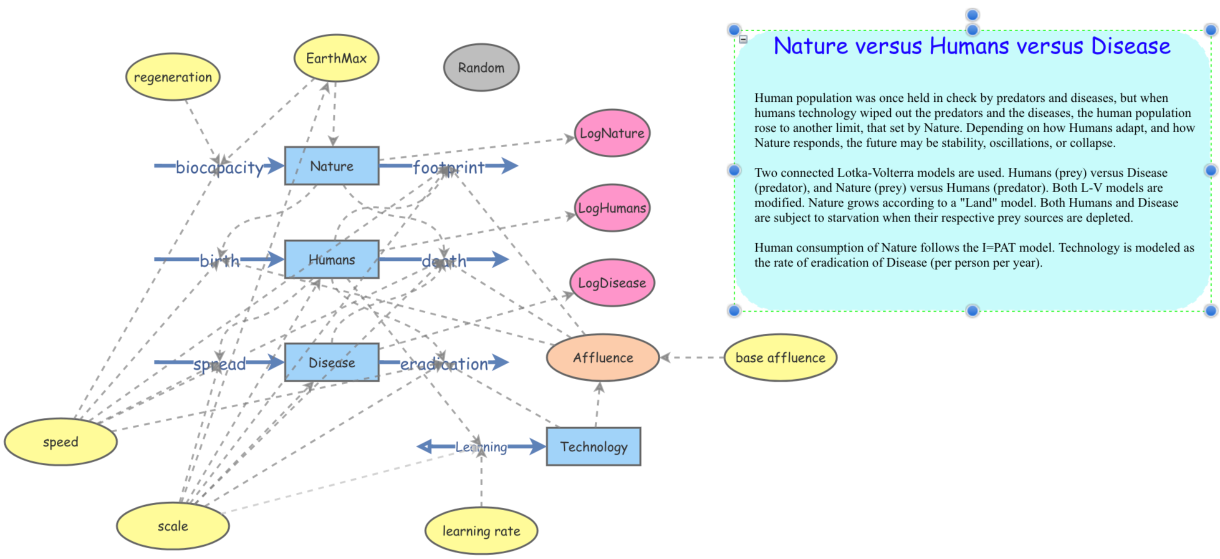
Human Population 2018

Homework 4 -- Tandem modified Lotka-Volterra model.

NOTE: In this narrative, I use brackets to refer to stocks, flows and variables in the model.

Find the insight that has been shared with the group called
"Tandem modified Lotka Volterra".
Clone it and rename it.



Run a simulation and have a look. Display the three output variables (pink) and [Technology].

In this model, the human population starts at 175 million in Year 0. Initially, [Disease] controls the population of [Humans]. But [Technology], initially set to zero, contributes to the [eradication] of [Disease]. [Learning] adds to [Technology] at a rate that is dependent on [Humans] and their intrinsic [learning rate]. As [Technology] grows, [Learning] flows in reverse (forgetting!) in proportion to [Technology]. Note that [Humans] grow hyper-exponentially during the time that [Disease] is being eradicated, due to the exponential decline in the death rate.

Your job is to understand the behavior of the model with respect to each of the six yellow input variables.

[base affluence]
[regeneration]
[Earth max]

[learning rate]
[scale]
[speed]

For each of these input variables, run sensitivity testing. For your convenience, there is a random number generator called [Random]. Link [Random] to each variable in turn and then edit the variable to multiply its value by [Random]. [Random] is a log normal distribution (https://en.wikipedia.org/wiki/Log-normal_distribution) centered around 1.

Identify and describe the effects of increasing/decreasing the variable in question. Use the equations within each of the variables and flows to explain the model behavior.

Make a slide show (Powerpoint, PDF, Keynote, Word, Pages, or googledoc) showing the sensitivity test (quartiles or runs), and a one or two paragraph explanation for each variable.

<u>Advice on how to talk about systems dynamics models</u>

A good model should be *(1)* ***simple****, (2)* ***true to the nature of things****, (3)* ***an accurate fit to real data***. If a model satisfies criteria (2) and (3) we say the model is "*realistic*". After all, if the equations and parameters are true to the nature of the things that the model models, and the model generates data that looks just like the real, observed data, then it is -- not "real" of course, but -- "*realistic*". If the model does not satisfy criterion (1), then we may never know whether it satisfies criterion (2)! As a model deviates from simplicity it may or may not become more accurate, but it certainly becomes more and more difficult to tell whether or not it is true to the nature of things.

It is possible for a simple model to produce accurate data but not be **true to the nature of things**. For instance, you could create a Converter in InsightMaker that simply converts the Year to the Population. Would it be accurate? Yes! Realistic? No, because the converter is not true to the nature of things. It is not the true nature of a Year to be converted into a Population. There is no such natural process. On the other hand, exponential growth is true to the nature of living things. The true nature of disease and predators is to increase human deaths proportional to the amount of disease or predators. The true nature of the reproductive rate is that it depends on food supply. And the true nature of biocapacity is that it has upper and lower limits. I'll leave it to you to evaluate the true nature of [Technology] and [Affluence].

Each equation in the model must represent a natural process. For example, the equation mapping [Disease] to [death] models the natural process of disease transmission which is proportional to both [Disease] and [Humans]. In other words, [death] = *rate**[Disease]*[Humans], where *rate* is a constant. If instead you wrote, [death] = rate*([Disease]^2)*[Humans], then you would *not* be true the nature of diseases which tend to be transmitted in proportion to the amount of the disease agent, not in proportion to the disease agent squared! OK. Maybe this is a weird new disease that has a cooperative component. But, I don't know of any diseases like that. Finally, please note that a trivial equation that only scales or changes units does not need to represent a natural process!

The need for **simplicity** means that we cannot afford to talk about the dynamics of an individual disease or predator. We can only talk about the collective nature of these things. It also means we cannot afford to talk about the regional distribution of [Humans], and how people migrate from region to region. These and other "complexities" must be ignored in order to keep the model simple. The model as a whole may be unrealistic if these complexities are necessary for the model to be accurate. On the other hand, we can justify ignoring any complexities if the model satisfies (2) and (3) without them. Adding complexities (i.e. additional stocks, flows, variables and parameters) is justified only if there is no way to satisfy (3) without those added complexities. In that case we would say the model is "unrealistic" without adding the complexities.

Due by Friday March 23 by email.