An Introduction to system dynamics

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Historical background

The , system dynamics was developed by professor (Jay Wright Forrester) of the Massachusetts institute of technology in 1950s

His effort was oriented towards tackling the concern about unmanageable complexities in real systems through the application of the ***control system theory*** on them

At first the approach was termed ***Industrial Dynamics*** in which the dynamics of industrial system is modeled

The foundations of Industrial Dynamics are:

- ***The information feedback control theory***
- ***The modeling of fundamental decision-making processes***
- ***The experimental approach to system analyses***
- ***The use of digital computer simulation***

Next: the theory was generalize into the

(Principles of Systems)

The concept of rates and levels where introduces for first time

In the next step: an urban system was introduced

This model shows the growth and decay of the urban system

It encompasses the general characteristics of complex systems

Then: the methodology was applied on global scale by the model **WORLD 1** and its revised version **WORLD 2**

Formulated as the bases for ”Project on the Predicament of Mankind”

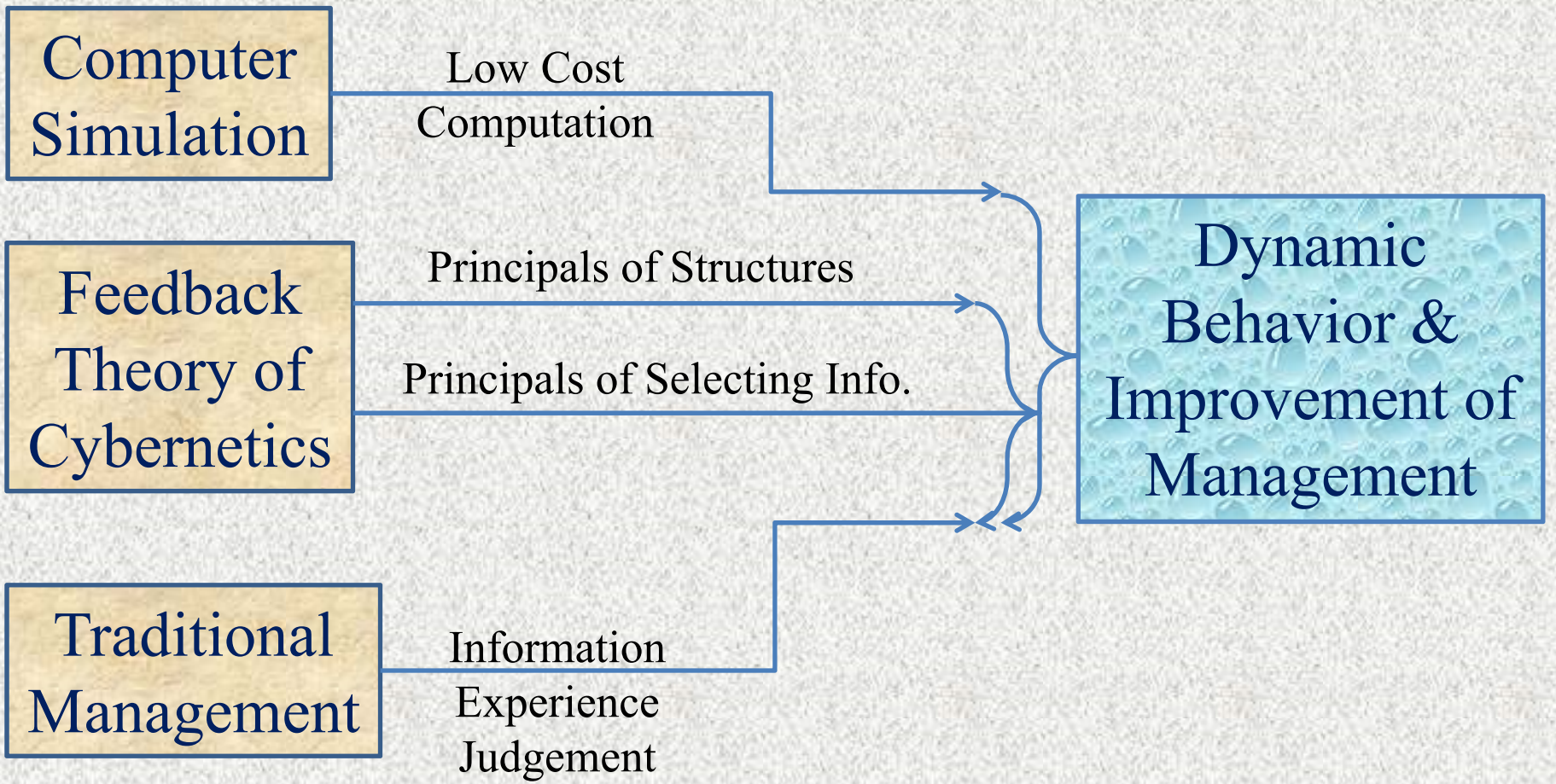
The first system dynamics model of the world’s socioeconomic system

System Dynamics Approach

- System dynamics is an approach to understanding the dynamic behavior of complex systems over time
- It deals with structures of social systems
- It also represents this system structure in form of *diagrams* and *mathematical equations*
- It deals with almost any complex system that changes over time

Background Threads

- Combine the strengths of the ability of computer models in process information
- Avoid the weakness of mind inability to manipulate huge amount of information

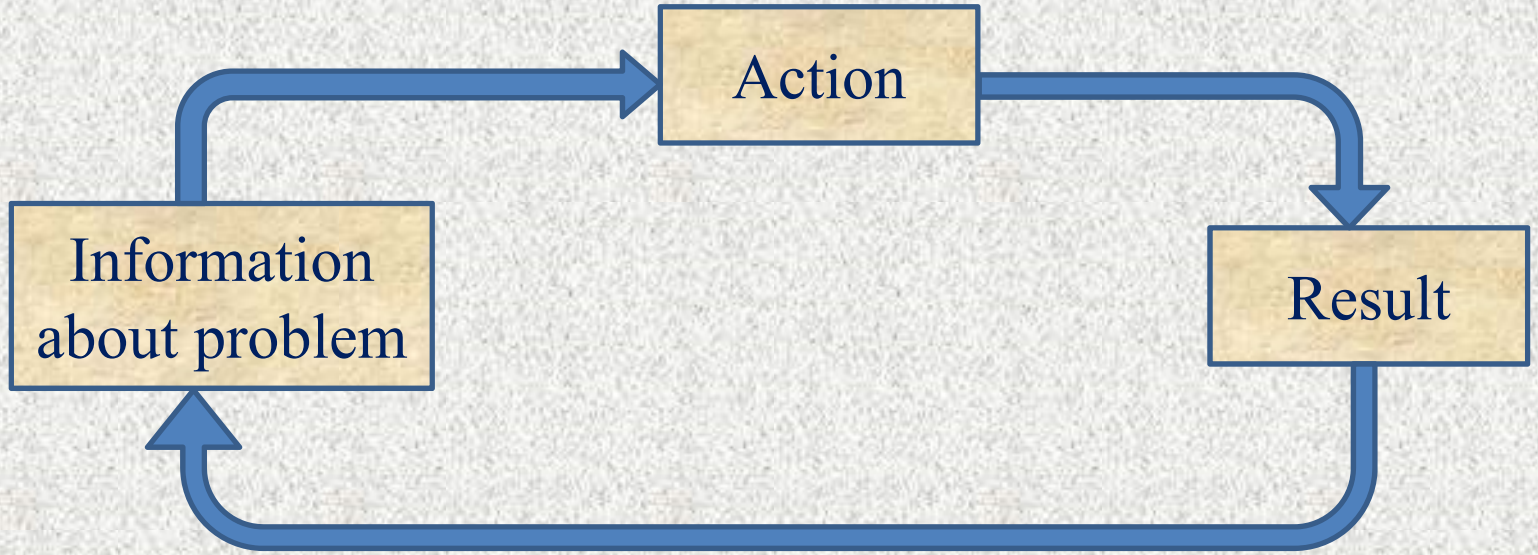


Principles of feedback viewpoint

Open Loop Impression of the World

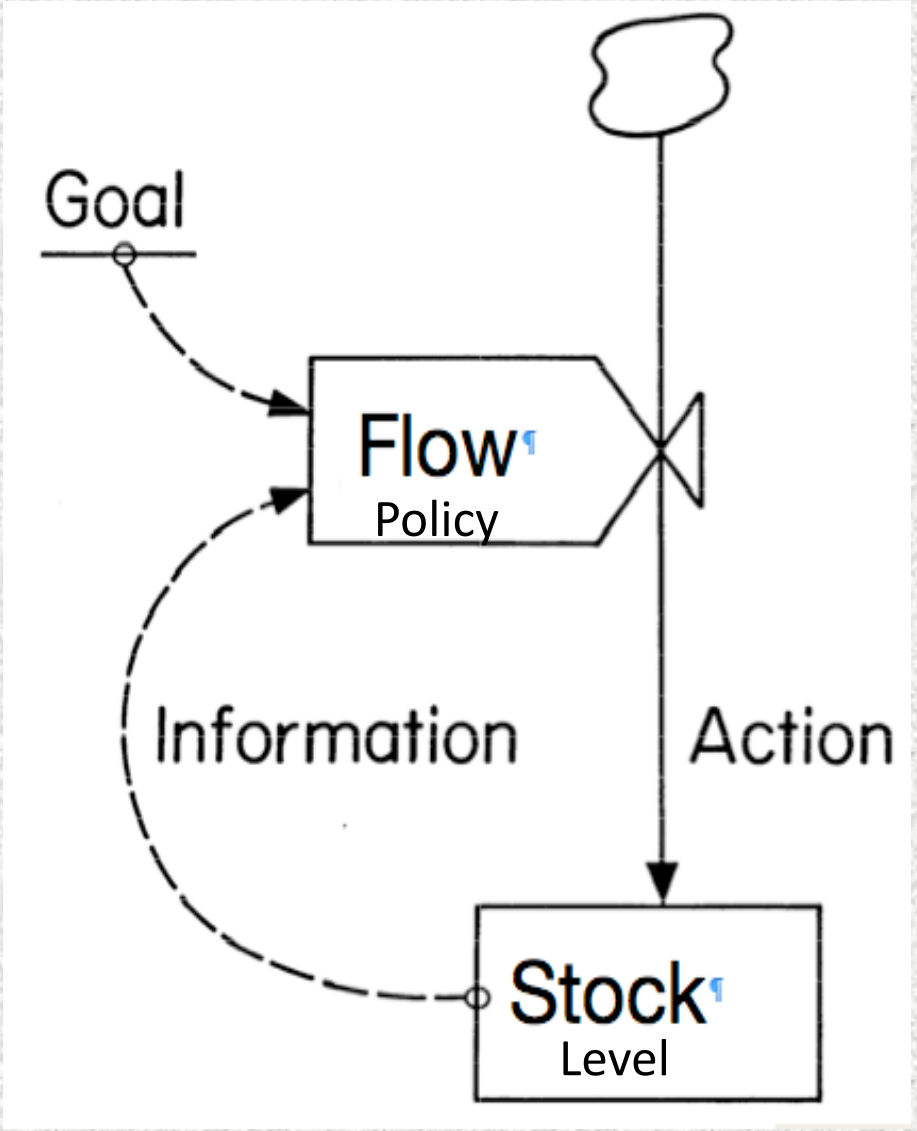
Wrong image of the World

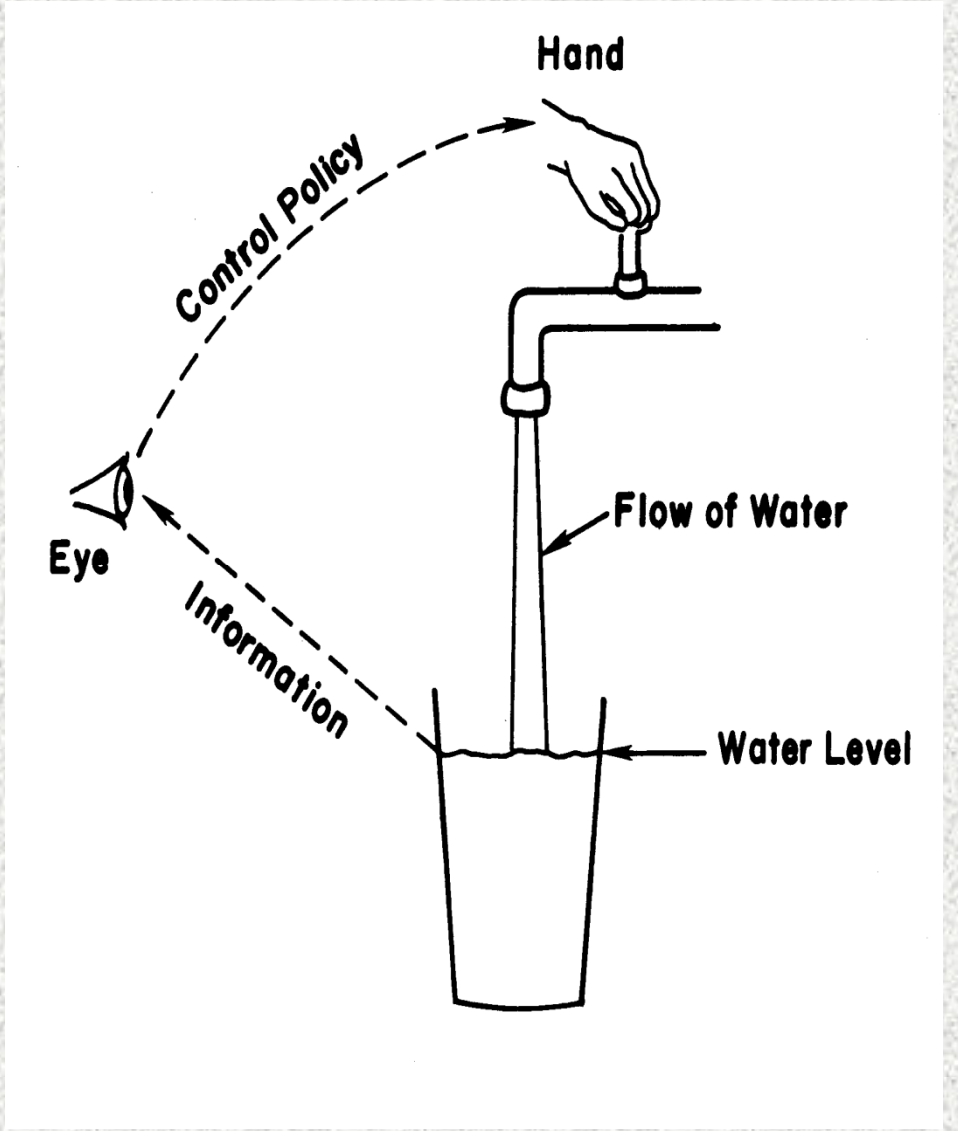
Closed Loop Structure of the World



Appropriate image of the World

Simple feedback Loop



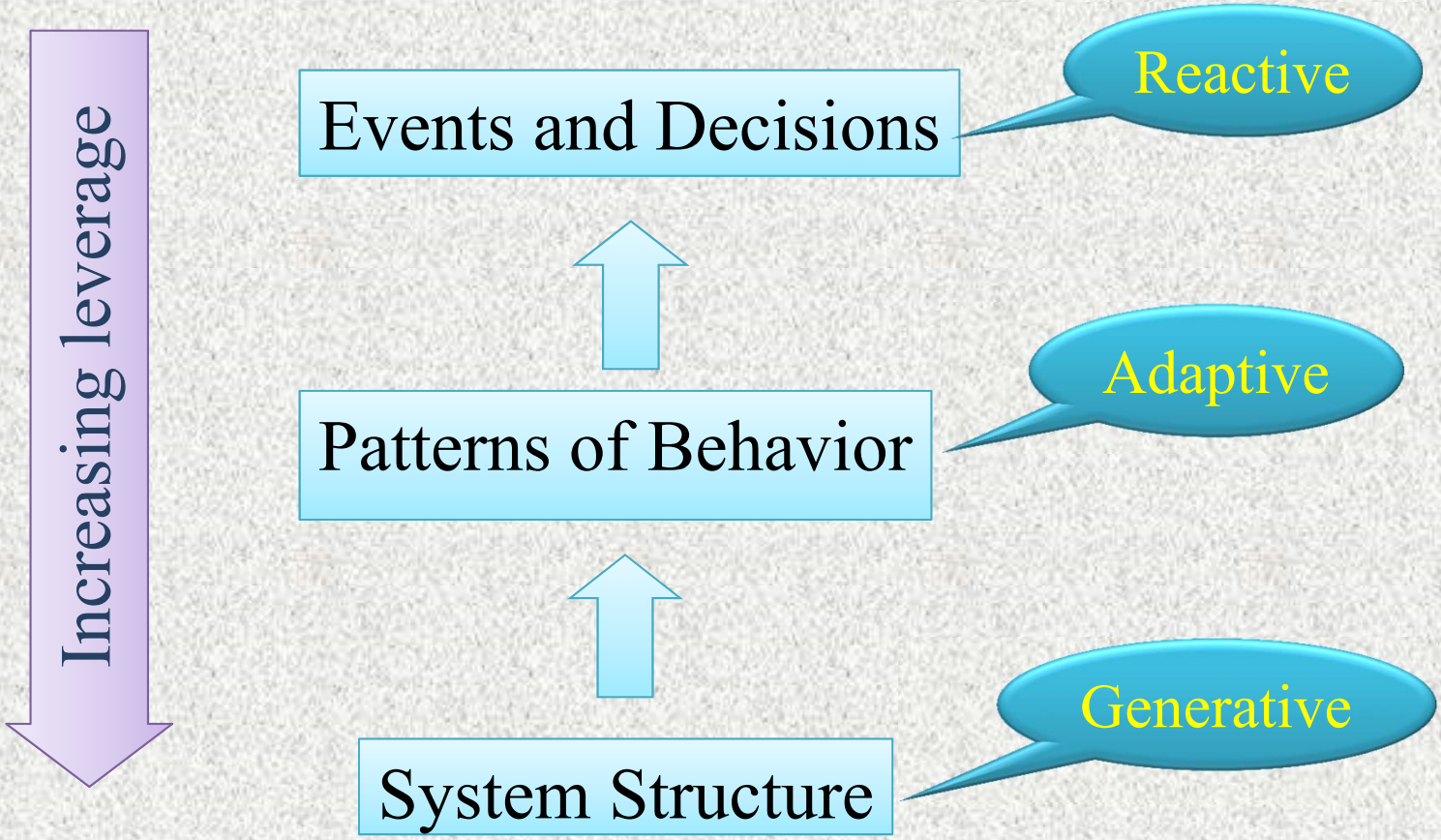


Central Concept of System Dynamics

- Capturing feedback processes
- Seeing the structures that underlie complex systems
- providing insight to the dynamic interactions

System Dynamics provide the capability of recognizing patterns and interrelationships that can be managed in more effective and efficient ways

A Systems Perspective



Systems View Distance

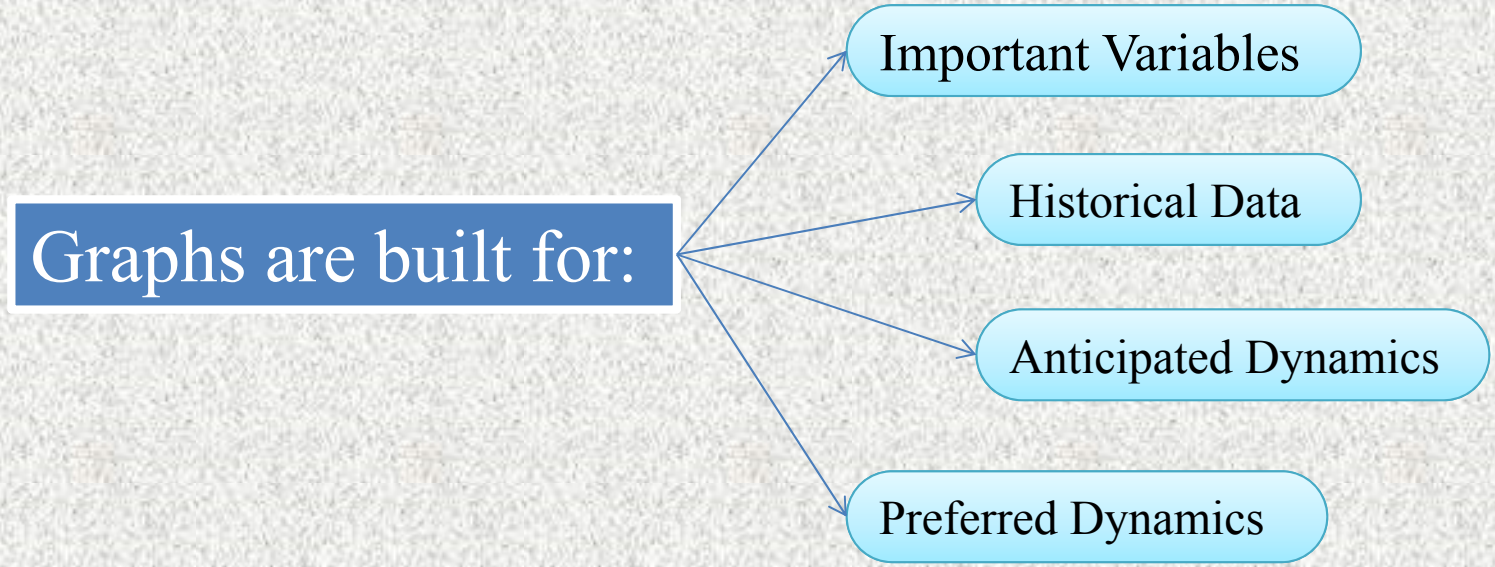
- Relate discrete events to patterns of behavior
- Focusing on policy structure rather than individual decisions

Four Key Patterns of Thought

- Dynamic Thinking (graphs over time)
- Causal Thinking (feedback loops)
- Stock-and-Flow Thinking (accumulation)
- Thinking endogenously (system as cause)

Dynamic Nature

- Problems are defined in terms of graphs over time

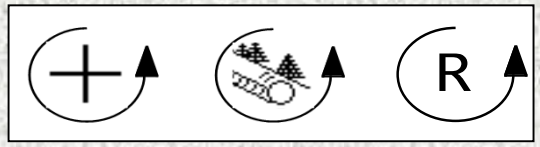


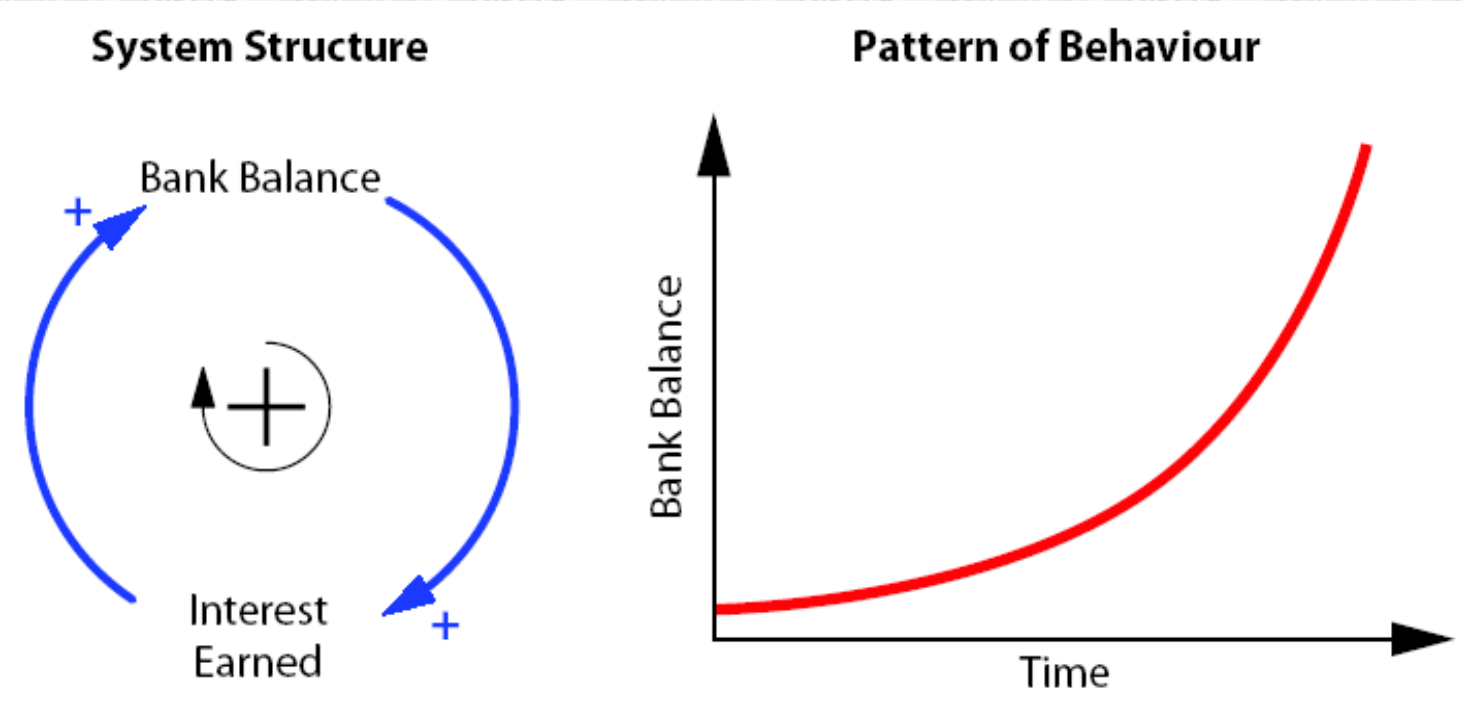
- These graphs are used to focus systems thinking and modeling

Causal Loop Patterns of Behavior

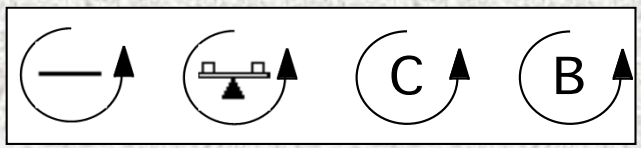
- A causal loop represents a building block that has its own pattern of behavior

Positive (Reinforcing)

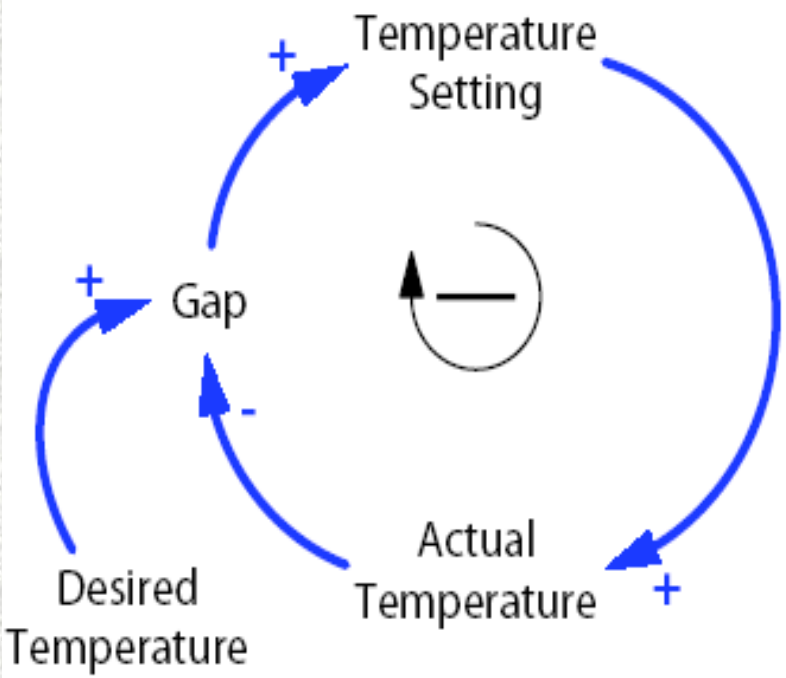




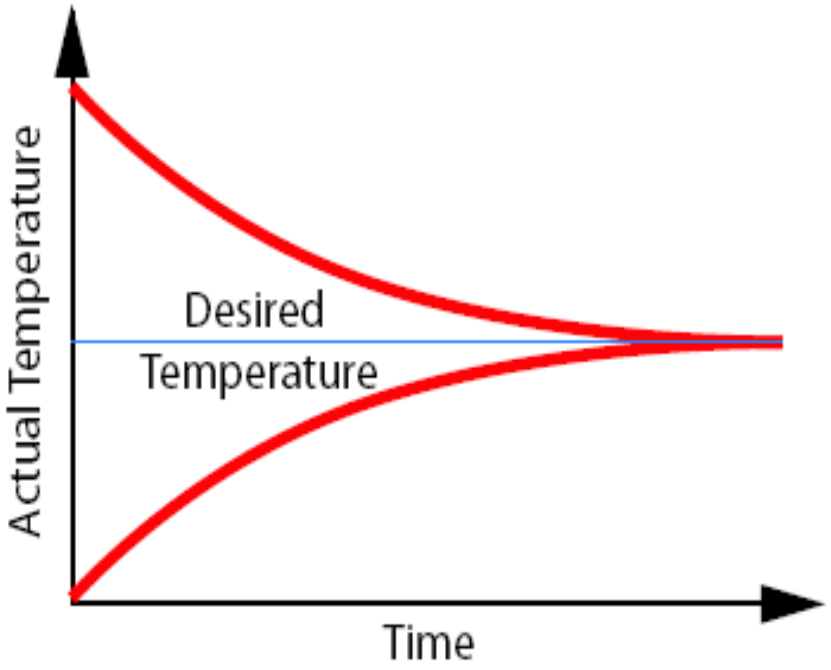
Negative (Balancing)



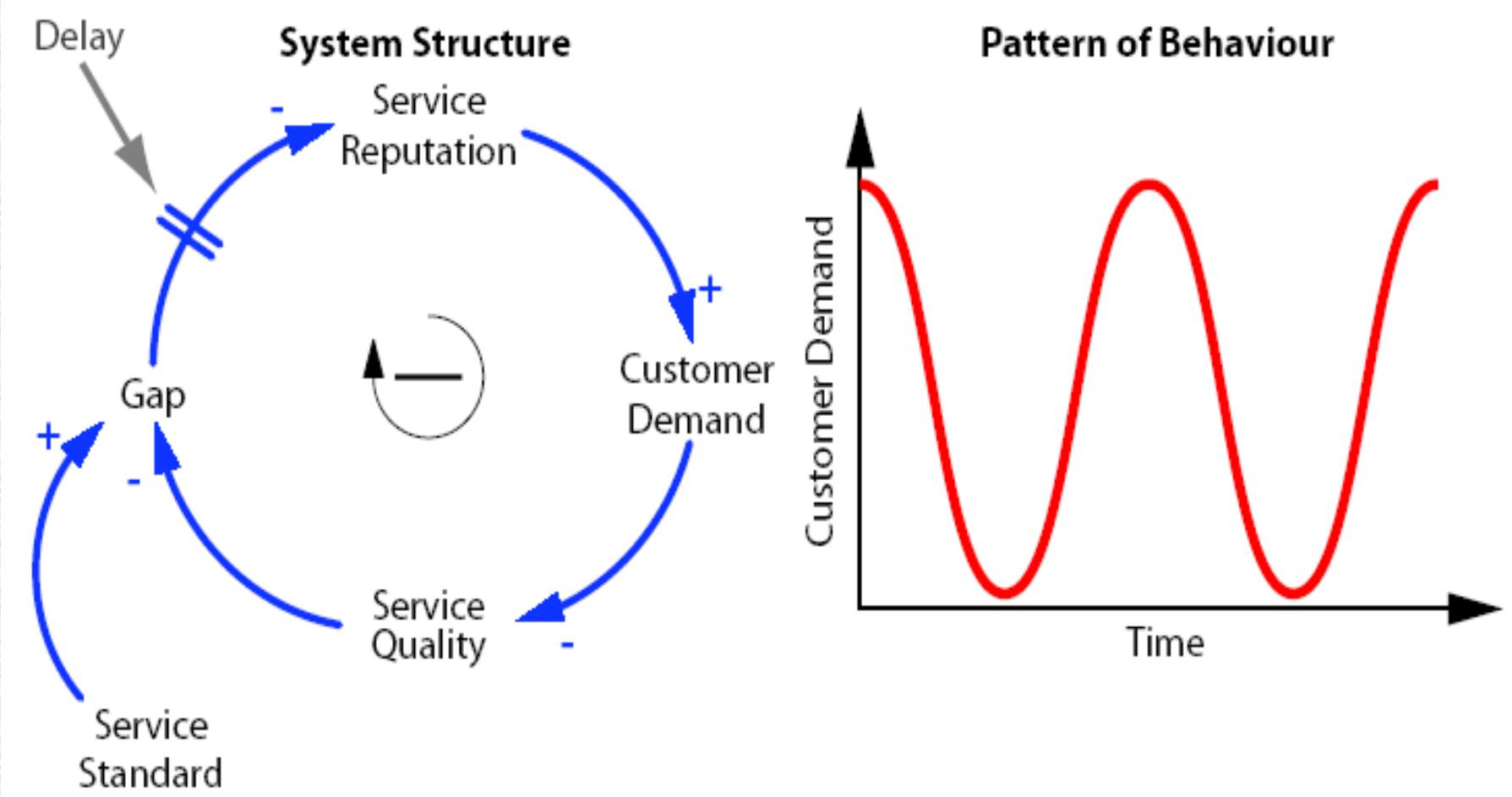
System Structure



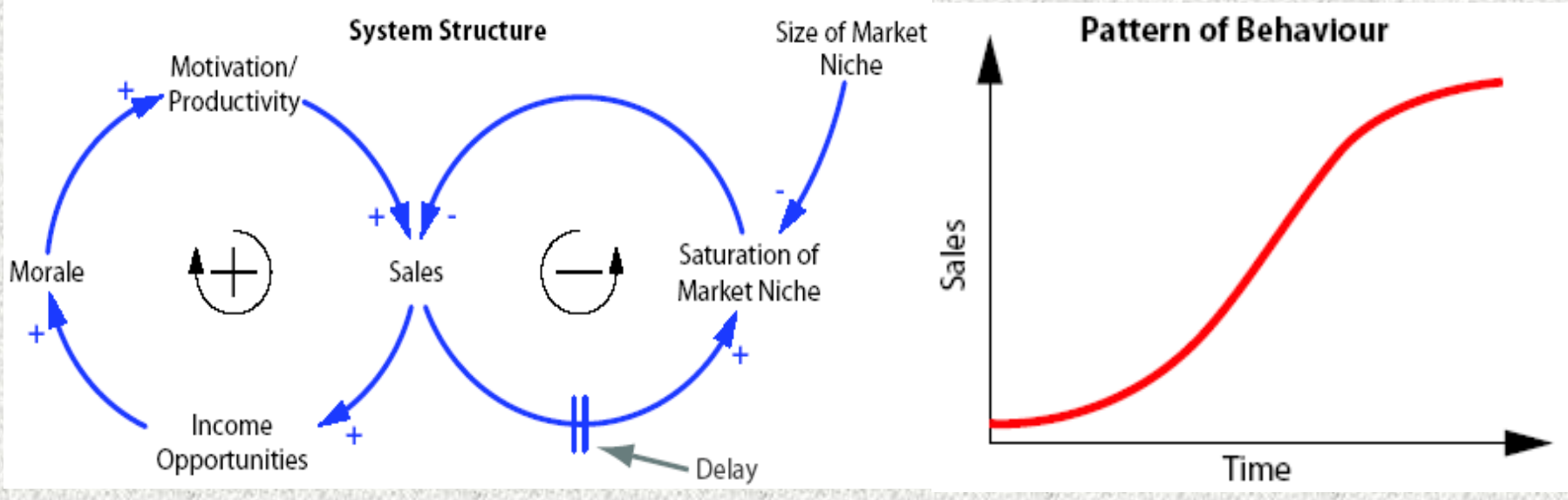
Pattern of Behaviour



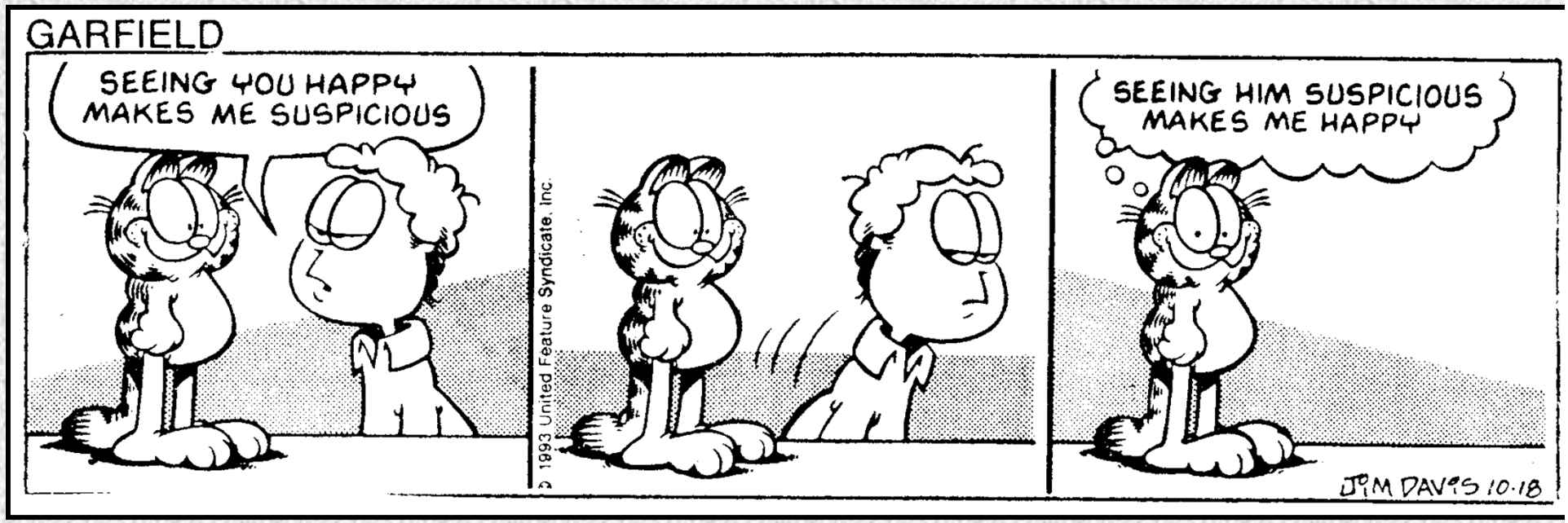
Negative with Delay

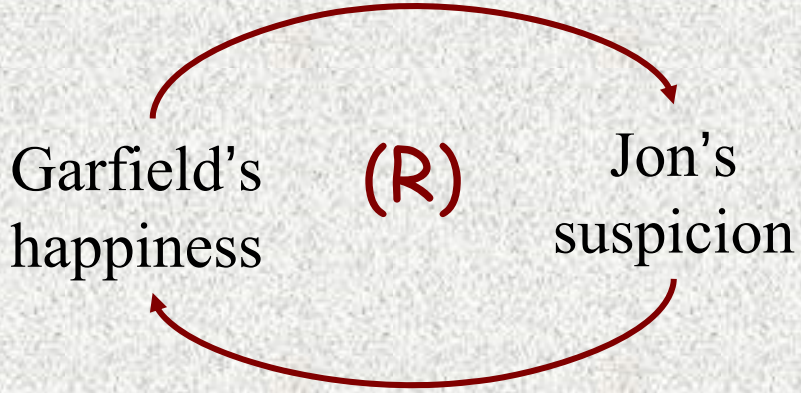


Combination of Positive and Negative loops



Reinforcing Feedback

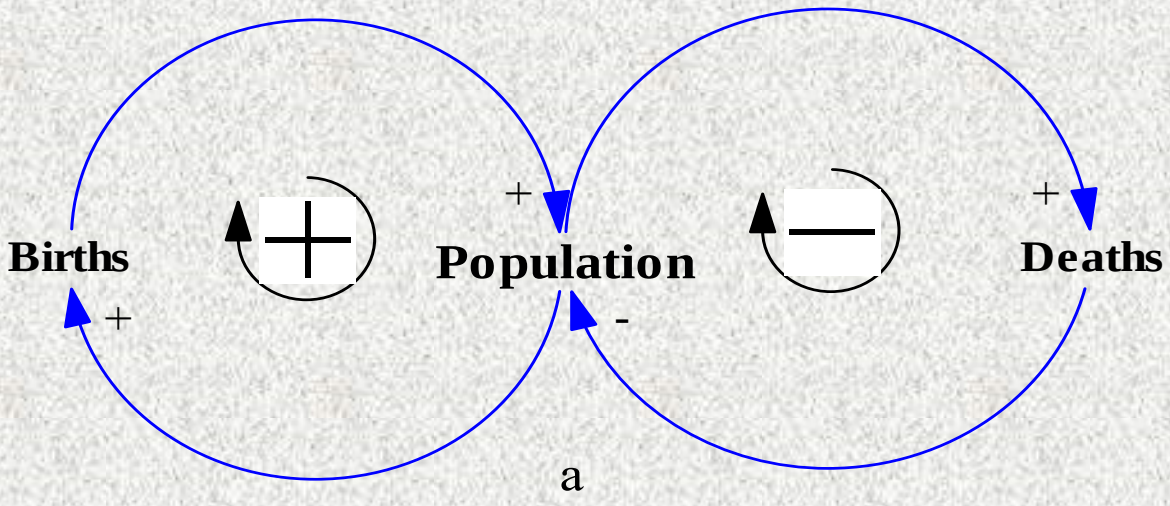




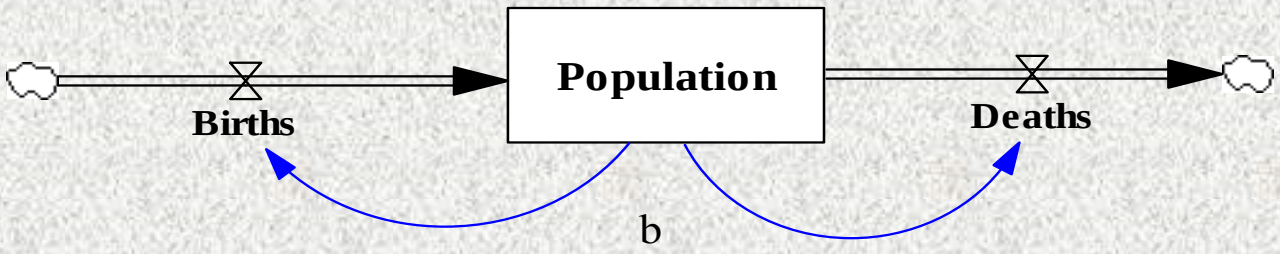
Stocks and Flows

- They are used as bases for developing a quantitative model
- Every system has these two concepts (only two)

Causal Loop



Stock and Flow



Stock, (Level) or (Accumulation)

- a state variable that changes over time by accumulating or integrating rates (flows)

- used to represent the real-world processes such as stocks of material, knowledge, people, or money. . . . . etc.

$$S_t = \int_o^T (F_i - F_o)dt$$

S_t = value of stock at time t.
F_i = the sum of the inflow rates.
F_o = the sum of the outflow rates.
t = time.

Flow, (Rate)

- Provides the basic representation of the change in stock values
- Resembles the movement from one stock to another
- It is a directional variable that has a start and ending

$$F_t = \frac{d}{d_t} S_t$$

St = value of stock at time t.
Ft = the flow rate at time t.
t = time.

Stock and Flow Comparison

o Stock (Level)

- Tangible or intangible
- Measured in "units"
- Accumulation (Integral)
  - Add inputs
  - Subtract outputs
- Sometimes considered stationary in a period of time
- Examples: Bank account, inventory, tank, knowledge.

o Flow (Rate)

- Tangible or intangible
- Measured in "units/time"
- Rate of change (Derivative)
  - Difficult do determine instantaneous
- Sometimes considered in motion
- Examples: interest, water flow, births, deaths.

Information Link

- Usually represented by a curved arrow
- Means that the value of the originating variable influences the value of the destination variable

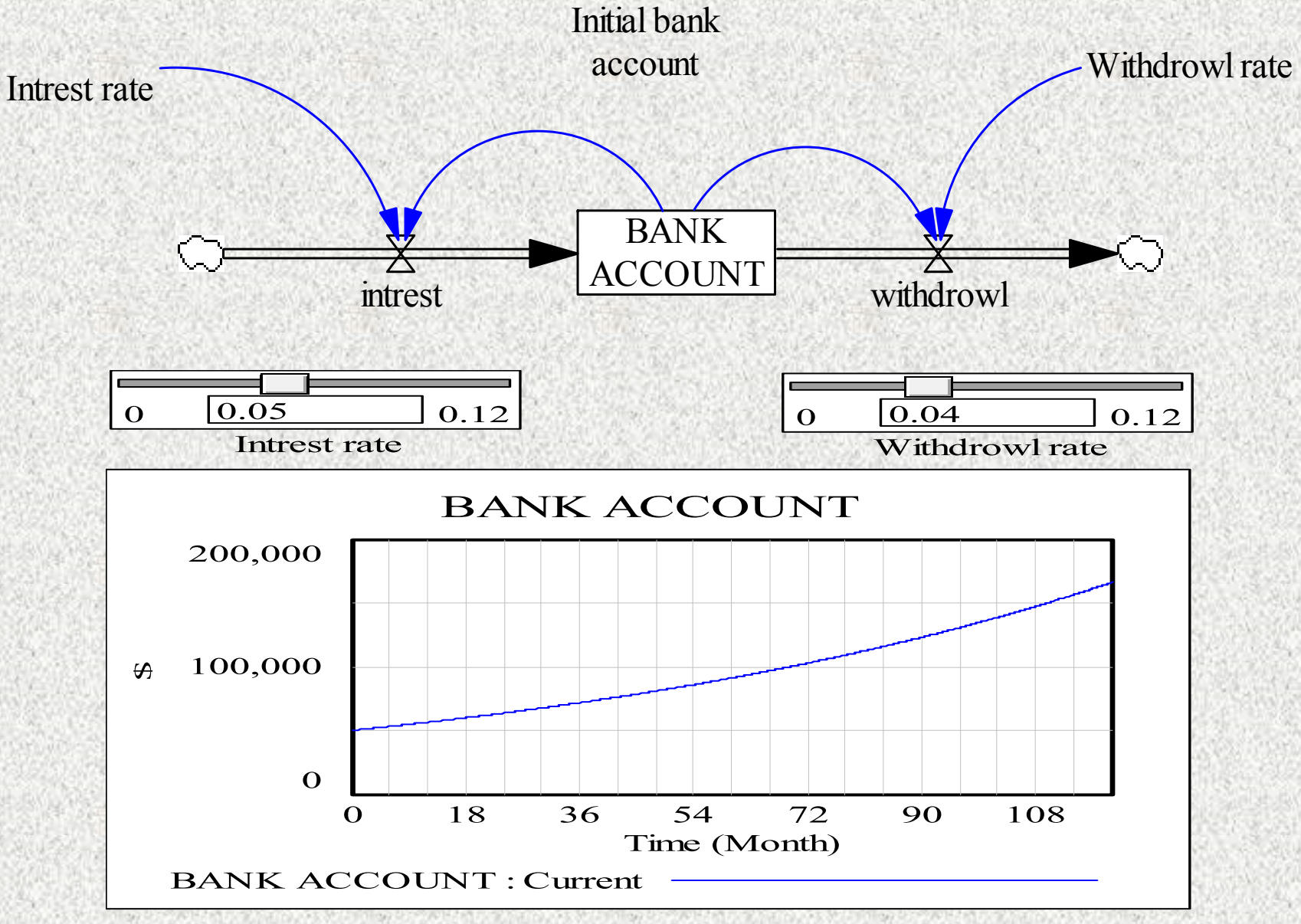
An increase in A makes B *higher* than it would have been without the change.

An increase in C makes D *lower* than it would have been without the change.

Auxiliary

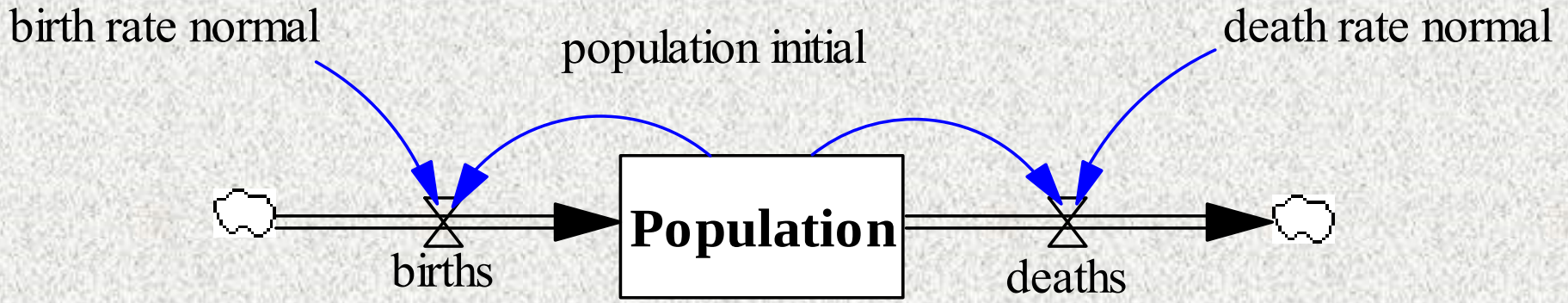
- An additional variable usually introduced to clarify the structure and process of the model
- Any dynamic variable that is computed from other variables at a given time
- Often presented as intermediate concepts or calculations utilized to determine the values of flows

Building S.D. Model

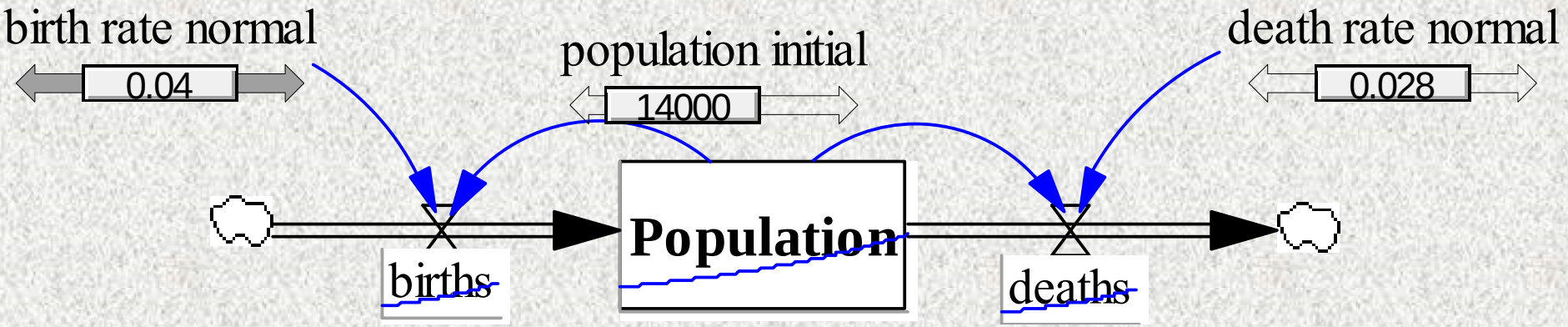


Building S.D. Model

Population & Food

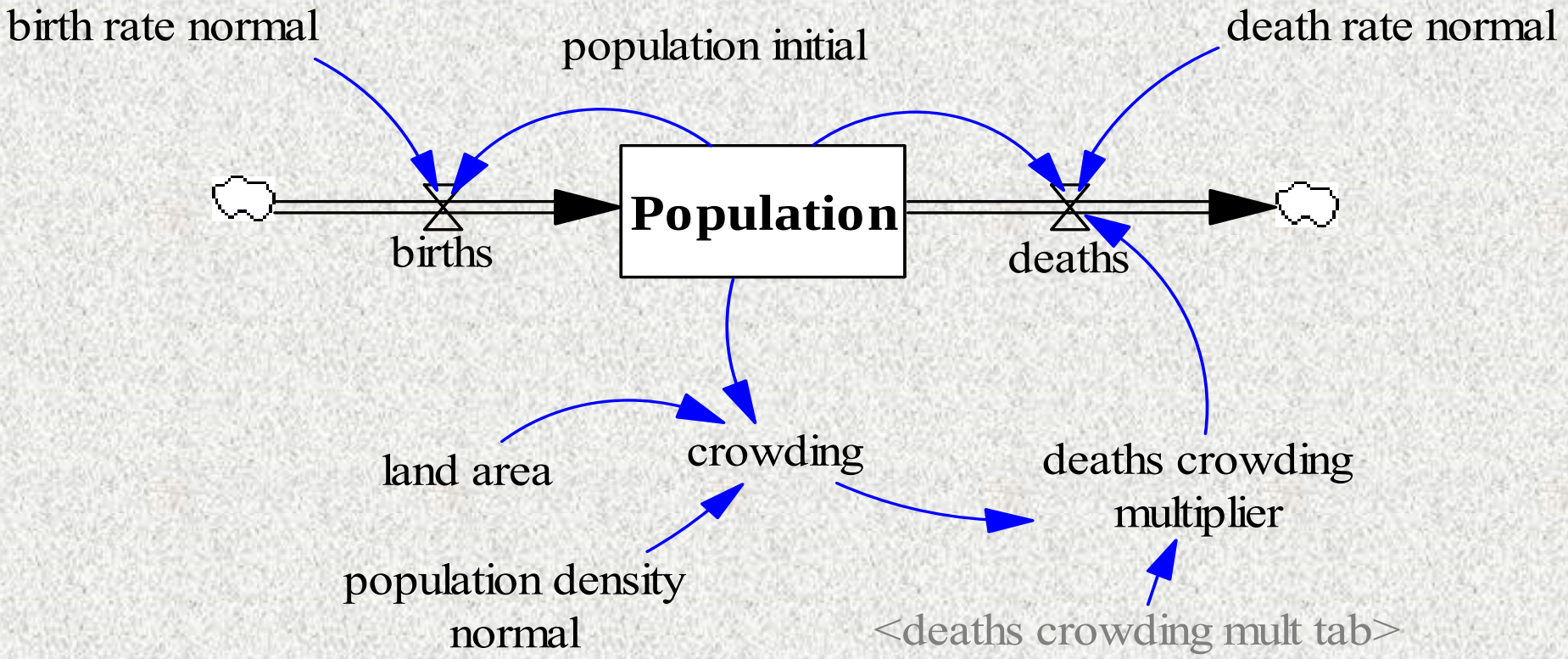


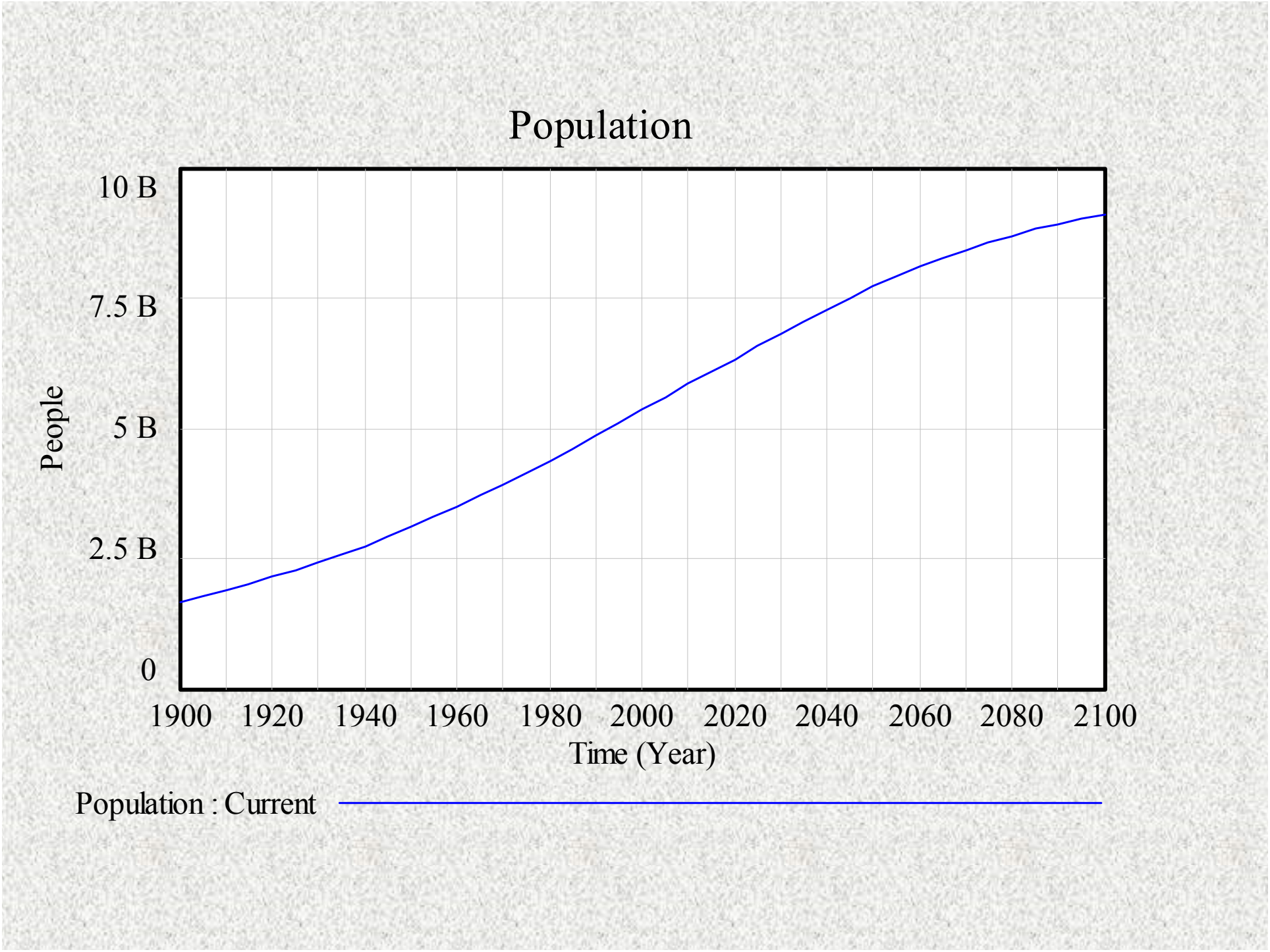
Population & Food

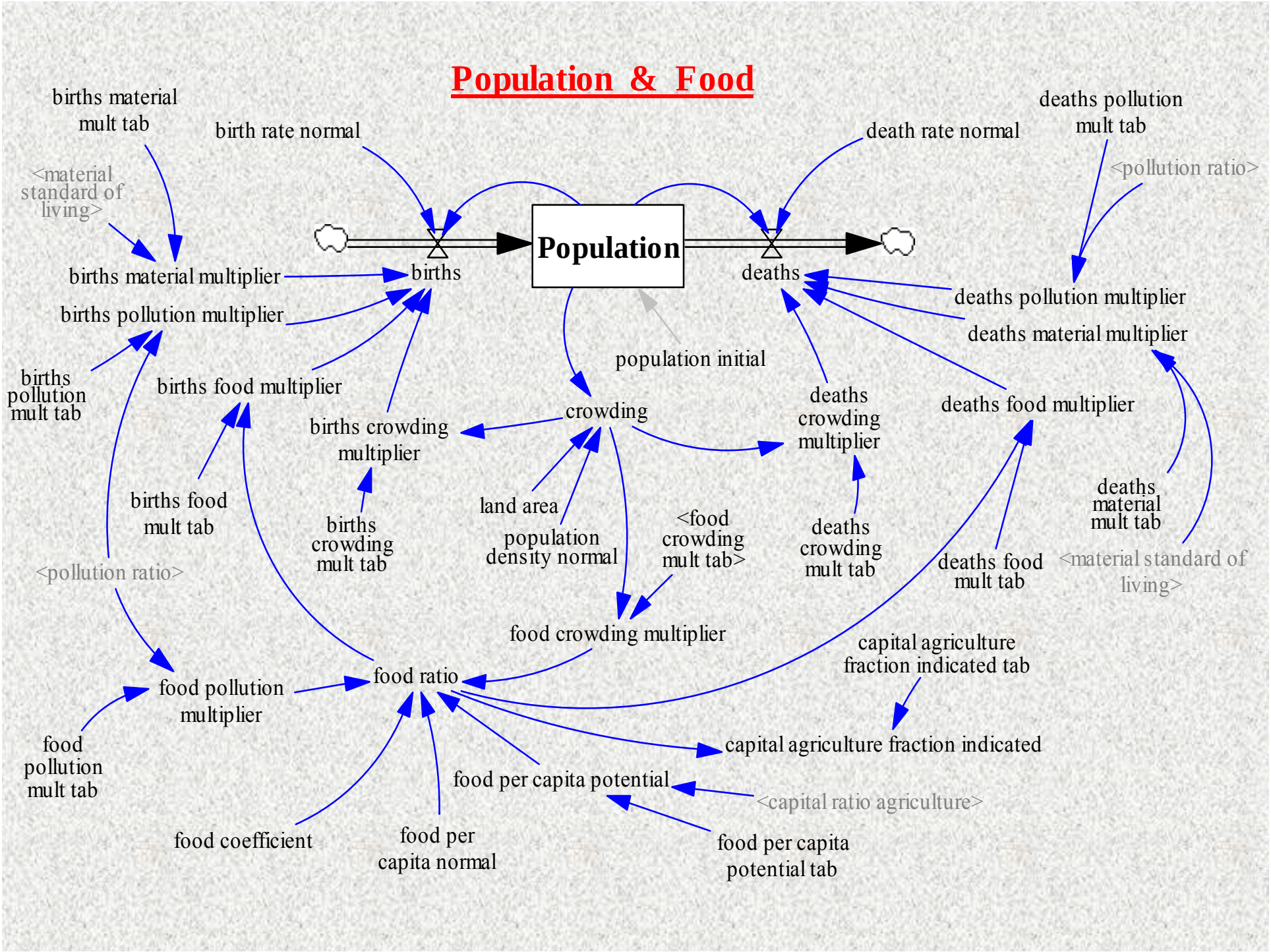


Building S.D. Model

Population & Food




Population
10 B
7.5 B
5 B
2.5 B
0
People
1900
1920
1940
1960
1980
2000
2020
2040
2060
2080
2100
Time (Year)
Population : Current


Population & Food
births material mult tab
birth rate normal
death rate normal
deaths pollution mult tab
<material standard of living>
<pollution ratio>
Population
births material multiplier
births
deaths
deaths pollution multiplier
births pollution multiplier
deaths material multiplier
population initial
births pollution mult tab
births food multiplier
crowding
deaths crowding multiplier
deaths food multiplier
births crowding multiplier
births food mult tab
births crowding mult tab
land area
population density normal
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deaths crowding mult tab
deaths food mult tab
deaths material mult tab
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food crowding multiplier
capital agriculture fraction indicated tab
food pollution multiplier
food ratio
food pollution mult tab
capital agriculture fraction indicated
food per capita potential
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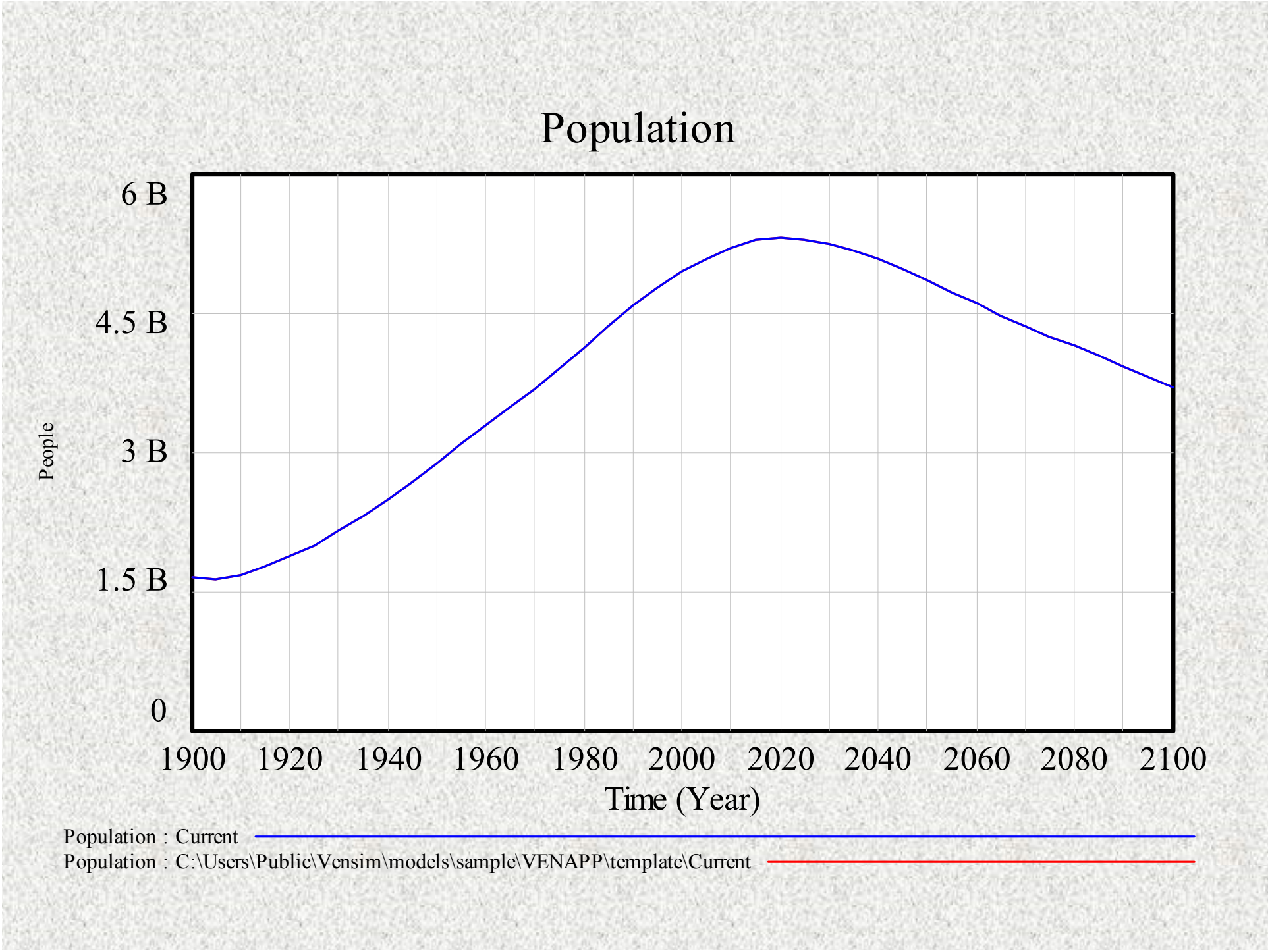
food coefficient
food per capita normal
food per capita potential tab


Population
6 B
4.5 B
3 B
1.5 B
0
People
1900
1920
1940
1960
1980
2000
2020
2040
2060
2080
2100
Time (Year)
Population : Current
Population : C:\Users\Public\Vensim\models\sample\VENAPP\template\Current

THANK YOU FOR LISTINING