Human Population
2017
Lecture 2
Overshoot
Bring a Question to Class

• Question should be based on the reading.
  (If you don't have a question, I assume you didn't really read the assignment.)

• Keep your question to a reasonable length.

• Selected questions will be discussed at the beginning of class.

• 15% of your grade is how many questions you upload. \[ (=15\% \times \text{# of questions} \times \text{quality} / \text{# of reading assignments}) \]

• Questions will be selected pseudo-randomly until done or until question time is exhausted. All questions count towards your grade, \textit{whether answered or not}. 
Are we in overshoot?
Overshooting a turn

Cause: curve + momentum + delay
Consequence: loses race
Overshooting a budget

income = $1000/mo at beginning of month
expenditures at end of month (credit card)
causes: growth versus hard limit.
consequences: debt payments, lifestyle adjustment.
Overshoot

• Components of overshoot
  – Growth, change
  – Limits to growth, change
  – Delays

• Result
  – crash
  – correction
Examples of Growth

• Linear growth
  – filling of a bathtub
  – no-interest savings account when you add $10 per month
  – constant acceleration
Examples of Growth

• Exponential growth
  – rabbits without predators and plenty of food.
  – interest on a loan that you are not paying back.
Examples of Growth

• Limited growth
  – enzyme activity as a function of substrate concentration.
  – tree height versus tree age
Examples of Growth

• Logistic growth
  – Exponential plus limited growth
  – rabbits without predators and limited supply of food.
  – enzyme activity for a cooperative enzyme
Examples of Growth

• Hyperbolic growth
  – pressure of an ideal gas as volume approaches zero
  – neutron emission as a function of time after nuclear reaction.
Examples of Limits

- supply of food.
- size of storage shed.
- size of Earth.
- total food production of Earth
- monthly salary
Examples of Delays

• Physical
  – Slow absorption of CO2 by the ocean.
  – Delayed warming of permafrost, sea ice.

• Human
  – The slow pace of Science.
  – disinformation
  – bureaucracy
  – democracy
Systems Dynamics

• a "bottom-up" approach to modeling, understanding and predicting the behavior of complex systems. Numerical models of physical systems in the time domain.

• **System** -- a set of interacting entities.

  • Consists of **Stocks, Flows, and Variables**.

  • **Open system** -- a system that allow Flows to or from an external Sink or Source (external Stocks). Total sum of all Stocks may start from zero or go to zero.

  • **Closed system** -- a system that does not allow external Sources and Sinks. No net change in total of all Stocks.
https://en.wikipedia.org/wiki/System_dynamics
• **Systems dynamics web app**

• **Stocks**
  Stocks are quantities, physical or otherwise. Quantities can be *measured*, have *units*, may be *added* to, may be *subtracted* from.

• **Flows**
  Flows *send* quantities of a Stock to another Stock, or to the Sink, or from the Source.

• **Variables**
  Numbers or functions that interact with Flows and Stocks.

insightmaker.com
Stock

- **Stocks**
  Must be *quantifiable*. Should have *units*. May be *added* to, or *subtracted* from. May contain a built-in *Delay* (conveyor stock).

- **Flow** into a stock comes from its **Source**
  - A Source may be another Stock or **External**.

- **Flow** out of a stock goes to its **Sink**
  - A Sink may be another Stock or **External**.
Flow

- Flow
  Should have *rate units* (or no units) Must connects two Stocks.
  - Rate units have reciprocal time \((y^{-1}, \text{tons/y, etc})\)
- May be forward-only or reversible.
- Starts at **Source**, ends at **Sink**.
  - May be external (no stock attached)
- Pair of stocks pair may have more than one Flow, each under different controls. Or, achieving the same effect, one Flow can have multiple input Variables.
Variables and links

• **Variables**
  numbers, equations, programs.

• **Links**
  Tells InsightMaker that the target of the link depends on the Variable pointing to it.
Zombie apocalypse

http://www.livescience.com/57407-zombie-apocalypse-would-take-100-days.html
InsightMaker exercise -- World War Z

Stage 1 -- Zombies wipe-out humans.

Create a stock "Humans".
   Set it to 7.5 billion.

Create a stock "Zombies".
   Set it to 1.

Create a flow from Humans to Zombies, "Conversion".

Create a variable, "Success rate".
   Set it to 1. One zombie converts one human per day to a zombie.
   Link to Conversion.

Set Conversion to [Zombies] *[Success rate]

Simulation Time Settings.
   Set to Days.
   Range 0 to 365.

Hit Simulate!

-- How long do humans last? Not long, right? --

Does changing [Success Rate] to a lower value change the outcome?

Stage 2 -- Weaker zombies, still wipe out humans.

Create a flow from [Zombies], "Death" (really dead this time!).

Create a variable "Zombie Lifetime".
   Set it to 20 days.
   Link it to [Death].

Edit [Death]. (click the = sign to edit)
   Set to Delay([Zombies],[Zombie Lifetime], 0)

--- Look up Delay function to see what it does. ---

Add a comment using the # sign: "# Zombies die after [Zombie Lifetime] days"
-- Is Humanity any safer with self-expiring zombies? --

Create variable "Log zombies" and "Log humans"
  Link [Zombies] to [Log Zombies]
  Link [Humans] to [Log Humans]
  Set [Log Zombies] to Log([Zombies]+1)
    Adding 1 assures that [Log Zombies] does encounter a log-zero error.
  Set [Log Humans] to Log([Humans]+1)

Simulate.
  In simulation window: Add Display.
    Select [Log Zombies] and [Log Humans]

-- Note "linear" changes in log space. Exponential growth! --

Stage 3 -- Humans hide, survive.

-- Add Hollings response function, type 2. Humans are harder to find. --

Create a variable "Population density"
Create a variable "World"
  Set it to 2e9
Create a variable "Hiding ability"
  Edit [Hiding ability]. Make it a slider from 1 to 10.
  Link [Humans] to [Population density].
  Link [World] to [Population density].
  Link [Population density] to [Success Rate].
  Link [Hiding ability] to [Success rate].

Edit [Success rate]. Turn off slider. Edit Value/Equation. Add the lines
    holling2 <- ([Population density])/(Hiding ability) + [Population density]
    return holling2  # Holling's type 2

Simulate. Try many settings for Hiding ability.

-- How well do we need to hide to avoid extermination? --

Edit [Hiding ability].
  Set Equation/Value to
    Rand(1,10)  # selects a random value between 1 and 10

-- Add Hollings response function, type 3. Humans cooperate! --

Create a variable "Cooperation".
  Link it to [Success rate]
  Edit it. Make it a slider from 1 to 5.

Edit [Success rate]. Edit Value/Equation. Remove "return holling2"
  Add the lines
    return holling3  # Holling's type 3

Simulate. Try different values of [Cooperation].

-- SENSITIVITY TESTING --

Edit [Cooperation]. Set Value/Equation =
  Rand(1,5)
Simulate. Try different values of [Cooperation].

-- SENSITIVITY TESTING --

Edit [Cooperation]. Set Value/Equation = Rand(1,5)

Tools | Sensitivity Testing...
      Set confidence regions to 50, 70, 90
      Set runs to 50
      Check Plot Each Run.
      Monitor: [log Humans], [log Zombies]
      Ran analysis.

Stage 4 -- Humans sound the alarm.

-- Use PAUSE function to change parameters on the fly --

Settings
      Set Pause interval to 5 days

Edit [Cooperation]. Make it a slider from 1 to 5.

Edit [Hiding ability]. Make it a slider from 1 to 10.

Start sliders at lowest levels. (DefCon "Green")

Simulate!
      Simulation will pause.
      Hit Play until [Zombies] have reached a dangerous level. (DefCon "Red")
      Adjust sliders to increase [Hiding ability] and [Cooperation].

-- What happens? Can humanity be saved if we delay? --
Holling's Response function

As the density of prey decreases, the number of prey consumed decreases (I) linearly, or (II) saturating, or (III) logistic.
Holling set up an experiment in which subjects were blindfolded and stood in front of a large table with small sandpaper disks on it. A second person stood with a stopwatch while the subject searched blindly for the disks, counting how many disks were found in a given time.

Naturally, where then were fewer disks, fewer disks were found. As more disks were added, more were found, linearly. This is Holling's response function Type I.

$$y = bx$$

If enough disks were placed on the table, a limit was reached beyond which the subject could not go. (The speed of removing the disk and putting in on a pile was limiting.) This was Holling's response function Type II.

$$y = bx/(1 + bx)$$

If Holling added a disk of a different color (blue versus red), and repeated the experiment, then the subject (who is blindfolded and can't see the color) initially found less of the red disks than expected by their number, because at low numbers they were outnumbered by the blue disks. This is Holling's response function Type 3.

Type 3 models any situation in which low numbers make finding the "prey" object less likely than expected by Type I or II. These work:

$$y = bx^2/(1 + bx^2)$$ ..or..  
$$y = x^2/(b^2 + x^2)$$ ..or..  
$$y = x^k/(b^k + x^k)$$ .

What we have covered, so far, in InsightMaker.

- Stocks
- Flows
- Variables
- Links
- Settings
- Simulate
- Delay()
- Rand()
- sliders
- Pause
- Sensitivity testing
Work on Homework