

Dynamics of Stocks and Flows

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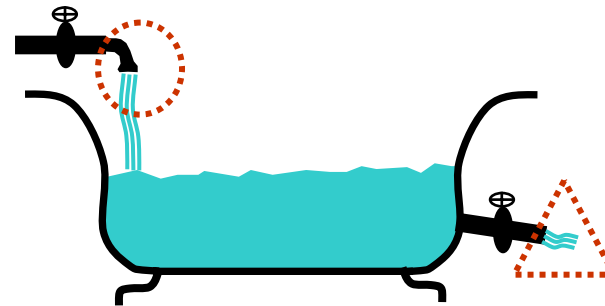
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Equilibrium

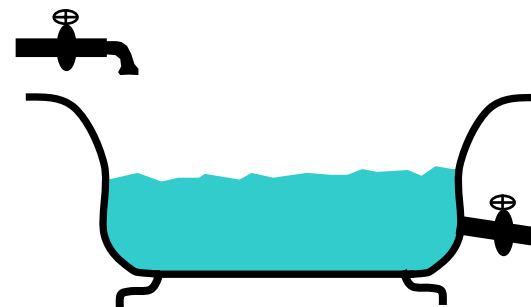
- Stock in equilibrium when unchanging
**System in equilibrium when all its stocks are unchanging.*
- Dynamic Equilibrium
e.g., # of US senate

$$\text{inflow} = \text{outflow}$$



- Static Equilibrium
**Same contents. e.g., # of Bach cantatas*

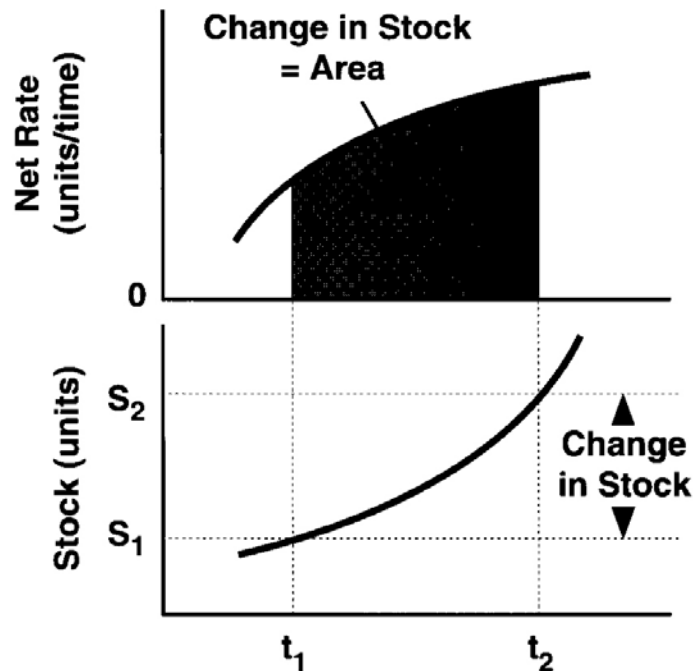
$$\text{inflow} = \text{outflow} = 0$$



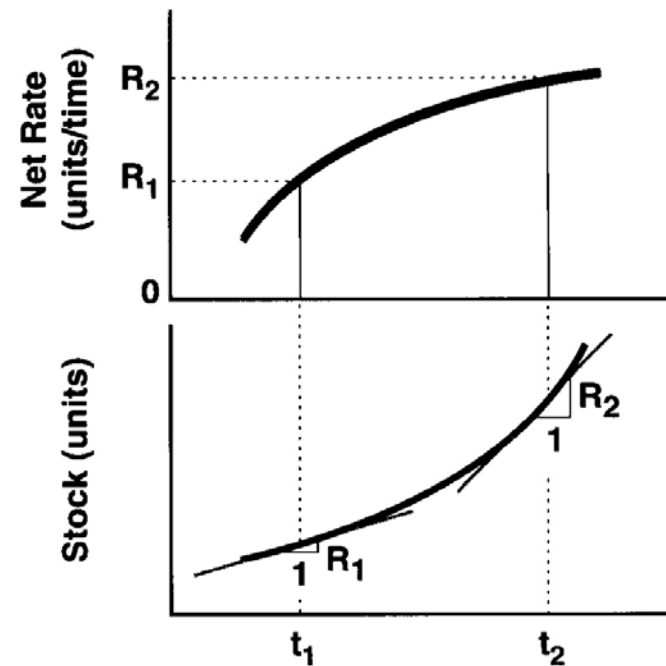
Integration & Differentiation

Stocks accumulate or *integrate* their net flow. The quantity added to a stock over any interval is the area bounded by the graph of the net rate between the start and end of the interval. The final value of the stock is the initial value plus the area under the net rate curve between the initial and final times.

In the example below, the value of the stock at time $t_1 = S_1$. Adding the area under the net rate curve between times t_1 and t_2 increases the stock to S_2 .



The slope of a line tangent to any point of the trajectory of the stock equals the net rate of change for the stock at that point. The slope of the stock trajectory is the *derivative* of the stock. In the example below, the slope of the stock trajectory at time t_1 is R_1 , so the net rate at $t_1 = R_1$. At time t_2 , the slope of the stock is larger, so the net rate at $t_2 = R_2$ is greater than R_1 . The stock rises at an increasing rate, so the net rate is positive and increasing.



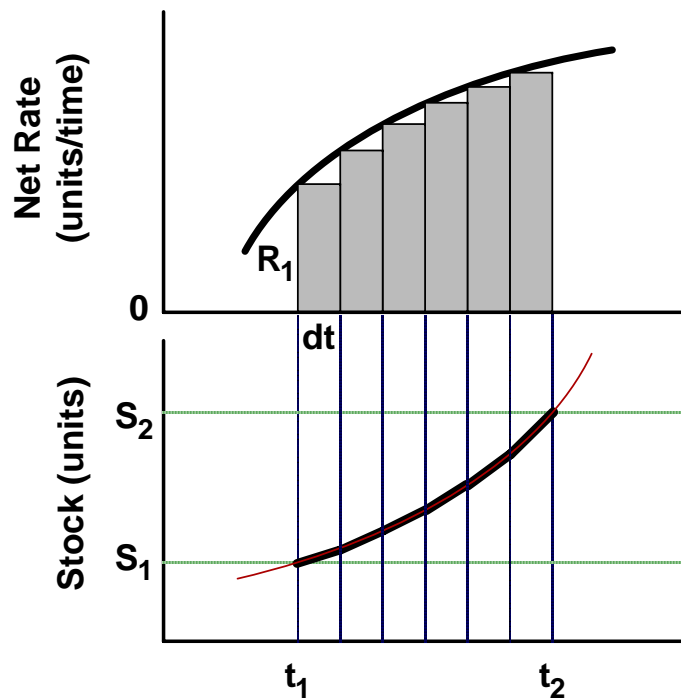
Calculus without Mathematics

Quantity added during interval of length dt

$$= R \text{ (units/time)} * dt \text{ (time)}$$

*R = the net flow during the interval

Concrete Mixer Example



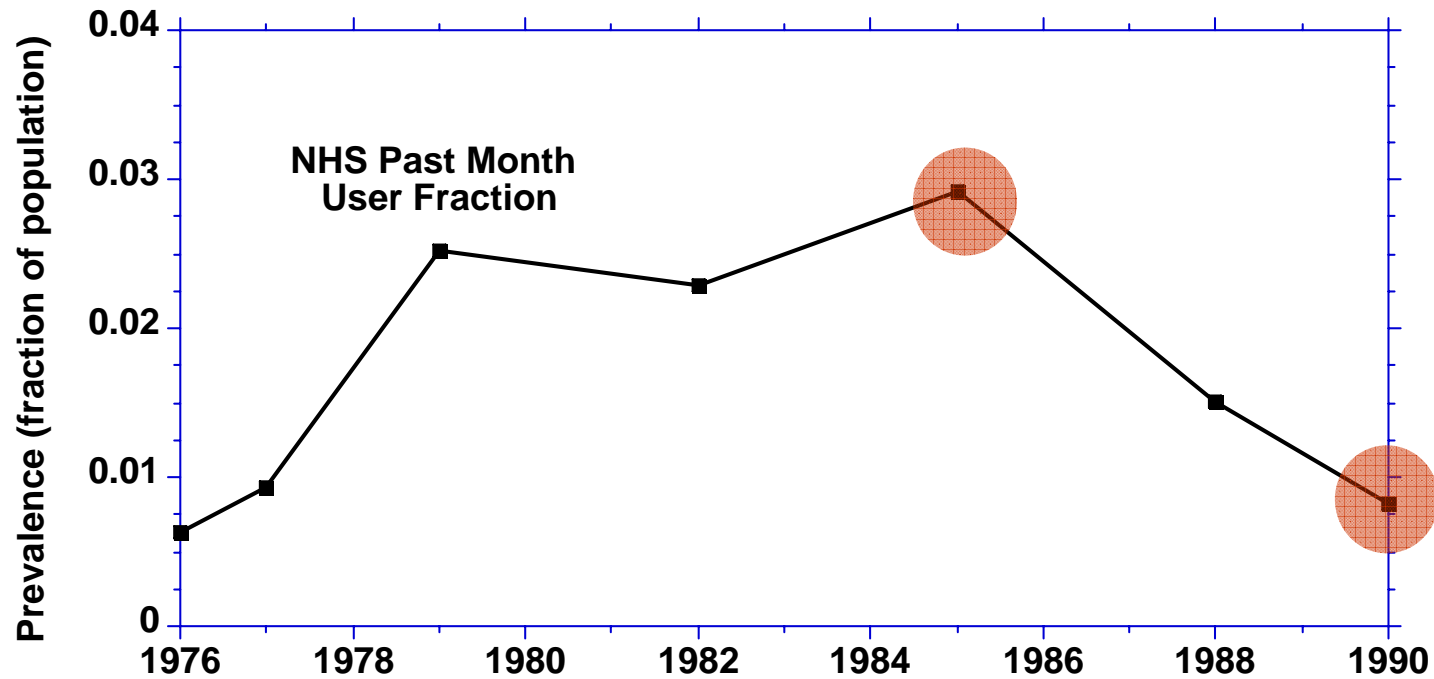
- Area of each rectangle = $R_i dt$
- Adding all six rectangles = Approximation of total water added
- How to increase accuracy?

The War on Drugs

- Use of Cocaine dramatically increased in 1980s
- Billions spent to increase enforcement, focusing on the supply side
- On demand side: “Just say NO”
- Did it work?

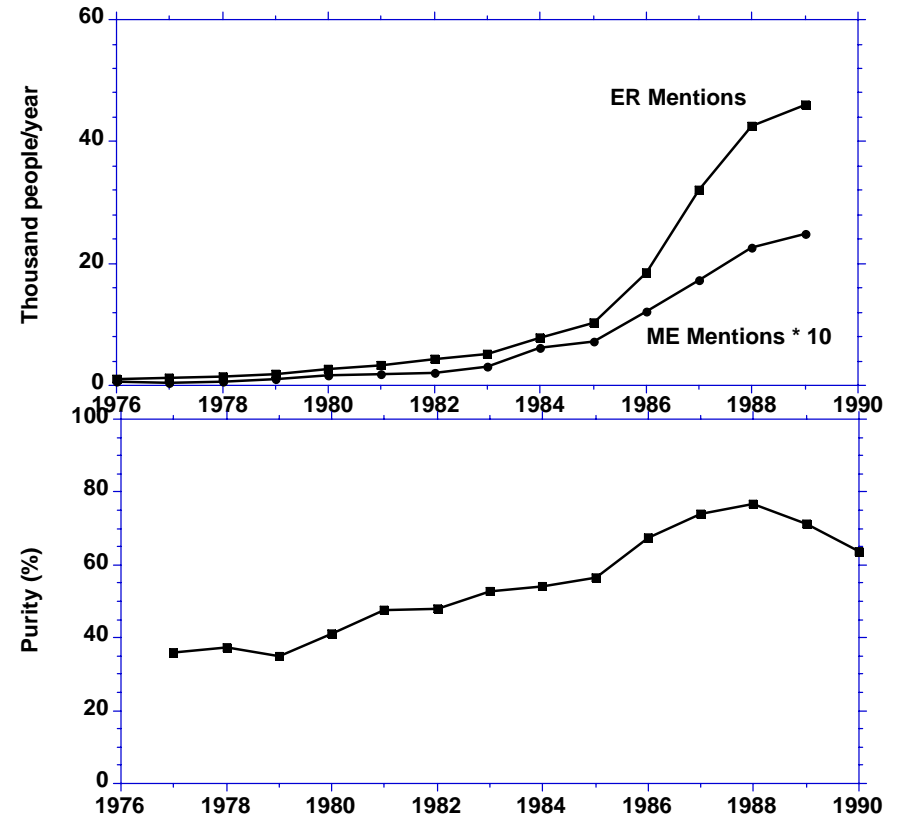
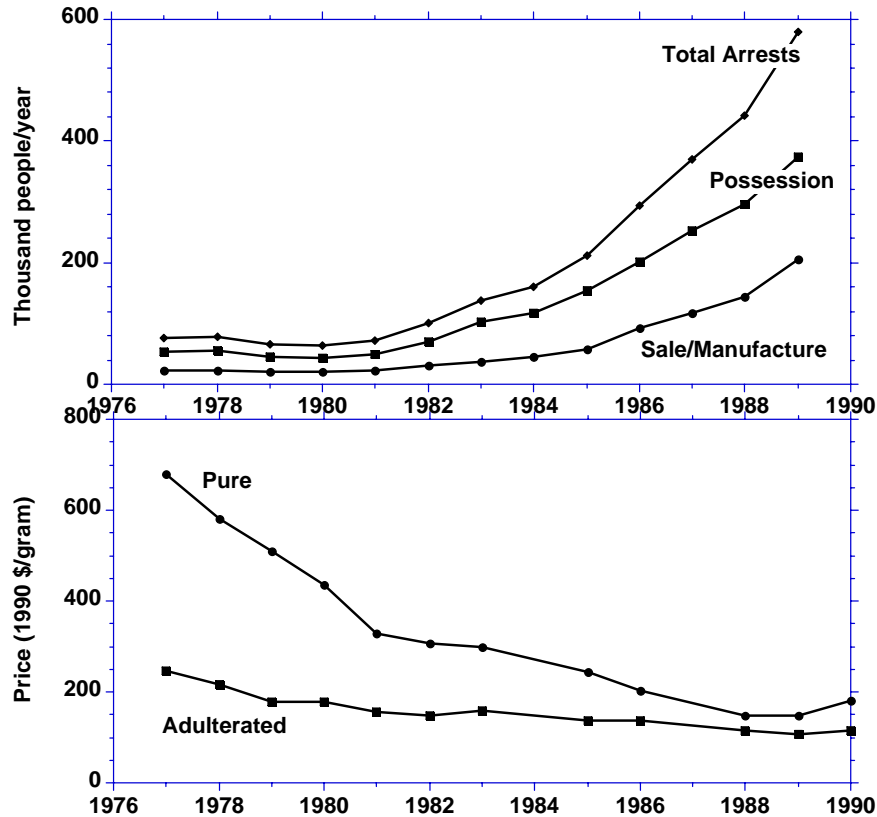


It seemed to be working...



Down from 3% in 1985 to 1% in 1990

But, the problem was getting worse...



Source: Homer (1993, 1997).

As a result,...

- Cocaine use was up sharply and availability was growing.
- The same failure of prohibition in 1920s and 1930s.
- Critics argue “ interdiction could never work and call for stronger demand-side measure (MacCoun and Reuter, 1997)”

How to explain?

Supporters

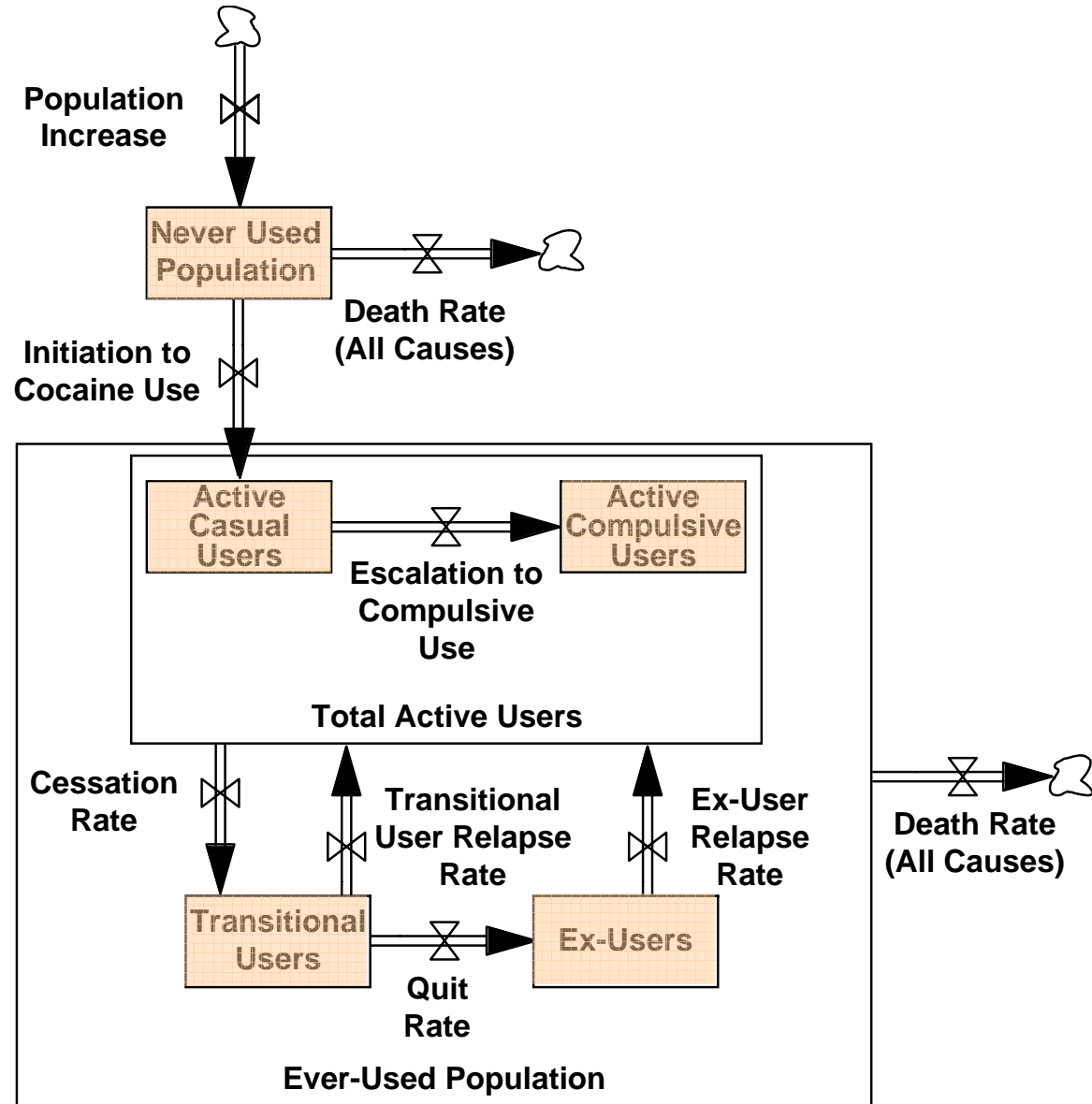
- Rising arrest rates by greater enforcement, not by greater drug use
- Falling prices, rising purity, surge in ER by substitution of more potent crack for the less pure power form

Critics

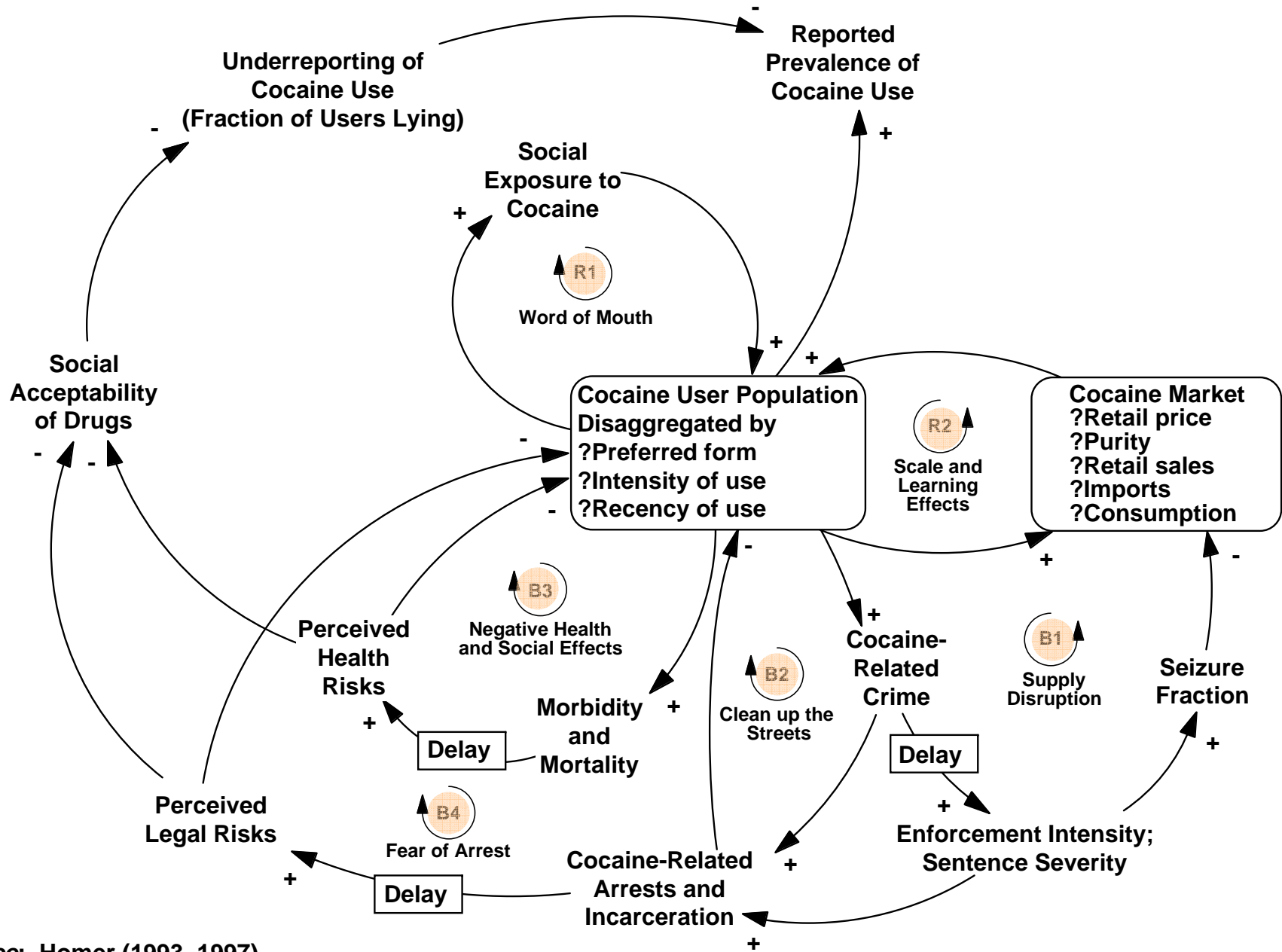
- Cocaine users are less likely than law-abiding citizens to be selected for the survey. Thus,
- They are likely deny they use drugs.

System Dynamics Model

The national Institute of Justice commissioned a study, 1980s

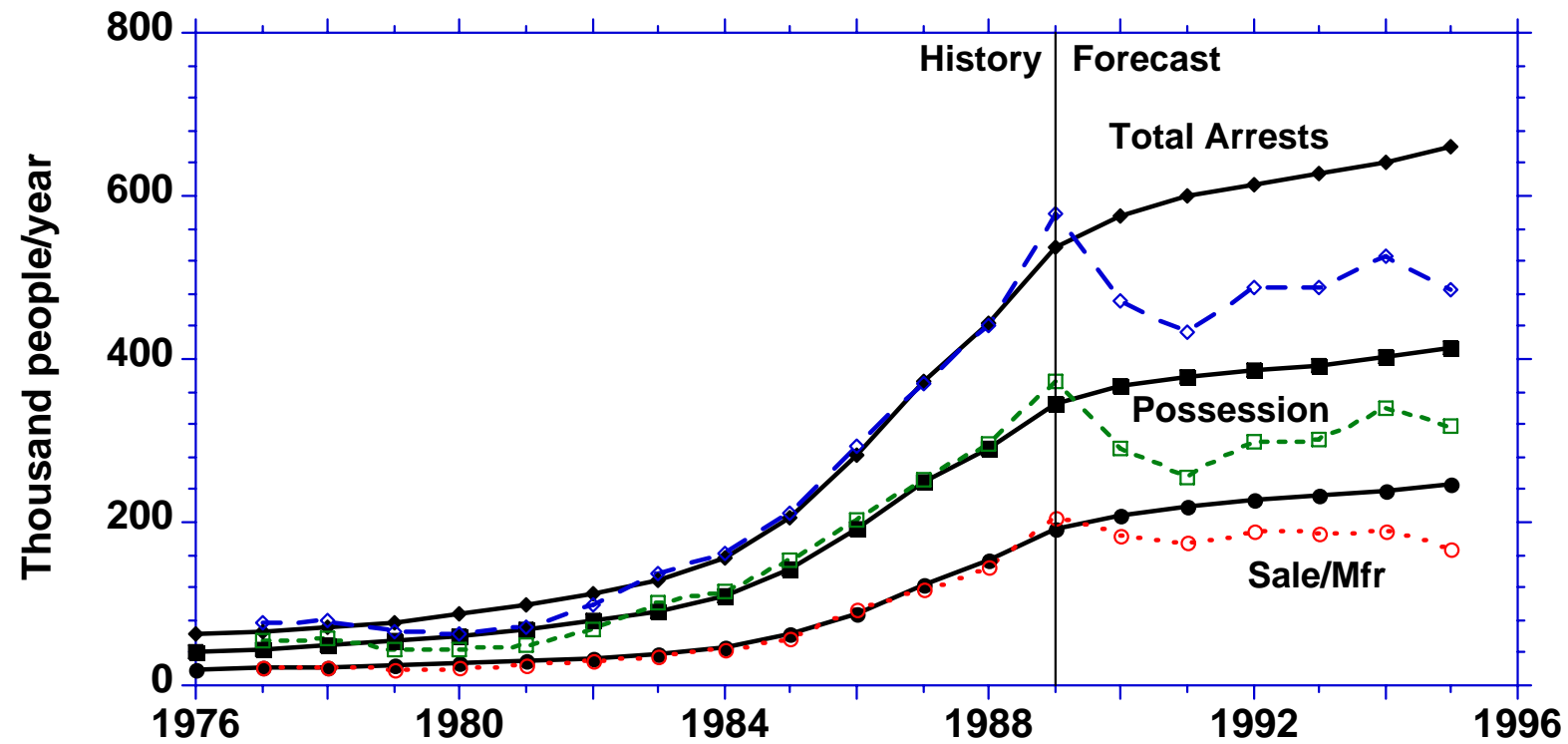


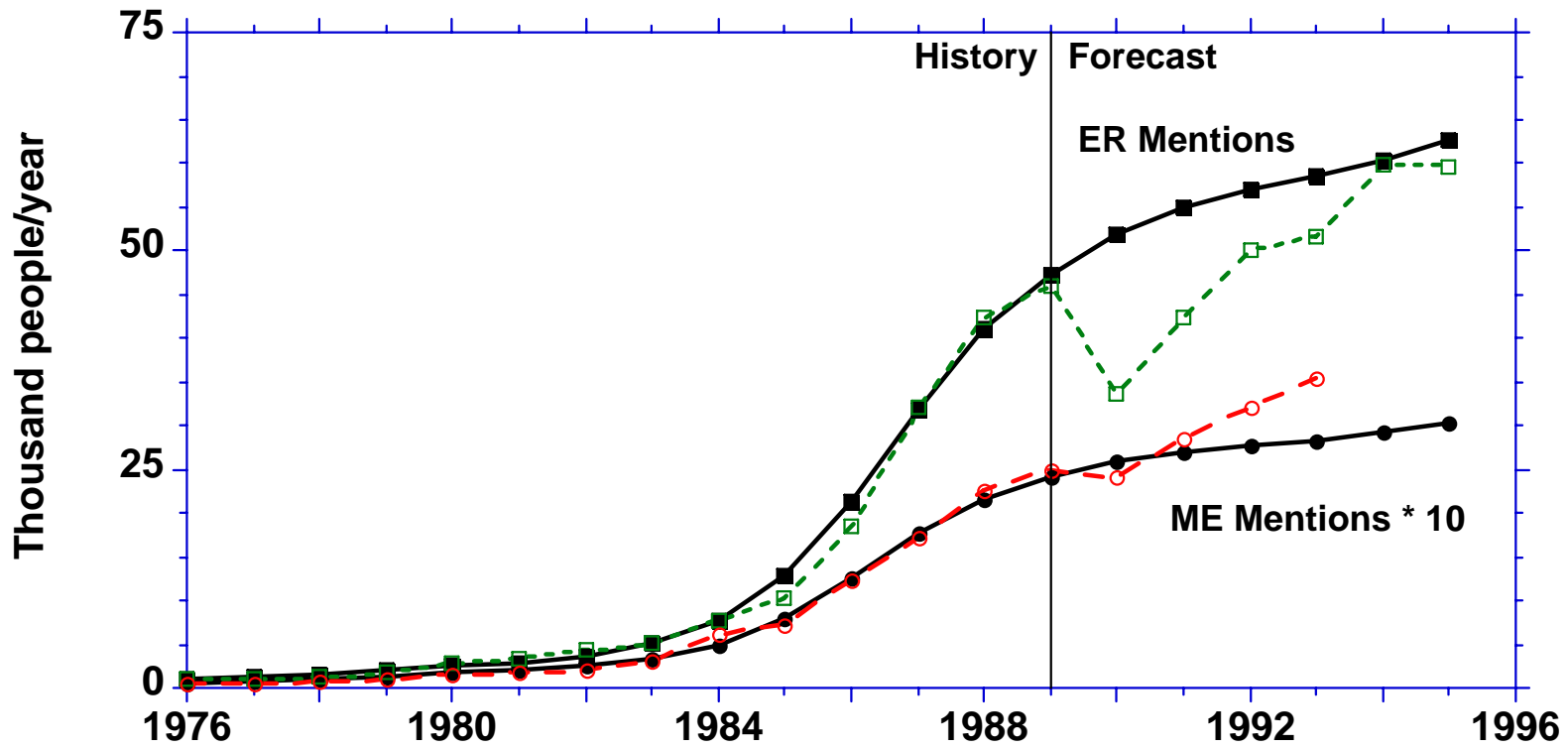
Source: Homer (1993, 1997).

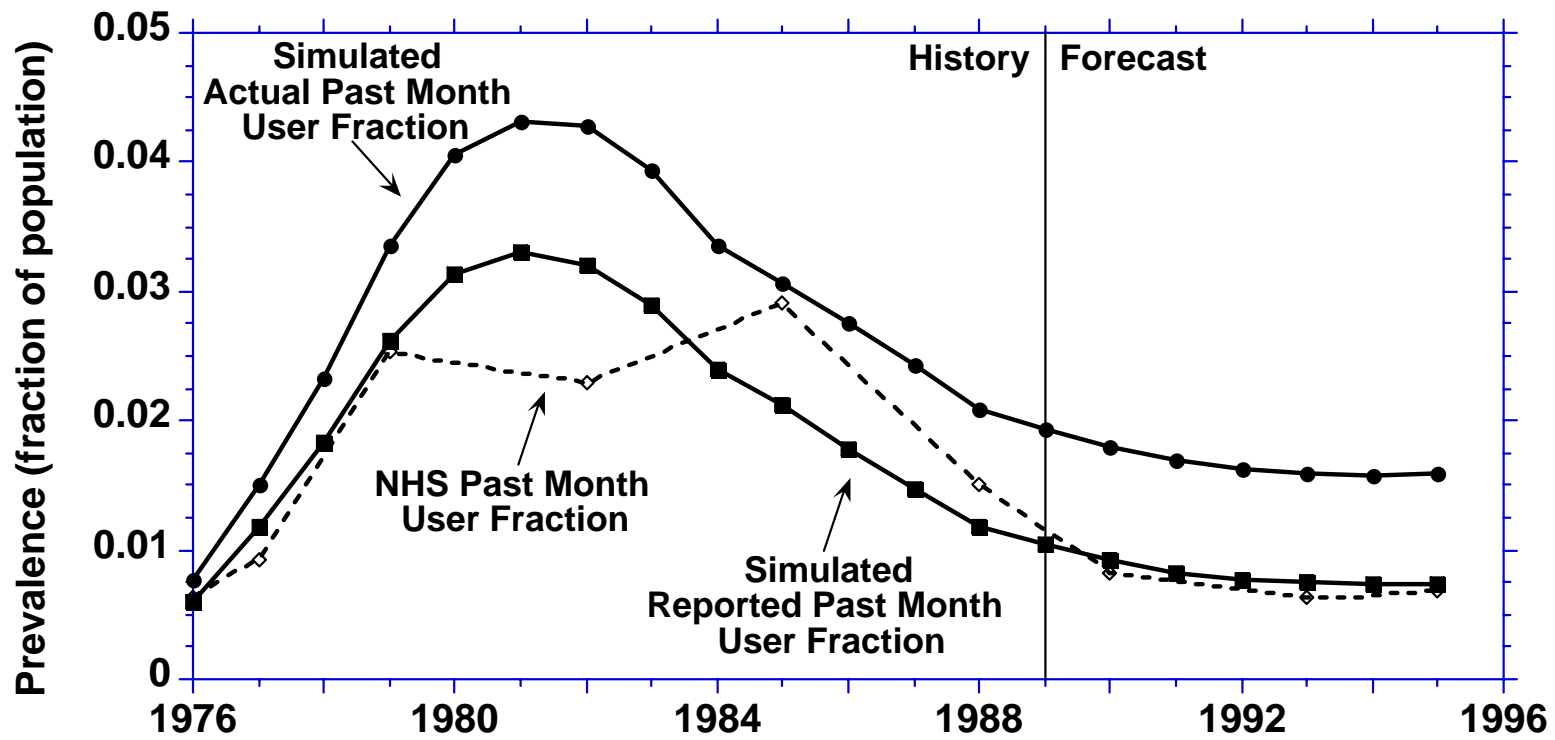


Source: Homer (1993, 1997).

Simulated / Actual Data







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