How does the increasing production of Beef impact the growing global climate problem?

By

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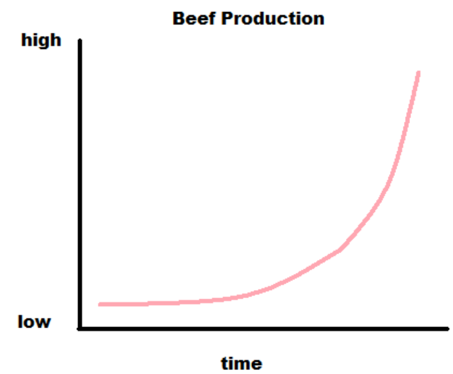
THE INTRODUCTION

Industries are constantly pumping carbon dioxide into our atmosphere, dirtying up our air and increasing the threat of global warming. This model focuses on one of the less well known industry that contributes to green house emission, and that is the beef industry. Brazil has become the fastest growing exporter of beef in the world and they have plans to continue to produce more in the near future. Using system dynamics it is easy to observe the relationship between the production of beef and its impact on the atmosphere. With this model you can easily observe the complicated relationships between the production of beef and the CO_2 in the atmosphere.

Beef impacts the carbon dioxide levels in the atmosphere in two distinct ways. The first way is by emitting more of the harmful gases in the process of producing the beef. For example the trucks that are used to transport the water and the feed to the animals and later are used to transport the animals to the slaughter house burn up gasoline and release CO_2 into the atmosphere. Also the slaughter houses that are there to package the meat and ready it for the market, use up tons of energy that comes from coal burning power plants that also releases a big amount of CO_2. In the end if you add up all of the CO_2 emitted by the beef company it is equal to 36 pounds of CO_2 for every pound of beef produced.



The other way that the beef industry is affecting the CO_2 in our atmosphere is by taking part in deforestation. Trees are nature's way of removing the CO_2 from the atmosphere. They do this by taking the CO_2 from the air combine it with sunlight and producing oxygen and glucose. As the beef industry grows they need more land to use for cattle grazing. In Brazil they turn to the Amazon rain forest were the land is plentiful and cheap. If more trees are cut down then the dwell time of the CO_2, or the time the CO_2 spends in the atmosphere increases. This causes more of the CO_2 to accumulate in our atmosphere which speeds up global warming.

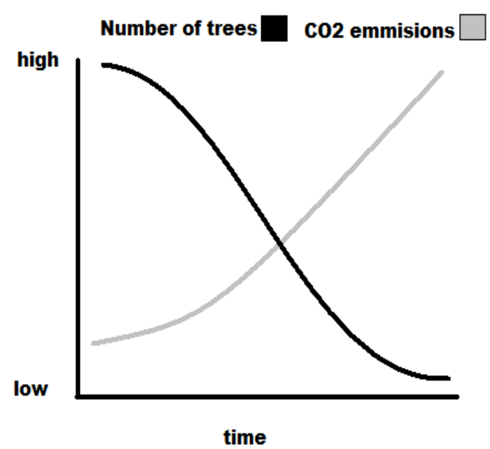


Figure1: Two graph showing the Predicted behavior over time of the number of trees and co2 levels as beef production increases

THE PREDICTION

What I think is going to happen is that the production is going to continue to rise and since that requires more land for grazing I believe this means the number of trees are going to go down. Also I believe that as a result of the trees being cut down and there being less and less of them each year, there will be more CO_2 in the atmosphere.

THE PROCESS

To begin to model this system it was necessary to first model the relationship between the consumption of beef and the production of beef. The two are both ruled by the law of supply and demand, and the factor that ties them together is price. The supply and demand of beef model is set up to with one stock, which is there to measure the beef inventory, and two flows. The inflow is there to represent production while the outflow would represent consumption. The model is design to reach equilibrium, a situation where the outflow is equal to the inflow and the beef inventory flat lines. This works by using the simple laws of supply and demand. The law of demand states that there is an inverse relationship between the price of a product and the quantity demanded. On the other hand the law of supply states that there is a direct relationship between the price of a product and the quantity supplied. With these two laws programmed into the model it is possible to change the price in order to make the production and consumption equal to each other. The reason I know that the model is working properly is because if you start it

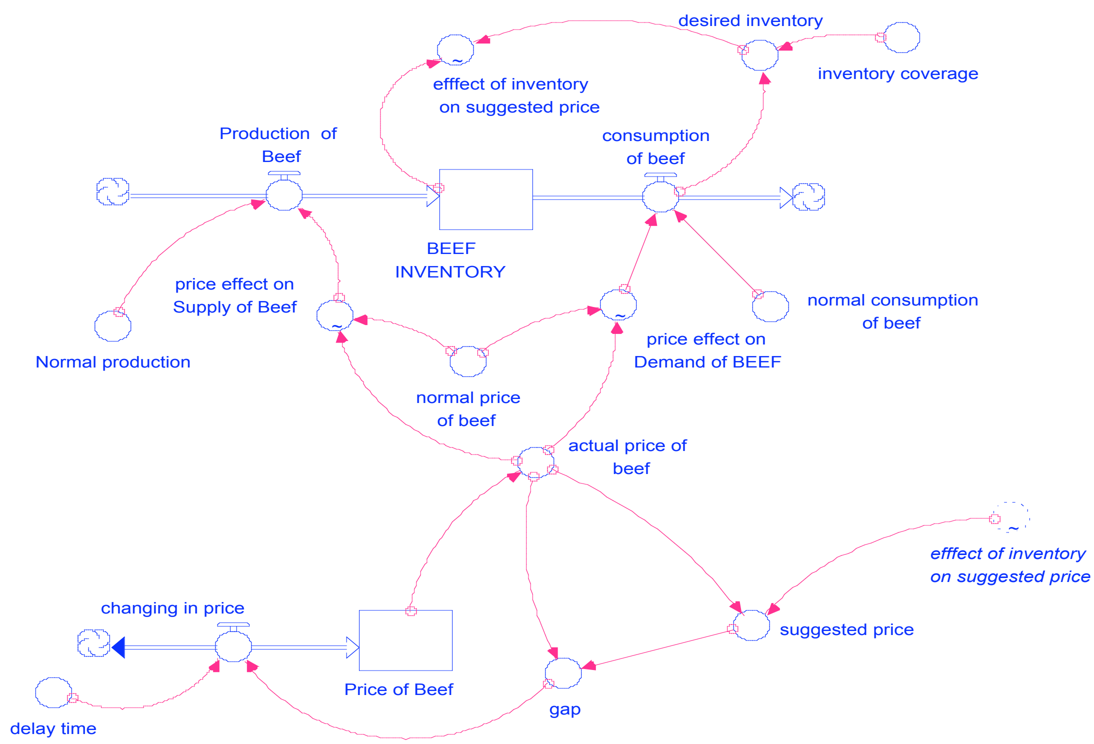


Figure 2: The Supply and Demand of beef. This is the first half of the complete model

at equilibrium and change the value of consumption or production with a step function the model will automatically corrected it self and make the two equal each other which in effect, makes the model return back to equilibrium.

The second part of the process of building this model is starting to connect the supply and demand of beef model to the constantly changing dynamics of CO_2 emissions. The CO_2 model is composed of a linear input and an exponential output. The inflow is described as the product of the current beef production times the pounds of CO_2 emitted per pound of beef. The conversion factor is set at 36 so that 36 pounds of CO_2 is emitted per every one pound of beef produced. The out flow of this graph is set to equal a percentage of the total CO_2 in the atmosphere the reason for this is because the more emission there are in the air the faster the emission will be absorbed by trees and other plant life. The amount

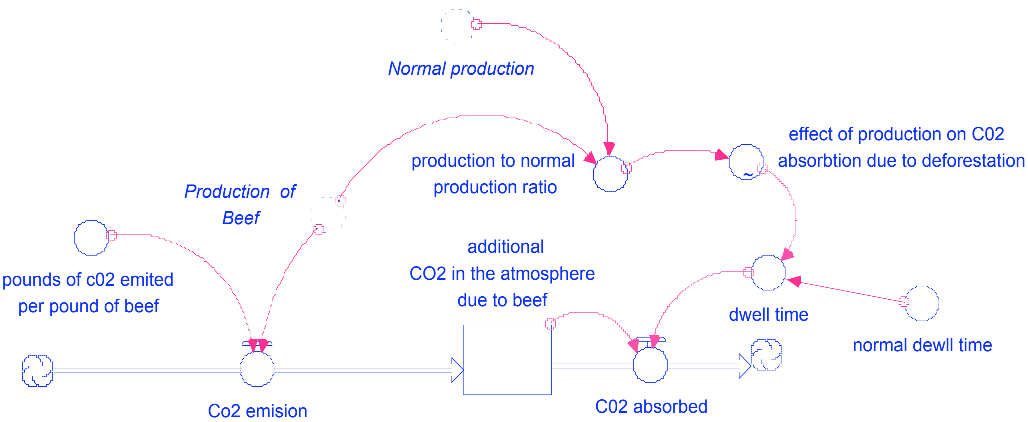


Figure 3: The First Version of the CO_2 stock inflow and outflow as it is effected by the beef production.

of time the CO_2 is in the atmosphere is known as the dwell time. The dwell time in this model is designed to increase when production increase. This is because when beef industry decides to increase their production that means they need more land for cattle and that means more deforestation.

The problem with the way that this model was set up at this point is that the dwell time changes in a direct relationship with production. If the production was to constantly increase this would not be a problem but the production dose not always grow. When the

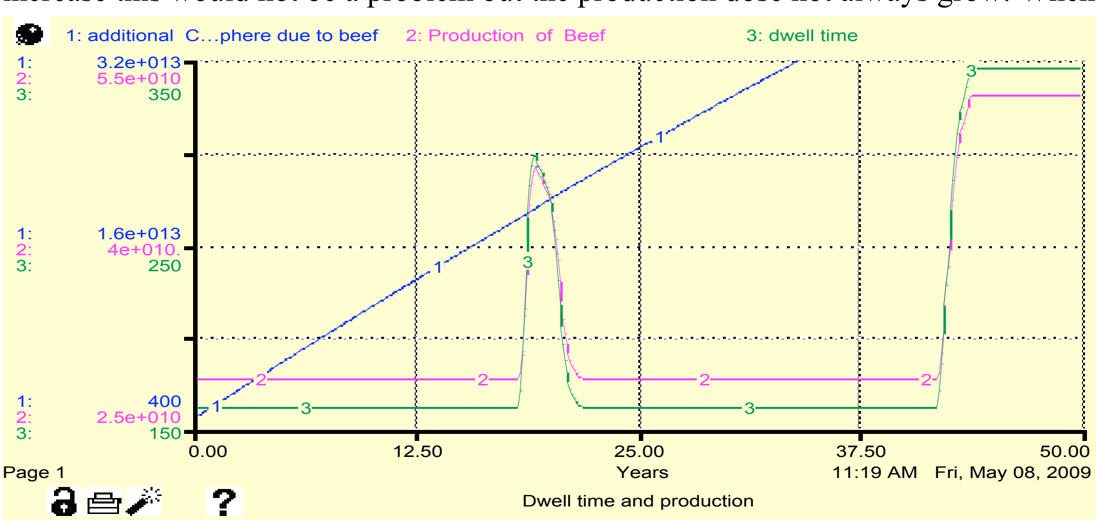


Figure 4: Graph showing the relation of beef production and the co2 dwell time under the first version of the model.

production is reduced the dwell time should not fall as well. The reason for this is because the effect that the production of beef has on the dwell time is due to deforestation and just because the production has fallen doesn't mean that trees are suddenly grown back to there original size and population. This graph shows how unrealistic this relationship is, in the graph the dwell time goes back to its original value as soon as the production falls.

The only way to fix this problem is to build a model of the tree population in the Amazon. The dwell time is inversely related to the number of trees so since this is true it is possible to set up a unit less multiplier that changes the dwell time according to how the number of trees changes over time. To model the growing trees I build a simple population model with a birth and a death rate. This model also has a second outflow that is there to represent the trees that are lost by deforestation. The model is built with an effect multiplier that increases the rate of deforestation as beef production increases.

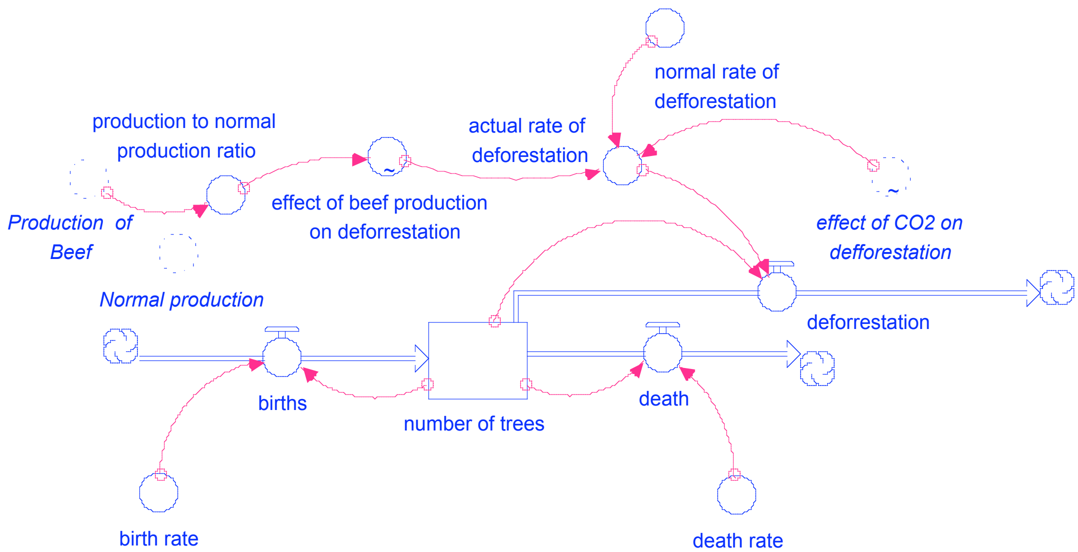


Figure 5: The Tree model as it is effected by the production of beef

With the addition of this model it was easier to model the dwell time. The way I did it is by calculating a ratio to compare the current trees to the initial trees. Then it was possible to set it up so that the dwell time changes in an inverse relationship with the number of trees.

THE FINAL MODEL

The finished model is composed of three major stocks that interact with one another to create an educated prediction of what could happen to the trees and to the CO_2 levels in the atmosphere if the production of beef continues in the same course.

The main part of the final model is the supply and demand model of beef. This uses multiple effect multipliers to make a realistic connection between the consumption and the production of beef. This part of the model did not change much throughout the process of building and that's because it works separately from the rest of the model. Even though the supply and demand model affects the other part of the model there is no major feedback that goes back and changes the consumption or production latter on.

The CO_2 part of the model works differently then it originally did because I added the tree model. To include the trees in the CO_2 model I had to make an effect multiplier to change the dwell time according to how the number of trees changes over time.

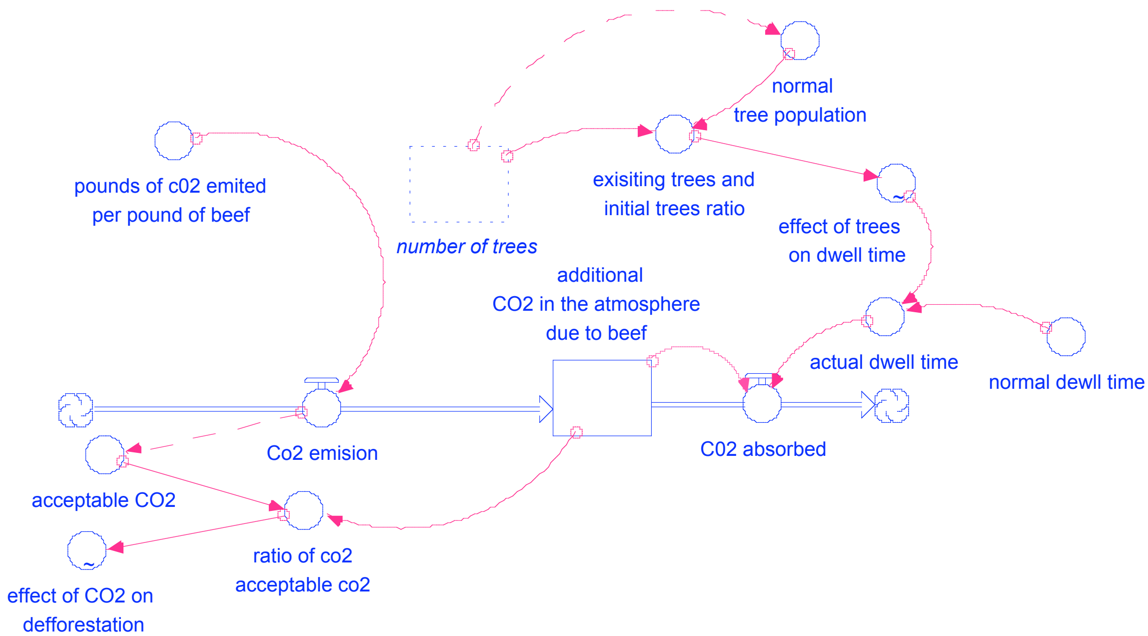


Figure 6: The second and final Version of the CO_2 stock's inflow and outflow as it is effected by the beef production and tree deforestation.

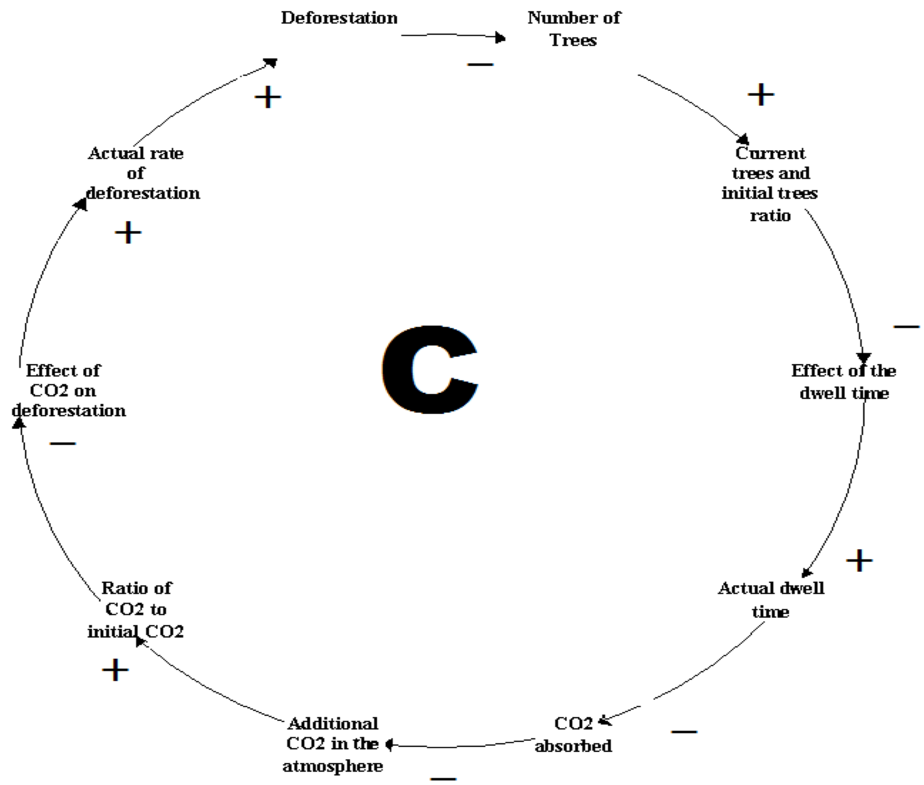
Also in this part I made a ratio that measures the current CO_2 level to the initial CO_2 level. This ratio is the center piece of one of the major feedback loop in the model. With this ratio it is easy to see exactly how much the CO_2 levels grow over this period of time. The Final Model contains the segments shown in figure 1, 4 and 5.

THE FEEDBACK

The deforestation loop

This loop represents a government policy that could be used to address this problem of deforestation. This is a counter acting loop meant to slow down the rate of deforestation once the CO_2 level reaches a certain point. The Brazilian federal government, after constant urging from Greenpeace, has decided to implement a policy like this that will hopefully reduce deforestation to zero by the year 2015.

Figure 7: The Diagram explaining the feedback loop describing the eventual effect the growing CO_2 levels has on deforestation.



As the number of trees decreases the effect on the dwell time increases. This makes the dwell time increase and if that happens then the CO_2 absorption will go down. Lower CO_2 absorbed per year means that CO_2 levels in the atmosphere will go up. Now once the levels of CO_2 in the atmosphere have reach a certain point and the government realizes that this is a major problem then the policy kicks in and starts to lower the deforestation rate. If the deforestation rate goes down that means that trees can start to grow again and the number of trees goes up again.

The price/consumption loops

The supply and demand has many loops that work together to balance the consumption and production out. For example sometimes in the market for beef there can be what is called as a shortage. During a shortage the consumption becomes bigger then the production making the beef inventory to go down. When this happens the model notices the change in the beef inventory and increases the price. When the price is increase two things happen the production goes up and consumption comes back down. On the other hand when the production becomes bigger then the consumption this is called a surplus. To fix a surplus the model lowers the price which makes the consumption rise and the production lower. In both of these situations the model returns to equilibrium thanks to these feedback loops.

THE TESTING

To make sure the model was working properly I had to do certain tests. The way to test the model is to change certain values and to see if the model reacts properly to those changes.

First I checked to see if the supply and demand model of beef was working properly. To do this I spiked up the consumption and checked to see if the model returns to equilibrium. As it turns out the model did what it was supposed to but just to make sure I tried spiking up consumption by different values in order to see if the model returns to equilibrium in all situations. This graph show one of the test I did in which I changed the inventory coverage to see if that made a difference. As you can see in all three cases the model was successful in returning to equilibrium the only difference in the tree is how long it took for the model to return to equilibrium.

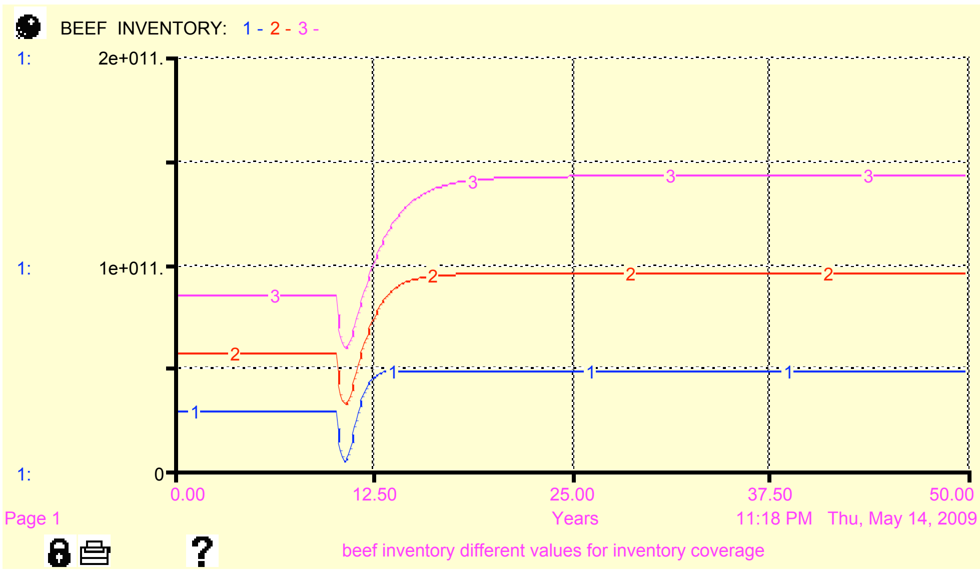


Figure 8: A graph showing the beef inventory with three different spikes in consumption, in all three the beef inventory returns to equilibrium

Another big test that I had to do was to check if the changes in production affected the trees and the CO_2 emission the way they were suppose to. To do this I spiked up the consumption of beef to an unrealistic amount and observed to see if it had the desired effects on the CO_2.

If you look at this graph in figure 9 you can see that immediately the second that the production spikes up the trees begin to fall dramatically and the CO_2 spikes up in a steeper angle. I know that this sort of spike in production in the real world would be very improbable and unrealistic but at least it allowed me to see that the model is behaving as it should. Latter on I changed the model so that the consumption increased gradually over time instead of having it spike up all at once since this is way is more realistic.

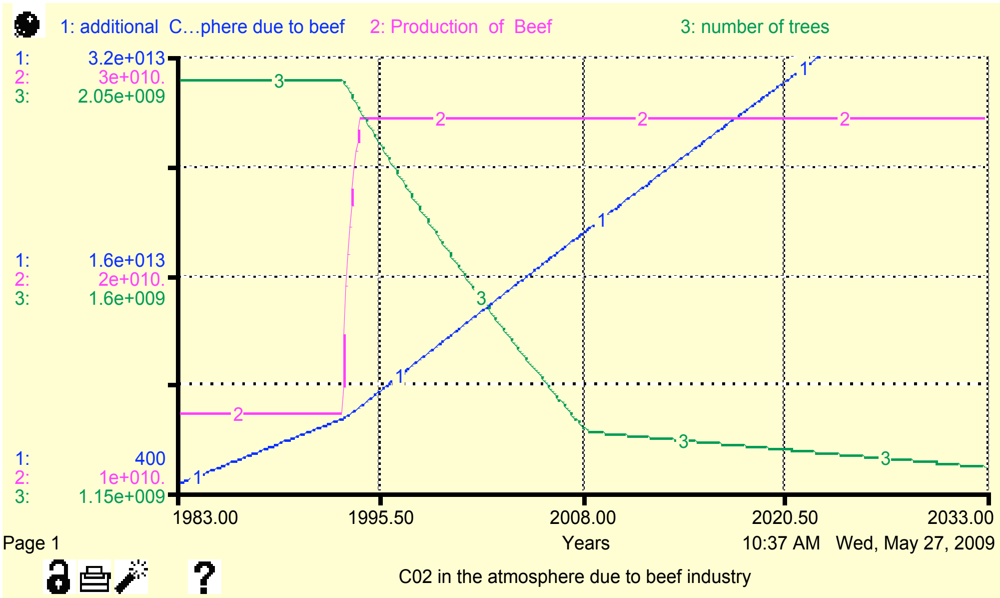


Figure 9: A graph showing a sudden increase in production

THE RESULTS

I think that the most import fact that can be taken from this model is that all these effect that Beef production has on the environment are worth taking a look at. If we continue

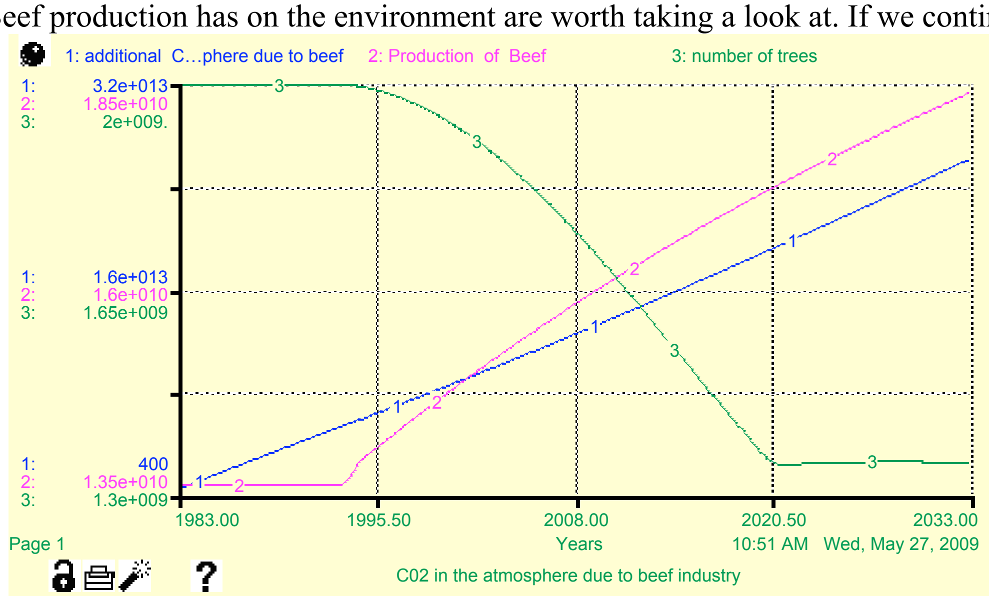


Figure 10: Final Graph showing all major stocks

producing beef at this rate and don't take measures to save our environment we could end up killing our planet. The rainforest could suffer some permanent damage if we don't slow down the rate at which we cut down trees. Also this deforestation dose not only affect CO_2 emission but also the wildlife that call the rainforest home will suffer. There is an amazing amount of wildlife that only lives in the rain forest so by destroying all of the trees we could be making some of these animals extinct.

Another thing I learn is that to save our environment we must do more then just lower the deforestation rate. The model show that when the government policy was implemented the deforestation rate did fall and the number of trees lower at a smaller rate but it didn't stop. The government must work together with environmental organizations, like Greenpeace, to implement the necessary policy that will reduce the deforestation to zero

Model, by the year 2033 the tree population fell to 68 percent its original level. Also the CO_2 grew to 51 times what it was at the start of the model.

THE LEARNING

- Beef production increases at alarming rate
- 80% of the deforestation in the Amazon rain forest is due to Beef
- The Production of Beef is increasing in respond to the demand for beef
- The model shows that in the future we could destroy all of our rainforest if we continue to cut trees down
- The RAMP function does a better job at describing the increase in Beef production then does the Step Function
- Some sort of cap and trade policy should be implemented by government in order to keep production and CO_2 levels in check

This model is closely related to other problems in the world today. This model only focuses on one of the many industries that contribute to the emissions of CO_2. This same idea could be uses to explain a coal burning power plant effect on CO_2 or a hydropower plant's effect on river life.

THE BIBLIOGRAPHY

"Background Statistics: U.S. Beef and Cattle Industry." USDA Economic Research Service - Home Page. 2007. 15 May 2009 <http://www.ers.usda.gov/news/BSECoverage.htm>.

"Beef...from Farm to Table." FSIS USDA. 15 May 2009 <http://www.fsis.usda.gov/factsheets/Beef_from_Farm_to_Table/index.asp>.

Brook, Dan. "Meat Is a Global Warming Issue | Environment | AlterNet." Home | AlterNet. 24 Aug. 2006. 15 May 2009 <http://www.alternet.org/environment/40639>.

Butler, Rhett A. "Deforestation in the Amazon." Tropical Rainforest Conservation - mongabay.com. 2006. Mongabay. 15 May 2009 <http://www.mongabay.com/brazil.html>.

"Carbon Dioxide Comfort Levels." Engineering ToolBox. 15 May 2009 <http://www.engineeringtoolbox.com/co2-comfort-level-d_1024.html>.

Carlsson-Kanyma, Annika. "Energy Use in the Food Sector: a data survey." Department of Systems Ecology Stckhom University. 15 May 2009 <http://www.infra.kth.se/fms/pdf/energyuse.pdf>.

Davis, Christopher G., and Bing-Hwan Lin. "Factors Affecting U.S. Beef Consumption." USDA Economic Research Service - Home Page. Oct. 2005. USDA. 15 May 2009 <http://www.ers.usda.gov/Publications/LDP/Oct05/LDPM13502/>.

"Eat less meat: CO2 emission of our food | Time for change." Time for change | For whom enough is too little - nothing is ever enough. Time For Change. 15 May 2009 <http://timeforchange.org/eat-less-meat-co2-emission-of-food>.

Ensha, Azadeh. "Meat vs. Climate: The Debate Continues - Green Inc. Blog - NYTimes.com." Energy and Green Business - Green Inc. Blog - NYTimes.com. 27 Mar. 2009. The New York Times. 15 May 2009 <http://greeninc.blogs.nytimes.com/2009/03/27/meat-vs-climate-the-debate-continues/?scp=2&sq=meat%20environment&st=cse>.

"Farm Animal Statistics: Meat Consumption." The Humane Society of the United States. 30 Nov. 2006. 15 May 2009 <http://www.hsus.org/farm/resources/pubs/stats_meat_consumption.html>.

"Lag Between temperature and CO2." RealClimate. 27 Apr. 2007. 15 May 2009 <http://www.realclimate.org/index.php/archives/2007/04/the-lag-between-temp-and-co2/>.

"MLA Beef." MLA Meat & Livestock Australia. Meat and LIvestock Australia. 15 May 2009 <http://www.mla.com.au/TopicHierarchy/MarketInformation/OverseasMarkets/RedMeatMarkets/UnitedStates/Beef/Default.htm>.

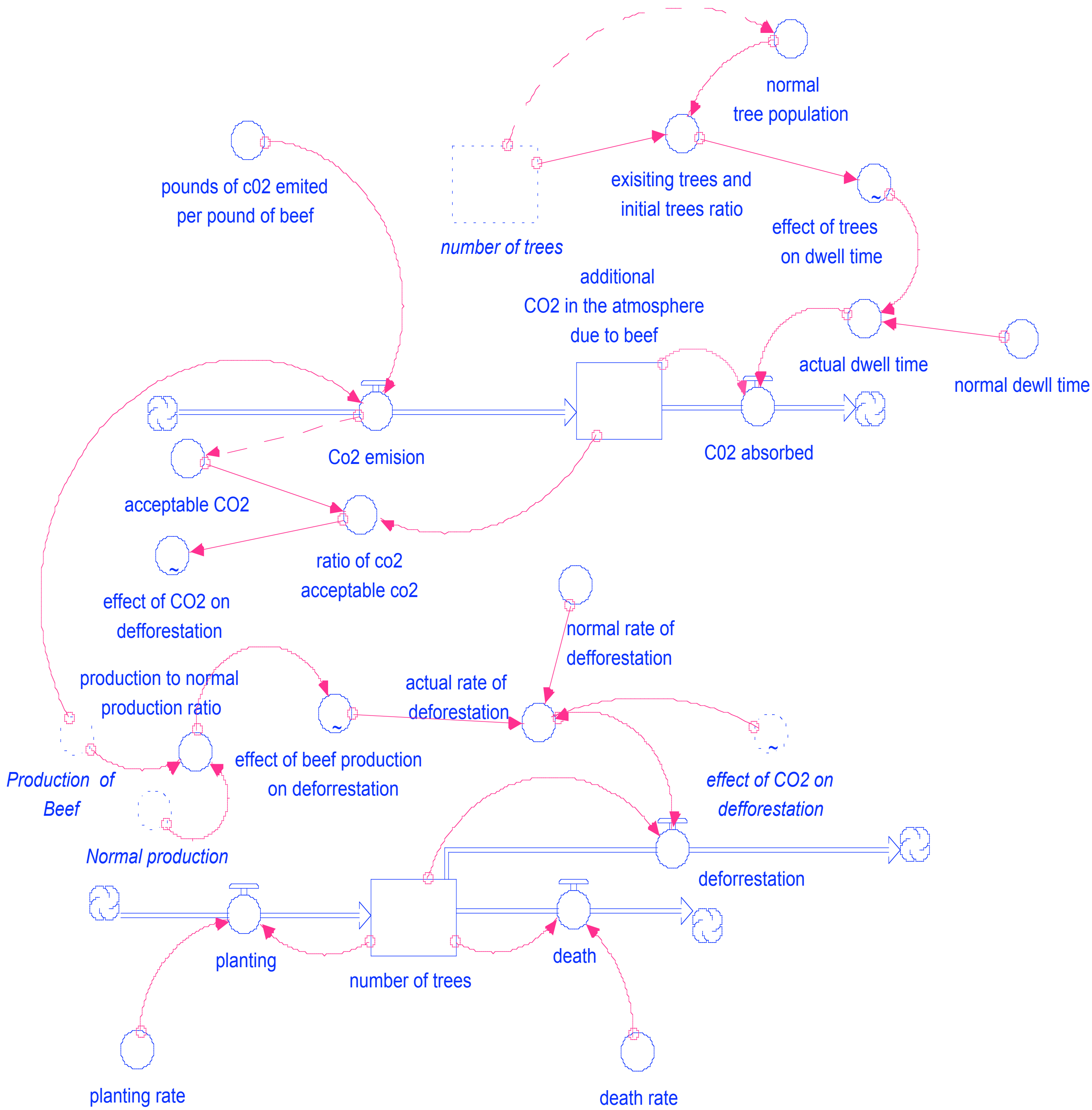
"Pound of beef produces 36 pounds of CO2 emissions." Conservation news and environmental science news. 18 July 2007. 15 May 2009 <http://news.mongabay.com/2007/0718-beef.html>.

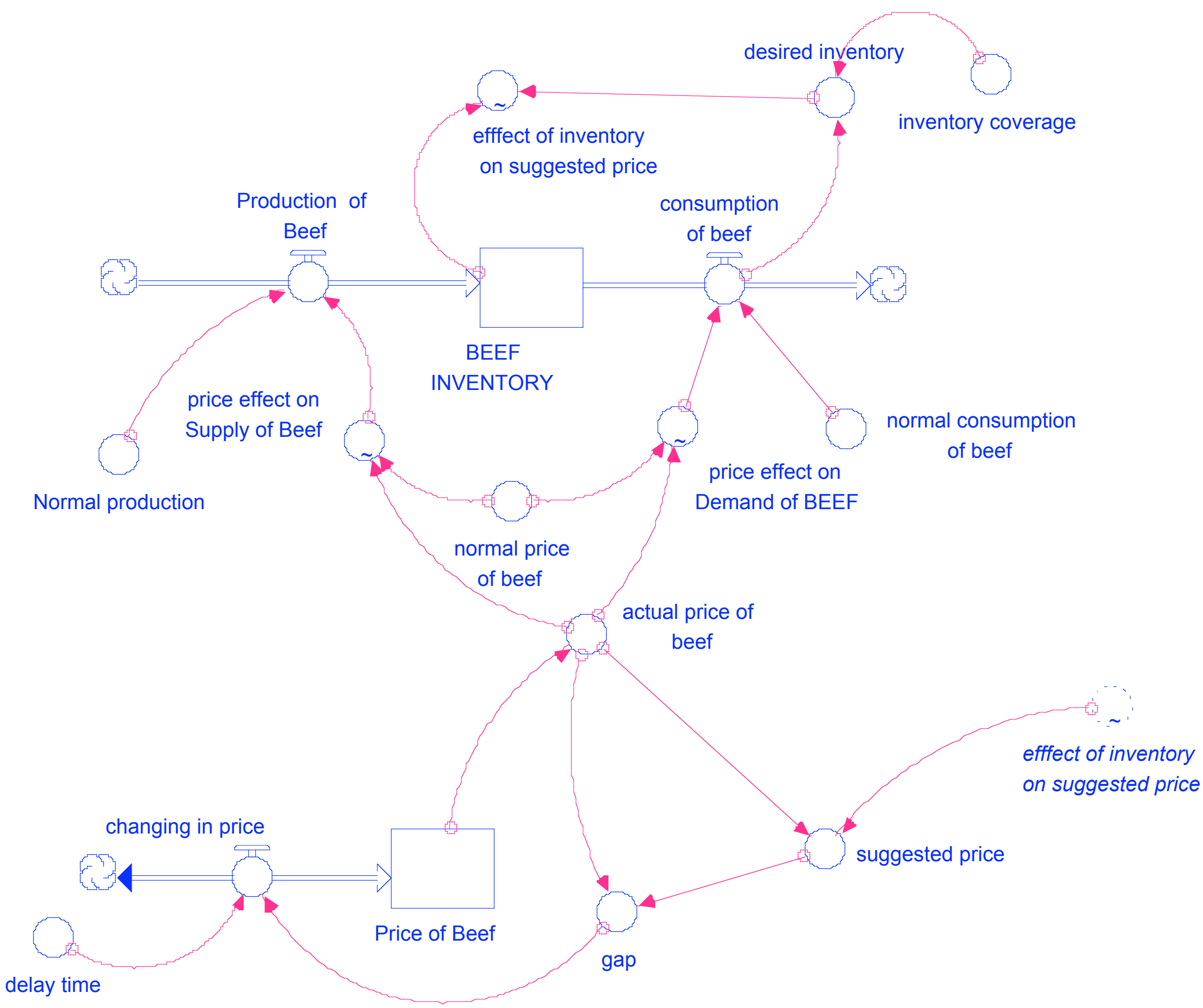
Shukman, David. "BBC NEWS | Science/Nature | Sharp rise in CO2 levels recorded." BBC NEWS | News Front Page. 14 Mar. 2006. BBC. 15 May 2009 <http://news.bbc.co.uk/1/hi/sci/tech/4803460.stm>.

Villarroel, M., G. A. Maria, C. Sanudo, J. L. Olleta, and G. Gebresenbet. "ScienceDirect - Meat Science : Effect of transport time on sensorial aspects of beef meat quality*1." ScienceDirect - Home. 2002. 15 May 2009

THE APPENDIX

THE FINAL MODEL





THE EQUATIONS

Omitted

THE OTHER SOURCES

http://www.usmef.org/Misc_News/International_Market/03_BrazilBeef_IndustryHighlight.pdf

http://www.rain-tree.com/facts.htm

http://news.mongabay.com/2009/0129-brazil.html

http://www.greenpeace.org/raw/content/international/press/reports/amazon-cattle-footprint-mato.pdf

http://news.mongabay.com/2007/0718-beef.html