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|  | [[home](http://docs.google.com/index.htm)]  [[abstract](http://docs.google.com/abs.htm)]  [[introduction](http://docs.google.com/intro.htm)]  [[hypothesis](http://docs.google.com/hypo.htm)]  [[experiment](http://docs.google.com/exp.htm)]  [[data](http://docs.google.com/data.htm)]  [[conclusion](http://docs.google.com/conc.htm)]  [[we recommend](http://docs.google.com/rec.htm)]  [[daily log](http://docs.google.com/log.htm)]  [[other](http://docs.google.com/other.htm)]  [[bibliography](http://docs.google.com/bib.htm)] |  |  | Due to the unusual nature of our project (it involves programming rather than a lab experiment), the procedure will discuss the nature of the program that we wrote and how it works, rather than a step-by-step detail of what we did to make it.  ***Materials:***              A C++ compiler (I recommend Visual Studio 6.0) or a Java compiler (I recommend Borrland JBuilder)              Microsoft Excel (to graph the data)    ***Procedure:***              After extensive research into the subject, a series of equations were found/developed to simulate the interactions between the producer, the herbivore, and the carnivore.  Obviously, this model could not be very detailed, as a lifelike model of an ecosystem is way outside the realm of mere high school students.  Thus we limited the simulation to just the biotic interactions of the three species.              First, we created a basic model of the interactions using word equations based on a single ecosystem, with no migration.  The equations are in bold, our commentary is underneath.  **Carnivore(t) = Carnivore(t � dt) + (Births � Deaths) \* dt**  *Simply put, the amount of carnivores at time t is equal to the previous number of carnivores (dt is the Calculus term for the increment) plus the births, minus the deaths.*  **Births = Birthrate\*(Carnivore � Deaths)**  *Births are equal to the birthrate times the number of surviving individuals*  **Deaths = Carnivore � Consumed/ConsumptionRate**  *Deaths are equal to the amount of carnivores who starved*  **Herbivore(t) = Herbivore(t � dt) + (Births � Deaths) \* dt**  *Like above, the amount of herbivores at time t is equal to the previous amount of herbivores plus the amount of births, minus the amount of deaths.*  **Births = Birthrate\*(Herbivore � Deaths)**  *Births are equal to the birthrate times the number of surviving individuals*  **Deaths = Herbivore � Consumed/ConsumptionRate**  *Deaths are equal to the amount of herbivores  who starved*  **Producer(t) = Producer(t � dt) + (Births � Deaths) \* dt**  *Like above, the amount of producers at time t is equal to the previous amount of producers plus the amount of births, minus the amount of deaths.*  **Births=(Producer�Deaths)\*Birthrate\*(1� Producers/CarryingCapacity)**  *The number of births are equal to the amount of surviving producers times the birthrate times one minus the producers divided by carrying capacity.  This is the logistic model of growth defined by the equation:*  dP/dt = r0\*P\*(1-P/K)  **Deaths = Consumption**  *In this model, producers die when they are consumed by herbivores.*  **Consumption = min(prey, max(0, consumptionrate\*predator))**  *Consumption is the minimum value between the number of prey and the number of predators times the consumption rate.  The max function is there to prevent negative consumption from occurring.*  ***Constants:***  *For this model, we specified some constants for simplicity�s sake:*  **Consumption Rate = 1**  *In one iteration, one predator eats one prey*  **Producer Birth Rate  = 2**  **Herbivore Birth Rate = .2**  **Carnivore Birth Rate = .02**  **Carrying capacity = 100000**  **Producer(0) = 10000**  **Herbivore(0) = 1000**  **Carnivore(0) = 100**  *This model has a tendency to �crash� (all the species die)  and so was not really an accurate model of an ecosystem.  After some more research, we stumbled upon a different method of modeling.  Basically, instead of one big �bubble� of an ecosystem, this method divided the ecosystem up into smaller �bubbles� with immigration and emigration of individuals in between.  So, if conditions were not favorable for herbivores in bubble number 1, a certain amount of them would migrate towards bubble number 2.  My model has only 4 bubbles, which made it much more stable, but still able to crash.  The equations were revised to this:*  *[Note: We have simplified them due to over-redundancy.  The complete equations can be seen in the source code.]*    Levels of migration are related directly to the amount of deaths in the quadrant  **Organism1(t) = Organism1(t � dt) + (Births1 + Immigration1 � Emigration1 � Death1**  *The number of organisms at time t in quadrant 1 is equal to the previous number of organisms in quadrant 1 plus the amount of births in quadrant 1, plus the amount of immigration to quadrant 1 minus the amount of emigration from quadrant 1 minus the amount of deaths in quadrant 1.*  **Births1 = Birthrate\*(Organism1 � Deaths1)**  *Births are equal to the birthrate times the number of surviving organisms in quadrant 1.* **Immigration1 = OrganismsFrom2 + OrganismsFrom4** *Immigration to quadrant 1 is equal to the number of organisms from quadrants two and four.*  **Emigration1 = min(Organisms1 � Deaths1, migrationRate\*Deaths)**  *The amount of emigration from quadrant one  is the minimum value between the amount of organims in quadrant one minus the amount that died in quadrant one, and the rate of migration times the amount of deaths.  Basically, the amount of organisms that migrate is a fraction of those who die.  Dying organisms signify bad conditions for that particular �bubble�* **Deaths1 = Organisms1 � Consumption/ConsumptionRate** *The amount of deaths are equal to the amount of organisms that starved.*    *Several of the other constants were specified, such as the migration rates of the Producers (.1) the herbivores(.05) and the carnivores(.01).*  *This model produced a more stable simulation, which was much harder to crash the ecosystem than the previous model, since bubbles that had unfavorable conditions tended to ameliorate themselves by immigration and emigration.  Also, the only way the system could truly crash would be if all four bubbles crashed.  If only one crashed then it could be restarted again by populations immigrating into them.*                The C++ program we made was able to export the results to a .txt file which we could import into Microsoft Excel and graph to see our data better.  The results of our test runs are in the data section.  [[data](http://docs.google.com/data.htm)] |  |
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