New World Order- Tent Caterpillar Infestation in Carson National Forest

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Executive Summary

Western Tent Caterpillars are a serious problem in the Carson National Forest. The objective of our project is to model annual generation-to-generation cycle of tent caterpillars in a known parameter using Netlogo. Caterpillars are defoliators creating a problem in the Carson National Forest where infested areas may or may not survive repeated infestations. Our code will represent most of the state of a tree in two patch variables, such as health and infestation-level.

We are doing this to help forest service's know where an outbreak is occurring and when to intervene with necessary interventions. According to USDA, "Trees repeatedly defoliated will have sparse foliage, minor branch dieback, and in some cases, tree mortality."(Forest Insect Defoliators) Mortality is a very real reality in the Canjilon canyon in Carson National Forest. There has recently been a closure near the Canjilon Lakes affecting many campers, hikers, fishers, and hunters because of dead downed trees from tent caterpillar infestation.

Statement of Problem

Tent Caterpillars are defoliators, which means they destroy the leaves. The young caterpillars skeletonize the leaves, and the adult caterpillars destroy the leaves. Western tent caterpillar is an early season defoliator with feeding damages typically occurring between the months of May and June. (Forest Insect Defoliators.) The caterpillars eat the leaves especially Aspen in which causes the tree to not regrow and reproduce because the leaves are the trees main energy source.

Outbreaks are generally short lived, lasting about 2 to 3 years. Tent caterpillars attack deciduous trees which include the Aspen, Willow, Cottonwood, and mountain mahogany. The tent caterpillars do not attack conifers or evergreen. The severity of the outbreak depends on moisture, length of attack, and the overall health of the tree.

Description of Method

In our program we would like to see the spread of a tent caterpillar infestation as random as possible. We are using a cellular automata model with a circular neighborhoods, meaning the state of any given cell (a tree) in time t+1 depends on the state of that cell and its neighbors at time t. There is a random component to the state of the cell in time t+1 because it is a stochastic CA model. (Bennett, 2017) . For example in order to move the caterpillars from tree to tree infestation will depend on the proximity and health of a neighboring infected tree. The neighboring cell will be more likely to be infected. So far we don't have a way for the infestation to stop without it destroying the entire forest. Our model has a density slider which is used to control the density of the randomized forest. The Number of start points slider is connected with the random bugs button where the slider is used to select how many random start points will be placed on the board where you click using your mouse to actually place the random start point. The number of clearings slider is used to generate a chosen amount of lakes. In the future we hope to code for moisture, terrain, and wind variables to control infestation.

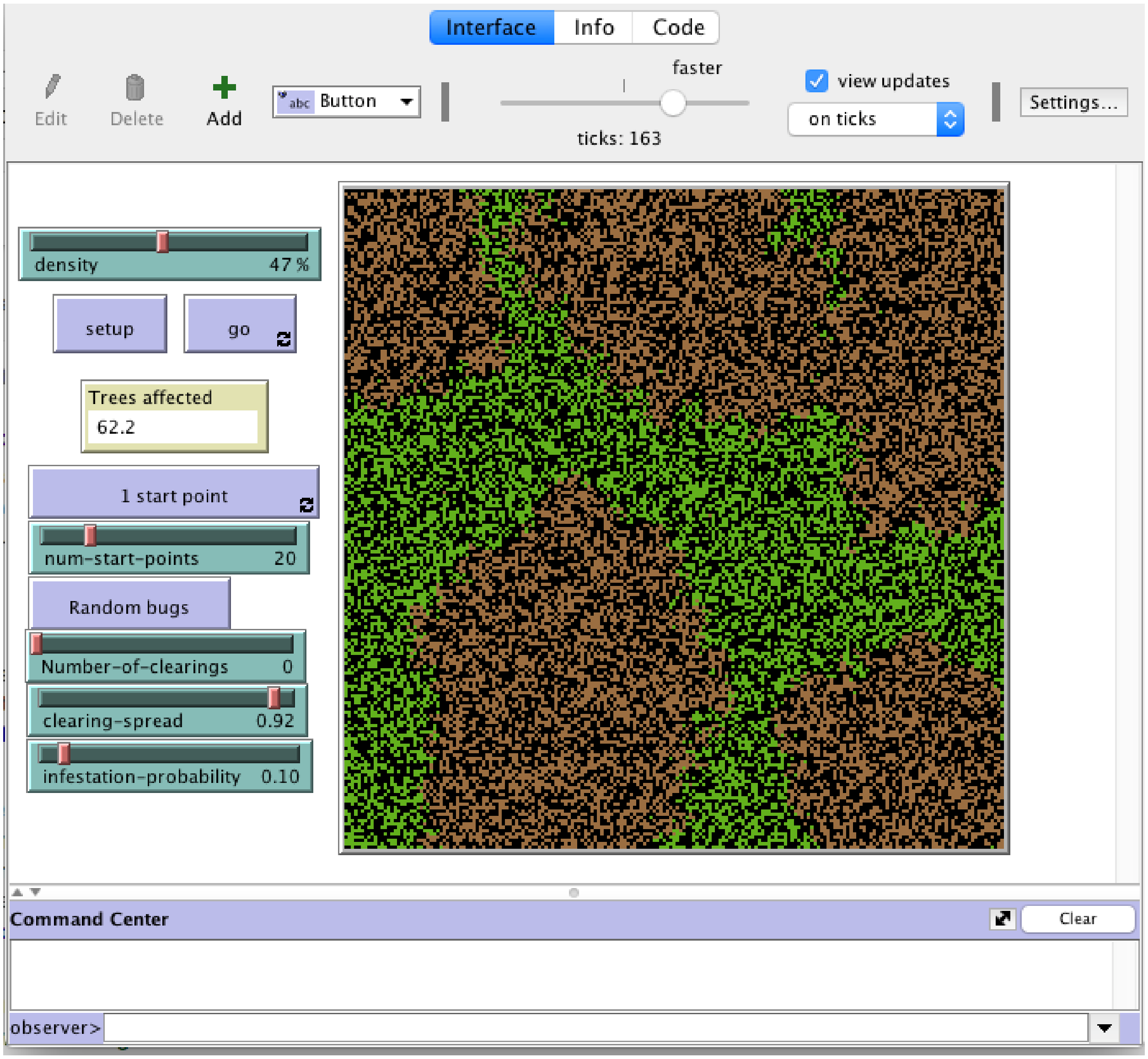
Validating The Model

NetLogo 2-D is the programming language we used. We chose the fire model and adapted the code to fit our vision and our goal. We liked the visuals and the spread of the fires. It simulated something very similar to the spread of caterpillar infestation. We changed code language like set-*fire*-location to set-*infestation*-location and changed things like how the infestation will spread compared to the north, east, south, and west to spread as random as possible. For example the spread of the caterpillar code would state if any given cell (a tree) in time t+1 depends on the state of that cell and its neighbors at time t. The bug may or may not infest a tree based on health and or spacing between trees.

We chose Netlogo language because it is fairly easy to learn and use since we are new to coding. Our code will represent the lifecycle of the tent caterpillars annually. After they emerge from their cocoons, the adult moths breed and lay eggs; the larvae are sequestered within the egg masses over the winter, emerging the following spring. Our time scale was something we had to deeply consider for example, we wanted to represent 1 tick for 1 day, but it does not make sense when looking at the long term effects of caterpillars on the forest. Therefore we had to change 1 tick to represent 1 year. We did this because an infestation can't spread from tree one tree to another tree, then from tree to another tree, all in a single year.

Looking at how the caterpillar would spread throughout the model we had to think about whether the trees are infected or not infected. Since the caterpillars spread in cycles it only makes sense to have levels of infestations for trees. For example, we had to decide if a tree is healthy enough to start the season with enough leaves to support itself. In that case if the tree is healthy and has sufficient leaves then the tree could be assumed to be infected enough to support many moths.(Bennett) The moth then in turn would lay eggs in nearby trees creating a cascade effect of infected trees. On the other side, if the tree is not healthy and does have infestation then the tree would not make it through the season. That is why representing each tick annually and showing annual generation to generation cycles best describes the impacts on the forest. (Bennett) Our code will represent most of the state of the tree in two patch variables, such as health and infestation-level. (This assumes that 1 patch = 1 tree, at most.)

Model



Our model is a rendition of the fire model. We took the basic layout and made it our own.

-Setup- Sets up the simulation.
-Density- How dense the forest is.
-Go- Starts the simulator.
-1 Start Point- Choose the start point of the infestation.
-Random Bugs- Infestation starts in random points.
-Num. Start Points- How many random places the infestation will start at.
-Number of Clearings- How many clearings there are in the model.
-Clearing Spread- How large the clearing will be.

-Infestation Probability- This is the probability that an infestation in one tree will spread to a given tree immediately adjacent (i.e. at the minimum practical distance between adult trees-which is the patch size. (Bennett, 2017)

Results

In conclusion our goal was to predict where the infestation might start and where it will go next. While running our code we found that the spread of infestation depends on the density of the forest. We have to run more tests to see how the number of start points, number of clearings, clearing spread, and the infestation probability will affect the forest.

We learned that there was a severe infestation in the Carson National Forest. The caterpillars have taken over a large part of the forest. The trees can collapse due to their bad health. Intervention is needed to control and save the forest. Our future goal is to use coding as a tool to predict where and why these infestations happen.

Our code could help save the forest and the wildlife living in the forest. We learned that coding is very complicated and takes lots of practice. If you misspell a word the code won’t work. If you make a mistake while coding it is easily fixed when you click the check button. The mistake you made will be highlighted and you can find what's wrong in the code.

We liked that Netlogo provided us a dictionary to help with coding. It also provided a template that we can edit to make our own. Our code is a great example of this, we used a forest fire model and made it our own for coding for bug infestation. Our next step would be to still build our code and more importantly run tests repeatedly to collect data. We would code for a photo of the Canjilon area in Carson National Forest. We would also reduce the picture to more simple colors that Netlogo would understand. For example, blue would represent water, brown would represent conifer, and green would represent aspen. We would also develop the code so Netlogo would recognize whether a tree is healthy or not.

Citations:

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