Introduction to System Dynamics Modeling
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Dynamic of Simple Structures S-Shaped Growth
Lecture - 10.2
Dynamic of Simple Structures: S-Shaped Growth-Conversion of CLD to SFD

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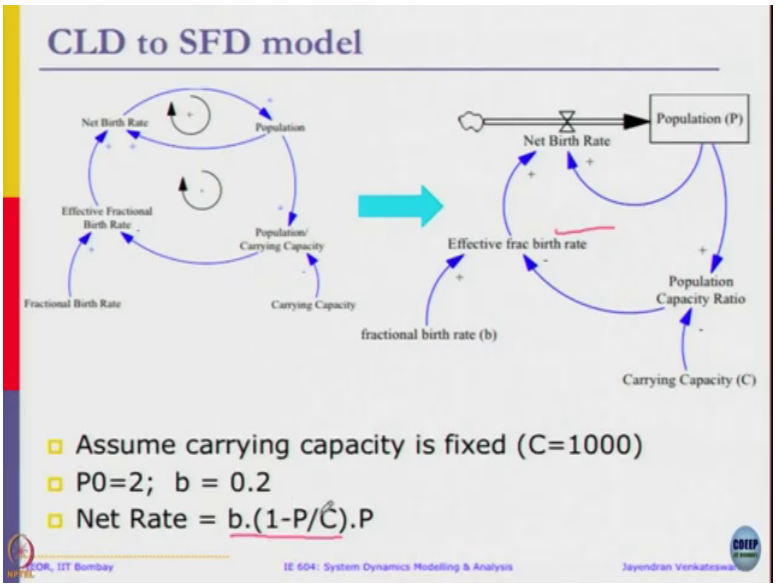

Let us convert this CLD model into a stock flow diagram model; the CLD is on left side as we had this exactly same as what we saw before. If you want to convert it into a stock flow diagram, the population is the only stock; net birth rate connector that is for the same for carrying capacity is a parameter. And then we design the population by capacity ratio, I will linked it to effective birth rate and then and birth rate and the fractional birth rate.

So, we can assume that the carrying capacity is fixed; that is C is equal to 1000 and let us assume P naught or the initial value of population is 2; and let us assume the small b is 0.2 so, these are all the constants. This population capacity ratio is as the name defines is nothing, but population P divided by C you can write that equation not displayed.

Now, let us see how the net birth, net rate is defined. So, this net rate is defined as b into 1 minus P by C into P; since P is capital P is directly linked here this effective birth rate this small b into 1 minus P by C represents the effective birth rate. So, this value here b into 1 minus P by C represents the effective fractional birth rate value here.

So, this is represented here b is constant. So, 1 minus P by C now represents the relation that we are trying to capture where it was constant and then it reduced. So, I am just making it a simple straight line 1 minus P by C for modeling purposes. Let us see what happens when we do that.

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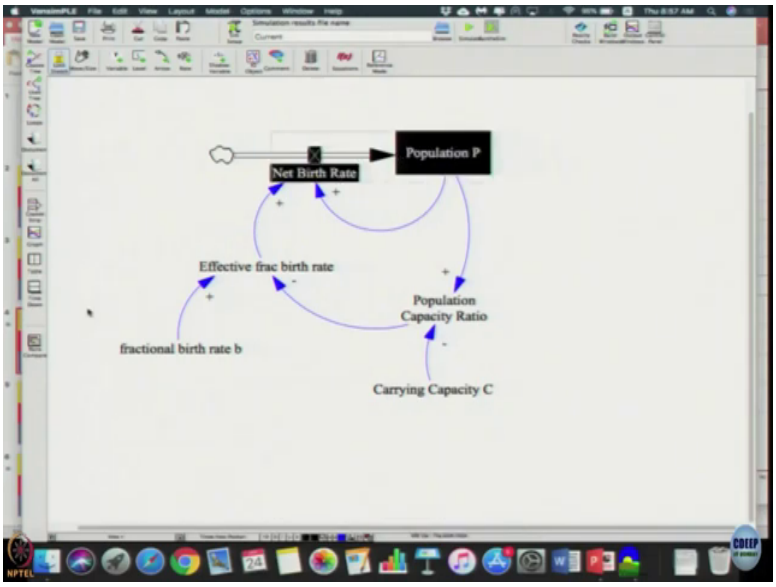

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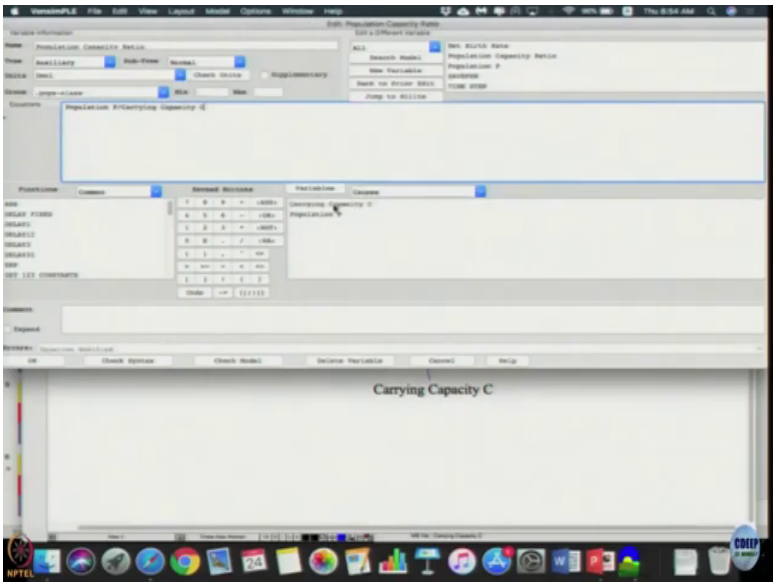

So, the first whenever you get such models, you click the equation and try to understand what is the underlying equations is the open population ok; its a level and its a initial value is 2 ok. Carrying capacity in several use 1000 or rather its value is 1000, population by capacity ratio is defined as just population divided by carrying capacity. Ok, is not a used I urge you to rename carrying capacity and then I would have put a bracket C remove the parenthesis.

And just write it as carrying capacity C, to do that either you can open it or you can just click this variable and then when you click on the same so, allow you to edit the title. So, you can edit it; once you finish editing that, where you go to the equation and delete that old value. And select the new value, new variable name carrying capacity C.

Because it does not accept parenthesis that is variable name yeah, apologies for that. We can check the fractional birth rate it will b; it will take a value 0.2. Effective fractional birth rate

we will observe that it is nothing, but fractional birth rate b into 1 minus population capacity ratio that is P by C which you saw in the slides. And, net birth rate will be population times the effective fractional birth rate ok; need this again this click simulate run the model.

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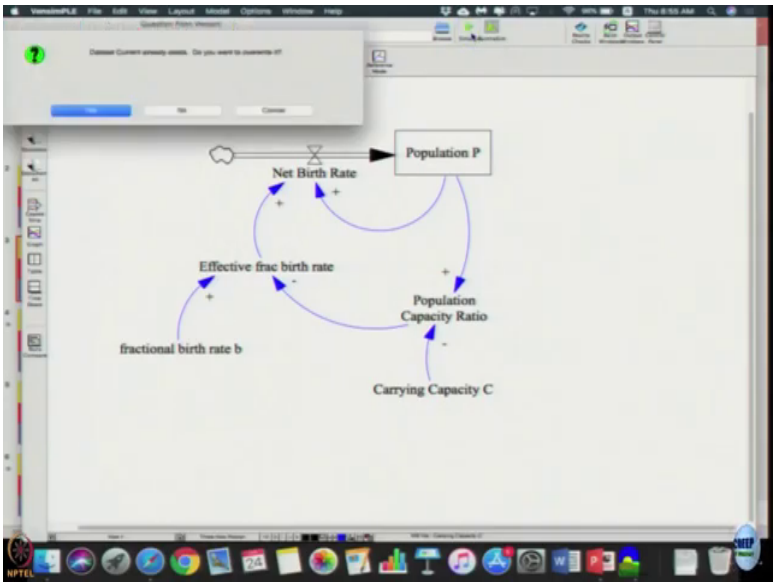

Then you can click population.

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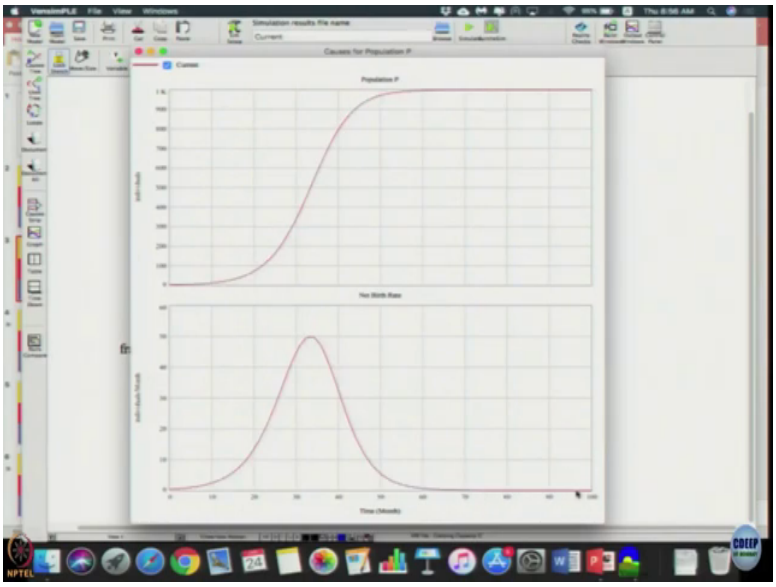

And click the left side the causes strip, you should get these two graphs. So, then this immediately shows you that the population is showing an s shaped growth and still has an exponential growth. And then finally, saturating at saturation will be at 1000. The carrying capacity is 1000 so, saturate rate 1000; that is because the equation that we wrote was 1 minus P by C.

So, P is equal to C that became 0. So, beyond that it is not allowing us to increase and here the net birth rate increased and after the inflection point; the net birth rate starts to decrease as expected finally, reaching 0; because this see some questions I have written.

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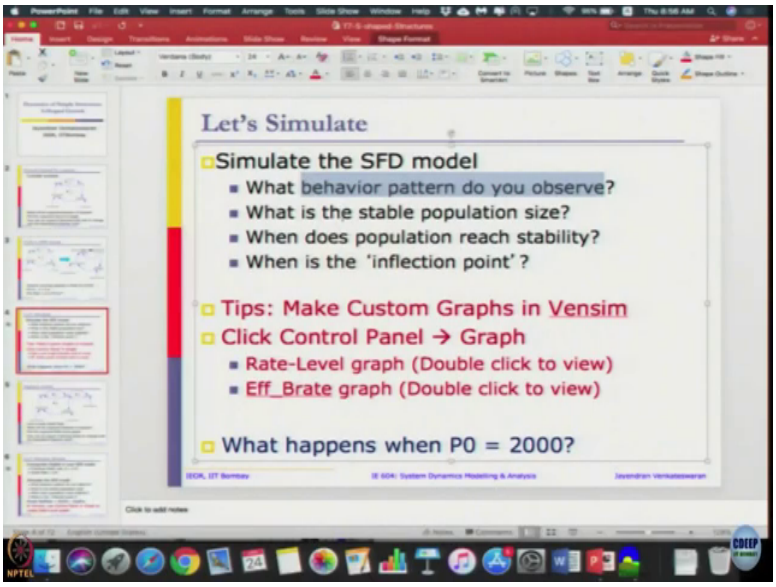

Now, paternally observed s shaped, stable population size is 1000. When does population reach stability? And when is the inflection point that we can see it from here. When does the population reach stability is about 70 weeks I guess, 70 to 80 weeks. This is when population is kind of reaching stability. Or, if you want to discount all the small fractions and around maybe around 65 years is what it is reaching or 65 months rather it reaches stability.

The inflection point how do you find it? No need to differentiate anything just using the simulation result what do you, how do you find it? Even the peak of the rate, the time at which this peak occurred right to find the exact time we can click and shift, click, click select both.

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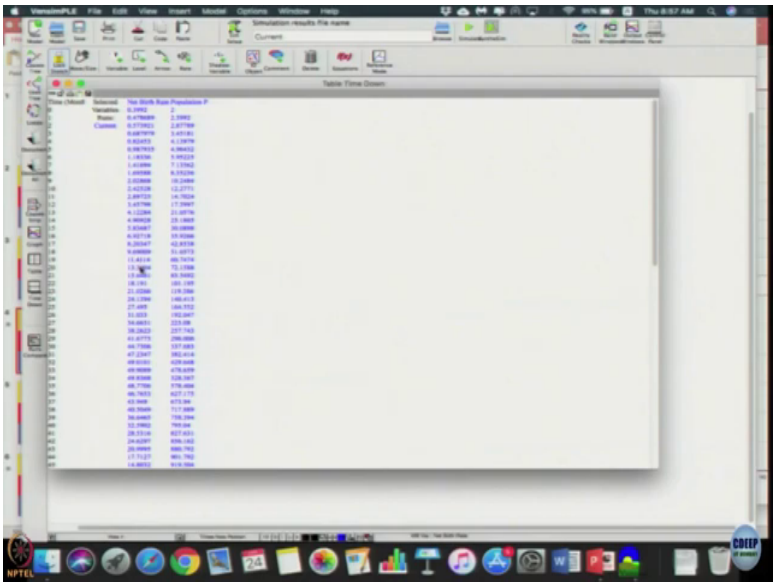

Click the table time down, observe the net birth rate, it keeps increasing 0, 1, 2, 4, 5.8, 6.92, 34, 38, 47, 49, 40. So, 32 it is 49.01, 33 is 49.9, 34 is 49.83. So, 33 is when it has reached the peak value afterwards it starts to fall down. So, the inflection point occurs at time since timestamp is 1 it occurs at time 33. Observe the stock value at that at time 33 is 478, time 34 it became 528 that is what has happened.

When we solve it analytically maybe we will see it next week or so, for this kind of system, when you solve it analytically it will show that the inflection point will be exactly at C by 2. That is the carrying capacity divided by 2 will be the inflection point which is kind of intuitive the 1000. So, inflection point should occur when population actually reach 500.

Here its quite close, you do not get exact 500 because of the integration timestamp we have used. You use smaller timestamp, you might get a more accurate estimate. Or if you solve it

analytically then use the same ideas of integration to figure it out, you will be able to get that the inflection point its C by 2.