Guided Study Program in System Dynamics
System Dynamics in Education Project
System Dynamics Group
MIT Sloan School of Management[1]

Solutions to Assignment #16
Monday, February 22, 1999

Please note that there are no "right" or "wrong" solutions to this assignment. Some of you analyzed the problems from a different point of view than we did, so your solutions might be quite different from what is presented below. These general solutions only show one of many possible ways of conceptualizing these three systems.

Reading Assignment:

Please refer to Road Maps 8: A Guide to Learning System Dynamics (D-4508-1) and read the following paper from Road Maps 8:

- *Building a System Dynamics Model Part One: Conceptualization, by Stephanie Albin (D-4597)*

Exercises:

In this assignment you will conceptualize two systems, following the steps illustrated in D-4597. For each excerpt, you should turn in:

- *Definition of the problem, in one or two sentences.*

- *Purpose of the model and the model audience.*

- *Endogenous and exogenous components of the model and an explanation of why you chose those components. Identify which elements are stocks and which ones are flows.*

- *Description of reference modes for the most important variables in the system. You should particularly pay attention to the causal relationships between the reference modes. You may include graphs of the reference modes created in a graphics*

application.

- *Hypothesis for the dynamics of the model behavior*

- *Stock and flow diagram of the basic mechanism*

Excerpt 1[2]

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The debate over Russia's pension system is similar to a debate now underway in the United States, where many conservatives want to supplement or replace parts of Social Security with a system of individual accounts. But Russia's huge number of retirees and shaky economy make the problem far more difficult.

Russia has what economists call a pay-as-you-go approach. That means the benefits of current retirees are paid by the current work force. But decades of Soviet planning have led to a financially strapped system, which gives too little to too many.

The problems are legion, one of the biggest being early retirement age. Russian men customarily retire at 60 and women at 55, years before people in most Western nations. Almost one-fifth of Russia's workers retire at even younger ages. They include coal miners, who have endured a lifetime of dangerous labor, as well as workers whose jobs are neither especially stressful nor hazardous.

Even allowing for lower-than-average life spans, Russia's retirement policies have created an immense army of pensioners. Roughly 38 million Russians receive pensions— about one for every two in the work force. In the United States, by contrast, the ratio is about one pensioner for every four workers.

The benefits are modest and provide little extra reward for especially dedicated or successful workers. The vast majority receive 300 rubles (about $50) to 400 rubles (about $67) a month.

The system is also chronically short of cash. Many Russian companies have simply ignored the 28 percent payroll tax that is supposed to go toward retirement. Workers pay a minuscule 1 percent of their income to the pension fund.

Russia has one advantage. The huge casualties it suffered during World War II depressed the birth rate, which means fewer men and women are expected to reach pension age between 2000 and 2007. That will give Russia a chance to get its house in order before the number of retirees begins to climb again.

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[2] Excerpt taken from "World Bank Vs. Reformers on How to Still Feed Russia When It's 64" by Michael R. Gordon, The New York Times, March 15, 1998.

Definition of the problem:

Russia's current Social Security system gives too little to too many.

Purpose of the model and the model audience:

The purpose of the model is to study possible improvements to Russia's Social Security system so that retired people receive higher payments. Additionally, we want to examine the effects of a lower inflow of new retirees between 2000 and 2007. The model is intended for the average person, but could also be used by economists and politicians who are trying to restructure the Social Security system.

Endogenous and exogenous components of the model. Identify stocks and flows:

ENDOGENOUS COMPONENTS	EXOGENOUS COMPONENTS
Current work force (S)	average time in work force
entering work force (F)	average time as pension-receiver
retiring (F)	payroll tax to pension funds
Pension-receivers (S)	income tax to pension funds
deaths (F)	average income per worker
Money in pension funds (S)	work force growth fraction
contributions to pension funds (F)	
pension payments (F)	
retirees to work force ratio	
average yearly payment to retiree	
total income by work force	

Reference modes for most important variables:

Work Force

Pension-Receivers

Years

Money in Pension Funds

Years
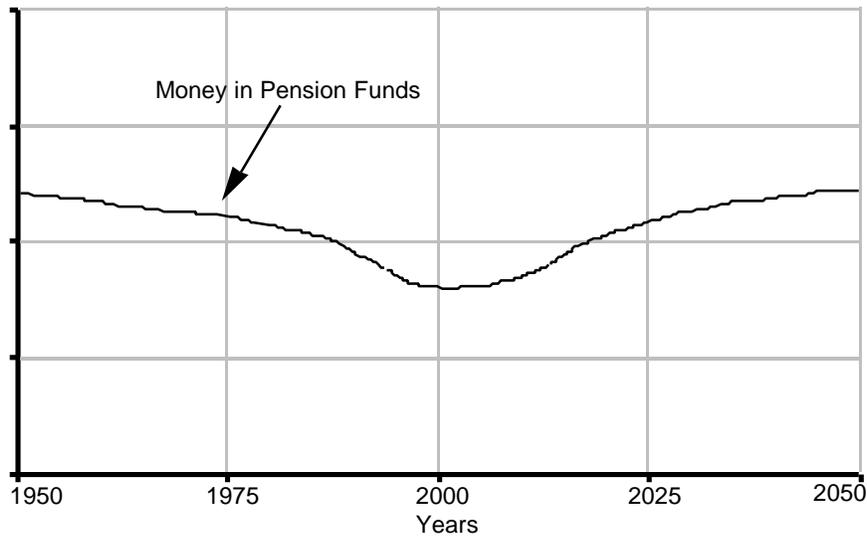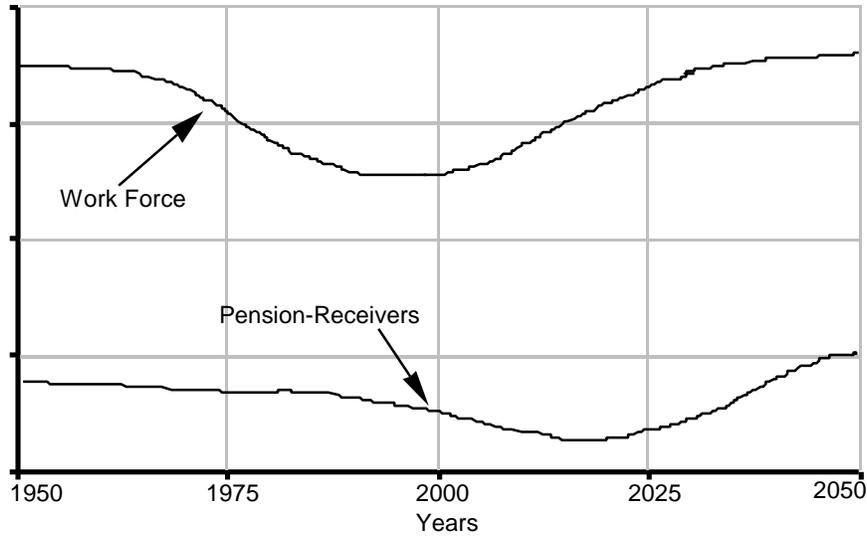
Hypothesis for the dynamics of the model behavior:

Because of the lower birth rate after World War II, the Russian work force started declining while the number of pension-receivers was fairly constant. After some delay, however, fewer workers will reach pension age, which will result in a decreasing number of pension-receivers, while the work force will start rising again. The amount of money in pension funds declines when the ratio of workers to retirees is low, but should increase again when the number of pension-receivers is low.

Stock-and-flow diagram of the basic mechanisms:
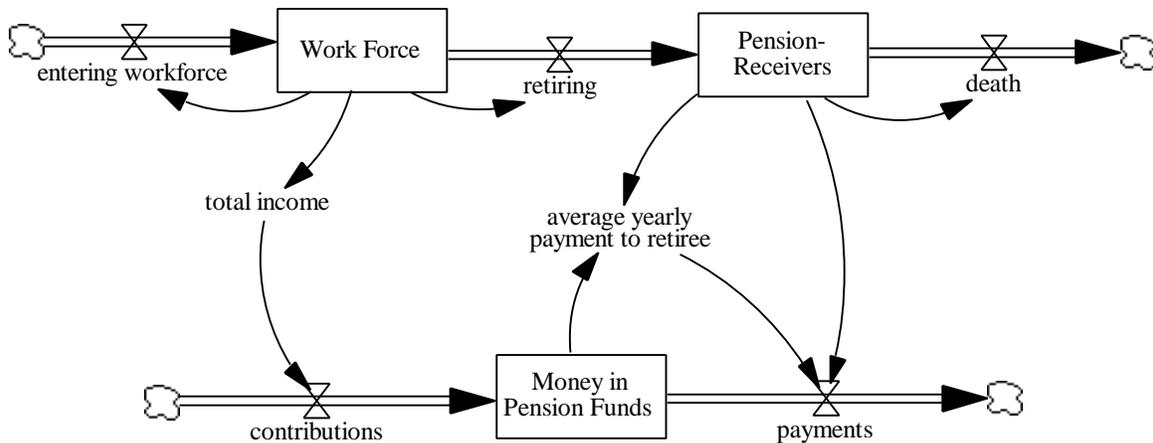
Excerpt 2[3]

Sydney, Australia — As if in some B-movie thriller, people here are raising a hue and cry about an alien predator that is spreading out of control across the land: a plague of millions of killer house cats run wild.

Interlopers on this isolated island continent like the settlers who brought them here 200 years ago, stray cats have multiplied through Australia's deserts, forests, and urban alleys, driving indigenous species to extinction as they go.

Without any natural enemies to keep them in check as on other continents, perhaps 12 million wild cats have been killing small creatures whose evolution has not taught them that cats are their enemy.

"I'm calling for the total eradication of cats in Australia," proclaimed Richard Evans, a member of parliament, putting the issue on the national agenda last October. Though he now says a cat-free continent may be beyond reach, Evans drew wide support with his proposal to kill all cats by the year 2020 by neutering pets and spreading fatal feline diseases in the wild.

The proposal recalls a partly successful attempt earlier in the century to eliminate rabbits, another species imported to Australia, with a virus popularly known as white blindness. By the thousands, dying rabbits staggered onto highways and were hit by cars, causing widespread alarm. The rabbits, however, were mostly a threat to crops. But with the perception that the survival of the native fauna is at stake, a hatred of cats has swept the nation, causing some cat owners to keep their pets at home to avoid cat-killing vigilantes.

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[3] Excerpt taken from "For Australia's Errant Cats, 9 Lives Might Not Be Enough" by Seth Mydans, The New York Times, January 28, 1997.

Members of the Cat Protection Society have protested the anti-cat campaign and the Royal Society for Prevention of Cruelty to Animals called Evans's proposals "outrageous and unnecessary."

Responsible pet ownership and government regulation can solve the problem better than mass killings, which only create a temporary dip in cat population, Hugh Wirth (RSPCA) said.

Definition of the problem:

In Australia, the population of cats is growing rapidly without any natural enemies, threatening to drive indigenous species to extinction.

Purpose of the model and the model audience:

The purpose of the model is to search for actions that would effectively control the cat population, rather than allowing mass killings that only create a temporary dip in cat population. The model is intended for politicians who have to take measures against the growing cat population, as well as cat owners and those who promote mass killings.

Endogenous and exogenous components of the model. Identify stocks and flows:

ENDOGENOUS COMPONENTS	EXOGENOUS COMPONENTS
Reproducing Cats (S)	cat lifetime
cat births (F)	cat birth fraction
cat deaths (F)	fraction of cats neutered
mass killings (F)	
neutering (F)	
Neutered Cats (S)	

Reference modes for most important variables:
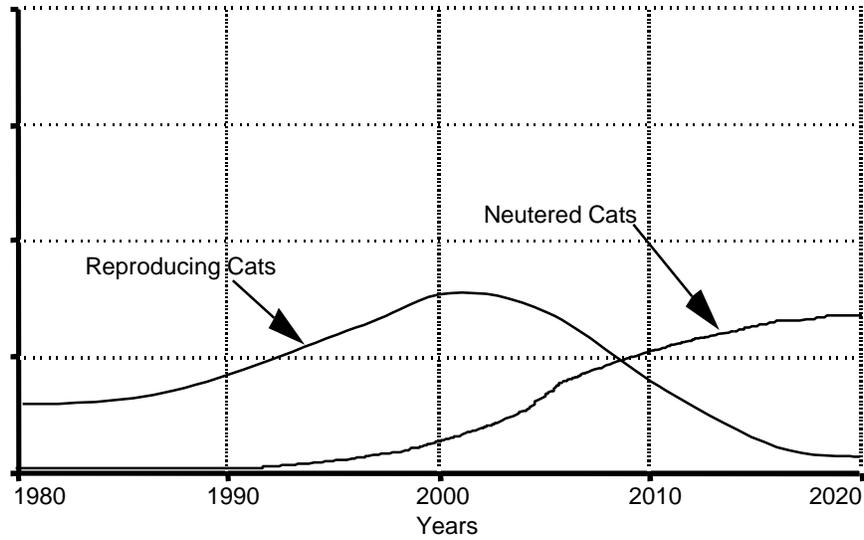
Hypothesis for the dynamics of the model behavior:

Because of the lack of natural enemies, the cat population will continue to grow even if mass killings and neutering take place. In the reference mode above, we assume a policy that will keep increasing the fraction of neutered cats. The population of reproducing cats decreases and reaches equilibrium at a value such that reproduction equals total cat deaths. Thus, the total cat population eventually reaches equilibrium.

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Stock-and-flow diagram of the basic mechanisms: