For this week my progress can be summed up as having nearly every piece of my Honey Bee Colony Collapse Disorder Model implemented and fully functional. First off, I want to give an organized summary of my model now that it has a clearer direction.

My model will be designed to simulate Bee Colony Collapse Disorder where a variety of factors cause the sharp decline of honey bees, and as a result, a shortage of pollinators for which crops and flowers require to grow. However researchers are having trouble finding just one factor causing CCD and instead theorize that it is a mixture of different factors working together to cause the decline in honey bee populations. The goal of the model is to be able to find out how these factors work together, and which ones might be best to tackle if we want to save bee colonies form collapse.
The four factors I plan to model are the following:

1. Pesticides - Various crops are sprayed with pesticides in order to kill off any insects that might damage said crops. While these pesticides are effective, they usually don't harm bees unless the bees are already weakened. The plan for this in my model is to allow users to click on patches to "spray pesticides" which will slightly harm bees that pass it.

2. The Varroa Mite - While there are a variety of different diseases and mites that affect honey bees, the Varroa Mite is by far the worst. It attaches itself to the honey bee and sucks their blood, damaging the bee. Miticides are often used to get rid of them, but just like with pesticides, if not worse since the mite has a similar biology to the honey bee, this can damage weaker bees and potentially kill them. I hope to represent the Varroa Mite by having a random chance of bees to be affected by the mite, which will drain the energy of the bee at a quick rate.

3. High Fructose Corn Syrup - Because there are less and less wild flowers, bees often cannot find the amount of pollen that is needed for a large colony. As a result, farmers will feed bees high fructose corn syrup which does not give bees the same essential nutrients as pollen does. This causes a colony to thrive, but have poor nutrition and become more susceptible to the various things that can kill them. I plan on showing this in my model as a switch, which will consistently boost the energy of the bees but increase the damage done to them by outside sources

4. Deforestation/Removal of flowers - The last issue for bees is simply the lack of flowers to feed pollen off of. There are less and less wild flowers out in nature due to the rapid development of civilization in the form of roads and buildings. I hope to depict this in my model by giving the users the option to construct roads which will replace grass patches and not allow any flowers to grow on them.

Here are the changes that have occurred this week:

Agents:

Bees:

Attributes: For the attributes of bees I've added in age as well as energy so that energy correlates to hunger and age correlates to age, so that eventually all bees will die regardless of how much pollen they eat.

Behavior: For the behavior of the bees I've changed their searching behavior a bit. Now bees will fly at .25 per tick if they cannot find a flower, but will speed up to .5 per tick once they have a target.

Hive:

Attributes: Nectar has been implemented. Now once a bee returns 5 pollen it will add 1 nectar to the hive. The next step is to have farmers come in and collect it once in a while. Growth number has also been added which increases with nectar until it hits 100 and resets, while adding another hexagon hive to the initial hive.

Behavior: Bee spawning has been implemented to come from the hive. Now bees will spawn based on the spawn rate set by users. Also hive growth has been implemented so the hive will grow a hexagon every 100 nectar raised.

Flowers:

Attributes: Pollinized? Attribute has been added which is one if a flower received pollen from another flower, and 0 otherwise. Only pollinized flowers can spawn new flowers. Also like the bees, age has been added

Behavior: Flowers now age and die! Also a flower spanning function has been implemented. Flowers that have been pollinated by other flowers and bees will have a chance of releasing seeds which will find a spot not growing a flower already and spawn a new flower of the same of slightly lighter or darker color.

Patches:

Patches in general can have three colors, green, pink, and gray. Green is the default grass. Pink means that pesticides have been applied and will damage the bees by decreasing energy of bees, and gray is roads which will not allow flowers to spawn. These can all be applied with mouse interaction by clicking.

System:

The system right now has the general bee flower pollination factors working now. The bees are successfully finding flowers and collecting pollen. Once they decline to a certain energy level, the bees will consume one pollen and gain energy. Once a bee gets 5 pollen, it will immediately return to the hive and deposit them, allowing the hive to collect nectar.

If a bee brings pollen from one flower to another, that flower will be pollinated and have a chance of spawning a new flower some distance away from it. Once a new flower is spawned, the original flower will set its pollinated? Value to 0.

I have added two of the 4 detrimental factors that cause CCD. These are pesticides, and deforestation/road work. For pesticides, if the chooser is set to pesticide, clicking on a grass patch will turn it pink which, if bees fly over it, will cause those bees to lose energy according to a customizable "pesticide potency". For roads if the chooser is on roads, clicking will create a gray block that does not allow for flowers to be born from.

Rationale:

I gave all these agents these rules mainly to simulate the nature of pollination by bees, the lifespan of bees and flowers, and the detrimental effects of pesticides and deforestation that lead to CCD.

Model Output: Right now my measures are monitors that show the population of bees and the population of flowers which gives a decent description of the system since the populations are the

aspect we are actively looking at. To make the output better I plan on adding plotting to see trends in the population, and perhaps add in percentage of land that is roads, and how many bees/flowers have been born overall.

Questions:

1. I now need to implement Varroa Mites and Corn Syrup Consumption to my model, should I have random bees be infected by the mite? Should I make corn syrup replace pollen as the food source or instead have it added on? Research might help with these.
2. Is having the flowers spawn close to each other realistic?
3. Should I have the world warp around itself?
4. Are the bees flying at a good speed? Is it too slow?

Next Steps:

1. Implement the Varroa Mites and Corn Syrup Consumption. This should be easy to do.
2. Start organizing my UI to be cleaner and easier to follow
3. Have a set list of outputs that the user can draw conclusions from.

Model Analysis:

So some really interesting stuff is happening with the addition of pesticides and roads. In my research no one factor should cause the collapse of bees so I've been careful to keep the effects of these factors to a low severity. If the pesticide itself is used with a relatively low potency, it might cut down on the number of bees but won't have a huge effect given that there are enough flowers and pollen for bees to eat. However when roads are added that cut off the hive from part of the land, then the bees will focus on the flowers that are on the side of the road closer to the hive since other flowers are now too far to be worth going to. This ends up having all the flowers grow close to the hive enclosed by the roads. When a pesticide is added here, since all the bees are congregating in this area, it does much more considerable damage, often causing the collapse of the hive completely.