ESCPF/	ESCPF\	INKFN/	INKFN\	INPFN/	INPFN\
1976	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1977	0.214	0.214	0.214	0.202	0.228	0.214	0.214	0.220	0.209	0.214	0.214	0.219	0.210
1978	0.243	0.243	0.243	0.224	0.264	0.243	0.243	0.256	0.229	0.243	0.243	0.261	0.227
1979	0.288	0.288	0.288	0.264	0.316	0.288	0.288	0.312	0.263	0.288	0.288	0.330	0.252
1980	0.350	0.350	0.350	0.321	0.383	0.350	0.350	0.386	0.312	0.350	0.350	0.413	0.287
1981	0.409	0.409	0.409	0.378	0.445	0.409	0.409	0.454	0.361	0.409	0.409	0.483	0.322
1982	0.453	0.453	0.453	0.421	0.491	0.454	0.453	0.502	0.400	0.454	0.453	0.532	0.351
1983	0.489	0.488	0.490	0.458	0.526	0.491	0.486	0.536	0.436	0.498	0.484	0.567	0.387
1984	0.567	0.564	0.571	0.537	0.602	0.583	0.552	0.610	0.517	0.637	0.523	0.619	0.536
1985	0.763	0.749	0.780	0.738	0.791	0.811	0.714	0.796	0.721	0.948	0.620	0.745	0.858
1986	1.050	1.016	1.089	1.033	1.067	1.142	0.953	1.069	1.021	1.339	0.787	0.958	1.244
1987	1.361	1.302	1.429	1.351	1.370	1.493	1.218	1.369	1.345	1.713	0.996	1.218	1.602
1988	1.635	1.551	1.732	1.629	1.638	1.793	1.460	1.633	1.631	2.014	1.214	1.471	1.880
1989	1.858	1.750	1.985	1.854	1.860	2.039	1.657	1.851	1.861	2.271	1.402	1.685	2.104
1990	2.053	1.923	2.207	2.048	2.056	2.251	1.829	2.043	2.060	2.485	1.555	1.875	2.291
1991	2.216	2.068	2.392	2.209	2.221	2.423	1.978	2.203	2.226	2.646	1.689	2.042	2.434
1992	2.338	2.176	2.531	2.328	2.346	2.544	2.095	2.324	2.350	2.749	1.803	2.176	2.528
1980 Δ		0.0%	0.0%	-8.3%	9.4%	0.0%	0.0%	10.3%	-10.9%	0.0%	0.0%	18.0%	-18.0%
1984 Δ		-0.5%	0.7%	-5.3%	6.2%	2.8%	-2.6%	7.6%	-8.8%	12.3%	-7.8%	9.2%	-5.5%
1988 Δ		-5.1%	5.9%	-0.4%	0.2%	9.7%	-10.7%	-0.1%	-0.2%	23.2%	-25.7%	-10.0%	15.0%
1992 Δ		-6.9%	8.3%	-0.4%	0.3%	8.8%	-10.4%	-0.6%	0.5%	17.6%	-22.9%	-6.9%	8.1%
Note: Δ's computed relative to Base Run													

Table 2. Selected Sensitivity Testing Results

SELECTED SENSITIVITY TEST RESULTS, p. 4 [Active Compulsive Users-ACU]												
	ACU31H	ACU31L	ACU34H	ACU34L	ACU35H	ACU35L	ACU45H	ACU45L	ACU46H	ACU46L	ACU47H	ACU47L
TIME	SUKIFN/	SUKIFN\	SUPIFN/	SUPIFN\	SUPSKFN/	SUPSKFN\	TRPS |	TRPS -	TRAC |	TRAC -	TAK |	TAK -
1976	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1977	0.214	0.214	0.210	0.220	0.214	0.214	0.214	0.215	0.216	0.213	0.214	0.214
1978	0.243	0.243	0.227	0.263	0.243	0.243	0.242	0.244	0.252	0.236	0.243	0.243
1979	0.288	0.288	0.255	0.330	0.288	0.288	0.284	0.292	0.317	0.267	0.288	0.288
1980	0.350	0.350	0.294	0.411	0.350	0.350	0.339	0.360	0.403	0.307	0.350	0.350
1981	0.409	0.409	0.336	0.482	0.409	0.409	0.389	0.428	0.481	0.345	0.409	0.409
1982	0.453	0.453	0.368	0.535	0.454	0.453	0.420	0.486	0.541	0.372	0.454	0.453
1983	0.488	0.490	0.402	0.576	0.493	0.486	0.439	0.539	0.587	0.399	0.500	0.483
1984	0.555	0.581	0.530	0.632	0.593	0.544	0.512	0.631	0.658	0.498	0.656	0.517
1985	0.723	0.808	0.822	0.759	0.825	0.703	0.687	0.844	0.824	0.730	0.994	0.600
1986	0.971	1.135	1.184	0.973	1.142	0.956	0.909	1.182	1.096	1.024	1.401	0.744
1987	1.245	1.488	1.530	1.237	1.469	1.247	1.113	1.587	1.420	1.308	1.762	0.935
1988	1.491	1.798	1.805	1.494	1.743	1.519	1.262	1.988	1.721	1.541	2.038	1.152
1989	1.683	2.058	2.025	1.714	1.968	1.741	1.333	2.363	1.984	1.720	2.264	1.356
1990	1.849	2.284	2.211	1.911	2.163	1.935	1.373	2.707	2.218	1.874	2.445	1.531
1991	1.990	2.467	2.357	2.083	2.320	2.101	1.404	3.003	2.416	2.001	2.576	1.691
1992	2.098	2.601	2.456	2.222	2.432	2.232	1.421	3.239	2.567	2.095	2.653	1.835
1980 Δ	0.0%	0.0%	-16.0%	17.4%	0.0%	0.0%	-3.1%	2.9%	15.1%	-12.3%	0.0%	0.0%
1984 Δ	-2.1%	2.5%	-6.5%	11.5%	4.6%	-4.1%	-9.7%	11.3%	16.0%	-12.2%	15.7%	-8.8%
1988 Δ	-8.8%	10.0%	10.4%	-8.6%	6.6%	-7.1%	-22.8%	21.6%	5.3%	-5.7%	24.6%	-29.5%
1992 Δ	-10.3%	11.2%	5.0%	-5.0%	4.0%	-4.5%	-39.2%	38.5%	9.8%	-10.4%	13.5%	-21.5%
Note: Δ's computed relative to Base Run												

Table 2. Selected Sensitivity Testing Results

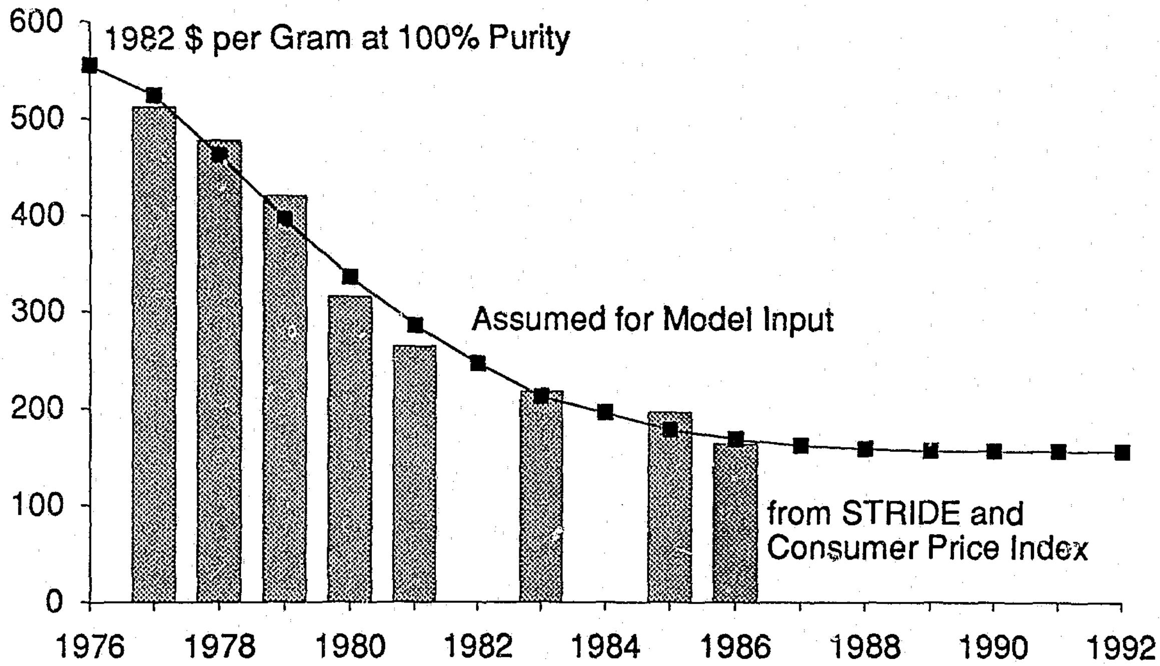

Figure 1. Retail Pure Gram Price (RGPRIC)

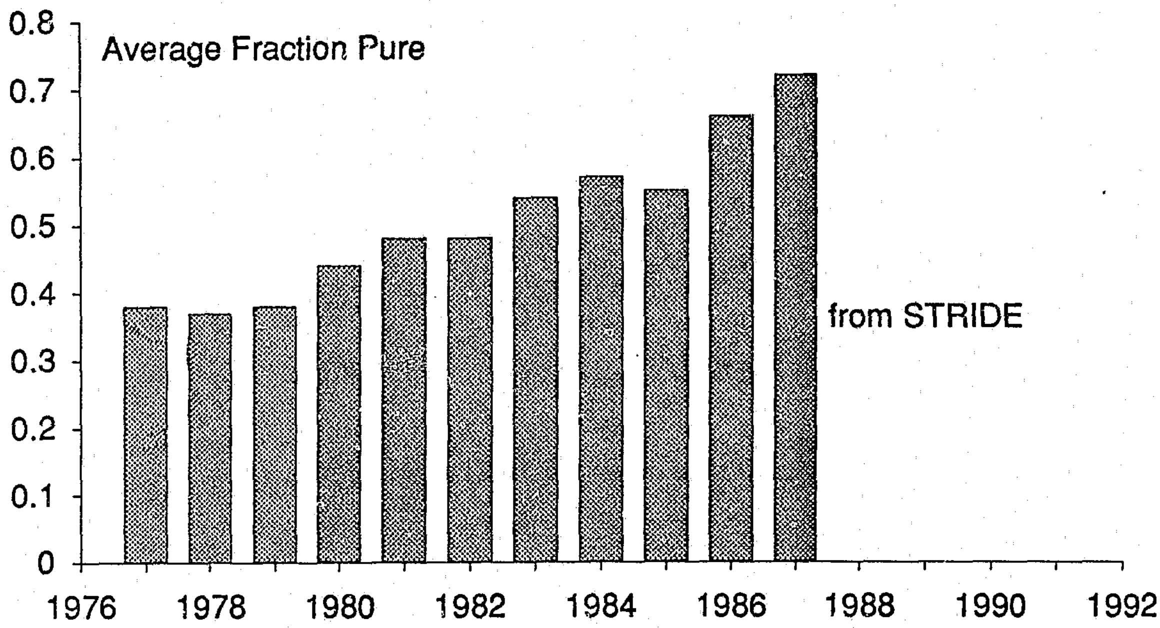

Figure 2. Retail Purity
(RPUR, not modeled)

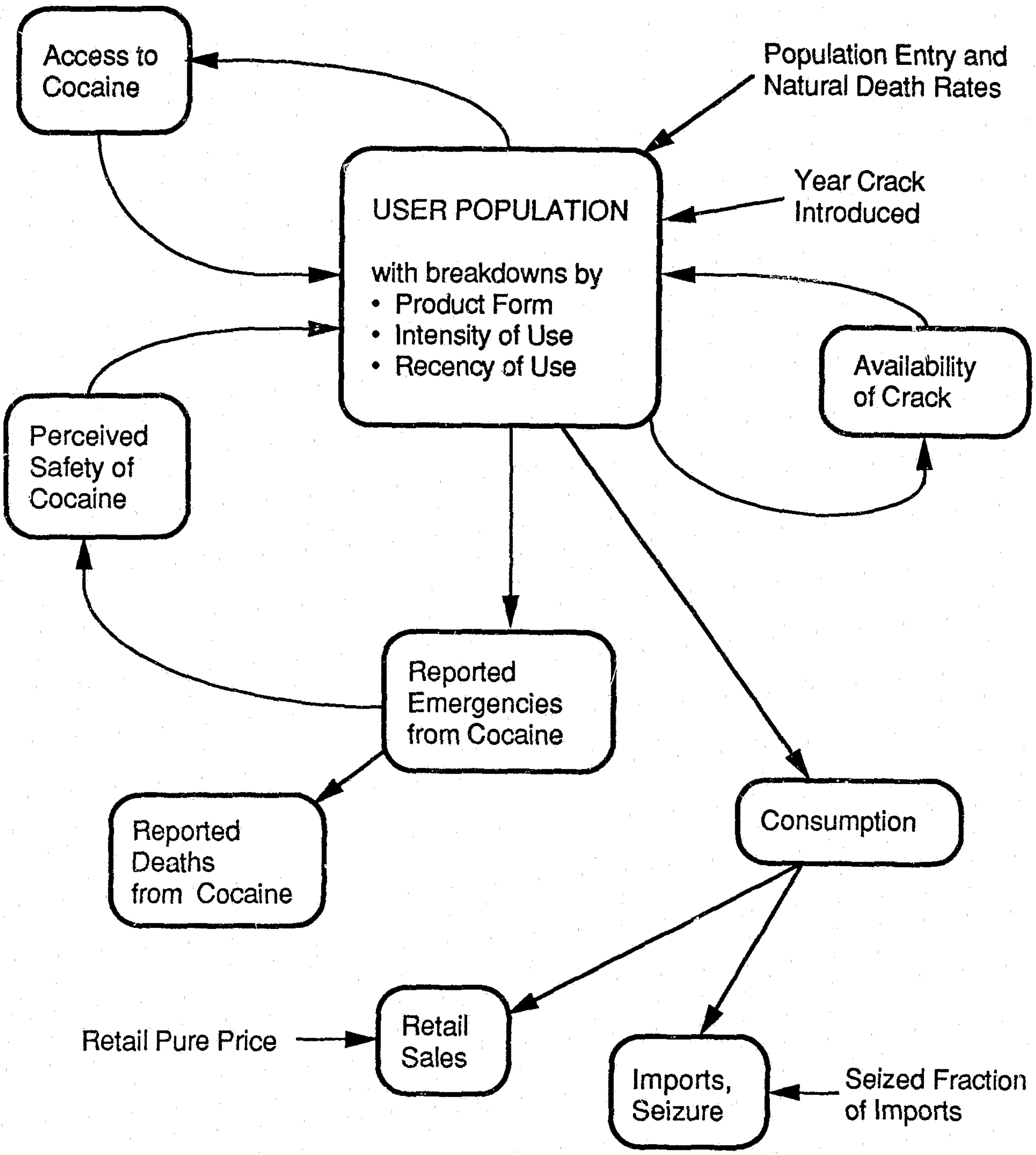

FIGURE 3. OVERVIEW OF CAUSAL INFLUENCES IN "COCAPOP" MODEL

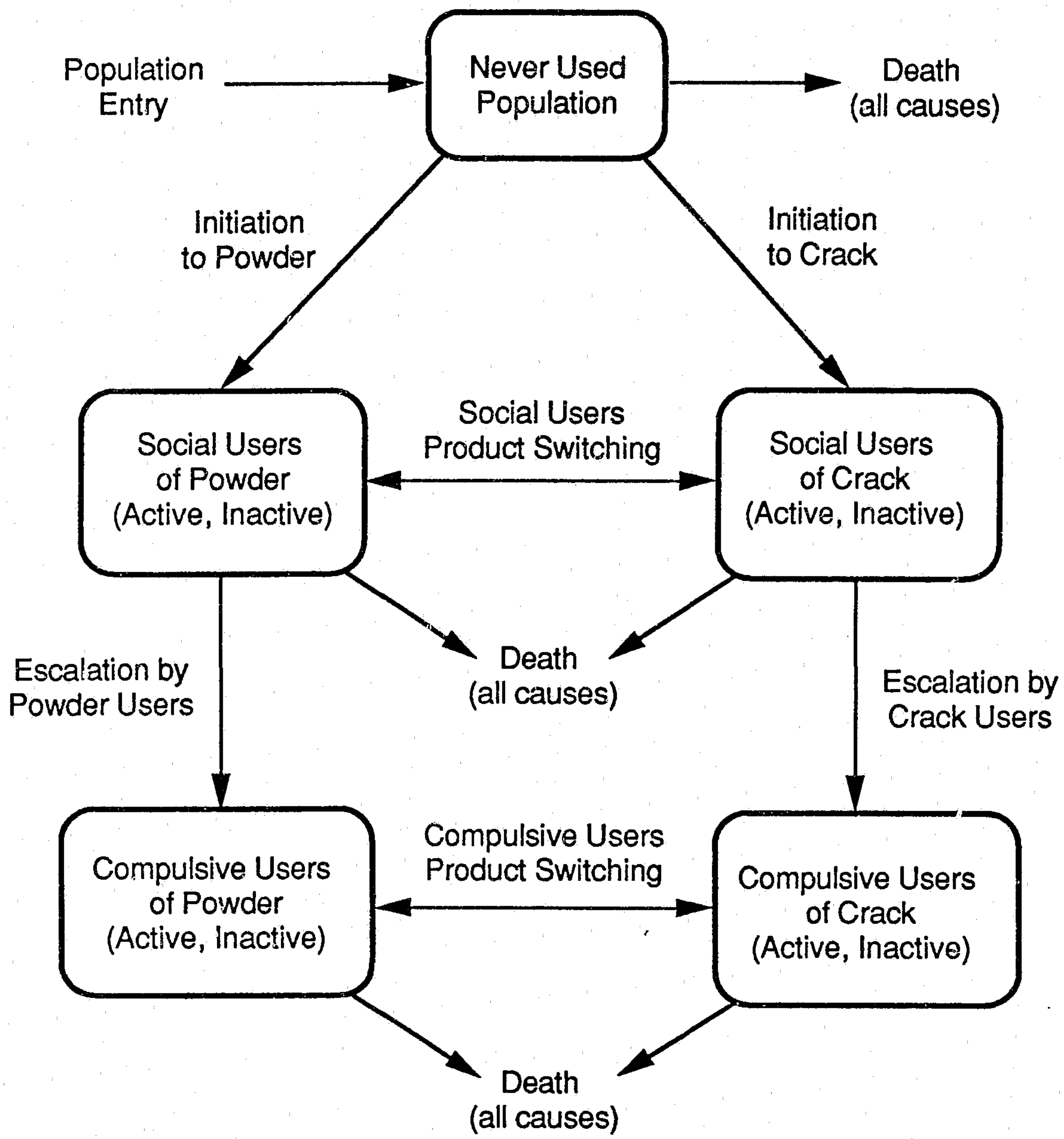

FIGURE 4. MAJOR POPULATION CATEGORIES AND THEIR CONNECTING FLOWS

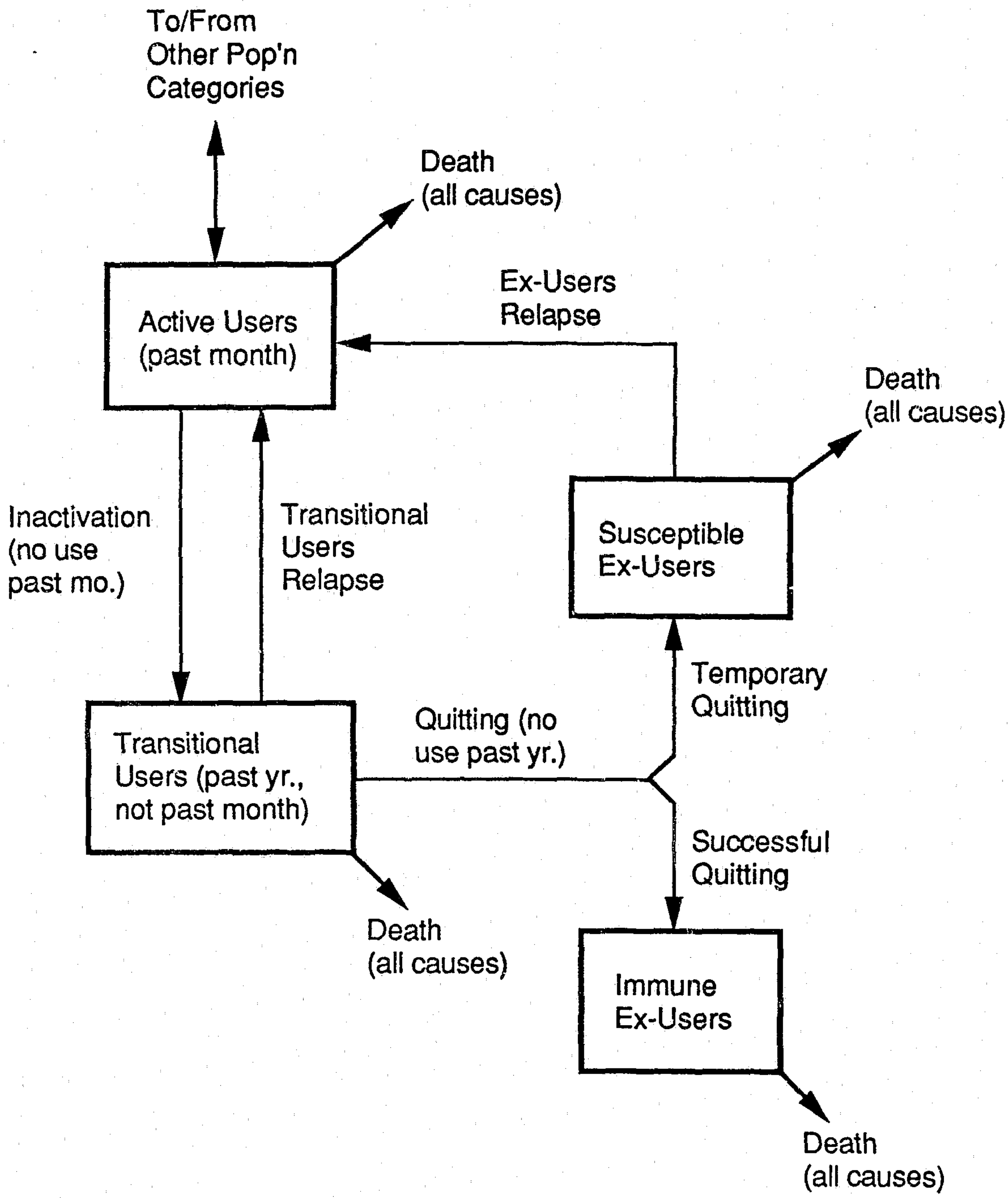

FIGURE 5. GENERIC WITHIN-CATEGORY STOCK AND FLOW DETAIL

(structure replicated for each of four major user categories in Figure 4)

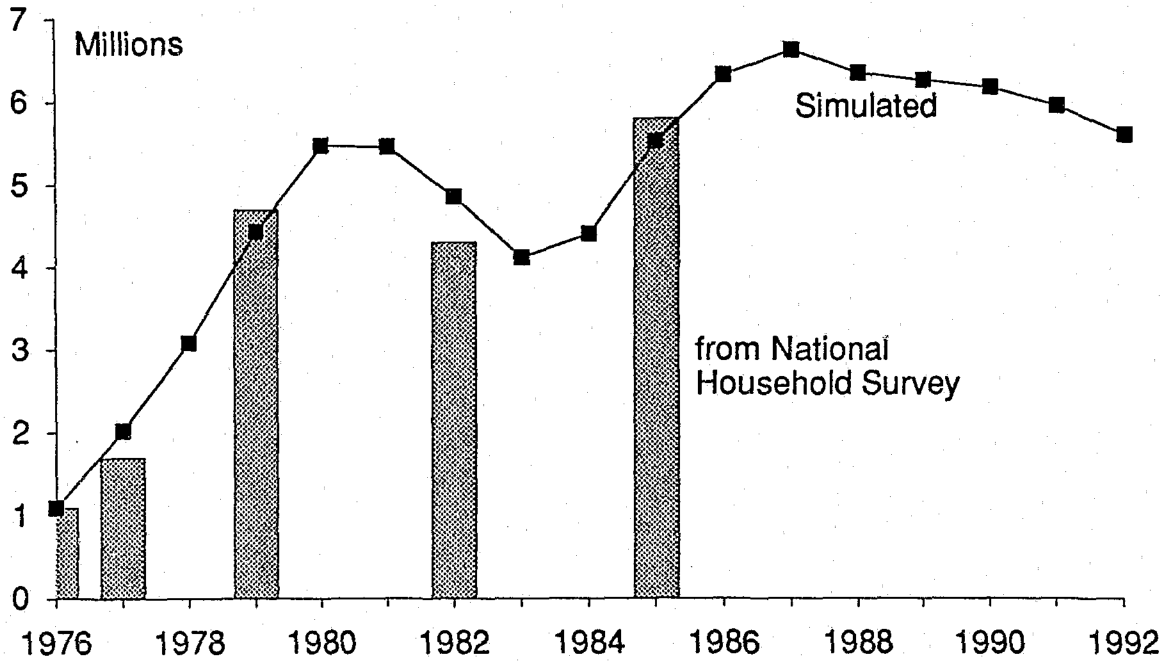

Figure 6. Total Active Users (AU)

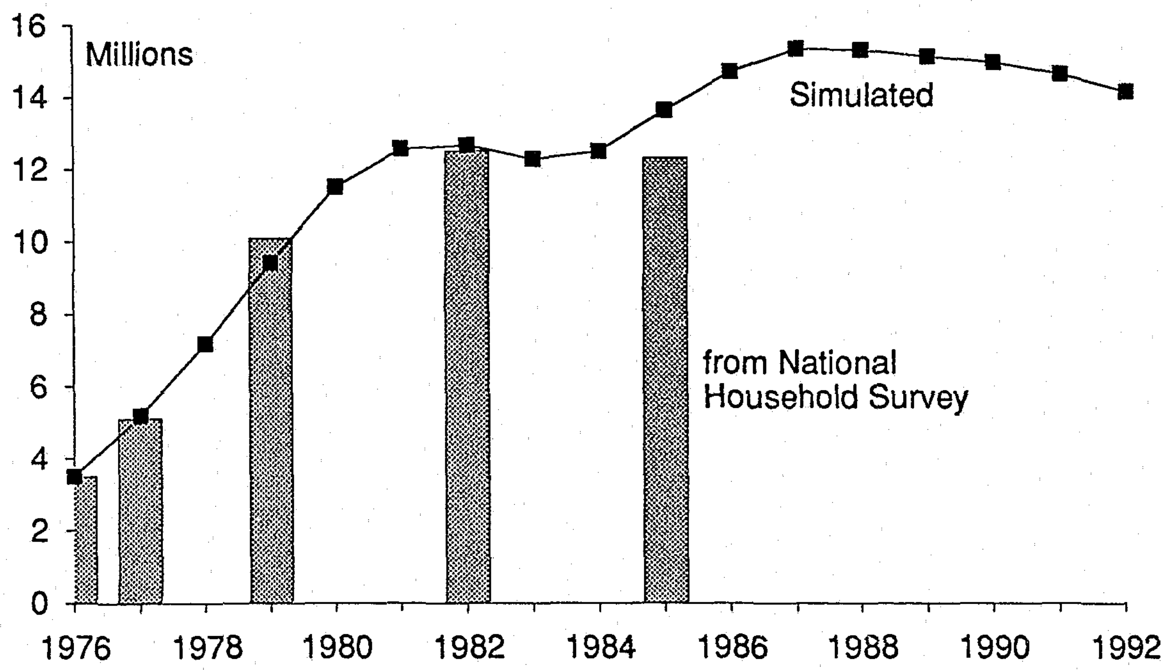

Figure 7. Total Past Year Users (PYU)

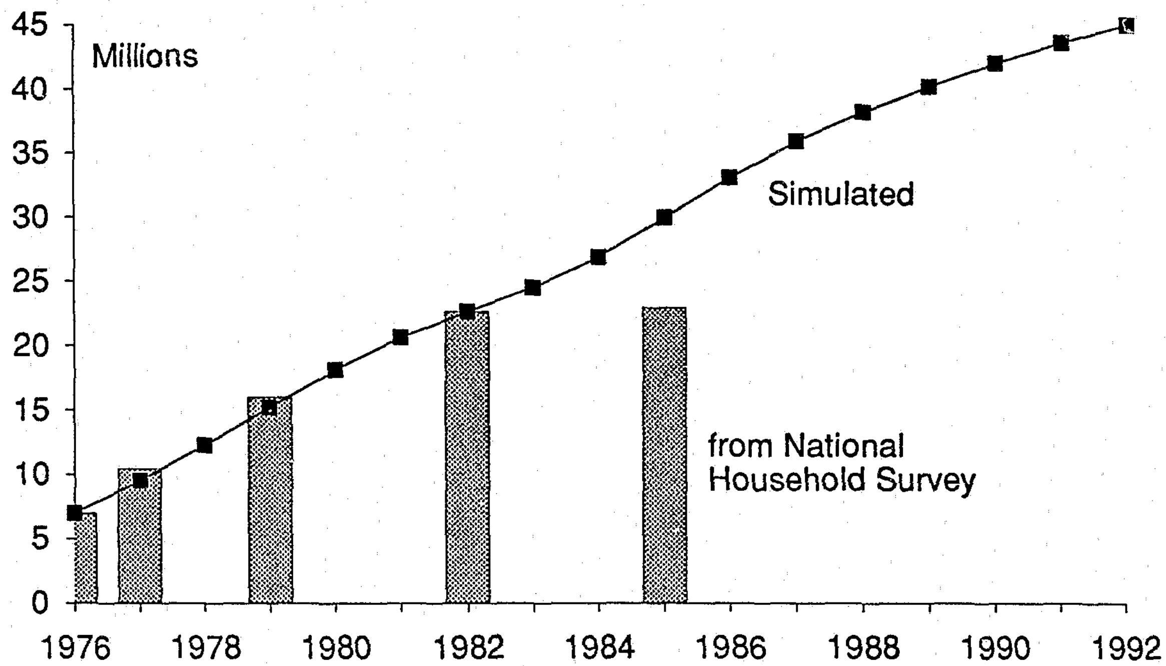

Figure 8. Ever Used Population (EUPOP)

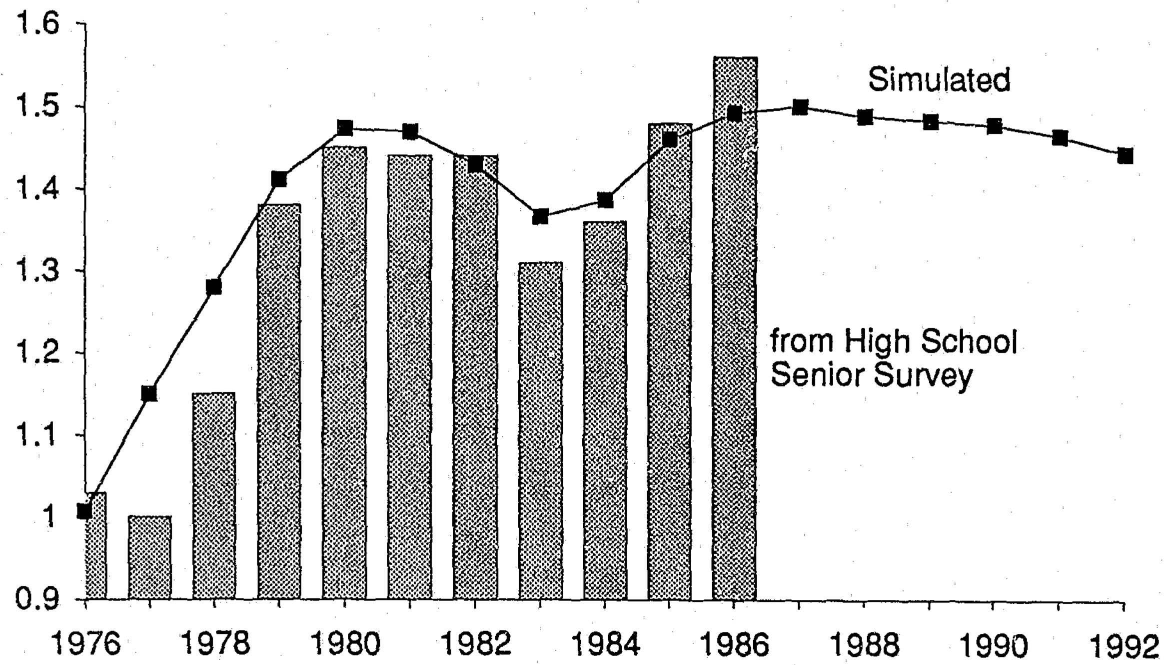

Figure 9. Relative Access to Cocaine (RAC)

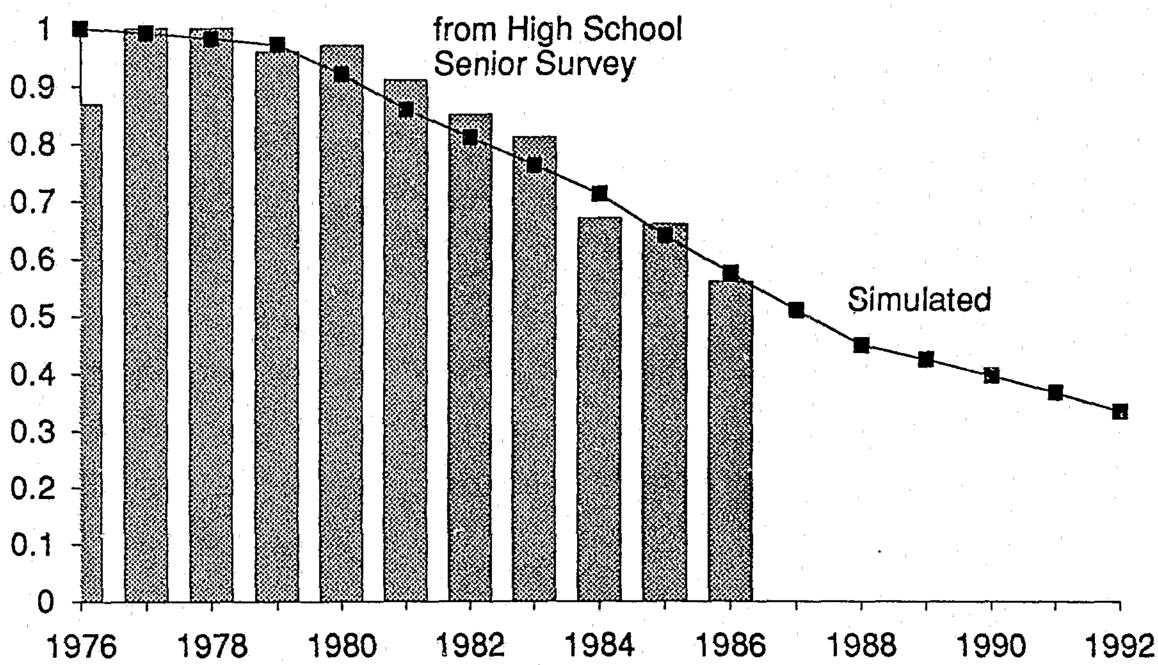

Figure 10. Relative Perceived Safety (RPS)

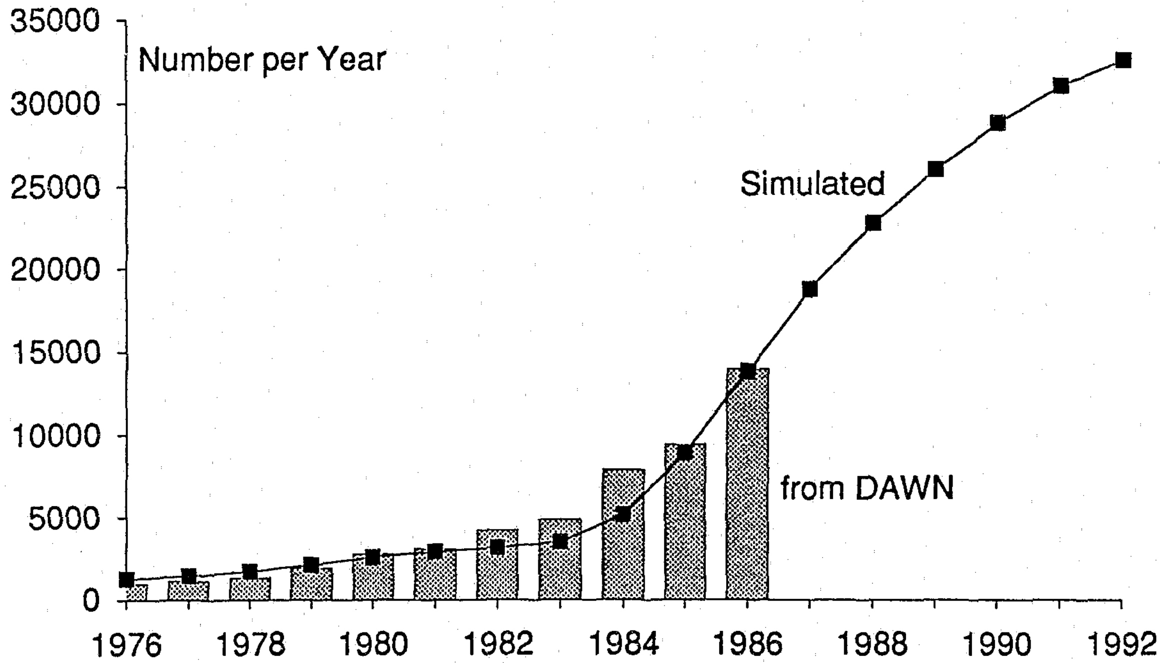

Figure 11. DAWN Reported Emergencies from Cocaine (DEM)

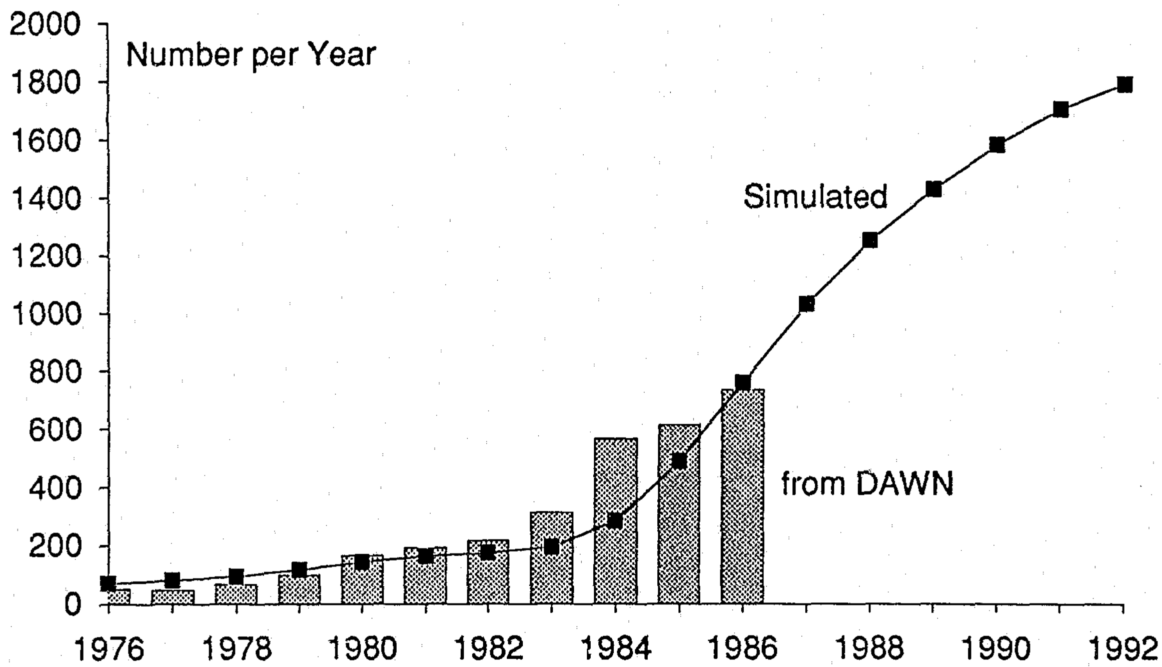

Figure 12. DAWN Reported Deaths from Cocaine (DD)

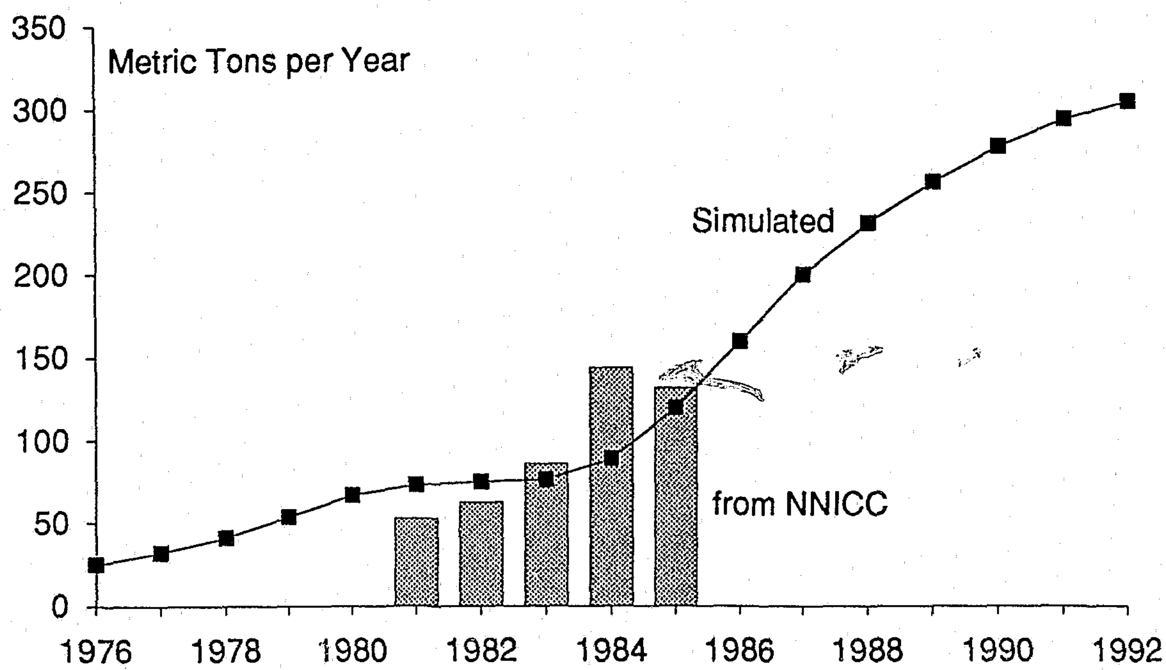

Figure 13. Imports before Seizure (IMP)

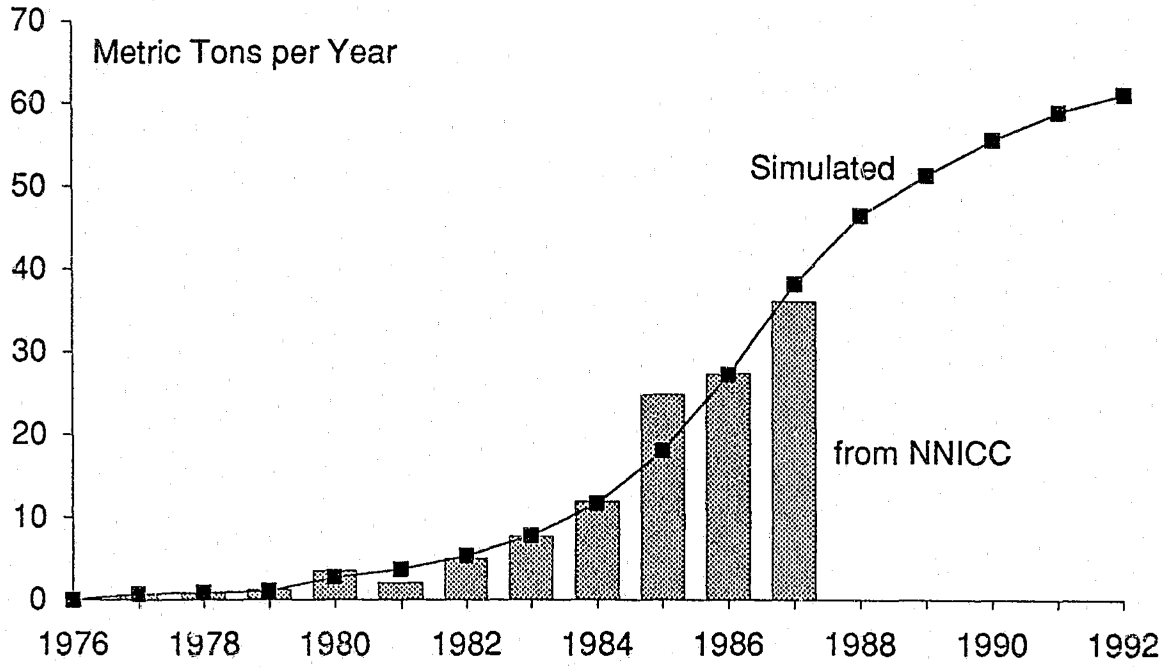

Figure 14. Seizures (SEIZ)

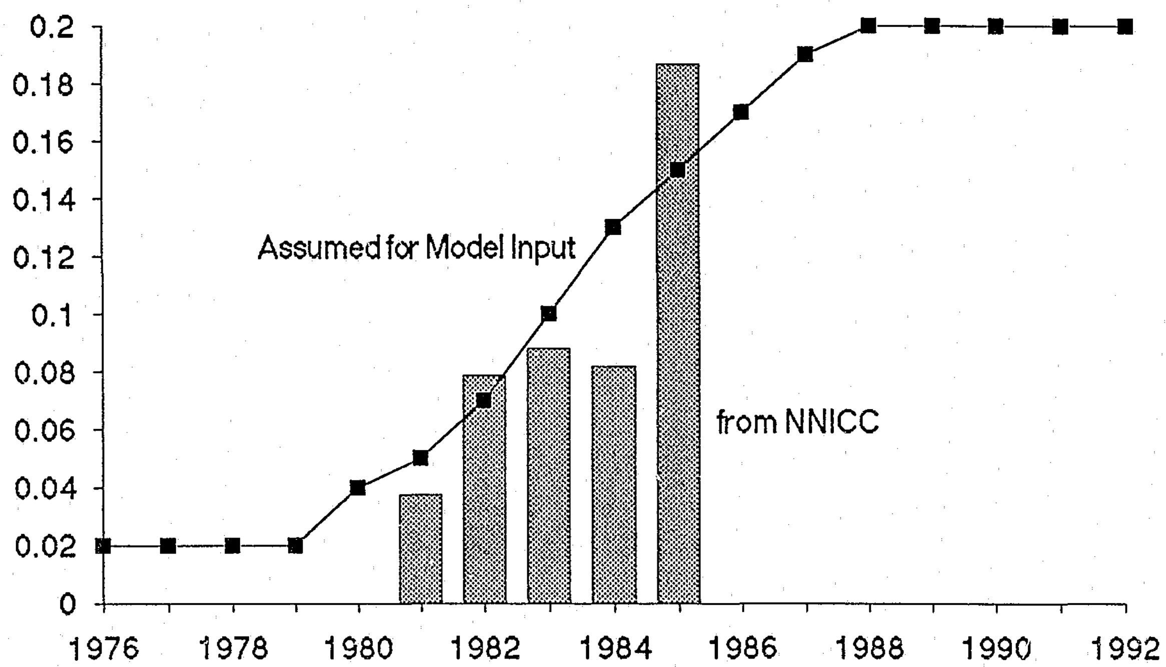

Figure 15. Seized Fraction of Imports (SEIZF)

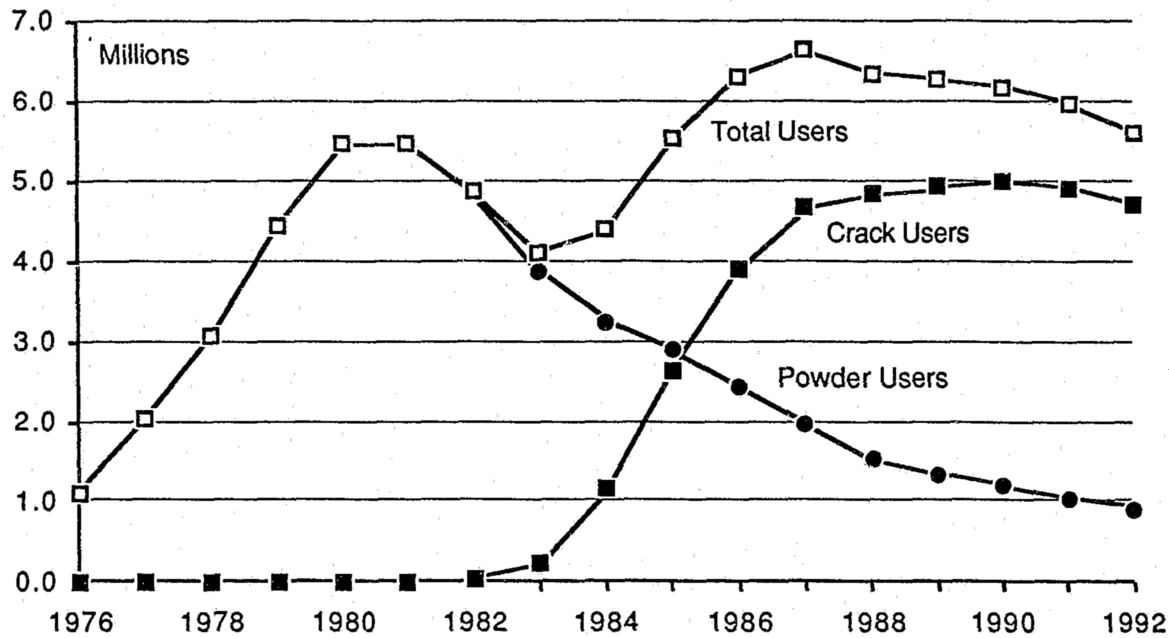

Figure 16. Total Active Users, by Product Type (AU, AUP, AUK)

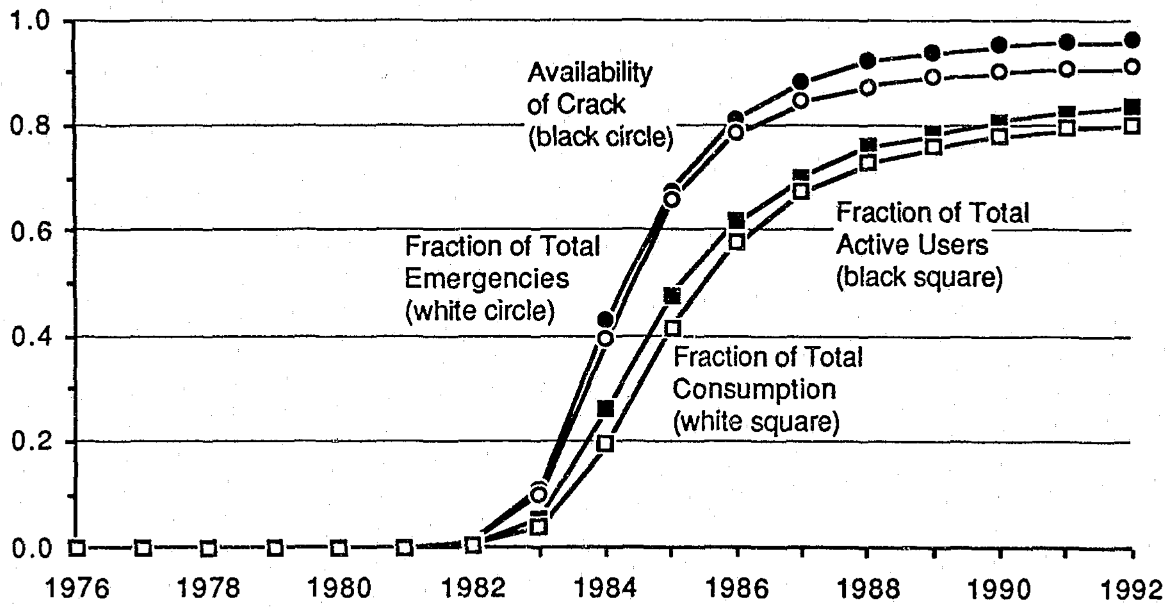

Figure 17. Crack Fractions (KFAU, KUFEM, KUFCON) and Availability (AK)

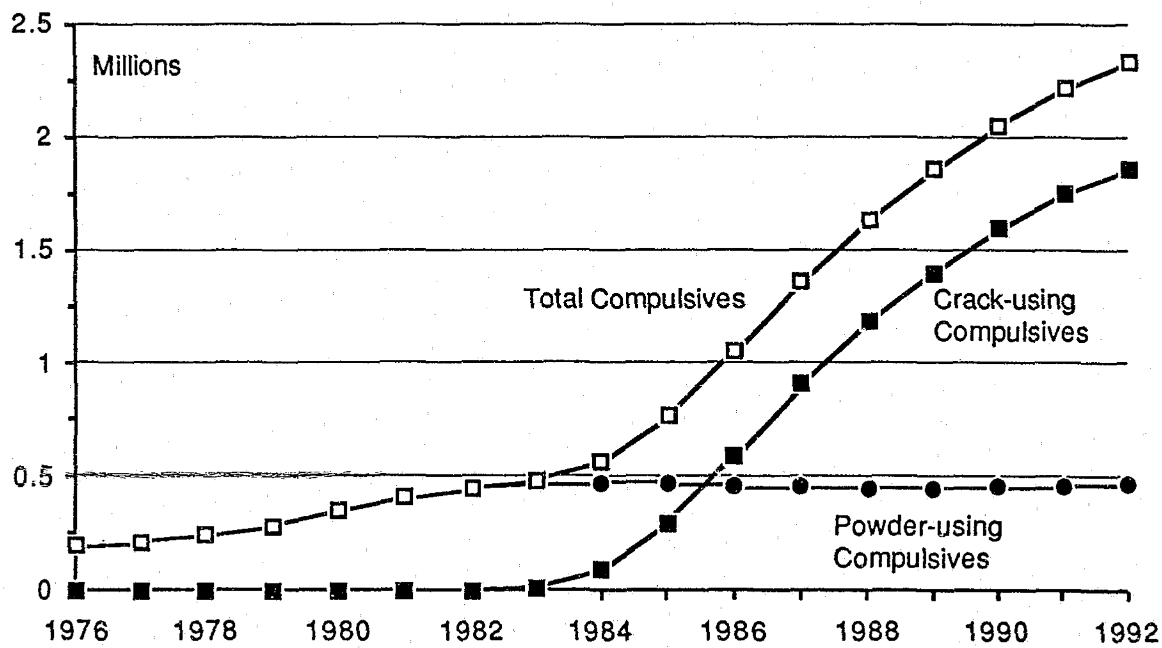

Figure 18. Compulsive Users, by Product Type (ACU, ACUP, ACUK)

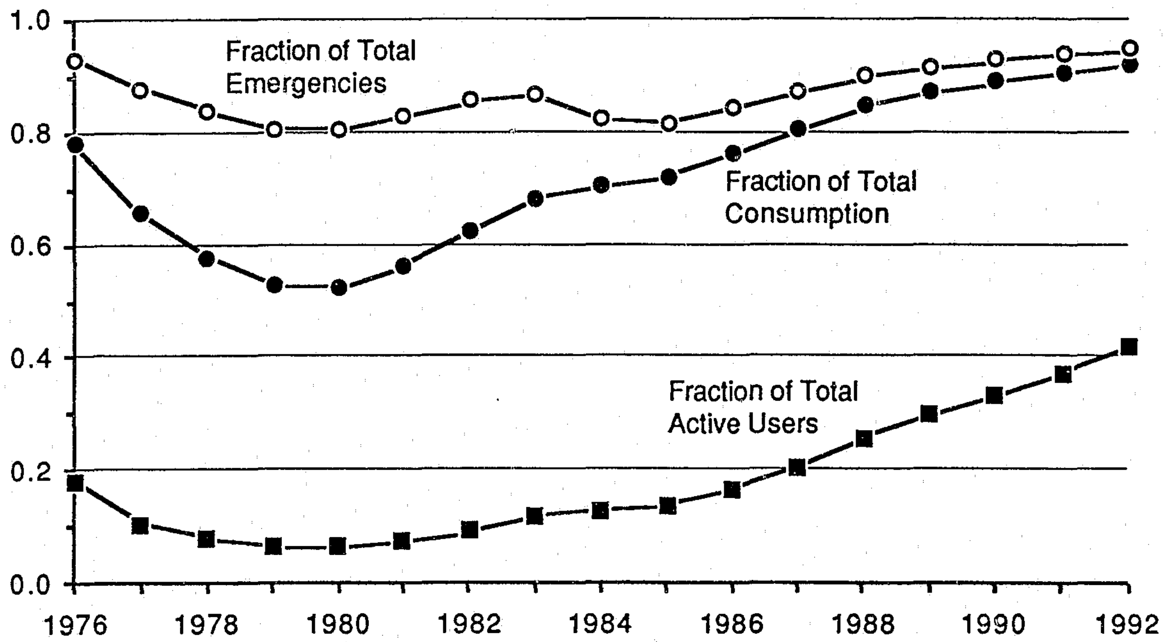

Figure 19. Compulsive Fractions (CFAU, CUFEM, CUFCON)

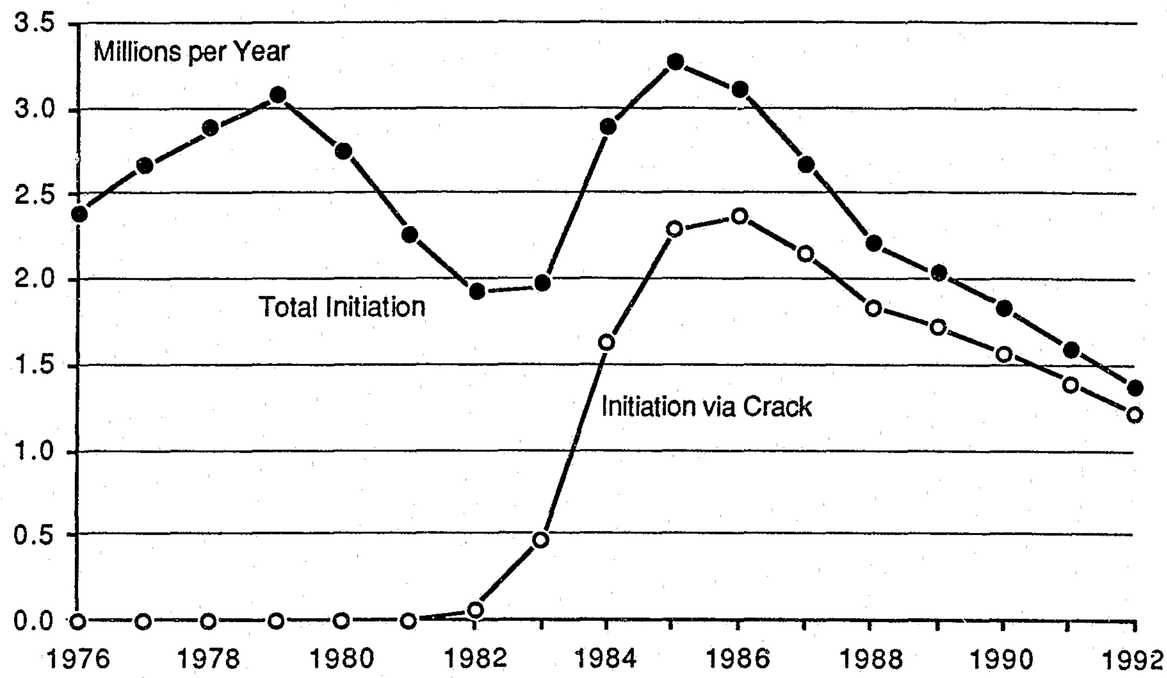

Figure 20. Initiation (IN, INK)

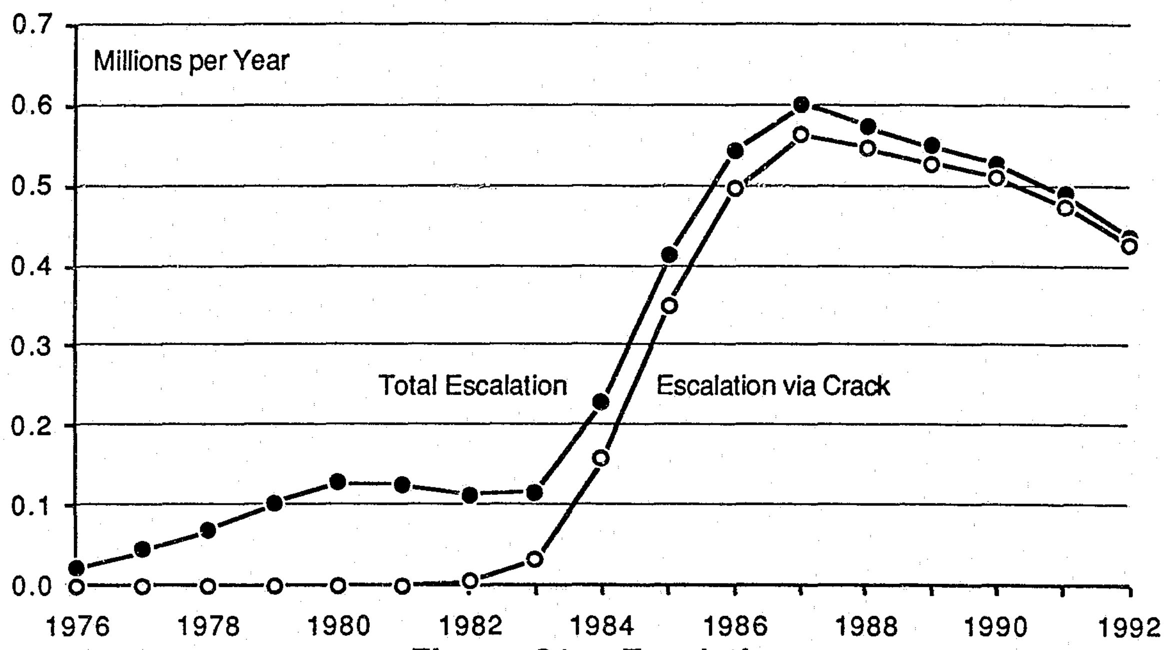

Figure 21. Escalation (ESC, ESCK)

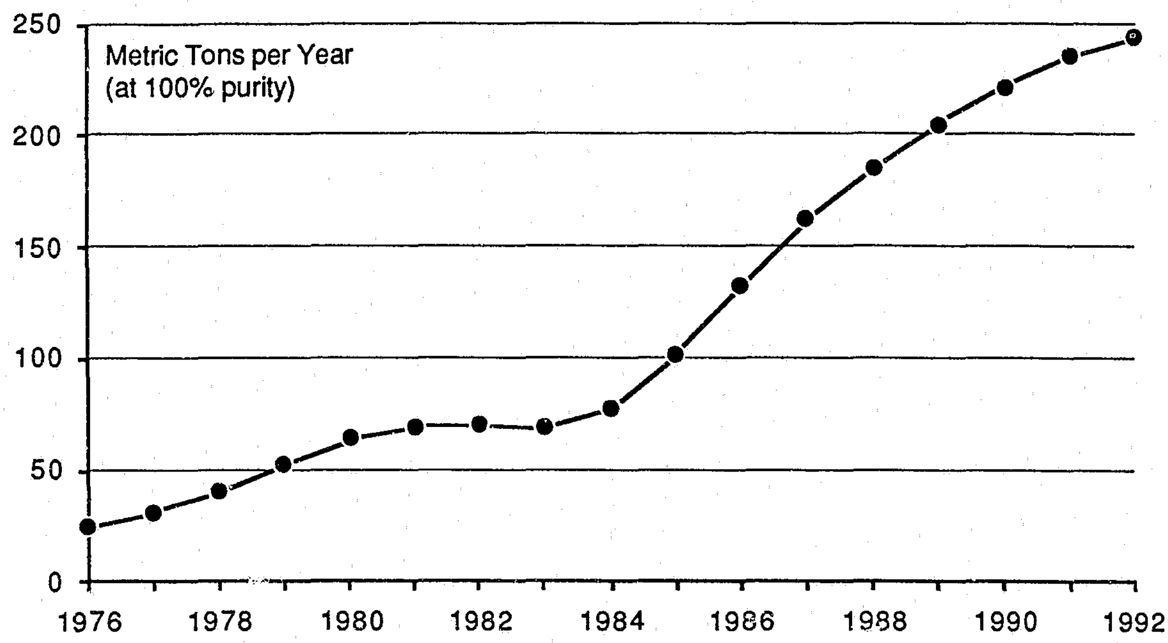

Figure 22. Total Pure Consumption (CON)

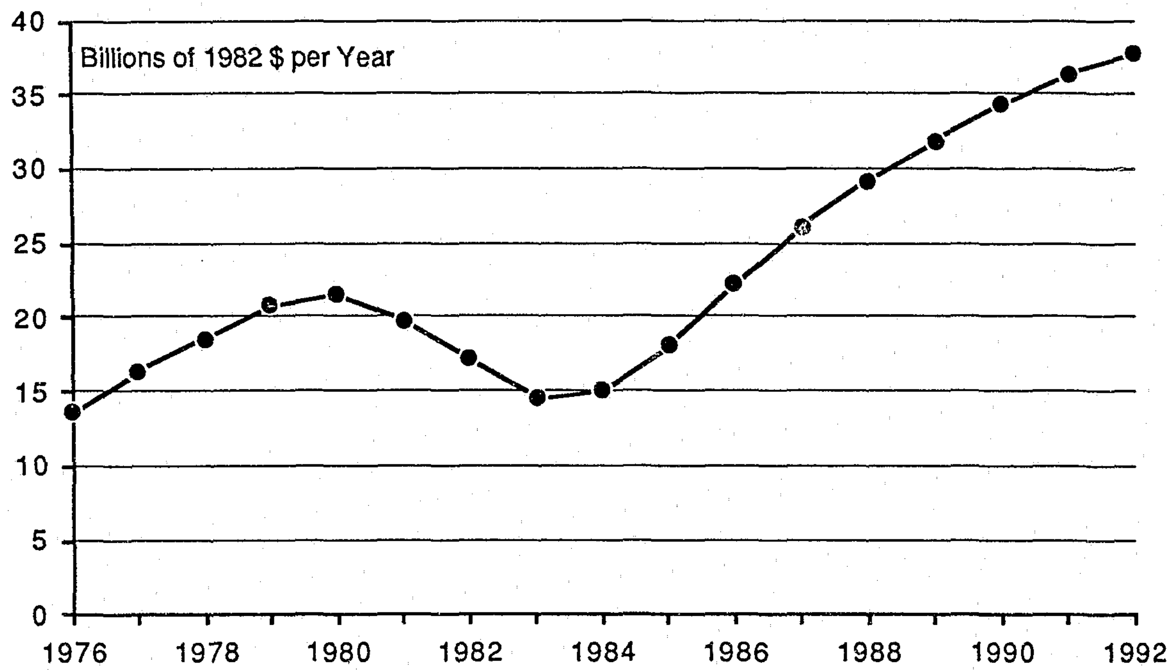

Figure 23. Retail Sales (RSALES)

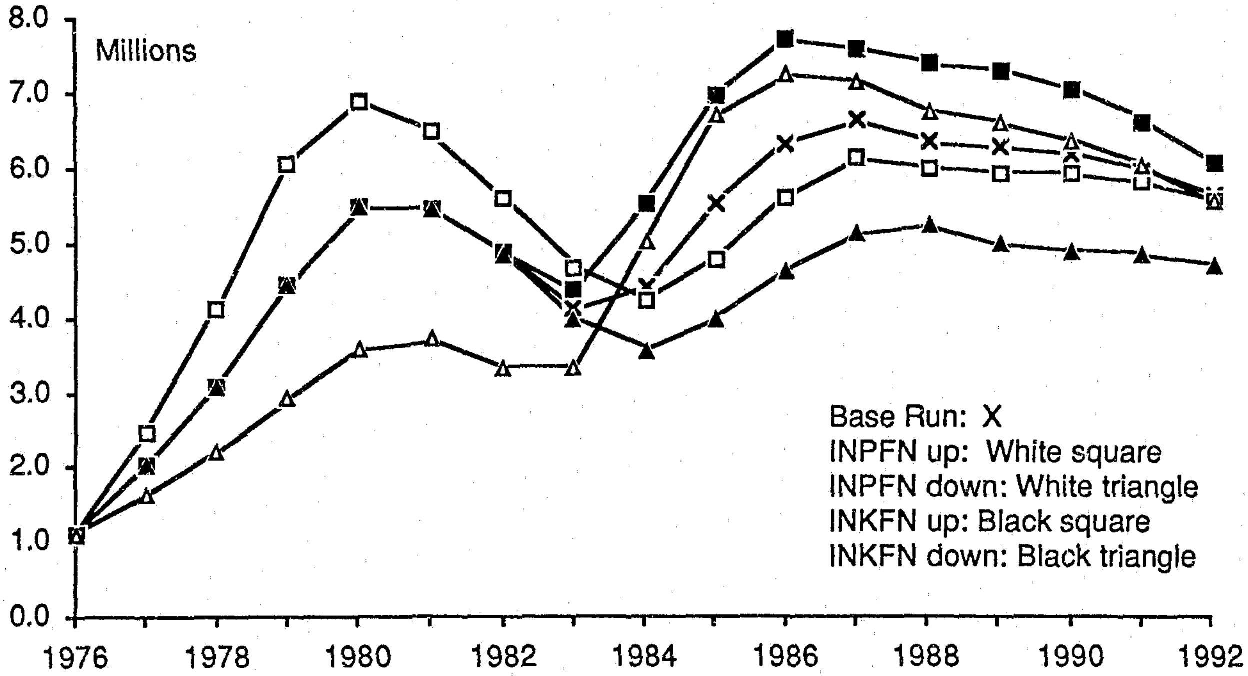

Figure 24. Total Active Users: Initiation Fractions (INPFN, INKFN)

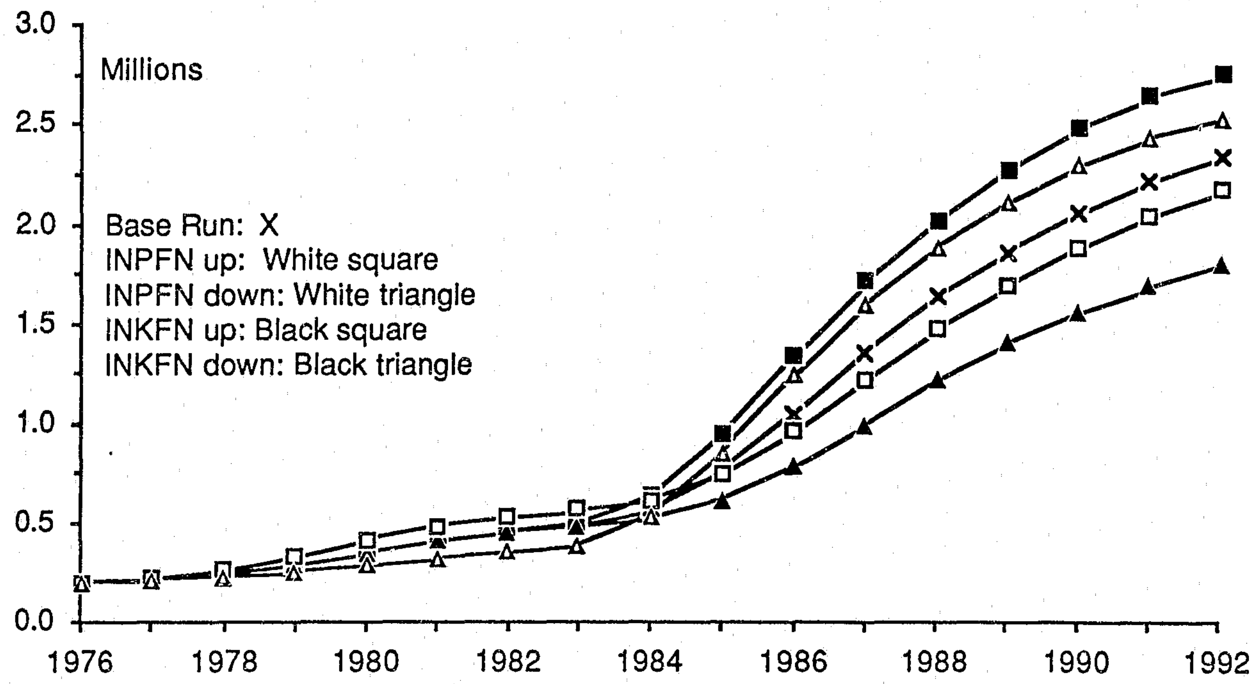

Figure 25. Active Compulsives: Initiation Fractions (INPFN, INKFN)

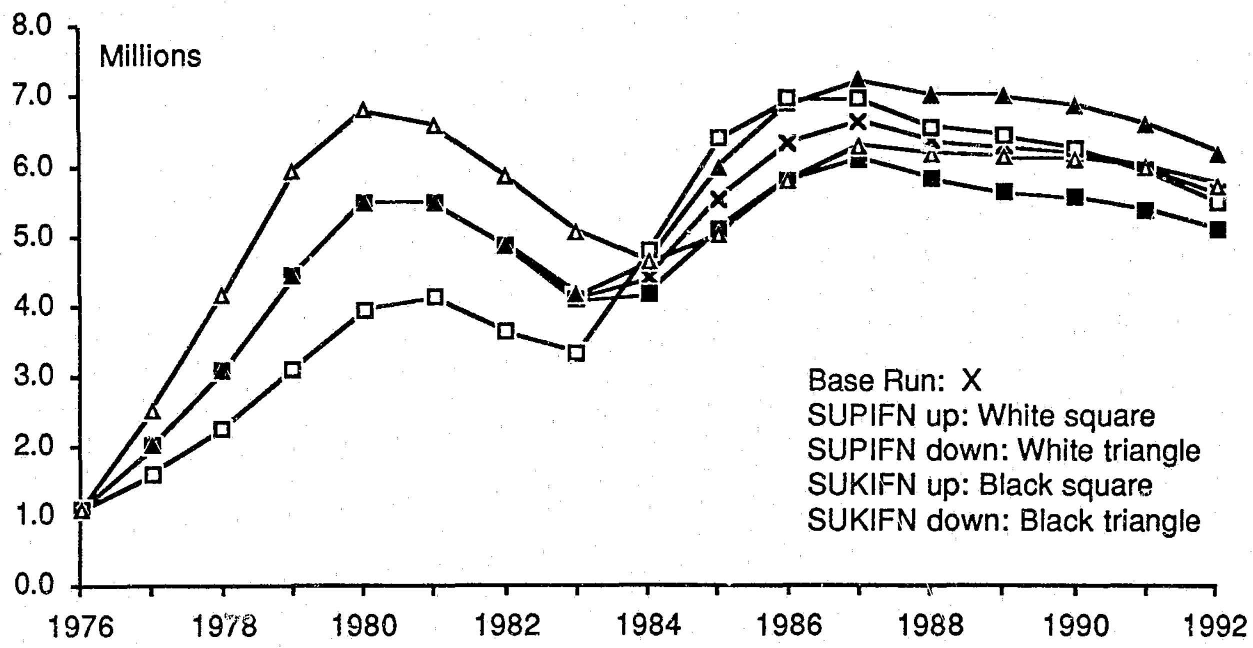

Figure 26. Total Active Users: Socials' Inactivation Fractions (SUPIFN, SUKIFN)

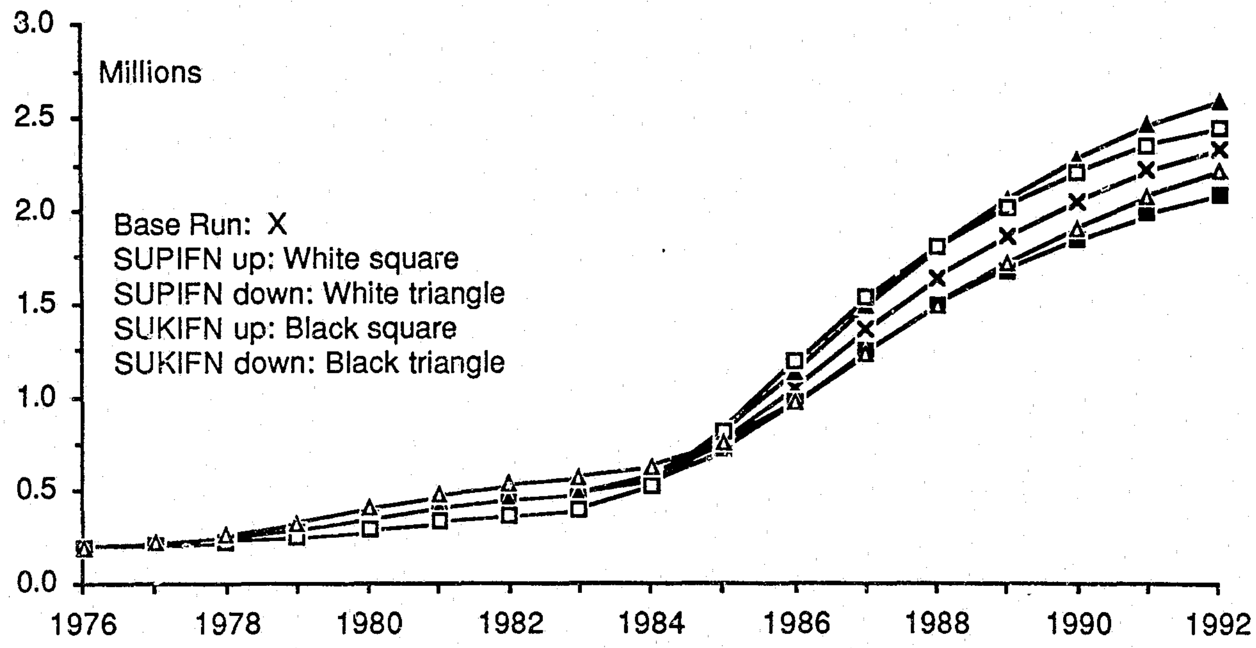

Figure 27. Active Compulsives: Socials' Inactivation Fractions (SUPIFN, SUKIFN)

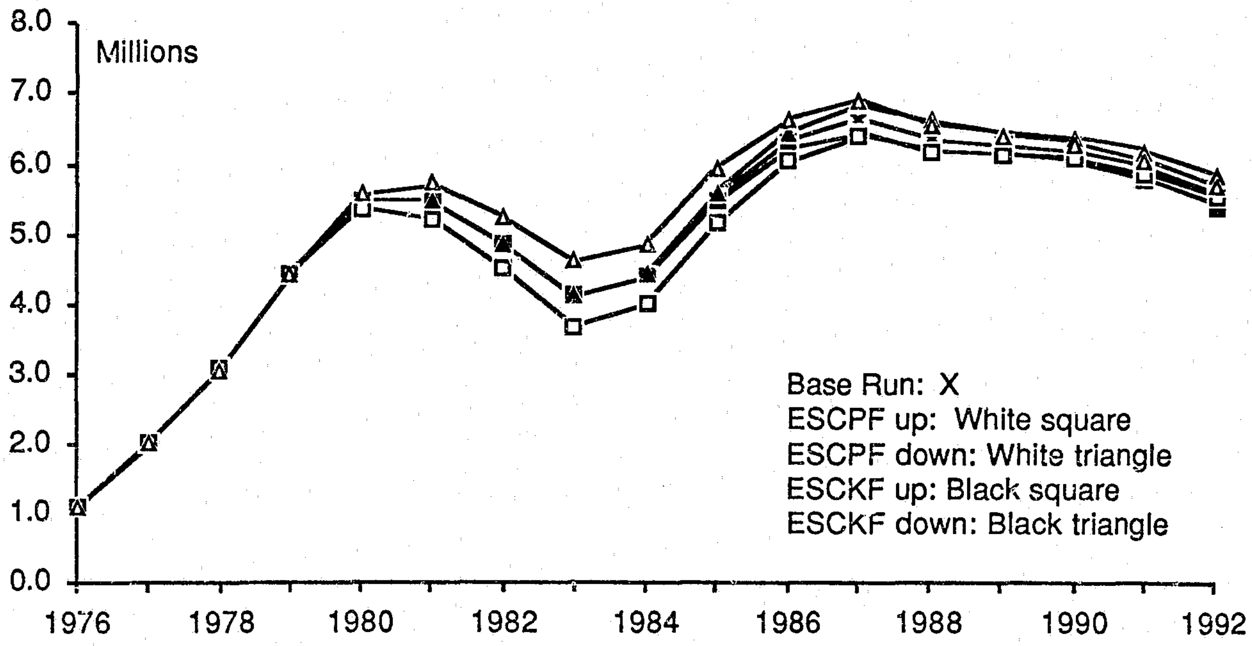

Figure 28. Total Active Users: Escalation Fractions (ESCPF, ESCKF)

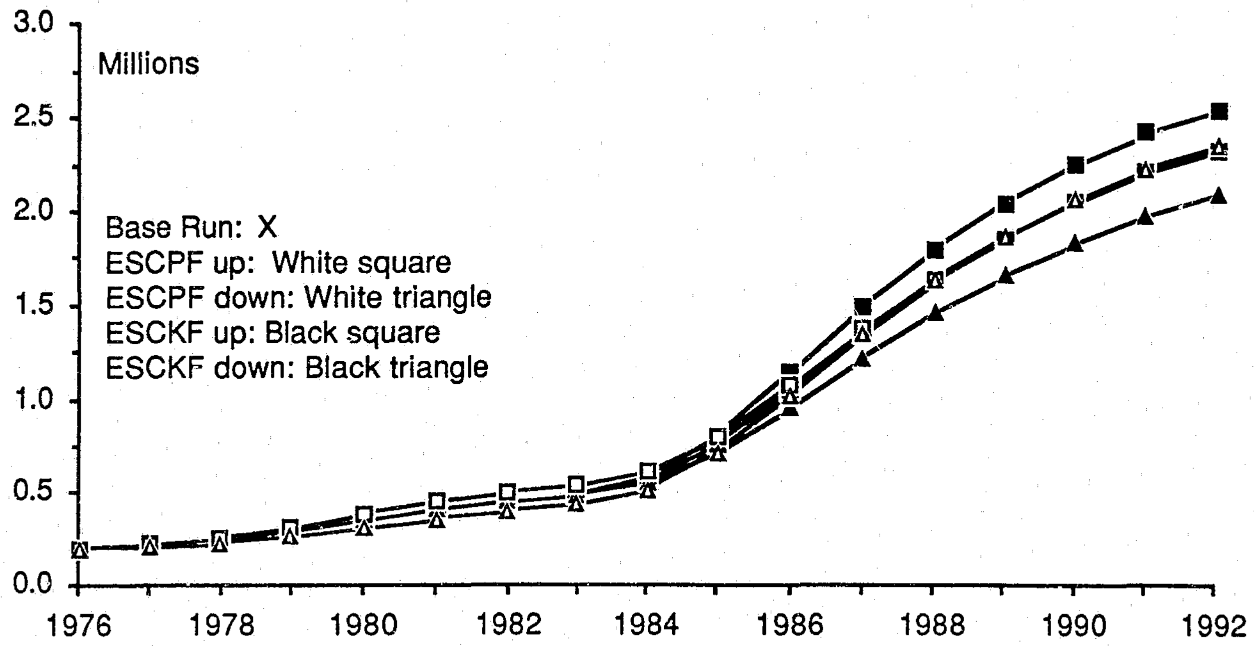

Figure 29. Active Compulsives: Escalation Fractions (ESCPF, ESCKF)

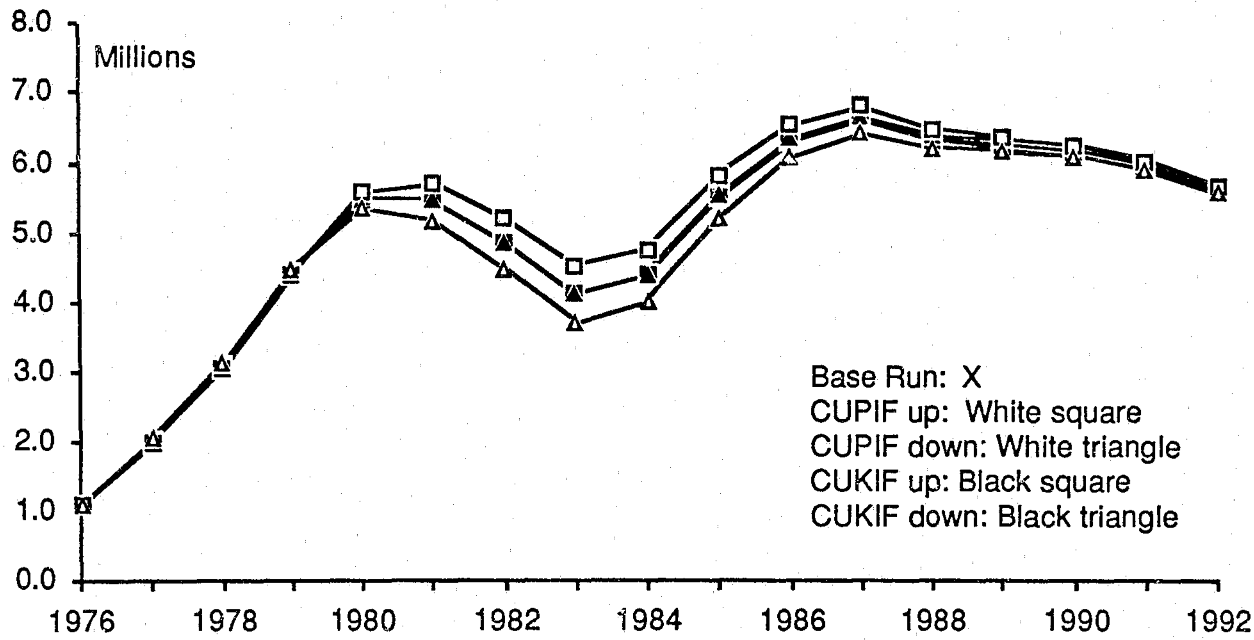

Figure 30. Total Active Users: Compulsives' Inactivation Fractions (CUPIF, CUKIF)

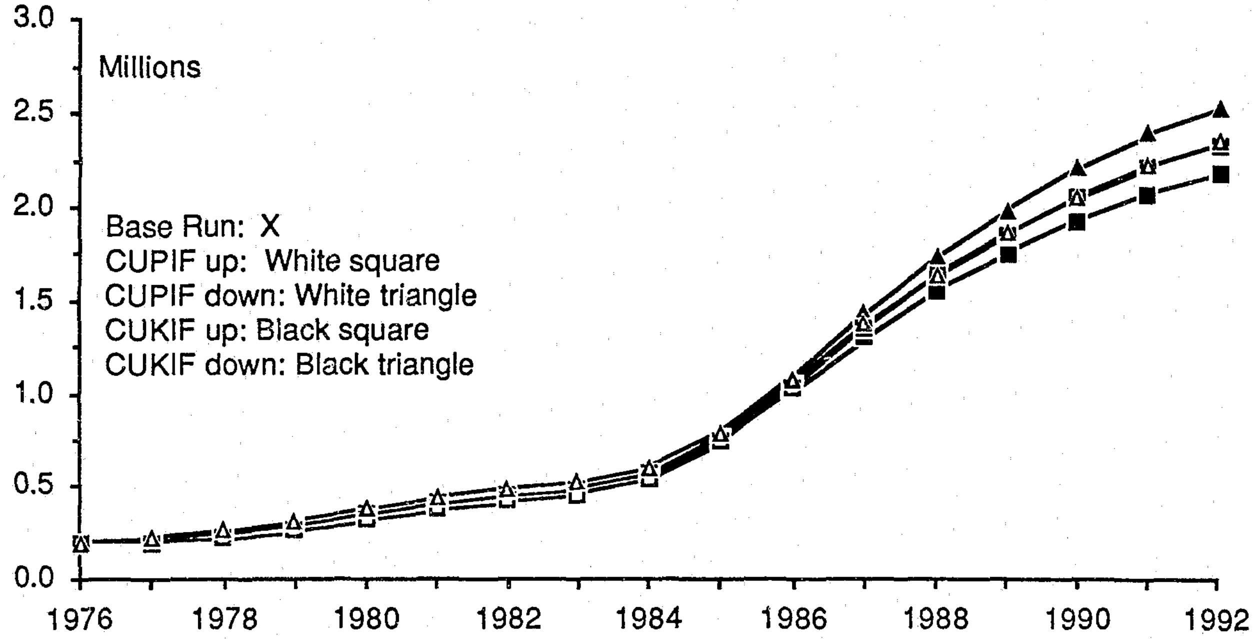

Figure 31. Active Compulsives: Compulsives' Inactivation Fractions (CUPIF, CUKIF)

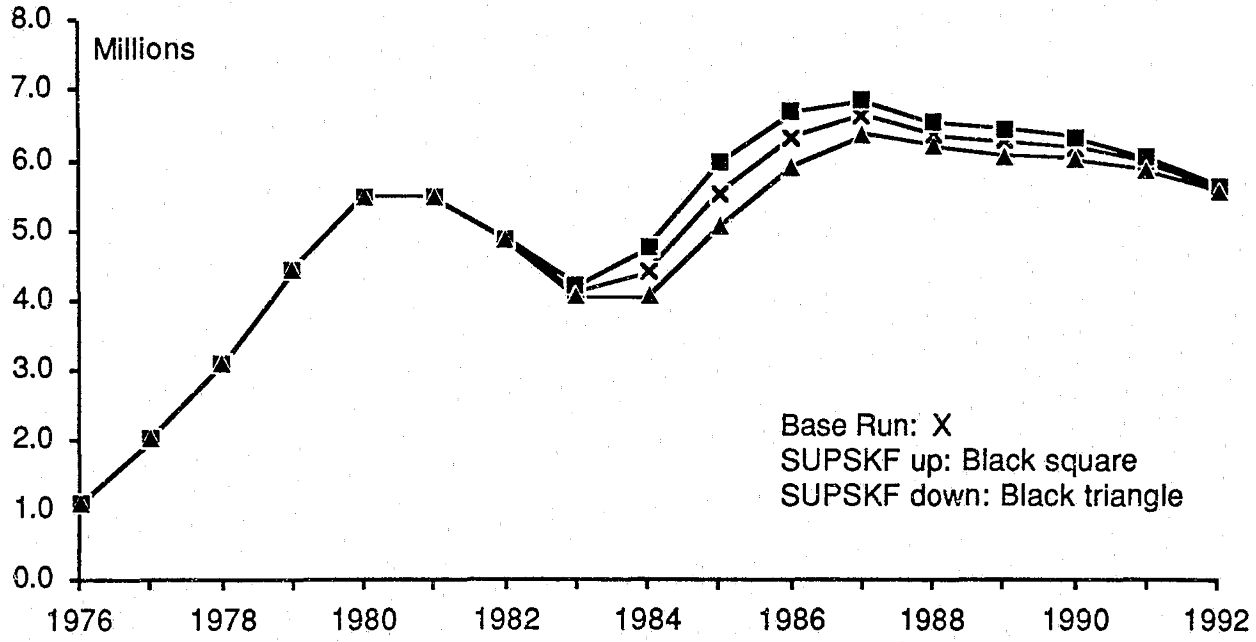

Figure 32. Total Active Users: Social Users' Switch-to-Crack Fraction (SUPSKF)

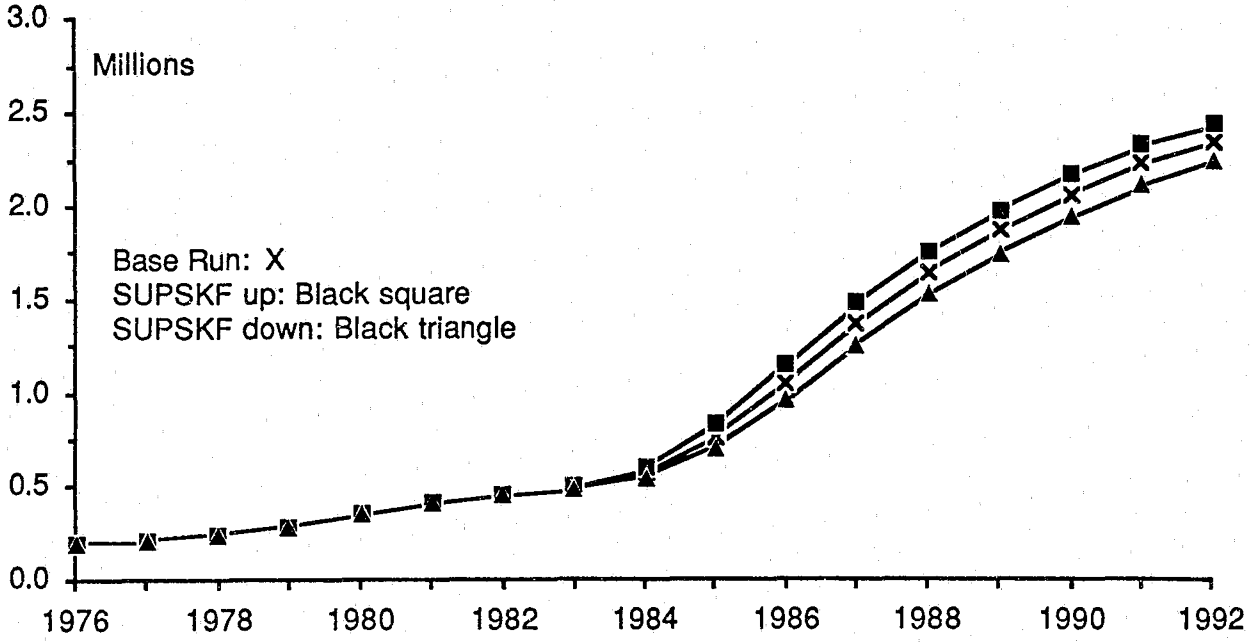

Figure 33. Active Compulsives: Social Users' Switch-to-Crack Fraction (SUPSKF)

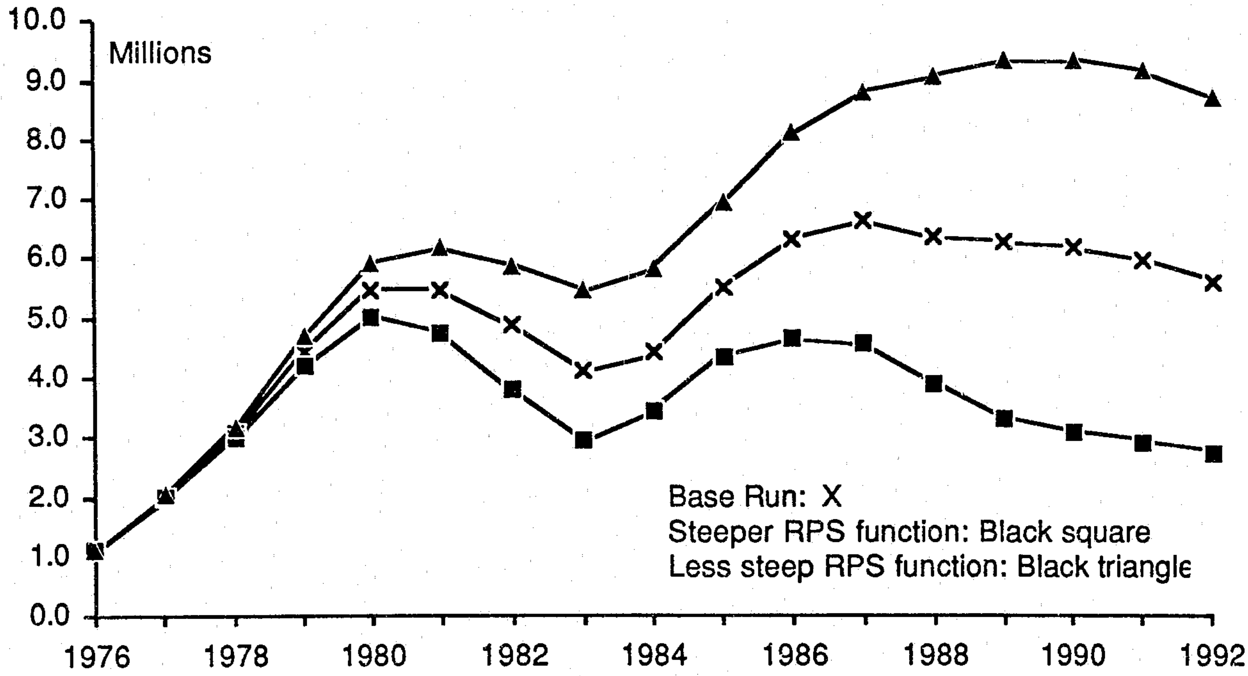

Figure 34. Total Active Users: Relative Perceived Safety (RPS)

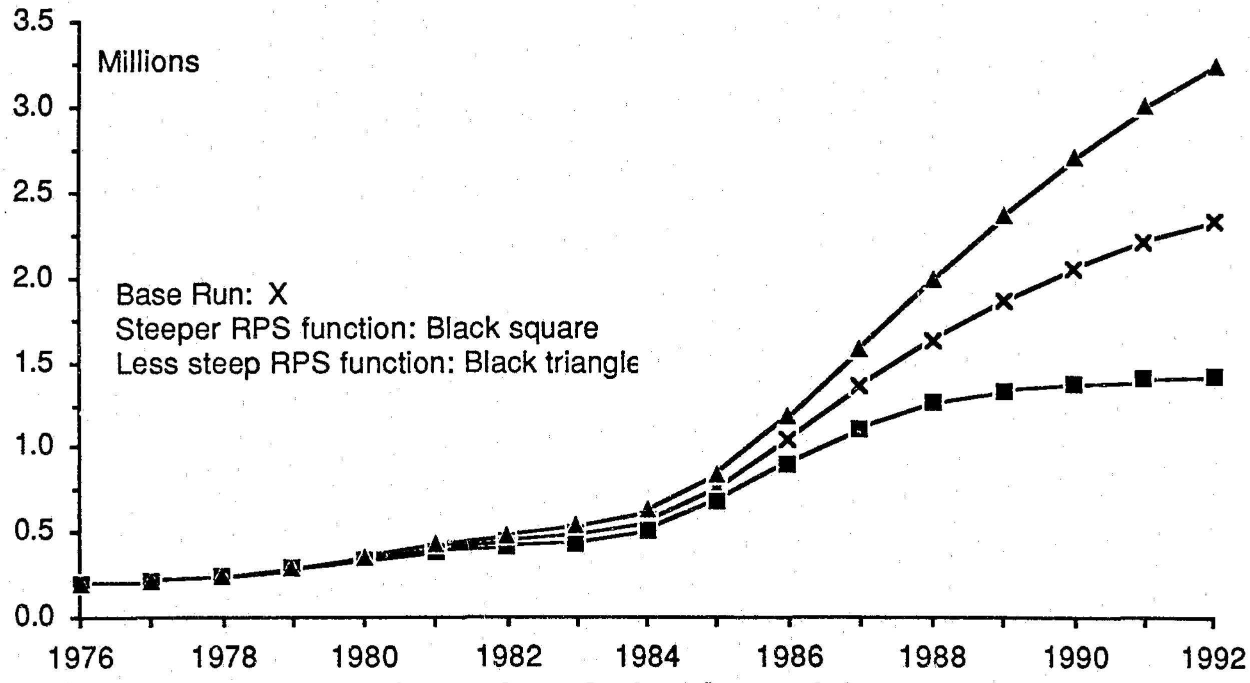

Figure 35. Active Compulsives: Relative Perceived Safety (RPS)

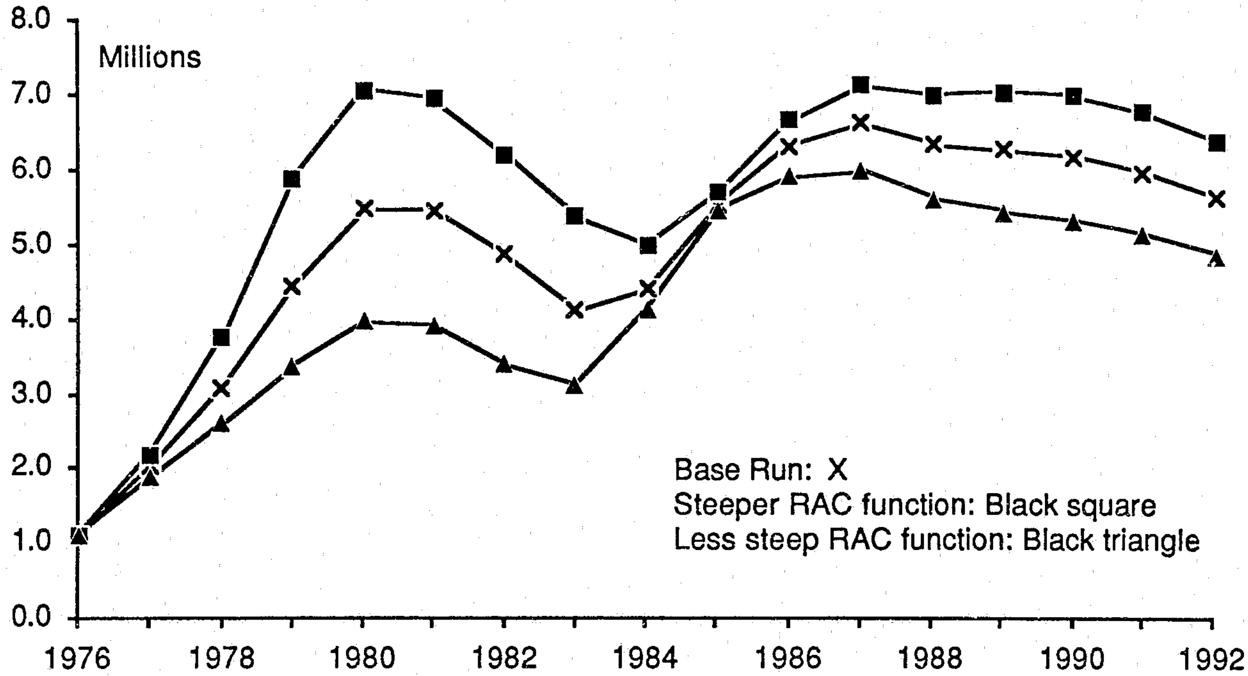

Figure 36. Total Active Users: Relative Access to Cocaine (RAC)

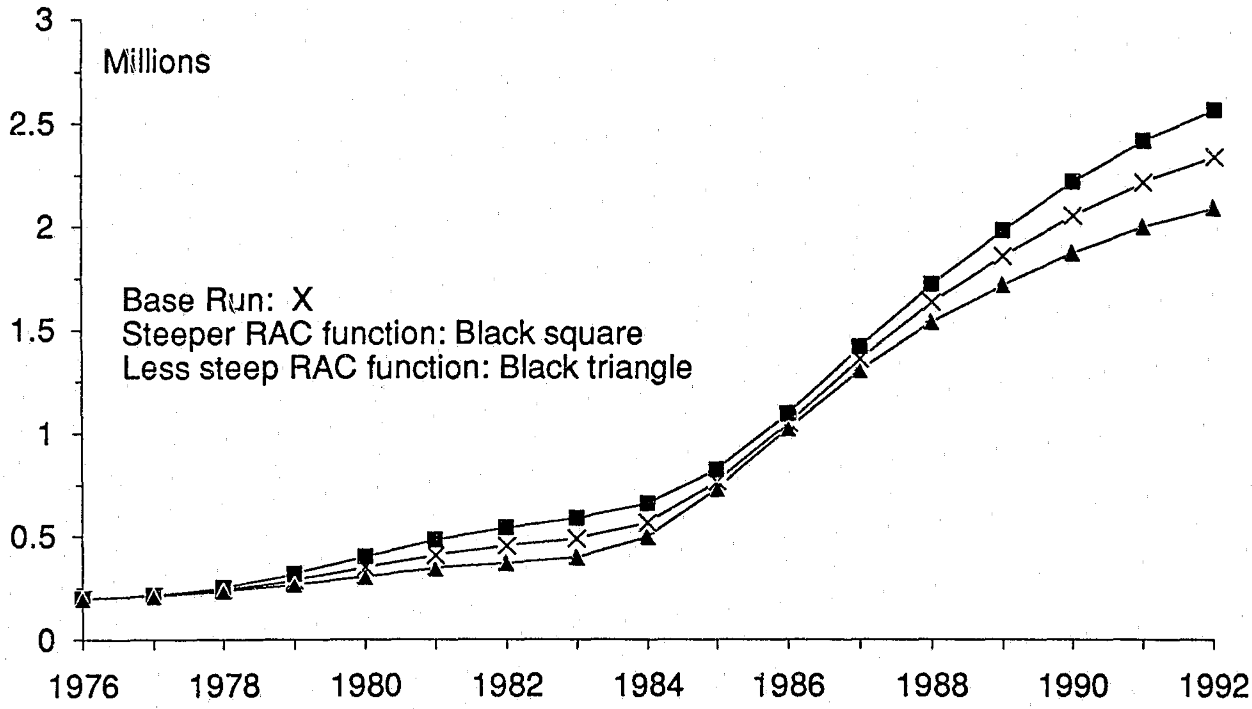

Figure 37. Active Compulsives: Relative Access to Cocaine (RAC)

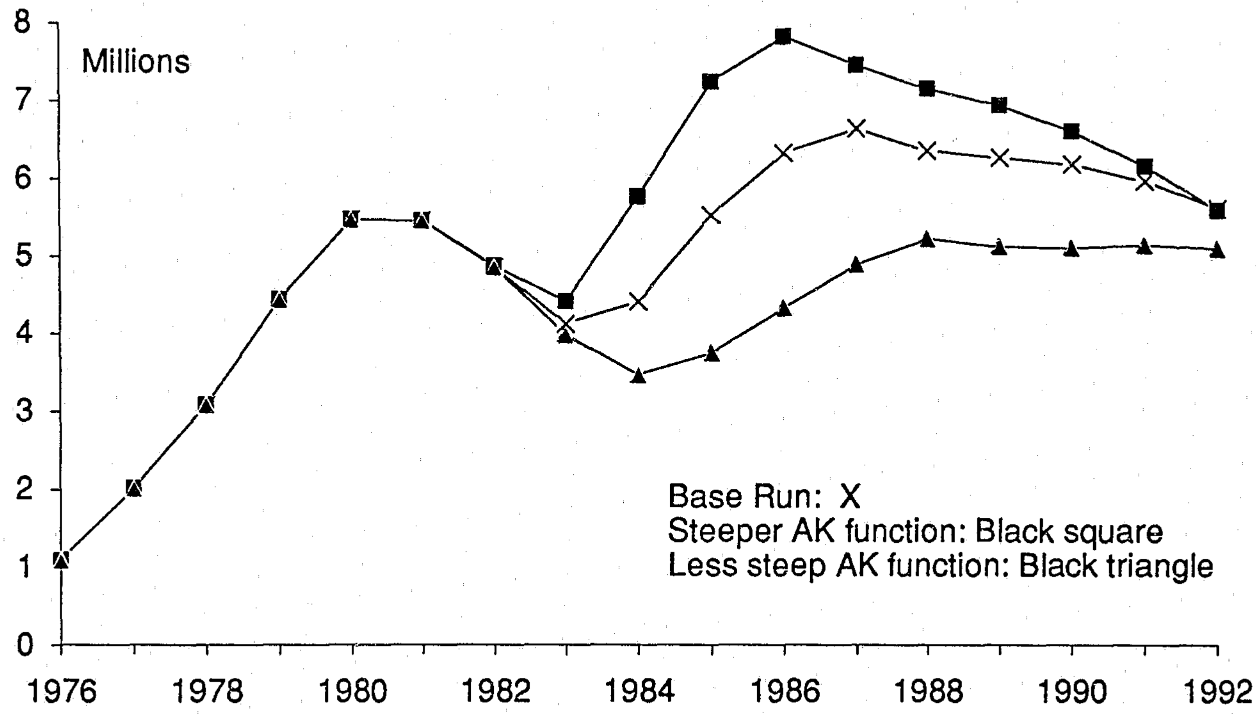

Figure 38. Total Active Users: Availability of Crack (AK)

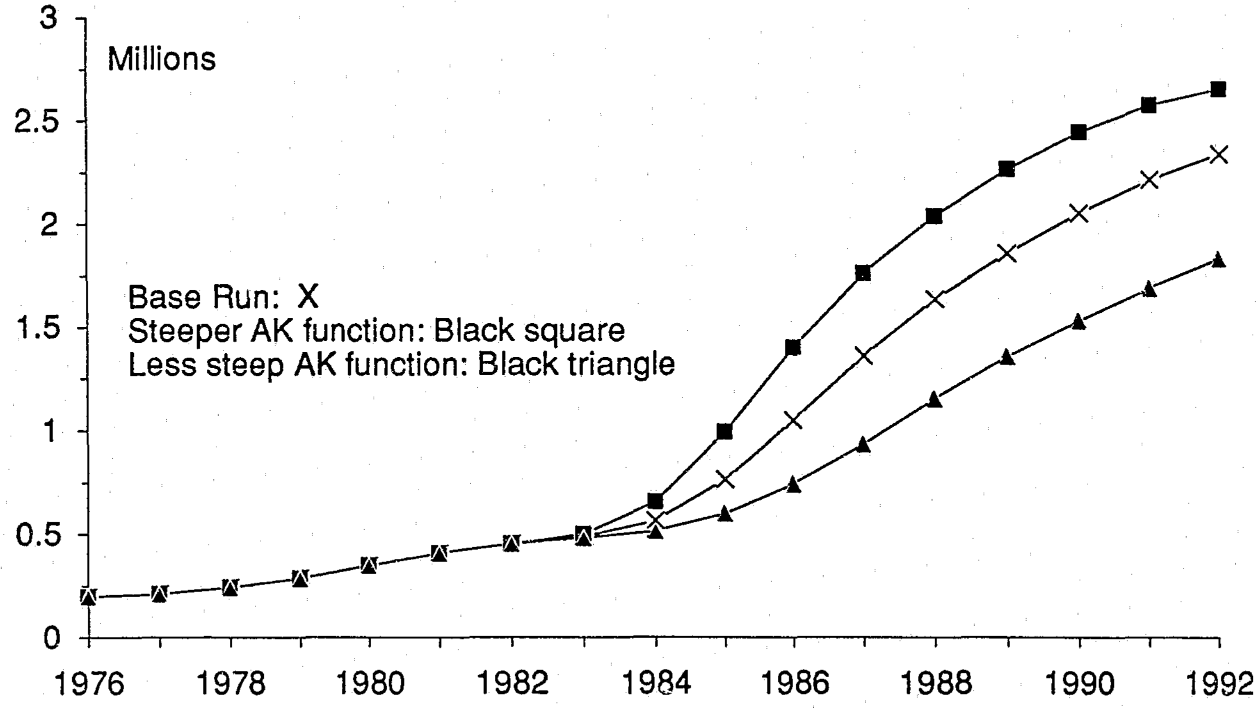

Figure 39. Active Compulsives: Availability of Crack (AK)