**Hawk, Caterpillar, Leaf Ecosystem Model**

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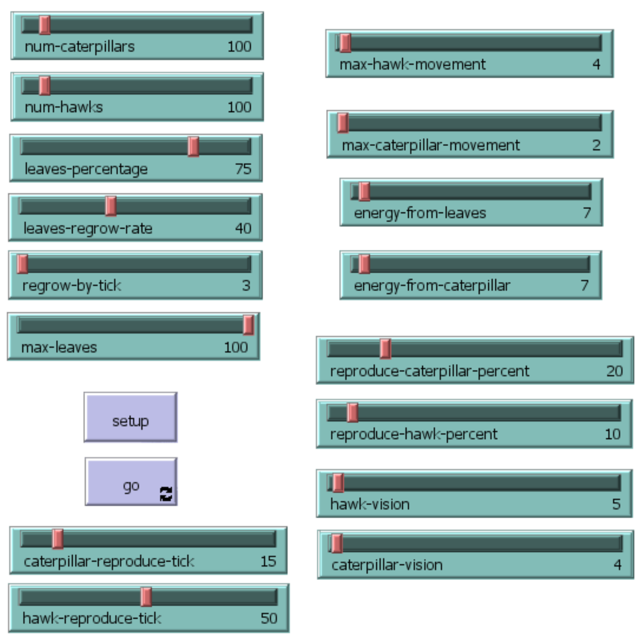
**Model Github Link:**

https://github.com/MarcBaura/Prey-Predator-Ecosystems

**Result Excel Sheet:**
https://docs.google.com/spreadsheets/d/1ULMktYyEJLyahMh0Mld2FA1qIeXE8jOxzW1KUUHIjZ8/edit?usp=sharing

**Scenario #1**: Set the initial population of preys to 100 and predators to 100. Run your model 10 times. In each run, stop the simulation at tick 500 and log the total population of your preys, predators, and food.

Configuration for Section #1:

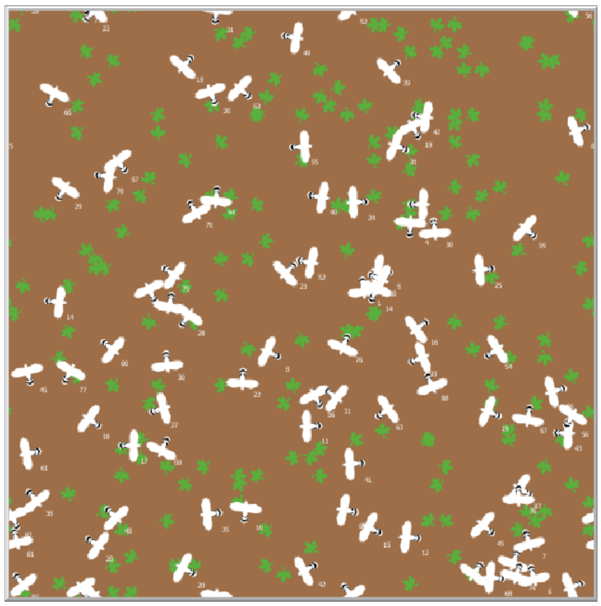



1. How would you describe the general behavior of your model up to tick 500?
   - The model, on average, was only able to run up to an average of 88.9 ticks. This is because the Hawk's ability to track, follow and eat the caterpillars in its vision killed off the population of the caterpillars too fast.
2. What is the average total population of your preys, predators, and food at tick 500 for all 10 runs of your model?
   - None of the runs lasted 500 ticks, because the caterpillars were killed off too fast resulting in the hawks dying off, too. The only survivors were the

leaves, which at the time of the hawks' and caterpillars' death, averaged at 558.3.

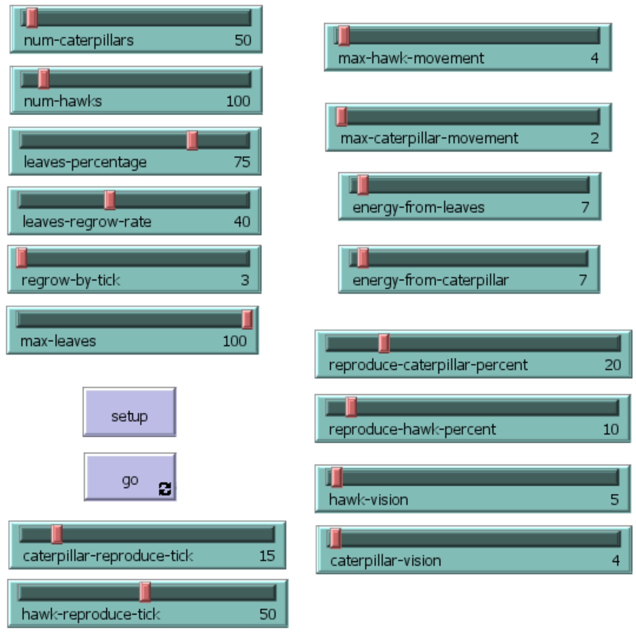
Now, run your model 10 times again. Let them run until either one of the prey, predator, or food populations go down to 0 (e.g. all predators died). Log the tick when that happened and the total population of the preys, predators, and food.

1. How would you describe the general behavior of your model when it runs indefinitely?
    - On average, the model's run ends in 20.1 ticks because that's how long it takes for the 100 hawks to kill all 100 of the caterpillars.



2. How does it compare to the average behavior up to tick 500?
    - The behavior is roughly the same because, if allowed to continue running even after the caterpillars all die, the hawks would die out at around the same tick count as the averages found in the tick 500 test cases.
3. Out of the 10 runs, how many times did the following populations become extinct (population == 0):
    - Preys = 10
    - Predators = 0
    - Food = 0

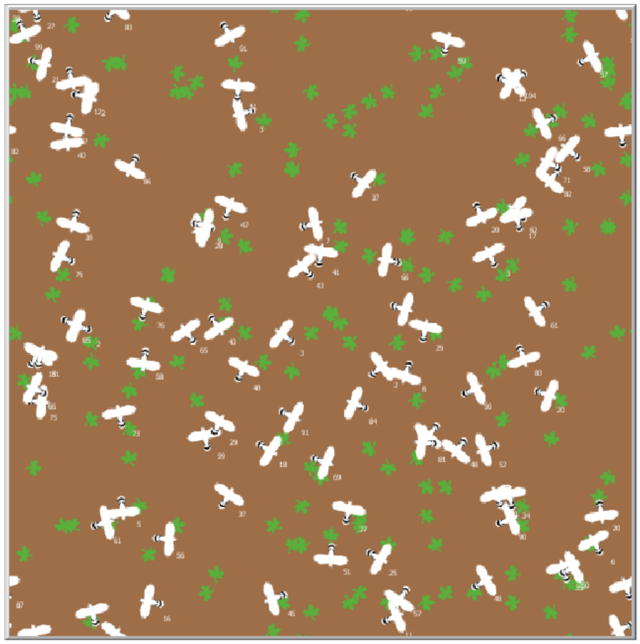
**Scenario #2**: Set the initial population of preys to 50 and predators to 100. Run your model 10 times. In each run, stop the simulation at tick 500 and log the total population of your preys, predators, and food.




1. How would you describe the general behavior of your model up to tick 500?
    - The same as scenario 1 but with less ticks on average before both the caterpillars and hawks die out. This is, again, because of the Hawks and their ability to track and kill the caterpillars.
2. What is the average total population of your preys, predators, and food at tick 500 for all 10 runs of your model?
    - Both the caterpillars and hawks die out before 500 ticks, leaving only the leaves as the survivors. At the time of their deaths, the leaves averaged at 566.

Now, run your model 10 times again. Let them run until either one of the prey, predator, or food populations go down to 0 (e.g. all predators died). Log the tick when that happened and the total population of the preys, predators, and food.

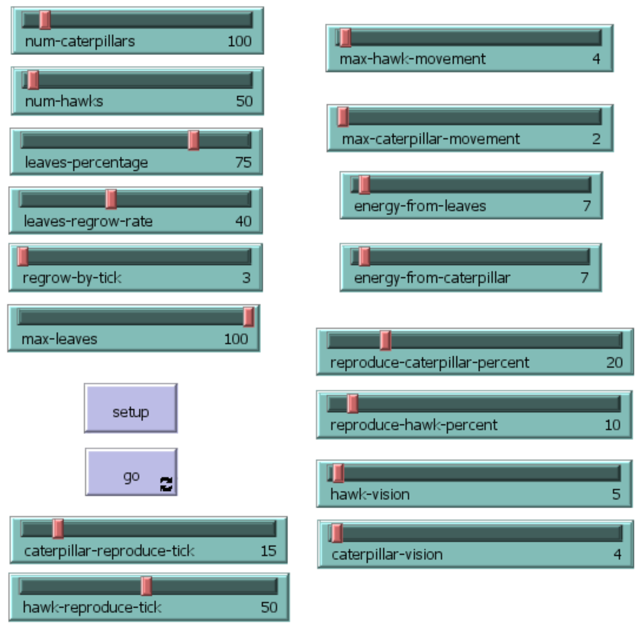
1. How would you describe the general behavior of your model when it runs indefinitely?
    - Same as scenario 1, except the run ends a bit faster at tick 12.2 because of the reduced population of caterpillars causing them to die out faster.



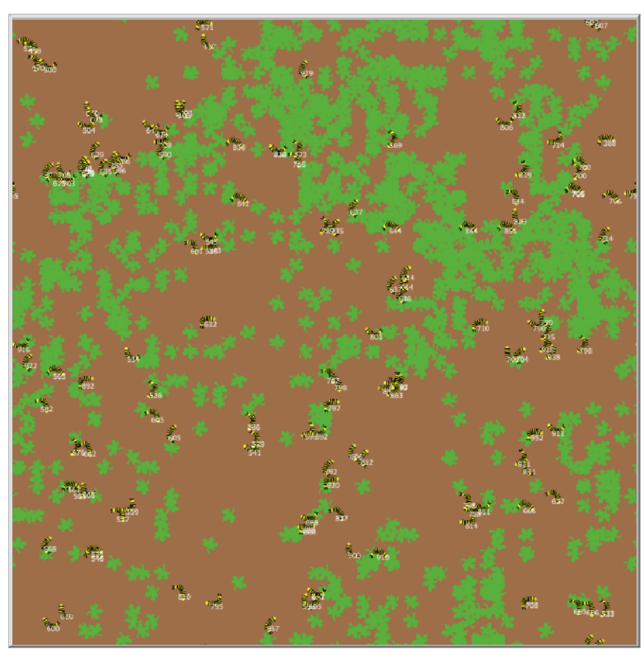
2. How does it compare to the average behavior up to tick 500?
   - The runs end sooner because it ends when the hawks will kill off the caterpillars rather than when both the hawks and caterpillars all die..
3. Out of the 10 runs, how many times did the following populations become extinct (population == 0):
   - Preys: 10
   - Predators: 0
   - Food: 0

**Scenario #3**: Set the initial population of preys to 100 and predators to 50. Run your model 10 times. In each run, stop the simulation at tick 500 and log the total population of your preys, predators, and food.

Configuration for section #3:



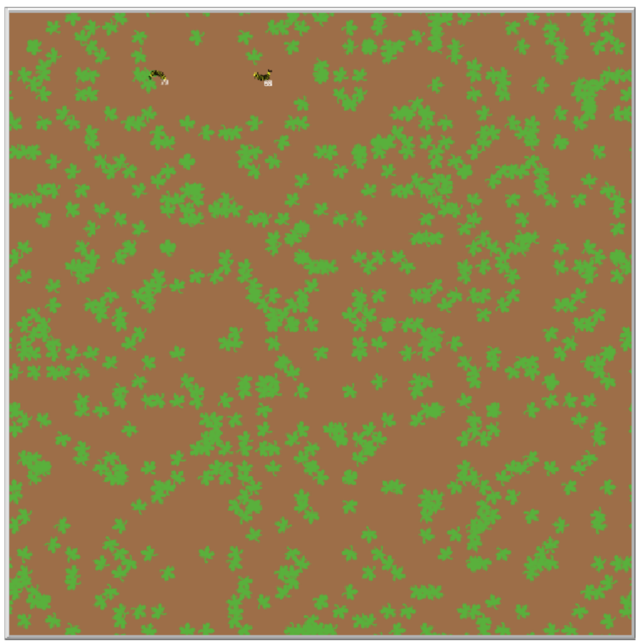

1. How would you describe the general behavior of your model up to tick 500?
    - The same as the previous scenarios, however there were some cases where the hawks spawned with low enough energy (starting energy is randomized), and the positions of both the caterpillars and hawks were just right that the hawks were not able to eat the caterpillars in time, resulting in the caterpillar population surviving until tick 500 (this is the only scenario that ever reaches tick 500).



2. What is the average total population of your preys, predators, and food at tick 500 for all 10 runs of your model?
   - Preys: 32.5
   - Predators: 0
   - Food: 710

Now, run your model 10 times again. Let them run until either one of the prey, predator, or food populations go down to 0 (e.g. all predators died). Log the tick when that happened and the total population of the preys, predators, and food.

1. How would you describe the general behavior of your model when it runs indefinitely?



   At around 38 ticks, the caterpillars have gone extinct, while the hawks go extinct at about 94 ticks. Most of the time the leaves, having no consumers, continue to multiply and reach a population of about 6747 per 1000 ticks. There were also instances where the caterpillars were able to survive extinction. This scenario can usually be observed when the caterpillars aren't extinct by around tick 230.

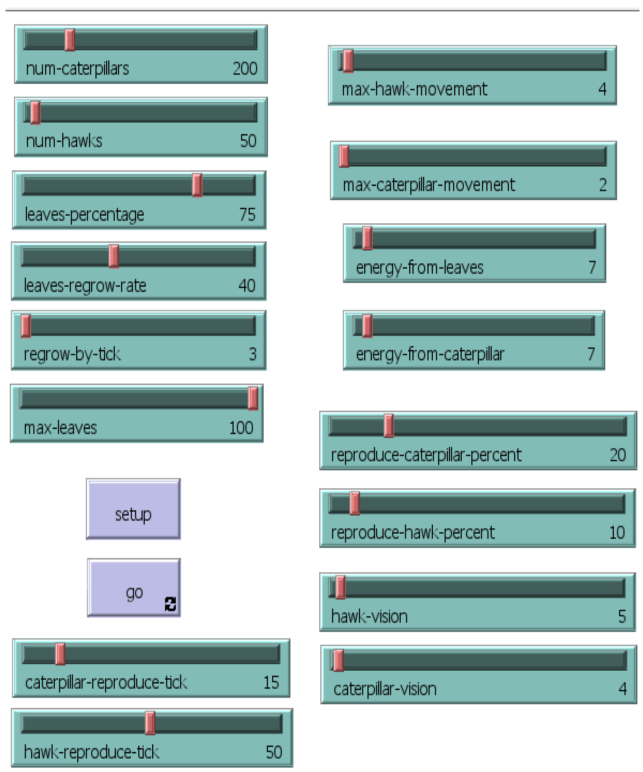
2. How does it compare to the average behavior up to tick 500?

   The model, when run indefinitely, does not have much difference to when it was run 'til tick 500. Because the extinctions of the prey and predator usually happen at around 90 ticks, anything beyond those ticks will just be the leaves reproducing.

3. Out of the 10 runs, how many times did the following populations become extinct (population == 0):
    - Preys: 4
    - Predators: 6
    - Food: 396

**Scenario #4**: Set the initial population of preys to 200 and predators to 50. You can also play around with your other variables if you hypothesize that they can change the behavior of your prey-predator ecosystem. Run your model 10 times. In each run, stop the simulation at tick 500 and log the total population of your preys, predators, and food.

Configuration for scenario 4:

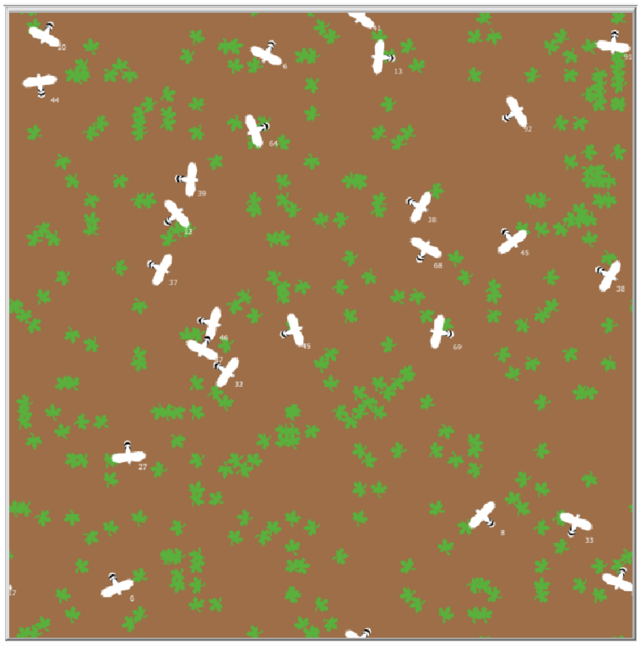



1. How would you describe the general behavior of your model up to tick 500?
    - The hawks ended up eating all the caterpillars and dying out after running out of caterpillars to eat, same as scenario 1, 2 and some test cases of scenario 3. At first, we thought we could alleviate the problem of the caterpillars dying out by increasing their numbers while also decreasing the number of the hawks, but the behavior of the caterpillars (seeking out leaves in the area) is detrimental to them because this means that caterpillars will tend to gather into groups they're lead towards the leaves,

which means that a single hawk will have an easy picking off groups of caterpillars.

2. What is the average total population of your preys, predators, and food at tick 500 for all 10 runs of your model?
   - Preys = 0
   - Predators = 32.5
   - Food = 710

Now, run your model 10 times again. Let them run until either one of the prey, predator, or food populations go down to 0 (e.g. all predators died). Log the tick when that happened and the total population of the preys, predators, and food.



1. How would you describe the general behavior of your model when it runs indefinitely?
   - Surprisingly, there were some runs where the hawks died out before the caterpillars did, kind of like scenario 3. This is because, by chance, the hawks spawned in a suboptimal position, far away from the caterpillars, and spawned with lackluster energy which caused them to die out before they could eat the caterpillars.
2. How does it compare to the average behavior up to tick 500?
3. Out of the 10 runs, how many times did the following populations become extinct (population == 0):
   - Preys = 8
   - Predators = 2
   - Food = 0

a. What are your key findings about the prey-predator ecosystem that you modeled?

One of our key findings was that a hawk's ability to target a caterpillar was incredibly strong. We decided to give the hawk that ability because, in the real world, a hawk will fly around until it spots a prey and then hunt it. We didn't give the caterpillars any opportunity to flee from the hawk because they are naturally slower. As a result, the majority of our findings show that caterpillars (prey) become extinct almost immediately.

Another key finding is that because the caterpillars' main behavior is moving towards the leaves on the ground, it's common for them to find themselves in groups. Since they were grouped and clumped together, the hawks, on average, had an easier time finding, killing and eating large numbers of them very quickly, especially since they are always hungry and can never get full in our model.

b. How confident is your group with your model, and why? Take this opportunity to reflect on the limitations of your approach.

We are somewhat confident in our model because it closely resembles what happens in a hawk, caterpillar, and leaf ecosystem. When our hawks saw a caterpillar, they went after it. We also changed the initial configurations of our variables to make them more realistic. As an example, hawks have a greater visual range to find prey than caterpillars to find a leaf. Which is why in our configuration, we decided to give the hawk a vision range of 5, while the caterpillars only have 2.

However, we also believe that there are limitations within our model. An example is that the hawks have no restraint and they will continue to eat until the caterpillars go extinct. It did not give the caterpillars any chance to repopulate, unlike in the real world where hawks also get full and will stop eating for a while. As a result, we did not have any results where the caterpillars managed to repopulate which is why all of our ticks have small values.

Another limitation was that a newly reproduced hawk or caterpillar don't go through their respective growth cycles (hawks spawn as hawks and caterpillars spawn as caterpillars, rather than eggs or larvae), and inherits their parent's energy, even though in actuality they should have less since they are still young and probably follow their parents around.