Estimation of Heroin Availability 1995-1998

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Introduction

In December, Abt Associates delivered[1] a model for estimating international cocaine movement – the Sequential Transition and Reduction (STAR) Model. The STAR model builds on the notion of sequential reduction: the model begins with the amount of cocaine production potential in the source zone; reduces it as cocaine is seized or consumed in the source zone, transit zone and at U.S. borders; and finally provides an estimate of cocaine entering the United States. This global production model advances our understanding of international cocaine trafficking by integrating disparate models and estimates of the movement of cocaine into the United States.

The modeling approach used for heroin differs from that for cocaine. While the bulk of cocaine production is destined for the United States, less than five percent of worldwide heroin/opiate production is sent to the United States,[2] so developing a sequential production model is impractical. Also, dissimilar data are collected for heroin and cocaine. For example, heroin has no counterpart to the Interagency Assessment of Cocaine Movement (IACM), so we know less about the dynamics of heroin movement. On the other hand, cocaine has no counterpart to the DEA's Domestic Monitor Program (DMP) and Heroin Signature Program (HSP). A heroin availability model must differ from a cocaine availability model, because it is constructed from a different empirical base.

This section presents a model of the movement of heroin into the United States. Like its cocaine counterpart model, the heroin flow model seeks to weave together and reconcile various estimation systems into one comprehensive model. It is an important step toward structuring what is currently known about the ways that suppliers provide heroin to the United States. Nevertheless, we do not consider the model as final, because data about heroin trafficking continues to grow, and modeling improvements will follow from better data.

Model of Heroin Availability

Figure 1 is an overview of the heroin flow model developed in the rest of this report. Note that the heroin flow model starts with consumption estimates, while its cocaine counterpart begins with production estimates. These consumption estimates come from the most recent version of a biennial report that Abt Associates has prepared for the Office of National Drug Control Policy for nearly a decade.[3] Based on an analysis of data from the Heroin Signature and Domestic Monitor Programs, we partitioned the source of that consumption into four production areas: South America, Mexico, Southeast Asia and Asia.[4]

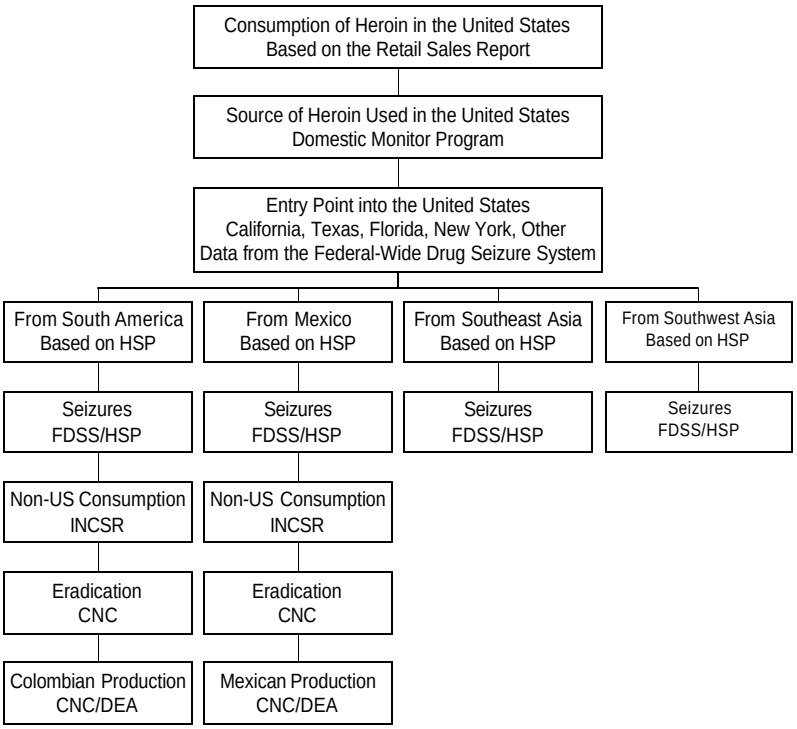
The Federal-Wide Drug Seizure System (FDSS) provides the best estimates of where heroin enters the United States.[5] As shown subsequently, most seizures were in California, Texas (and Arizona), Florida (and Puerto Rico), and New York (including New Jersey) so the figure identifies those four principal entry points. The source country of those seizures is estimated from the Heroin Signature Program (HSP).

According to reports by the Community Epidemiological Working Group (CEWG) and the U.N. World Drug Report, heroin consumption is minimal within South America and Mexico. Consequently, most South American and Mexican heroin is probably destined for the United States.

In summary, the heroin model develops a consumption-based estimate of the amount of heroin that is produced in South America and Mexico. After accounting for seizures, U.S. consumption of South American heroin should roughly equal South American production. Likewise, U.S. consumption of Mexican heroin should be approximately equal to Mexican production. But only a small proportion of Asian heroin gets consumed in the United States, so there is no practical way to equate U.S. consumption of Asian heroin to Southeast and Southwest heroin production.

Figure 1

Overview of a Heroin Flow Model



The Crime and Narcotics Center (CNC) provides a production-based estimate of the heroin production potential in Colombia and Mexico. After accounting for seizures and other leakage, the supply-based estimates should agree with the consumption-based estimate at least roughly – if not, something is wrong with the consumption model, with CNC's production estimates, or both. CNC also estimates potential production for Southeast and Southwest Asia, but there is no apparent way to tie a consumption-based model into those estimates.

U.S. Consumption

For nearly a decade, Abt Associates has produced estimates of the amount of illicit drugs consumed in the United States. Early estimates were crude, but the methodology has improved over time as new data have become available. Table 1 summarizes our most recent estimates.

To estimate the amount of heroin used in the United States, we begin with an estimate of the number of heroin users in the United States. Those users fall into two classes: occasional users (who use less than once per week) and hardcore users (who use at least once per week).[6] Hardcore users seem to use seventy to eighty percent of the heroin, so estimates of the number of hardcore users play an especially important role here.

To estimate the number of hardcore heroin users, we begin with data from the Drug Use Forecasting (DUF) system (now the Arrestee Drug Abuse Monitoring system). The National Institute of Justice has collected those data on a quarterly basis since 1988. The estimation procedure has several steps, which are described in a companion report,[7] the "retail sales" report. Estimates of the number of occasional heroin users were tabulated from the National Household Survey on Drug Abuse (NHSDA). No estimates can be precise, of course, but there seems to be somewhat more than 900,000 hardcore heroin users and somewhat fewer than 500,000 occasional heroin users during the late 1990s.

Unfortunately, the DUF interview does not ask a person how much he or she spent on a specified drug, but rather, it asks how much he or she spent on all drugs. We developed a regression model to infer the amount that is spent on heroin. The dependent variable in that model is dollars spent. The independent variables are the number of days during which the respondent used heroin, cocaine, marijuana and other drugs. Some additional assumptions – explained in the retail sales report – are overlaid on those inferences.

Results from that analysis suggest that hardcore heroin users spend somewhat more than $200 per week on heroin use. (All dollar estimates have been converted to 1998 dollar equivalents.) As explained in the retail sales report, this estimate may be low, because it is the estimated median rather than the estimated mean. The median seemed preferable because the data were highly skewed and because the $200 seemed to comport with estimates reported in an unfortunately sparse literature. We had no information on expenditures by occasional users, so we assumed $50 per week.

One additional adjustment is required. Heroin is often earned as income in kind, mostly when heroin users are themselves dealers (or dealers' helpers) who take their earnings in trade rather than dollars. Although estimates are uncertain, we assume that purchased heroin should be increased by 22 percent in the late 1980s, and by about 11 percent in the late 1990s, to reflect income in kind. The retail sales report provides justification.

Multiplying the number of heroin users by the amount typically spent on heroin suggests that, during the late 1990s, about $12 billion was spent on heroin every year. Adjusting for income in kind would increase the dollar equivalent expenditure to about $13 billion.

Table 1

Summary of Calculations Used to Derive Estimates of the Amount of Heroin Used in the United States

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Hardcore Heroin Users (thousands)	923	886	797	681	630	694	795	855	917	935	980	977	977
Occasional Heroin Users (thousands)	170	150	140	395	304	230	281	428	455	597	253	484	514
Median Weekly Expenditure	$446	$446	$417	$364	$308	$266	$236	$226	$221	$219	$214	$211	$209
Total Expenditure (billions)	$21.8	$20.9	$17.6	$13.8	$10.9	$10.2	$10.5	$11.2	$11.7	$12.2	$11.6	$12.0	$11.9
Price per Pure Gram	$3,153	$2,407	$2,378	$2,377	$1,925	$1,468	$1,131	$1,089	$1,048	$1,029	$1,029	$1,029	$1,029
Total Amount (MT)	8.5	10.5	8.8	6.8	6.5	7.9	10.5	11.4	12.4	13.1	12.5	12.9	12.9

Source: "What America's Users Spend on Illegal Drugs, 1988–1998." Report submitted to ONDCP by Abt Associates Inc., Nov. 23, 1999.

All dollars are expressed as 1998 dollar equivalents.

Although the above method provides an estimate of the expenditure on heroin purchased in the United States, it does not tell us the total weight of heroin used in the United States. If we knew the price paid per pure gram purchased, we could divide that price into the total expenditure to get a measure of purchased weight.

Fortunately, for nearly a decade, Abt Associates has produced estimates of the price paid at retail for a pure gram of heroin. Those estimates are based on a statistical analysis of the System to Retrieve Drug Evidence (STRIDE) and the Domestic Monitor Program (DMP) data. The methodology is described in detail in our recent price series report[8] for ONDCP and in the recent retail sales report. Toward the latter part of the 1990s, the price of heroin has been somewhat higher than $1.00 per pure milligram. Dividing the amount of expenditures by the typical price paid for heroin, and adjusting for income in kind, we get an estimate of the total amount of heroin used in the United States. In the second half of the 1990s, Americans seemed to use 12 to 13 metric tons of pure heroin per year.[9]

Determination of Source Area

The Drug Enforcement Administration supports two programs – the Heroin Signature Program and the Domestic Monitor Program – to determine the source area (South America, Mexico, Southeast Asia and Southwest Asia) of heroin sampled at three points: seizures at ports of entry, a random sample of other seizures and purchases, and DMP purchases.[10] We included all samples weighing less than one gram in a *retail-level sample*, comprising all the DMP data and several purchases from the random sample. We used that retail-level sample to estimate the sources of heroin used in the United States.

Our inferences are based on the retail-level sample, rather than an importation-level sample, because the retail-level sample comes closest to representing heroin actually consumed in the United States. Still, raw data tabulations are not very useful, for two reasons. First, some of the retail level samples have too little drug to afford a signature, so the source area is unknown. This creates some problems, because Mexican heroin is easily identified and therefore is rarely classified as unknown. To prevent Mexican heroin from being over-represented in the data, we developed imputation routines for assigning a signature to every sample in the retail level data where an imputation seemed justified. Second, the Domestic Monitor Program oversamples in places where heroin use is relatively rare. (For example, St. Louis has a quarterly sample size of 10 purchases, while Baltimore has the same sample size but many more heroin users and purchases.) We developed a weighting procedure so that the signature program would represent a national estimate.

We have been unable to classify about 10% of the heroin seized and purchased since 1995. These unclassified samples are reported as unknown (UNK) in Table 2, which details estimates for the percentage of heroin from each source area. Because data were not available for 1998 and later, the 1998 and 1999 estimates are projections – that is, they are the averages for 1995 through 1997.

Table 2 Estimated Source of Heroin Used in the United States

Year	Mexico	S. America	SE Asia	SW Asia	Unknown
1993	26.2	13.1	17.6	9.1	34.1
1994	25.6	27.6	21.4	3.8	21.6
1995	26.4	46.6	11.6	2.6	12.7
1996	26.1	51.2	11.6	4	7.1
1997	22.8	52.5	10	5.6	9.1
1998	25.1	50.1	11	4.1	9.6
1999	25.1	50.1	11	4.1	9.6

Sources: Unpublished analysis of data from the Heroin Signature Program and Domestic Monitor Program

If we are correct about these percentages, and if we are correct that between 1995 and 1998 about 12 to 13 metric tons of heroin was used per year in the United States, then we can derive estimates of the amount of heroin that comes from each area (Table 3). We do not provide earlier estimates, because the unknown signature category is comparatively large before 1995.

Table 3

Estimated Amount of Heroin from Each Source Area (metric tons)

	1995	1996	1997	1998
Mexico	3.0	3.2	3.0	3.1
South America	5.3	6.3	6.9	6.2
Southeast Asia	1.3	1.4	1.3	1.4
Southwest Asia	0.3	0.5	0.7	0.5
Unknown	1.4	0.9	1.2	1.2
Total	11.4	12.4	13.1	12.5

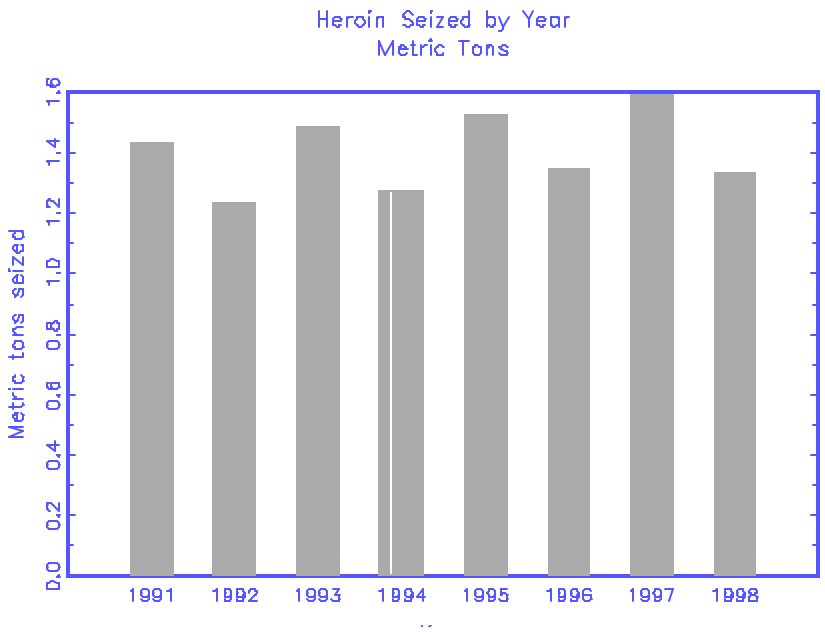
Source: See Table 1 and Table 2.

According to these calculations, U.S. consumers use somewhat more than 6 metric tons of South American heroin and somewhat more than 3 metric tons of Mexican heroin. However, the South American and the Southeast and Southwest Asian estimates might be higher depending on how the unknown signatures are partitioned across the data.

Seizure Levels

Seizures reduce the amount of heroin available for consumption, so the flow model requires estimates of the amount of heroin seized by U.S. and other authorities. We tabulated heroin seizures reported in the FDSS from 1991 through the first half of 1998. Results appear in Figure 2. To provide greater comparability between 1998 and earlier years, we interpolated seizures for the entire year by doubling seizures from the first half of 1998. The figure reflects that interpolation.

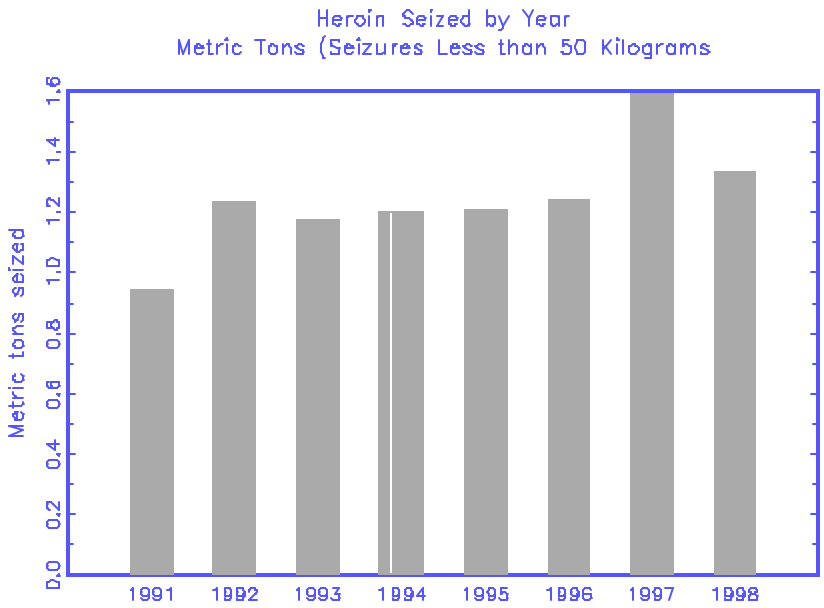
Figure 2



The figure seems to show that seizures have varied between about 1.2 and 1.6 metric tons from 1991 through 1998. There is no apparent trend.

There is a second useful way to look at these data. Between 1991 and 1998, 99.2 percent of all seizures were less than 10 kilograms. Likewise, 99.7 percent of all seizures were less than 20 kilograms and 99.9 percent of all seizures were less than 50 kilograms. If we exclude all seizures larger than 50 kilograms from the tabulation, the trend has a different appearance, shown in Figure 3.

Figure 3



Discarding seizures greater than 50 kilograms leads to the conclusions that seizures have remained fairly constant at about 1.2 metric tons. Apparently, exceptionally large seizures can occasionally lead to spikes in the seizures observed during any year, distorting the trend. When large seizures are included in the estimates, then, an average seizure rate of 1.3 metric tons may be more representative of law enforcement success at preventing heroin from entering the United States.

In fact, when imported into the United States, heroin is typically less than 80 percent pure.[11] According to the HSP data (for seizures at the importation level only), South American heroin has been about 80 percent pure since 1995, while Mexican heroin has been about 44 percent pure. Heroin from Southeast and Southwest Asia has typically been 70 to 75 percent pure. Thus the 1.3 metric tons of bulk heroin probably translates into somewhat more than 1 metric ton per year of pure heroin seized while entering the United States.

Importation Points

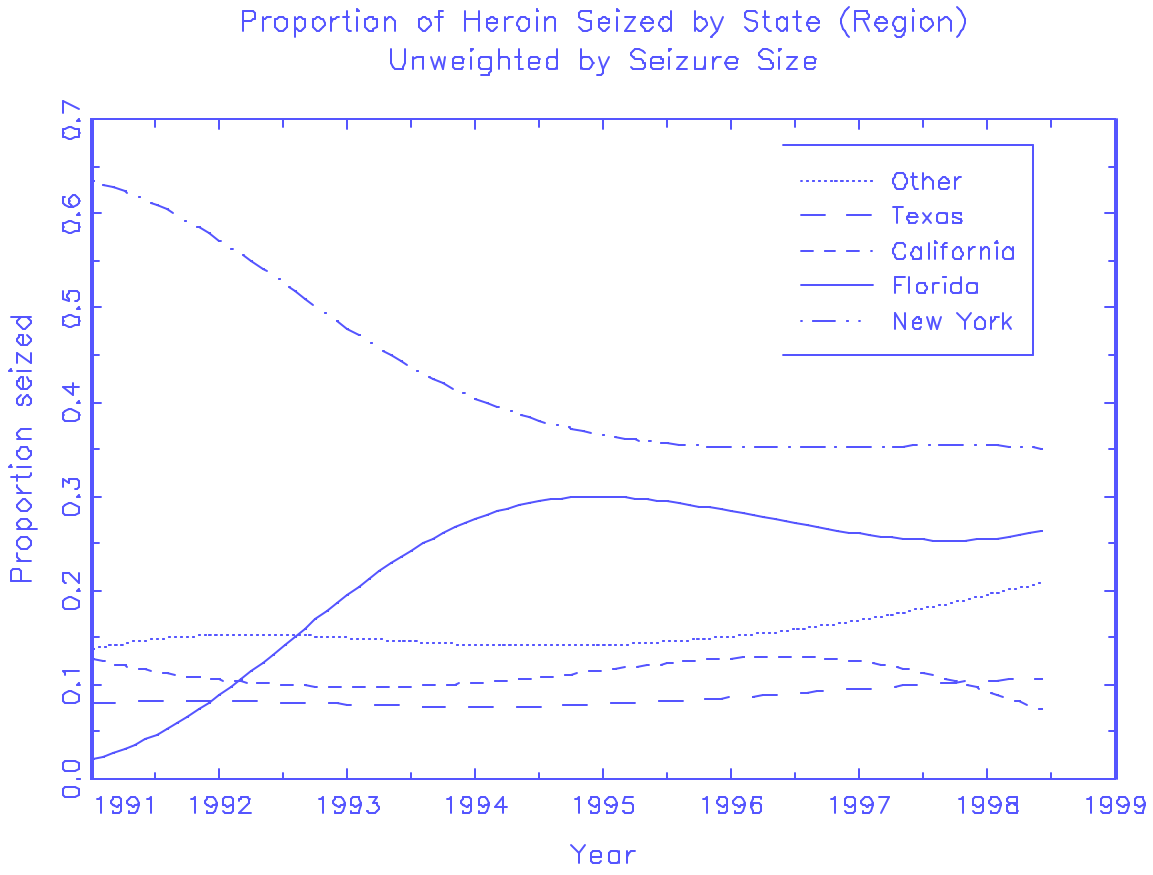
Where do these seizures occur? Most seizures happen in one of four importation areas, defined:

- New York (includes New Jersey)
- Florida (includes Puerto Rico)
- California
- Texas (includes Arizona)

The rest of the seizures occur throughout the United States. Figure 4 shows trends in where seizures have happened.

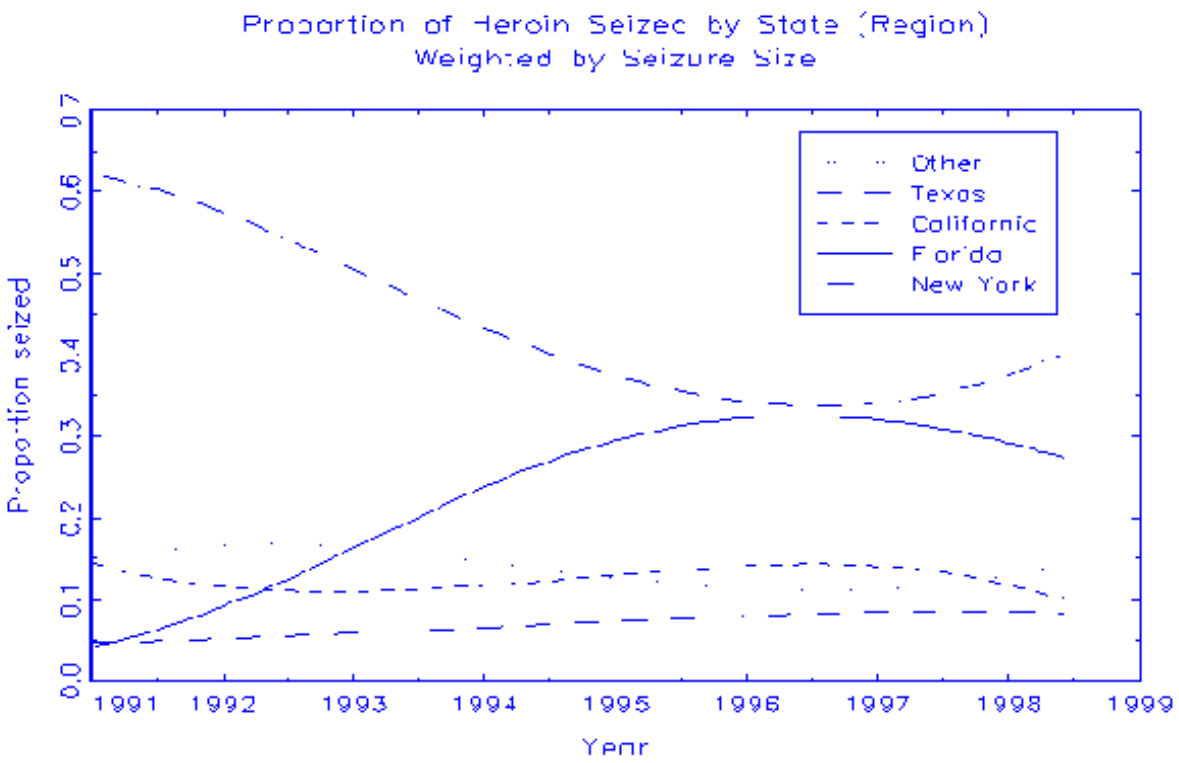
The curves shown in Figure 4 are a smoothed representation of how the location of seizures changed over time. The methodology used to develop these curves is reported in Appendix A. The figure shows that the proportion of seizures made in New York, represented by the highest line in this figure, decreased precipitously from 1991 through 1995 and then stabilized. Most of that reduction was balanced by a dramatic increase and then stabilization of seizures made in Florida.

Figure 4



A second useful way to look at seizures is to weight the seizure by the amount of heroin involved in the shipment. Figure 5 reports results after weighting.

Figure 5



Subsequent to the preparation of figures 4 and 5, the Office of National Drug Control Policy provided updated tabulations of seizure data. These are displayed in table 4.

Table 4 Annual Heroin Seizures by Region of the United States (kilograms)

Year	Number of Seizures	Amount of Seizures	Other	Florida	NY/NJ	Calif.	Texas
1989	697	1,293	207	10	845	188	43
1990	743	669	137	13	434	70	16
1991	889	1,432	193	24	558	627	30
1992	1,093	1,233	274	153	631	93	81
1993	1,140	1,481	375	173	709	167	57
1994	1,043	1,268	270	220	568	149	62
1995	1,153	1,524	264	383	574	168	135
1996	1,249	1,343	225	382	466	163	106
1997	1,480	1,588	241	474	551	231	90
1998	1,226	1,448	297	330	534	150	136
1999*	1,062	1,137	229	215	365	175	153

* imputed by doubling first six months

Source: FDSS, provided by Michael Cala, ONDCP

Both figures tell similar stories. The only difference is that the second figure suggests that more heroin was being shipped to New York during 1998 than was true in 1996 and 1997. This may be true, or given the contrary findings from the previous figure and the table, it may be that a few especially large shipments have distorted the trend. Also, the smoothing procedure can distort trends at the end of the period. It would be prudent, therefore, to discount the apparent change of trends in New York and Florida observed in 1998.

It any rate, one point is clear: By 1995, seizures had decreased markedly in New York, and they had increased correspondingly in Florida. There was little change in seizures in the rest of the nation. To the extent that seizures reflect where heroin enters the United States, the geographic movement of heroin into the United States has been relatively stable since 1995. Figures 4 and 5 imply that less heroin has been moving through New York and more heroin has been moving through Florida. A contrary conclusion would be that the same amount of heroin has been moving through New York, while more heroin has been going through Florida. Given the findings reported in Figures 2 and 3, however, total seizures have remained about the same, so Florida seizures must have displaced New York seizures.

Movement of Heroin from Source Areas into the United States

Table 5 reports the estimated source of heroin that was seized in the five areas identified in the previous figure. This table is based on seizures made at airports, at the borders, and through the mail. The probability that a shipment is seized likely varies across conveyance mode and geographic location, so a simple tabulation of seizure data would be a biased representation of where heroin enters the United States. To make the tabulations more representative of heroin imports, we weighted the data so that the source area of heroin *seized* was the same percentage as the source area of heroin *used* in the United States.[12] Estimates of the source areas of heroin in the United States have been reported already in Table 3.

Table 5

Estimated Percentage of Heroin Entering the United States by Importation Point for Each Source Area

Source Area	Importation Point				
	California	Florida	New York	Texas	Other
Mexico	82.4	0.0	0.0	69.2	53.2
South America	7.1	85.9	60.3	13.0	7.6
Southeast Asia	5.5	0.3	22.9	7.0	17.3
Southwest Asia	0.0	0.4	8.9	0.0	9.7
Unknown	4.9	13.5	7.9	10.8	12.2
Total	100.0	100.0	100.0	100.0	100.0

Table 5 should be read down its columns. For example, an estimated 82 percent of the heroin that entered the U.S. through California came from Mexico. Almost 86 percent of the heroin that entered through Florida came from South America.

Table 6 reports the estimated percentage of heroin from each source region that entered the United States through each of the five importation areas. This table should be read across its rows.

Table 6

Estimated Percentage of Heroin Entering the United States by Source Area for Each Importation Point

Source Area	Importation Point					
	California	Florida	New York	Texas	Other	Total
Mexico	64.3	0.0	0.0	16.3	19.4	100.0
South America	2.8	52.9	41.3	1.5	1.4	100.0
Southeast Asia	9.9	1.0	71.2	3.8	14.4	100.0
Southwest Asia	0.0	3.1	75.0	0.0	21.9	100.0
Unknown	10.0	43.3	28.3	6.7	11.7	100.0

If weighted seizures are a good reflection of where heroin enters the United States, then 64.3 percent of Mexican heroin enters through California and 16.3 percent enters through Texas. That is, more than 80 percent of Mexican heroin probably comes across the Southwest border, and the rest of Mexican heroin enters the United States through other diverse locations. More than half of South American heroin enters the United States through Florida, and most of the rest comes through New York. Almost three-quarters of Southeast Asian heroin enters through New York and the rest goes through diverse places. Three-quarters of the Southwest Asian heroin also seems to enter through New York City, and the rest goes through various places. The increased role of South America as a supplier of heroin explains why Florida has become an increasingly important heroin importation point.

Table 7 provides another useful way to summarize these data. Multiplying the percentages by source area (table 6) by the amounts per source area (table 3) provides an estimate of metric tons moved through each importation point by source area. To develop this estimate, we average across the five years reported in table 3. Year-by-year seizures are not shown because episodic large seizures can distort trends from one year to the next.

Table 7

Estimated Amount of Heroin (Metric Tons) Entering the United States by Source Area and Importation Point, 1995-1998

Source Area	Importation Point					
	California	Florida	New York	Texas	Other	Total
Mexico	2.0	0.0	0.0	0.5	0.6	3.1
South America	0.2	3.3	2.6	0.1	0.1	6.2
Southeast Asia	0.1	0.0	1.0	0.1	0.2	1.4
Southwest Asia	0.0	0.0	0.4	0.0	0.1	0.5
Unknown	0.1	0.5	0.3	0.1	0.1	1.2
Total	2.4	3.8	4.2	0.7	1.1	12.3

If we are correct that Americans used about 12.3 metric tons of heroin per year between 1995 and 1998, then table 7 gives some idea of how much heroin from each source moves into the country through each region of the United States. Of course, there exists considerable uncertainty in estimates that provide this much detail.

Almost 10 percent of the heroin was classified as unknown – that is, DEA chemists could not assign a source area to that heroin. Note that, excluding the unknown category, virtually all heroin seized in Florida came from South America. It seems reasonable to suppose that most of the 13.5 percent of the heroin seized in Florida and identified as "unknown" also came from South America. This same reasoning cannot be applied to other places where South America is not the dominant supplier, but it does suggest that South America's share of the U.S. market may be greater than is indicated by tables 3 and 7.

CNC Potential Production Estimates

How do our estimates of the amount of heroin from the producer nations compare with CNC's reports of production potential? Since 1995, CNC has estimated the production potential of South America at between 6.1 and 7.5 metric tons. (These estimates are after subtracting eradication losses from total hectares.) Unfortunately, estimates are of uncertain accuracy because the assumed conversion ratios from poppy to opium is based on intelligence fieldwork in Southeast and Southwest Asia. We cannot know for sure whether or not those conversions apply to South America. Nevertheless, we must take these estimates as the best currently available.

According to our consumption estimates, Americans consume somewhat more than 6 metric tons of heroin from South America, and United States authorities seize about 0.75 metric tons. Our consumption/seizure estimates exceed South America's production capacity, but the difference is not great.[13] This suggests that the estimated 12 to 13 metric tons of total domestic heroin consumption is about right if somewhat high.

Since 1995, CNC's estimates of the production potential for Mexico vary over time between 4.3 and 6.0 metric tons. According to our estimates, Americans consume somewhat more than 3 tons of Mexican heroin and another 0.34 metric tons are seized by U.S. or Mexican authorities.[14] The consumption-based estimates are less than the production-based estimates. The Mexican production estimates suggest that the estimated 12 metric tons of domestic heroin consumption is too low.

CNC's production estimates for Mexico are inconsistent with our consumption estimates. There seems to be no ready reconciliation, but speculation may be helpful. CNC emphasizes that its estimates are for *potential production*, and actual production may differ. Perhaps Mexico's production is well below its potential, but it is difficult to reason why potential production would be consistently less than realized production. A better explanation comes from CNC's warning that:

> The wide variation in processing efficiency achieved by traffickers complicates the task of estimating the quantity of cocaine or heroin that could be refined from a crop. These variations occur because of differences in the origin and quality of the raw material used, the technical processing method employed, the size and sophistication of laboratories, the experience of local workers and chemists, and decisions made in response to enforcement pressures. (INCSR, 1999)

CNC's assumptions may overstate Mexico's production efficiency. This is speculation, of course, but we observe that heroin imports are about 44 percent pure when from Mexico, 80 percent pure when from Colombia, and 70 to 75 percent pure when from Southeast and Southwest Asia. Because CNC makes the same assumptions about production efficiency for Mexico as it does for the rest of the world, the potential production may overstate Mexico's actual production.

Suppose that Mexican production were 0.59 as efficient as is assumed by CNC. (The 0.59 comes from dividing 0.44 purity by 0.75 purity.) Then an estimate of Mexico's actual production would be between 2.5 and 3.5 metric tons, numbers that agree with the consumption estimates. Using this same argument, we might assert that Colombian production is 1.07 times more efficient than is assumed by CNC. This would lead to a higher estimate of Colombia's production, which would be more consistent with the consumption estimates. This reasoning is speculative, but not unreasonable in the face of having no reliable data about the actual production efficiency in Mexico and Colombia.

Non-U.S. Consumption

How much heroin is consumed within Mexico and within South America? What other reductions occur in the production and distribution systems? Unfortunately the answers to these questions are all but unknown.

Perhaps the most useful published information about consumption comes from reports of the Community Epidemiological Working Group (CEWG). The CEWG is focused on the United States, of course, but most of its reports include sections on consumption in other nations. These reports are seldom quantitative, because nations outside the United States rarely have data collection systems affording estimates of domestic consumption. Based on CEWG assessments, we assume that the consumption of heroin within South and Central America is negligible. Most heroin produced in South and Central America is probably destined for North American markets.

Canada is a bigger problem. According to CEWG reports, heroin is seen as a major drug problem, at least in Vancouver and Toronto. But we do not know the amount of heroin used in Canada; nor do we know the source.[15] It seems reasonable to assume that some South American and Mexican heroin is shipped to Canada, but we do not yet have an estimate of the amount.

Conclusions

Table 8 summarize the calculations made in this report. The table reports estimates for 1995 through 1998. CNC potential production estimates are not available for earlier years; anyway, estimates of Colombia's contribution to consumption are uncertain for the period before 1995. Because of year to year measurement error, we have provided a column that averages over the four years.

On a yearly basis, over this period, Americans consumed about 12.3 metric tons of heroin. About 50 percent (6.2 metric tons) came from Colombia and about 25 percent (3.1 metric tons) came from Mexico. Seizures account for about 0.75 metric tons from Colombia, so Colombia would need to produce about 6.9 metric tons to satisfy the U.S. market. Only about 0.3 metric tons are seized from Mexico. So Mexico would need to produce about 3.4 metric tons to meet U.S. demand.

According to CNC, Colombia has the potential to produce about 6.4 metric tons, which comes close to satisfying the estimated demand. In fact, with an efficiency adjustment, the four-year consumption estimate is almost identical to the four-year adjusted production estimate. Also, according to CNC, Mexico has a production capacity of 5.3 metric tons. This estimate is considerably higher than the consumption estimate of 3.4 metric tons required to satisfy the U.S. demand. Application of the efficiency adjustments to Mexico brings consumption (3.4 metric tons) into agreement with production potential (3.1 metric tons), but that adjustment is speculative.

Our best estimate is that roughly 12 to 13 metric tons of heroin are used in the United States during a given year, and that the level of use has not changed appreciably during the last several years. (The number of heroin users may have changed, because relatively inexpensive and high purity heroin may have attracted occasional users, but occasional users account for a low proportion of heroin use.) The level of use could be different, of course, but if it were much higher or much lower than 12 metric tons then we could not account for production potential in South America and Mexico, all of which is presumably exported to the United States.

The potential heroin production estimates have a variety of uncertainties due to the lack of detailed country crop and processing data. The production process (the rate at which poppy is converted into heroin) is only now being studied (or at least documented) for South America and Mexico. Our research has depended on production estimates where the South American and Mexican production processes are assumed to be the same as those outside the Americas. Of course there is room to be critical of the consumption-based estimates as well. We cannot be sure of the number of hardcore and occasional users, of the amount of money they spend on drugs, of the prices they pay and consequently of the amount they use. Any one of the component parts of the estimates could be wrong; perhaps all of them are wrong. The fact that the consumption-based estimates are so close to the supply-based estimates is compelling but not convincing evidence that this heroin flow model provides an accurate profile of how much heroin enters the United States, how it gets here, and where it comes from.

Other domestic consumption estimates are available to the counterdrug community. The intelligence community has estimated that, during the late 1990s, Americans used about 18 metric tons of heroin per year. To get this estimate, the community accepted the ONDCP estimate of 980,000 hardcore heroin users and assumed those users consumed an average of 50 mg per day. Use by occasional users was apparently factored into these calculations, but the method is unclear.

This amount is considerably more than the 12 to 13 metric tons estimated in this report. The intelligence community considers the 50 mg per day estimate to be conservative. Indeed, some addicts can use much more as evidenced by consumption by opiate users who enter treatment. But beyond this upper bound, the 50 mg estimate seems to have no justification beyond the assertion that "Many analysts and treatment professionals, however, believe that 50 mg as the estimate for average daily dosage for heroin users in the United States underestimates overall US market demand." Thus, the 18 metric ton estimate would seem to rest on a shaky and unverifiable assumption.

This is not to say that the estimate from the intelligence community is wrong, of course. Nevertheless, if we accept the estimate of 18 metric tons, we have to deal with some inconsistencies. Perhaps those inconsistencies are ultimately resolvable, but surely they cannot be readily dismissed. For example, if we are correct that a milligram of heroin costs roughly $1, then the implied $350 per week expenditure exceeds our estimates of expenditures by hardcore users. As another example, the estimates imply that 8 metric tons of heroin come from Colombia and 5 to 6 metric tons come from Mexico. For reasons explained earlier, we doubt that Colombia can provide this amount of heroin after accounting for seizures. Furthermore, even this high estimate of 8 metric tons is lower proportionately than Colombia's apparent share of the heroin market. Mexico might be able to supply this level, presuming production estimates are realistic, but for reasons stated, we think that Mexico's production is overstated.

Table 8 - Summary of Calculations

	1995	1996	1997	1998	Four Year Average
Metric tons consumed:	11.4	12.4	13.1	12.5	12.3
Percentage from Colombia[1]	46.6	51.2	52.5	50.1	50.1
Percentage from Mexico[2]	26.4	26.1	22.8	25.1	25.1
Metric tons from Colombia[2]	5.3	6.3	6.9	6.2	6.2
Metric tons from Mexico[3]	3.0	3.2	3.0	3.1	3.1
Seizures:					
Metric tons from Colombia[4]	0.75	0.75	0.75	0.75	0.75
Metric tons from Mexico[4]	0.24	0.25	0.48	0.32	0.32
Total consumption and seizures:					
Metric tons from Colombia	6.1	7.1	7.7	7.0	6.9
Metric tons from Mexico	3.2	3.5	3.5	3.4	3.4
CNC Potential Production Estimates:					
Metric tons from Colombia[5]	6.5	6.3	6.6	6.1	6.4
Metric tons from Mexico[5]	4.6	5.4	5.3	5.3	5.3
Efficiency Adjusted Productions Estimates[6]					
Metric tons from Colombia	7.0	6.7	7.1	6.5	6.8
Metric tons from Mexico	2.7	3.2	3.1	3.5	3.1

Source:

1. Table 1
2. Table 2
3. Table 3
4. See discussion on seizures.
5. International Control Strategy Report, March 1999
6. See discussion on efficiency adjustments.

Endnotes

1. Layne, M., R. Johnson, and W. Rhodes, "Estimating Cocaine Availability," Abt Associates Inc., Cambridge, MA, December 1999.

2. Between 1994 and 1998, CNC reports that worldwide heroin production has ranged between 300 and 350 metric tons. Consumption in the United States in probably close to 12 metric tons, suggesting that U.S. consumption is less than 5 percent of heroin produced worldwide. See Rhodes, W., M. Layne, P. Johnston and L. Hozik, "What America's Users Spend on Illegal Drugs, 1988-1998." Report submitted to the Office of National Drug Control Policy by Abt Associates Inc., November 23, 1999.

3. Rhodes, W., M. Layne, P. Johnston, and L. Hozik. "What America's Users Spend on Illegal Drugs: 1988-1998." Report submitted to ONDCP by Abt Associates Inc., November 23, 1999.

4. Neither the Domestic Monitor Program nor the Heroin Signature Program provides probability samples. Using those data sources as the basis for partitioning consumption by source area requires mathematical modeling and statistical analysis. That approach is described in detail in a report for the Drug Enforcement Administration: Rhodes, W., L. Truitt, R. Kling, and A. Nelson. "The Domestic Monitor Program and the Heroin Signature Program: Recommendations for Changes," Abt Associates Inc., Cambridge MA, June 30, 1998. Calculations reported in this report, which were updated from that earlier report, are available by request from the authors.

5. Use of the FDSS data does not imply that seizures accurately reflect the source area of heroin entering the United States. For example, Mexican heroin seems to have a lower seizure rate compared with heroin from the rest of the world. See W. Rhodes, et al., "The Domestic Monitor Program and the Heroin Signature Program: Recommendations for Changes," Abt Associates Inc., Cambridge, MA, June 30, 1998.

6. Much of the data used to estimate the number of hardcore users comes from the Drug Use Forecasting System, a quarterly survey of arrestees conducted by the National Institute of Justice in twenty-four cities. The DUF interview does not ask about "weekly" heroin use, but it does ask about the number of days that a respondent used heroin during the month before the interview. Assumptions are that an answer of "more than 10 days " means at least weekly.

7. Rhodes, W., M. Layne, P. Johnston, and L. Hozik, "What America's Users Spend on Illegal Drugs: 1988-1998." Report submitted to ONDCP by Abt Associates Inc., November 23, 1999.

8. Johnston, P., W. Rhodes, K. Carrigan, and E. Moe, "The Price of Illicit Drugs: 1981 through the Second Quarter of 1998." Report submitted to ONDCP by Abt Associates Inc., February 1999.

9. Estimates pertaining to the late 1980s and early 1990s may be too low. The problem is that heroin retail markets appear to be bifurcated with low purity heroin (suitable for injection) available at relatively high unit price and high purity heroin (suitable for injection or snorting) available at comparatively low unit price. The "retail" price is a mixture of these two prices. A special addendum to the DUF data tells much about heroin purchase patterns in the middle and late 1990s, but there are no comparable sources for earlier years. Consequently estimating heroin prices is more uncertain for earlier years. Alternative ways of computing heroin prices lead to lower prices during that early part of the study period. If we had adopted those lower prices, then the amount of heroin consumed would have been correspondingly higher during those years. See W. Rhodes, S. Langenbahn, R. Kling and P. Scheiman, "What America's Users Spend on Illegal Drugs, 1988-1995," Office of National Drug Control Policy, Fall 1997.

10. The Domestic Monitor Program and the Heroin Signature Program are sometimes criticized because they lack a probability sampling basis. A second criticism, frequently made, is that the Domestic Monitor purchases are made mostly (but not exclusively) in open-air settings, so DMP purchases may not represent all purchases made in the city. In a review for the Drug Enforcement Administration, Abt Associates demonstrated how the data could be weighted and analyzed to reflect purchases made across the country. The fact that purchases come mostly from outdoor settings remains problematic, although agents interviewed by the Abt researchers felt that heroin sold in indoor and outdoor settings did not differ. Details are provided in W. Rhodes, L. Truitt, R. Kling and A. Nelson, "The Domestic Monitor Program and the Heroin Signature Program: Recommendations for Changes." Report submitted to the Drug Enforcement Administration by Abt Associates Inc., June 30, 1998.

11. Coomber argues that this dilution of imported heroin results from the heroin production process. Thus purity probably varies from source area to source area. South American heroin appears to be the most pure; Mexican is the least pure. Coomber, R., "The Cutting of Heroin," *Journal of Drug Issues, 29 (1), 1999: 17-35.*

12. Calculations began with all the seizure reports contained in the Heroin Signature Program data file. These reports are not comprehensive of all seizures at ports of entry, but we have no reason to believe this is a biased sample of seizures. From this file we selected all reports where: (1) the seizure occurred at an airport, at the border, or through the mail; (2) the seizure happened in 1995 or later; and (3) the seizure involved less than ten kilograms. Each report was characterized by the amount of pure heroin seized, and then the sample was weighted so that the distribution by source country for the seizure data matched the distribution by source country for the consumption data. For example, if 10 percent of the seizures came from South America while 15 percent of consumption came from South America, we weighted the seizures from South America by 15/10 or 1.5. By source area, the weights were:

0.73 for unknown

2.67 for Mexico

0.87 for Southeast Asia

1.32 for Southwest Asia

1.67 for South America

As a practical matter, then, this weighting gives much greater emphasis to Mexican heroin and somewhat more emphasis to South American heroin.

13. Between 1995 and 1998, CNC estimated Colombia's maximum production potential at 6.6 metric tons. It did not grow to 7.5 metric tons until 1999. Colombian authorities never seized more than 0.15 metric tons during this period.

14. According to the 1999 INCSR, Mexican authorities have seized between 0.14 and 0.38 metric tons of heroin (or opium equivalent) every year since 1995. Given what U.S. authorities seize, Mexican traffickers would seem to lose about 0.34 metric tons per year.

15. The Canadian Center on Substance Abuse reports that 5.9 percent of Canadians tried heroin at some time; 1.1 percent of the population used heroin during 1994. Canadian Center on Substance Abuse, *Canadian Profile 1999 Illicit Drugs*, downloaded from the Internet www.ccsa.ca/cp99.11.htm, November 11, 1999.

APPENDIX A

Anaylsis to Determine Trends in Seizures at United States Entry Points

Using seizures as a criterion, we sought to determine trends in the proportion of heroin that entered the United States through different importation areas. Seizure locations were identified by State. Tabulations showed that most heroin entered the United States through New York (including New Jersey), Florida (including Puerto Rico), Texas (including Arizona), and California. Those four states were identified as importation areas and seizures that did not occur in those four states were put into a fifth residual category called Aother.@

We estimated the proportion of heroin entering these five importation areas using a multinomial logistic model. Independent variables were time (coded 0 to 1), time squared, and time cubed. The first regression was unweighted. The second was weighted by the amount of heroin in the seizure. Seizures in excess of 50 kilograms were excluded from this analysis.

Results were plotted and reported in the main text.

```
==============================================================================
 LOGIT Version 3.1.2                          11/01/1999   2:26 pm
==============================================================================
                    Data Set :  c:\ondcp\temp: Unweighted Data
------------------------------------------------------------------------------

CASES PROCESSED BY LOGIT:

  8637 cases were kept out of 8637 in file.

DEPENDENT CATEGORIES ARE DESIGNATED AS:

  1 - OTHER
  2 - TEXAS
  3 - CALIFORN
  4 - FLORIDA
  5 - NEW YORK

DISTRIBUTION AMONG OUTCOME CATEGORIES FOR PLACE

                 OTHER     TEXAS     CALIFORN   FLORIDA    NEW YORK
PROPORTION      0.1576       0.0864       0.1100       0.2294       0.4167

DESCRIPTIVE STATISTICS (N=8637):

               Mean     Std Dev  Minimum   Maximum
 THE_TIME    0.5363    0.2878    0.0000    1.0000
 THETIME2    0.3705    0.3066    0.0000    1.0000
 THETIME3    0.2844    0.2957    0.0000    1.0000
```

ITERATION: 1 2 3 4 5

ESTIMATES FROM LOGIT ANALYSIS OF VARIABLE: PLACE

Convergence after 5 iterations.
Tolerance of 0.0000 achieved after 0.09 minutes.

Variable	Comparison	Logit Estimate	Std Error	t-value	2-tailed Prob	Exp Estimate
CONSTANT	1/5	-1.52930	0.1428	-10.71	0.000	2.1669e-001
	2/5	-2.06837	0.1819	-11.37	0.000	1.2639e-001
	3/5	-1.60172	0.1570	-10.20	0.000	2.0155e-001
	4/5	-3.43226	0.2147	-15.99	0.000	3.2314e-002
THE_TIME	1/5	1.78009	1.1746	1.52	0.130	5.9304e+000
	2/5	0.92461	1.4932	0.62	0.536	2.5209e+000
	3/5	-1.69247	1.3248	-1.28	0.201	1.8406e-001
	4/5	14.11919	1.4688	9.61	0.000	1.3548e+006
THETIME2	1/5	-1.90028	2.6301	-0.72	0.470	1.4953e-001
	2/5	0.34341	3.3345	0.10	0.918	1.4097e+000
	3/5	8.09904	3.0222	2.68	0.007	3.2913e+003
	4/5	-19.84582	2.9725	-6.68	0.000	2.4048e-009
THETIME3	1/5	1.12434	1.6880	0.67	0.505	3.0782e+000
	2/5	-0.40195	2.1354	-0.19	0.851	6.6902e-001
	3/5	-6.36637	1.9706	-3.23	0.001	1.7184e-003
	4/5	8.86685	1.8022	4.92	0.000	7.0929e+003

MEASURES OF FIT:

Test	LRX2	df	Prob
Overall	481.8139	12	0.000
CONSTANT	434.1462	4	0.000
THE_TIME	101.6379	4	0.000
THETIME2	62.2914	4	0.000
THETIME3	44.3841	4	0.000

-2 Log Likelihood for full model: 24530.9766
-2 Log likelihood for restricted model: 25012.7904
Percent Correctly Predicted: 41.6696

==========

LOGIT Version 3.1.2 11/01/1999 2:26 pm

==========

Data Set : c:\ondcp\temp: Weighted Data

CASES PROCESSED BY LOGIT:

8637 cases were kept out of 8637 in file.

WEIGHTING IS IN EFFECT:

Computations have used the weight variable: WEIGHT

DEPENDENT CATEGORIES ARE DESIGNATED AS:

1 - OTHER
2 - TEXAS
3 - CALIFORN
4 - FLORIDA
5 - NEW YORK

DISTRIBUTION AMONG OUTCOME CATEGORIES FOR PLACE

	OTHER	TEXAS	CALIFORN	FLORIDA	NEW YORK
PROPORTION	0.1367	0.0710	0.1254	0.2407	0.4262

DESCRIPTIVE STATISTICS (N=8637):

	Mean	Std Dev	Minimum	Maximum
THE_TIME	0.5354	0.2902	0.0000	1.0000
THETIME2	0.3708	0.3108	0.0000	1.0000
THETIME3	0.2861	0.3014	0.0000	1.0000

ITERATION: 1 2 3 4 5

ESTIMATES FROM LOGIT ANALYSIS OF VARIABLE: PLACE

Convergence after 5 iterations.
Tolerance of 0.0000 achieved after 0.10 minutes.

Variable	Comparison	Logit Estimate	Std Error	t-value	2-tailed Prob	Exp Estimate
CONSTANT	1/5	1.44806	0.1380	-10.49	0.000	0.2350
	2/5	-2.58411	0.2201	-11.74	0.000	0.0755
	3/5	-1.45229	0.1460	-9.95	0.000	0.2340
	4/5	-2.70859	0.1896	-14.28	0.000	0.0666
THE_TIME	1/5	1.96781	1.1615	1.69	0.090	7.1550
	2/5	0.97534	1.7187	0.57	0.570	2.6521
	3/5	-2.26836	1.2266	-1.85	0.064	0.1035
	4/5	7.11160	1.3326	5.34	0.000	1226.1085
THETIME2	1/5	-3.38102	2.6740	-1.26	0.206	0.0340
	2/5	3.10725	3.7586	0.83	0.408	22.3595
	3/5	9.32264	2.8024	3.33	0.001	11188.4644
	4/5	-4.57985	2.7501	-1.67	0.096	0.0103
THETIME3	1/5	1.82091	1.7476	1.04	0.297	6.1775
	2/5	-3.07813	2.3749	-1.30	0.195	0.0460
	3/5	-6.98389	1.8220	-3.83	0.000	0.0009
	4/5	-0.21001	1.6832	-0.12	0.901	0.8106

MEASURES OF FIT:

Test	LRX2	df	Prob
Overall	550.2537	12	0.000
CONSTANT	394.1137	4	0.000
THE_TIME	38.5245	4	0.000
THETIME2	20.5415	4	0.000
THETIME3	19.7866	4	0.001

-2 Log Likelihood for full model: 24089.4768
-2 Log likelihood for restricted model: 24639.7305
Percent Correctly Predicted: 42.6234

PREDICTED VALUES SUCCESSFULLY WRITTEN TO DISK:

The file c:\ondcp was written with 8637 cases.

The following variables are in the file:

Prob Y=i for i=1 to 5 : P_OTHER P_TEXAS P_CALIFO P_FLORID P_NEW YO

Dependent variable (Y): PLACE