Where Oh Where Did The Jumping Mice Go?

New Mexico
Supercomputing Project
Final Report
Team 16 Aspen Elementary

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Executive Summary

This project is about saving the jumping mouse, which is on the endangered species list. Our goal was to use computer simulations of the mice's habitat and factors that may be affecting it's survival. The challenge of this work was to make a computer program that did this. We had to make some simplifications that would enable us to create a working model of the mice's world. We settled on using one type of competitor, one predator, habitat loss, and pollution. We also included food, water, age, and sleep.

Since this was our first time using computer programing, we used StarLogo TNG. The competitor is a rabbit and the predator is a coyote. Habitat loss and pollution decrease the ability of the land to create food and decrease the health of the animal agents. The exchange between agents regarding eating involves energy loss and gains. Activities such as searching or hunting for food also involve energy. We found that the hardest part of this program was to get the energy levels set so that the program would work.

We were able to finish a program that gave expected results for just a mouse by itself with no competitors or predators. We almost got the program to create a stable situation with rabbits, mice, and coyotes present. With further changes to the energy exchanges between agents, we think that this program could simulate the mice's environment and help understand what are causes for the mice's decline in the Jemez Mountains.

Problem Statement

We are trying to understand why the jumping mice may be going extinct by simulating them in their environment with the variables that we think might be causing this.

Method:

We used Star-logo TNG with an agent based model made up of an environment with food and water (sometimes with pollution and/or habitat loss), predators, competitors and Jumping Mice. We used certain variables to keep the agents values: food energy, water energy, Coyote age, Jumping Mice age, Rabbit age, ect.

Background Input: We looked up breeding and life expectancies for the animal agents in our model. Their life spans, the number of young they give birth to and how long they sleep. Coyotes live about fifteen years, give birth to about two young and sleep 9-13 hours. Jumping Mice live 1-3 years, give birth to 5-20 young and sleep about 14 hours. Rabbits live 6-9 years, give birth to about 4-5 young and sleep 9-12 hours[1-4]

Simplifications: To make our program workable in the short time we had, we settled on the mouse having one competitor (rabbit) and one predator (coyote). Human influences were simplified into two areas we called habitat loss and pollution.

Assumptions: In picking a starting point, we assumed that the mouse by itself in the environment would follow a rapid rise and fall in population [5].

Agents

Jumping Mouse: This is the star of the our show and the agent we would like to see survive. In our program, he (or she) competes in the program with one competitors (rabbits) and predators (coyotes).

Competitors (Rabbits) The rabbit is the competitor and eats the same food and water as the Jumping Mice.

Predators (Coyotes) The Coyotes are the predator and eat both the Rabbits and the Jumping Mice. They also eat the same water as them.

Water The water is one of the resources that the animal agents consume. An animal agent dies when it has equal to or less than 20 water energy. Coyotes get fifteen water energy units when they eat a water agent. Jumping Mice get eighteen water energy units when they eat a water agent. Rabbits get fifteen water energy units when they eat a water agent.

Food The food is only consumed by the Jumping Mice and the Rabbits. These agents die if their food energy is less than or equal to zero. Jumping Mice get twenty food energy when they eat a food agent. Rabbits get fifteen food energy when they eat a food agent.

Burrows The Jumping Mice Burrows are the agents that the Jumping Mice hide in and go to when they are full. If a Jumping Mouse smells a coyote then it will run for the nearest Jumping Mouse Burrow and once at the burrow it is hidden. If a Jumping Mouse gets more than 250 food or water energy it goes back to its burrow. The Rabbit Holes are the agents that the Rabbits hide in and go to when they are full. If a Rabbit gets more than 250 food or water energy it goes back to its burrow also. Coyote Burrows are the agents that the coyotes go to when they are either full or sleepy. If a Coyote gets more than 250 food or water energy it goes back to its burrow also. Coyotes have a sleep energy level that they gain by sleeping in their burrows when they run out they go back to their burrows and sleep.

Settings

Habitat Loss The habitat loss is a black patch color that prevents food and water from being there. Any food or water on a habitat loss space dies although all other agents aren't harmed by it other than shortage of food and water.

Pollution The pollution is a red patch color that prevents food and water from being there and harms and sometimes kills animal agents that go over it. All food and water on a pollution space dies and all animal agents lose ten water and food energy.

Breeding Jumping Mice breed by two Jumping Mice that are opposite gender colliding with more or equal to 100 food and water energy. They have random 16+4 (5-20) young and lose 25 food and water energy from it. Coyotes breed by two Coyotes that are opposite gender colliding with more or equal to 100 food and water energy. They have random 2 young and lose 25 food and water energy from it also. Rabbits breed by two Rabbits colliding with more or equal to 100 food and water energy. They have random 2+3 (4-5) young and lose 25 food and water energy from it too.

Energy Levels All the agents share 2 common energy levels food energy and water energy. Food and water energy are levels that the agents fill up by eating food and water. If an agent runs out it dies. Coyotes have a sleep energy level that they gain by sleeping in their burrows and lose by being active. If they run out they move slower and head for their burrows.

Movement All the agents move in a simple wiggle when not running away or hunting they turn random 30˚ right and then random 30˚ left and then forward one. When a Jumping Mice or Rabbit smells a Coyote it starts running for the nearest burrow. When a Coyote smells a Jumping Mice it starts running after it.

Birth Levels The agents only breed when they have 100 or more food and water energy. Also they lose twenty-five food and water energy.

Death Levels All the agents have a certain amount of age they gain with each step and when their age exceeds the age limit they die. Jumping Mice and Rabbits gain 0.01 age with every step and Coyotes who live longer only gain 0.001 with every step.

Agent-Setting Interactions

Agent-Habitat Loss Food and water die if there on it but all the other agents other than burrows aren't affected.

Agent-Pollution Food and water die but all the other agents other than burrows lose ten water and food energy.

Agent-Energy-Movement This is the most difficult thing to set because its very how much energy an animal loses when it moves. Right now each Jumping Mouse loses one food and water energy per step. Each Rabbit loses one food and water energy per step too and Coyotes lose 0.5 food and water energy per step.

Agent-Agent Interactions

Agent-Burrow The agent becomes hidden in the burrow.

Jumping Mouse-Jumping Mouse If they both have 100 or more food and water energy they have random 16+4 (five to twenty) young and then lose 25 food and water energy.

Jumping Mouse-Rabbit There are no direct interactions between the jumping mice and rabbits. The only interactions are indirect through competition for food and water.

Coyote-Coyote If they both have 100 or more food and water energy they have random 2 young and then lose 25 food and water energy.

Program Methods

Shown in Fig. 1 is our spaceland view of our program in Star Logo TNG. Many, but not all the settings can be accessed from this page. Mice, Rabbits, Coyotes, Burrows, Food, Water, Food/Water Limits, Habitat Loss, Age Limits, and Pollution can be set here. Energy level settings, (losses or gains per action) are set within the program by accessing the StarLogo Blocks portion of the program and going to the individual agents or collisions pages. An example of this is shown in Fig. 2.

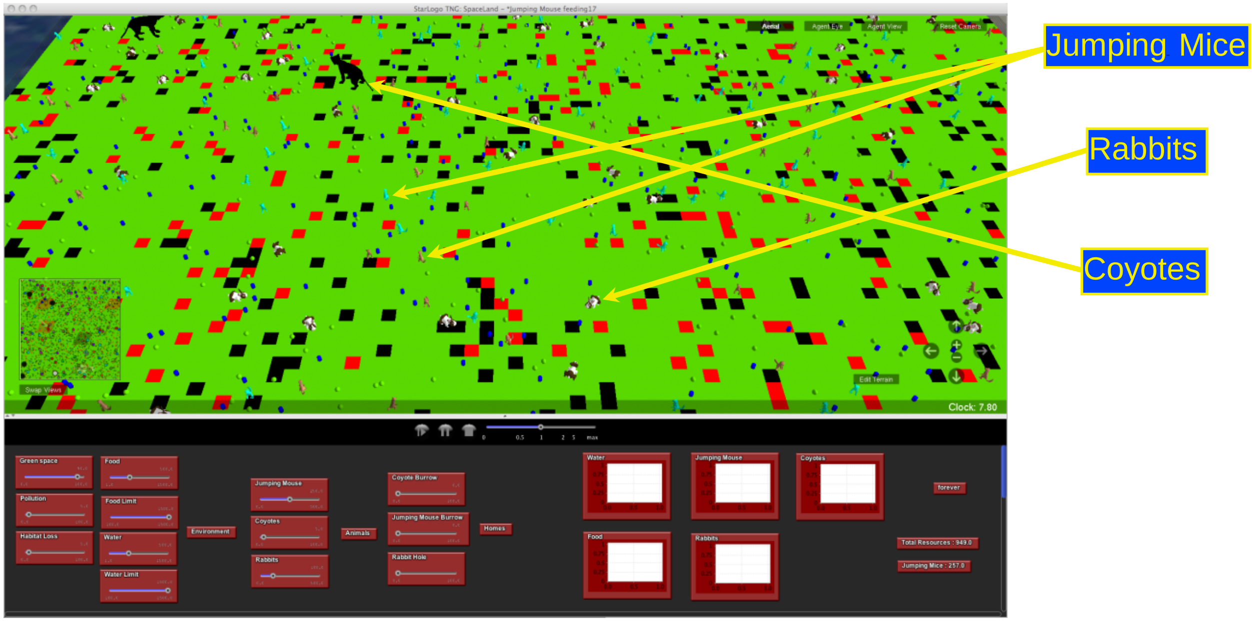


Figure 1: Spaceland view of the jumping mice program.

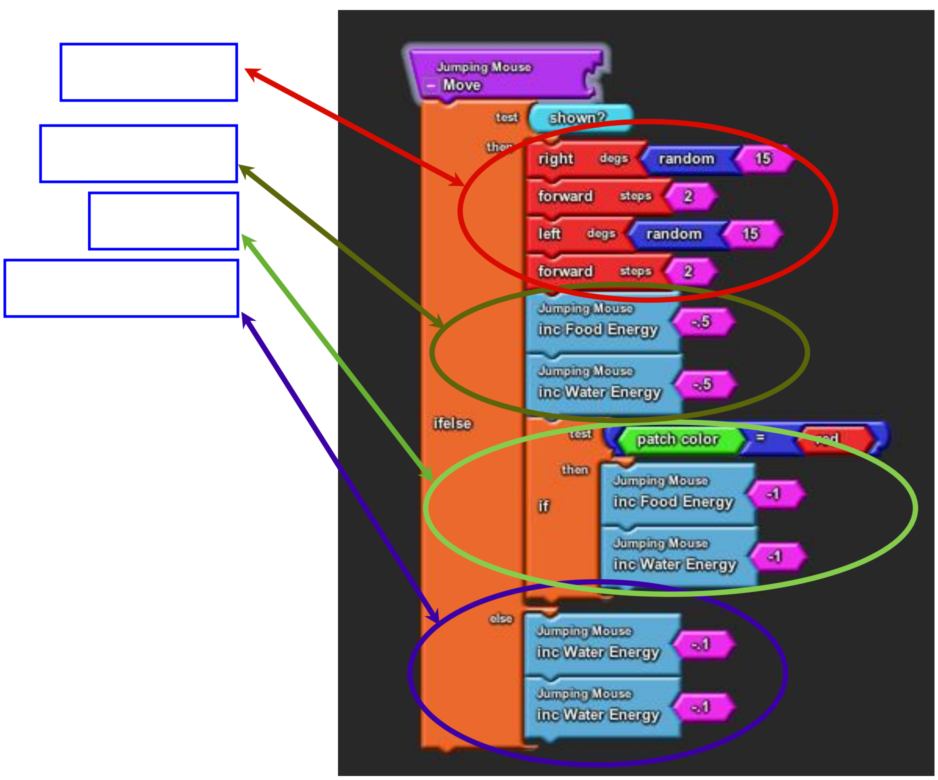


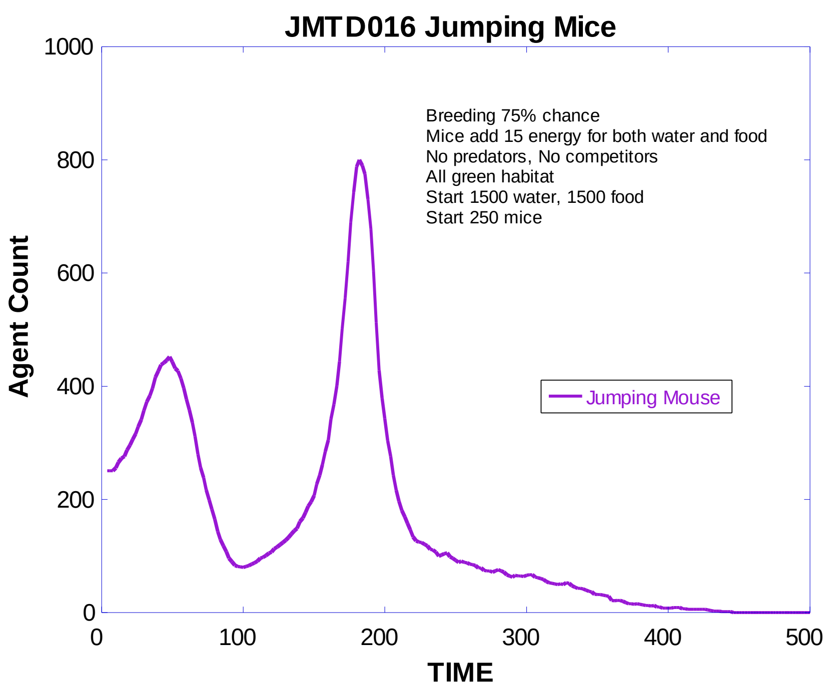
Figure 2: An example of a procedure in Star logo blocks where energy and movement levels are set within the program.

Testing Method

We used simple test matrixes to examine the program and how it runs. For example we look at just the Jumping Mice in a pristine environment and add different things that would affect the Jumping Mice like adding pollution or predators or competitors. We then looked at the results and changed the program so that the results of the Jumping Mice look how they should, a periodic line rising and dropping.

Results

Our initial tests were simple scenarios. One of our first tests was Jumping Mice alone, figure 3, with food and water. We did not have a way for the environment to regenerate the food and water when the mice at all of it. Hence, they died out. The shapes of these



curves depend upon the amount of starting food and water as shown in Fig. 4. Figure 5 represents the changes we made so that food and water would not completely die out, There was always a small amount of water and food that survives in the presence of a large number of consumers. What we found was a periodic change in them mice populations. These changes were large initially, but fell off with time. During analysis of the program results, we found that the hatced mice did not randomly take one sex or the other. Eventually, one sex died off and the population went flat as shown in Fig. 5. The changes to the program we made for tests after this were making the hatched Jumping Mice have a random gender.

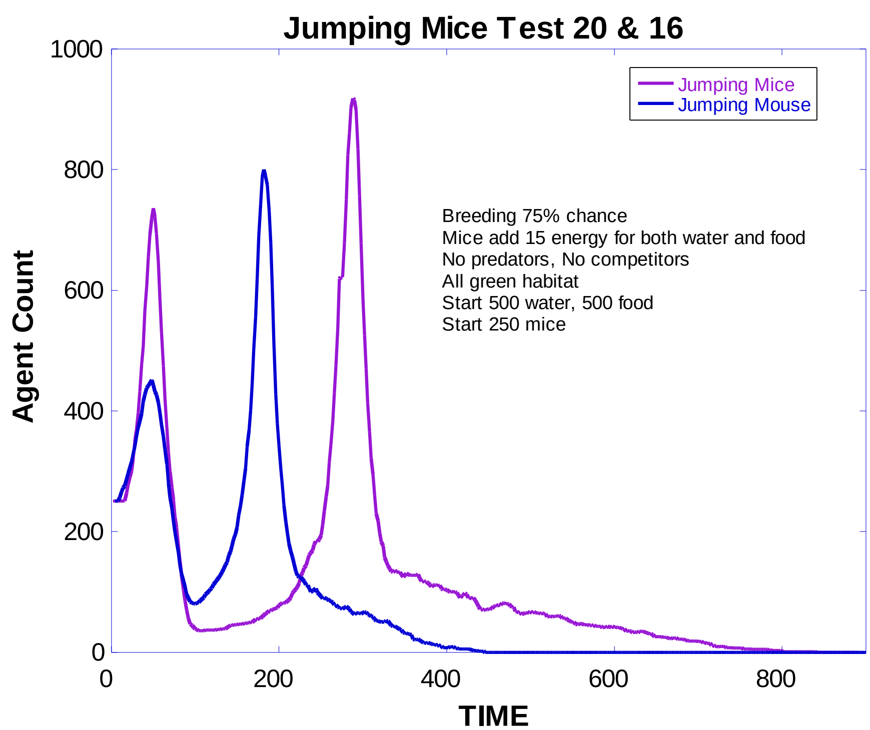


Figure 4. A comparison of two tests with just Jumping Mice run by an older version of the program being compared. The blue curve corresponds to starting with 1500 water and food while the purple curve represents starting with 500 water and food.

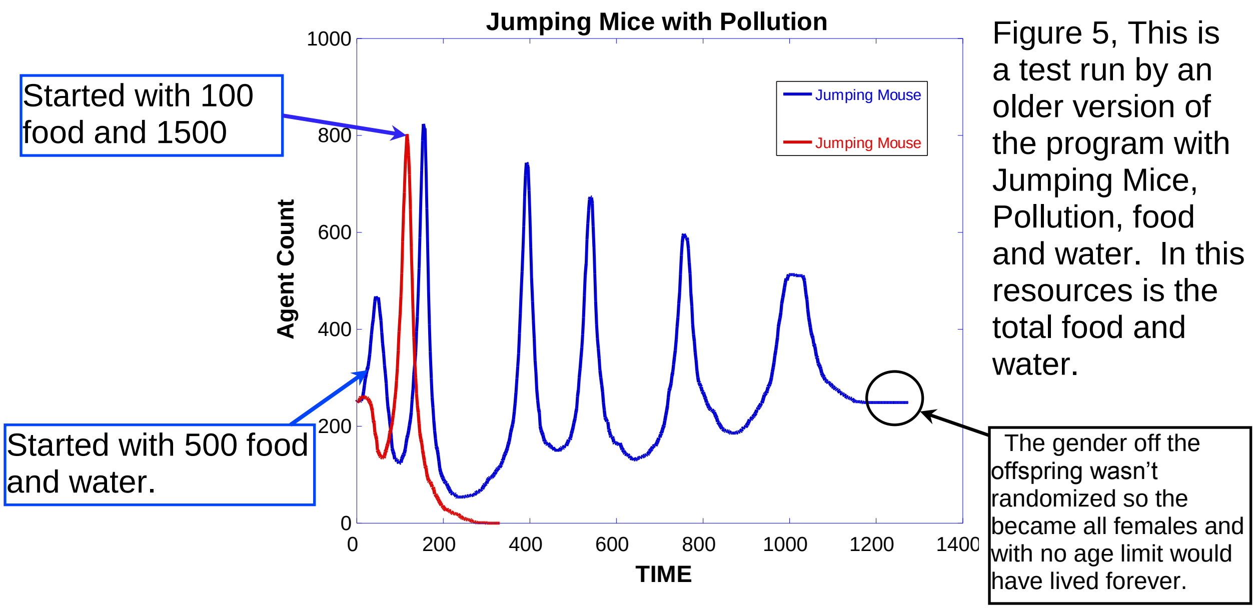


Figure 5, This is a test run by an older version of the program with Jumping Mice, Pollution, food and water. In this resources is the total food and water.

Results-Final Program Runs

In running our program, we realized that we were trying to model a very complex system, even with the simplifications we had made. These program runs were taking a large amount of time on our parents computers. So we were limited in the number of variable changes we could make between runs. All of the other tests 1-6 are run on the same settings with different variable settings. The animal settings are 300 jumping mice, 100 rabbits, 10 Coyotes, 125 jumping mice burrows, 25 rabbit holes and 10 coyote burrows. In between program runs, we changed the amount of energy the animals lose or gain in movements, eating, and food/water recovery.

In our first run of the final program, we wanted to test what would happen with just mice and their burrows in the program. This data is shown in Figure 6. These large cyclic changes in population would continue on forever as shown. The jumping mice eat most of the food and water and then start to die without much water and food left then the food and water recover and so do the jumping mice. This is a behavior we would expect without other controls on the mice population [5].

In the next runs, we spent time changing the energy exchanges between agents without habitat loss or pollution. It was our assumption that the mice, rabbits, and coyotes should survive as they did for many thousands of years before humans moved into their world. In Figures 7 through 10, we made small changes in these energy levels. In most cases, one, two or all of the animals died in the runs. For the final run, before we ran out of time, we believed we achieved a condition where all animals survived. (Figure 11). Unfortunately, as it oftened happened, the program developed a bug where water and food stopped reproducing. This would be eliminated by restarting the program from scratch. However, we feel that this is a demonstration of our program simulating the mice's environment. With the lack of time, (computer time) we were not able to fully investigate the effects of pollution and habitat loss.

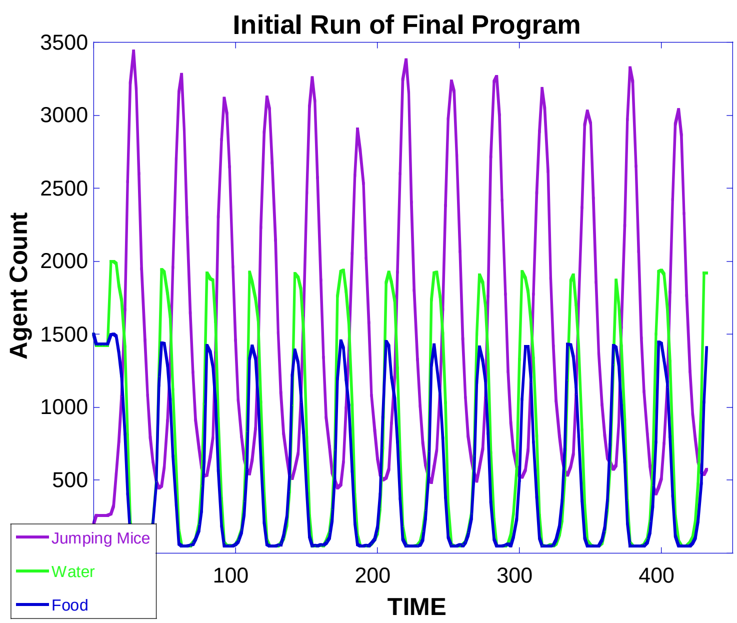


Figure 6. Final run of the program with just jumping mice and their burrows.

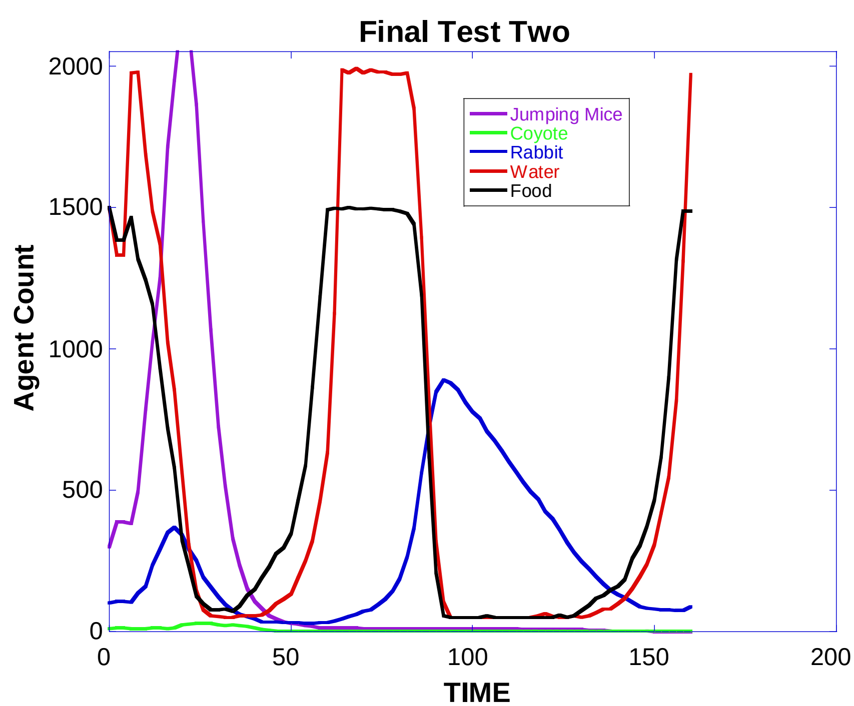


Figure 7: Final test run with the coyotes having a 15% chance of catching the mice and 25% chance of catching the rabbits. Rabbits use ½ of energy of movement compared to mice. Rabbits live, coyotes and mice die.

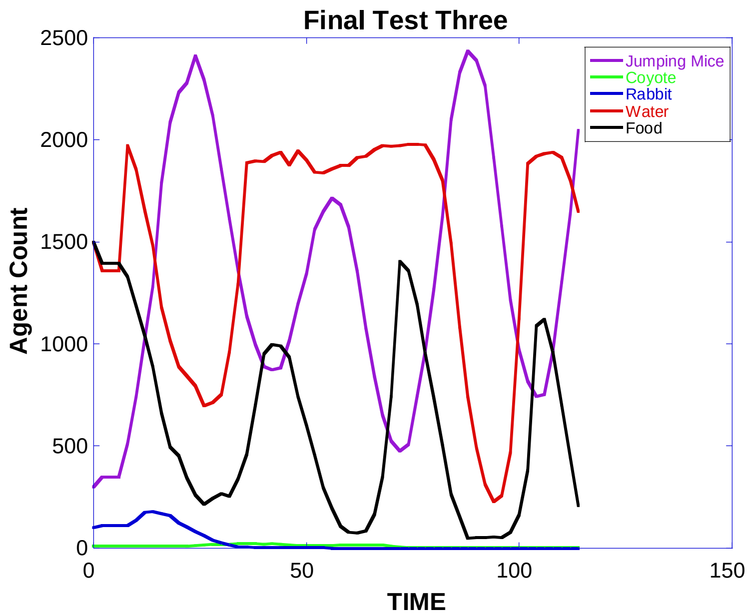


Figure 8: Final test run with the coyotes having a 15% chance of catching the mice and 25% chance of catching the rabbits. Rabbits now loose twice the amount of energy in movement compared to mice. The mice live while the coyotes and rabbits die out.

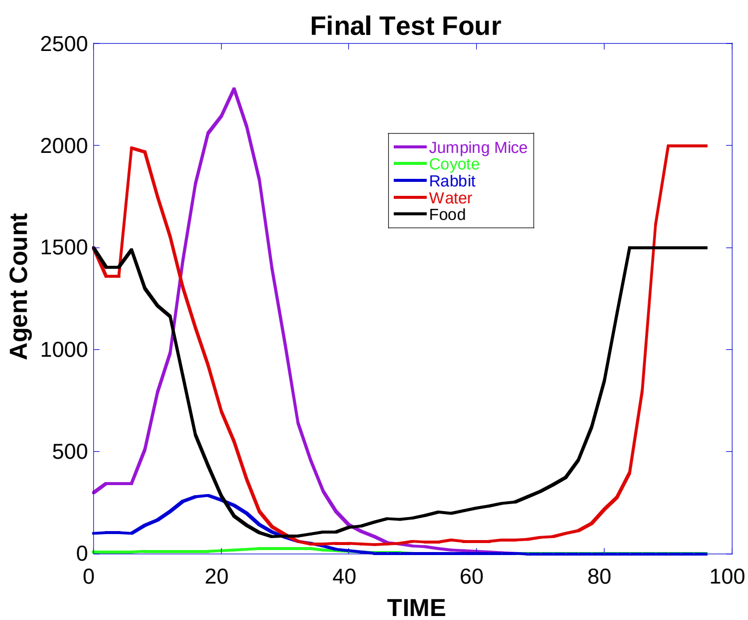


Figure 9: Final test run with the coyotes having a 15% chance of catching the mice and 25% chance of catching the rabbits. Rabbits now loose the same amount of energy as mice. Everyone dies.

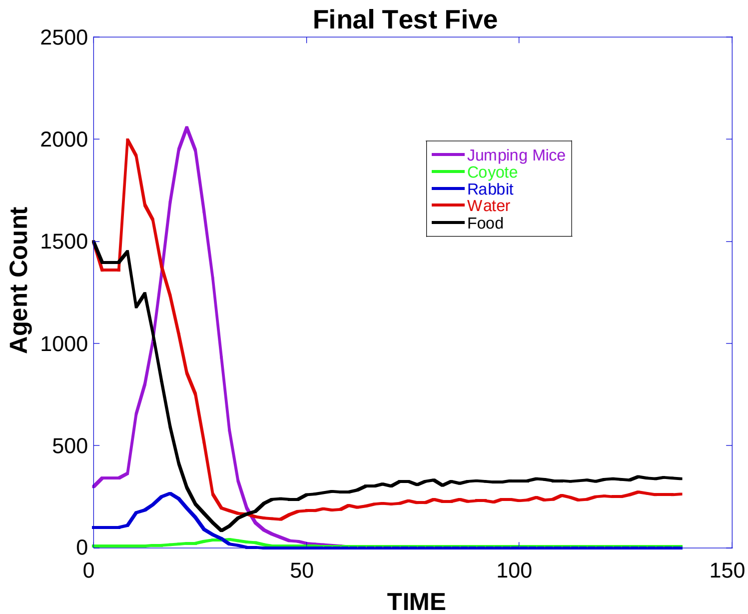


Figure 10: In this test, the coyote energy loss was doubled, but there chances for catching rabbits was increased to 35% and mice to 20%. Everyone still dies out.

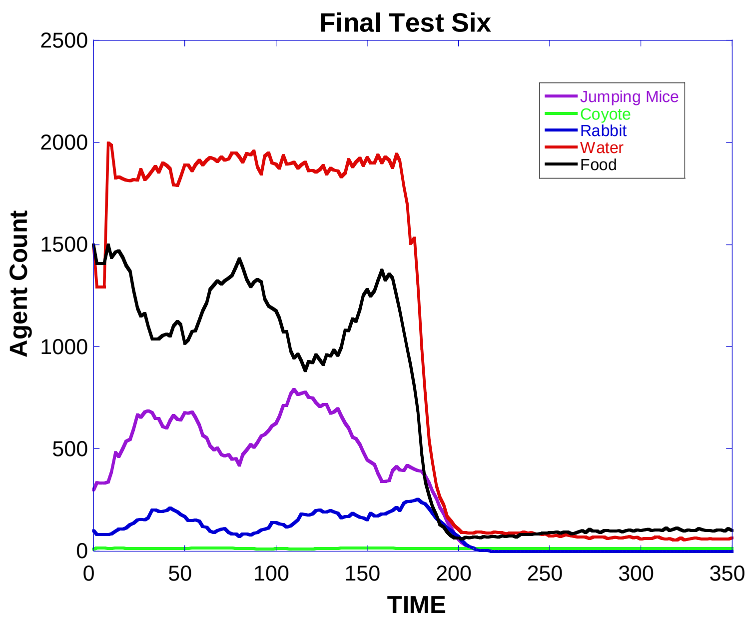


Figure 11: For our final test, we reduced the amount of energy that the mice and rabbits gain from the food and water. This appeared to work except that a bug developed during the fun in which the food and water stopped hatching.

Conclusions

We were able to make a program that would simulate the mice's environment. This we feel is a very big accomplishment as there are a large number of variable that need to be adjusted to make the environment work. Small changes in the amounts of energy the animals get from eating or loose from movement greatly affect their chances for survival. In running the final program, we did not have enough computer time to include the pollution and habitat loss. However, in runs of the early version of the program, we did find that these variables did greatly affect the animals and their survival. Hence, these will be important things to include in future runs of the program to see how they affect the mice's survival chances.

Recommendations for Future Work

In the future for problems like these we want to use a program other than StarLogo TNG because there are some limitations to the number of agents and some times the program just shuts down because there are too many things to calculate. It was clear from our work that there are a large number of variables to change in modeling the mice's environment. We need to include the habitat loss and pollution. Because of the large number of variables, our mentors suggested that we need to learn about statistically designed experiments to help with future work on this subject.

Acknowledgements

We would like to thank Jared Dreicer (mentor) for helping us prepare are interim report. We would like to thank Terry Holesinger (mentor) for helping us with the model and slide show.

We would also like to thank Mrs. Unal (teacher/sponsor) for helping us with our slide show and interim report.

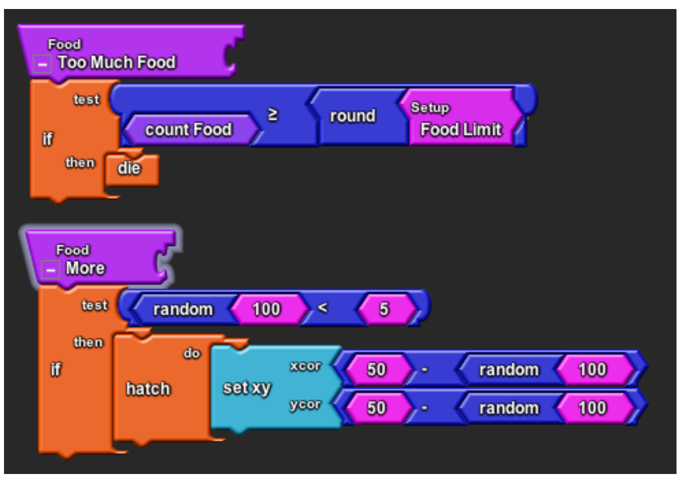
References

1. http://en.wikipedia.org/wiki/Meadow_jumping_mouse
2. Jo Wargo
3. "Meadow Jumping Mouse" Wildlife Note
4. "The Meadow Jumping Mouse In New Mexico: Habitat Preferences and Management Recommendations" Joan L. Morrason
5. " A "Law of Growth": The Logistic Curve And Population Control since World War II" Sabine Höhler

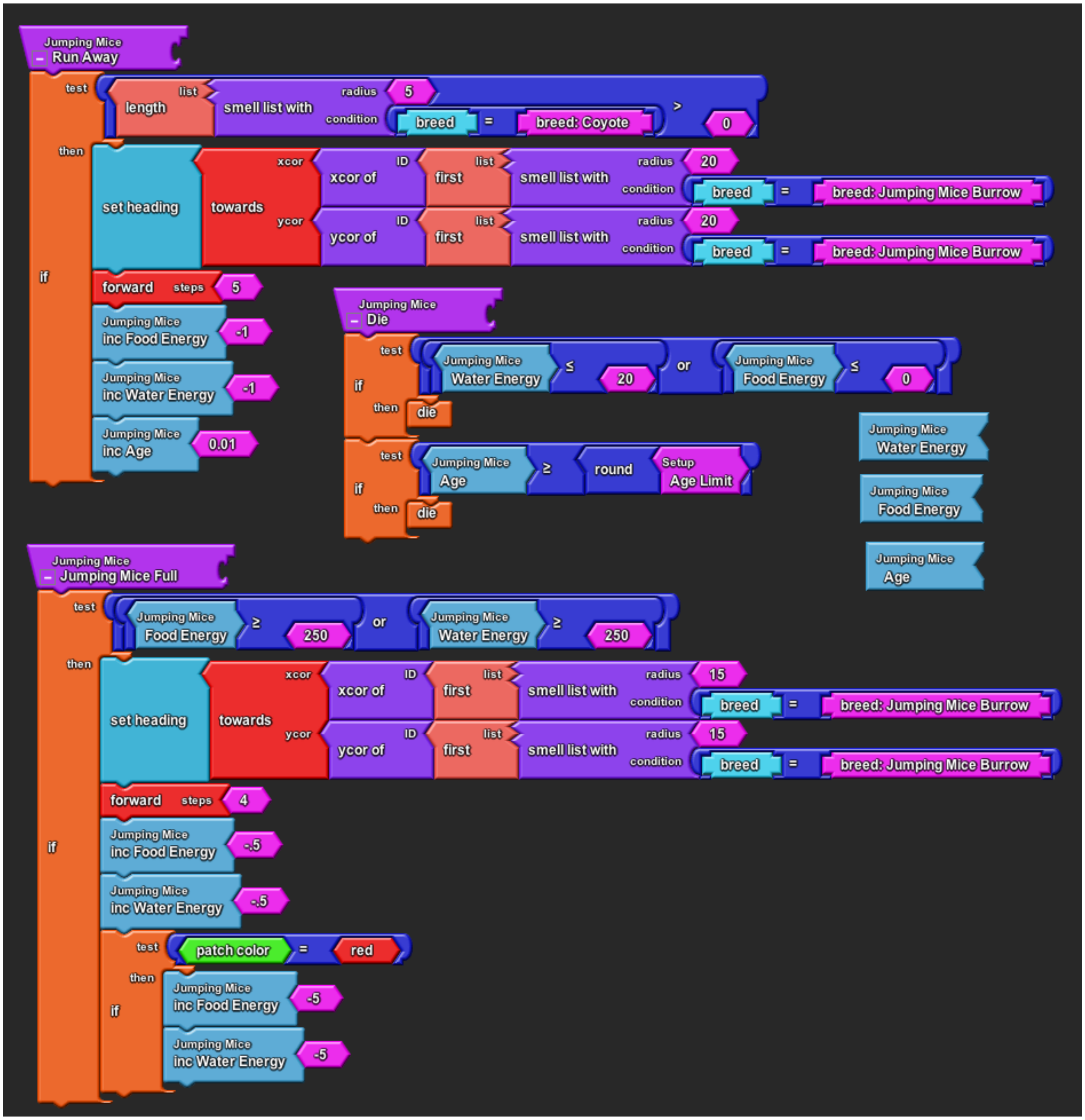
Appendix A: Agents

Food and Water: In this section, we can set the recovery rate of the food and water by changing the probability by which the water and food hatch. This is accomplished with a test line of code using a random 100 procedure.

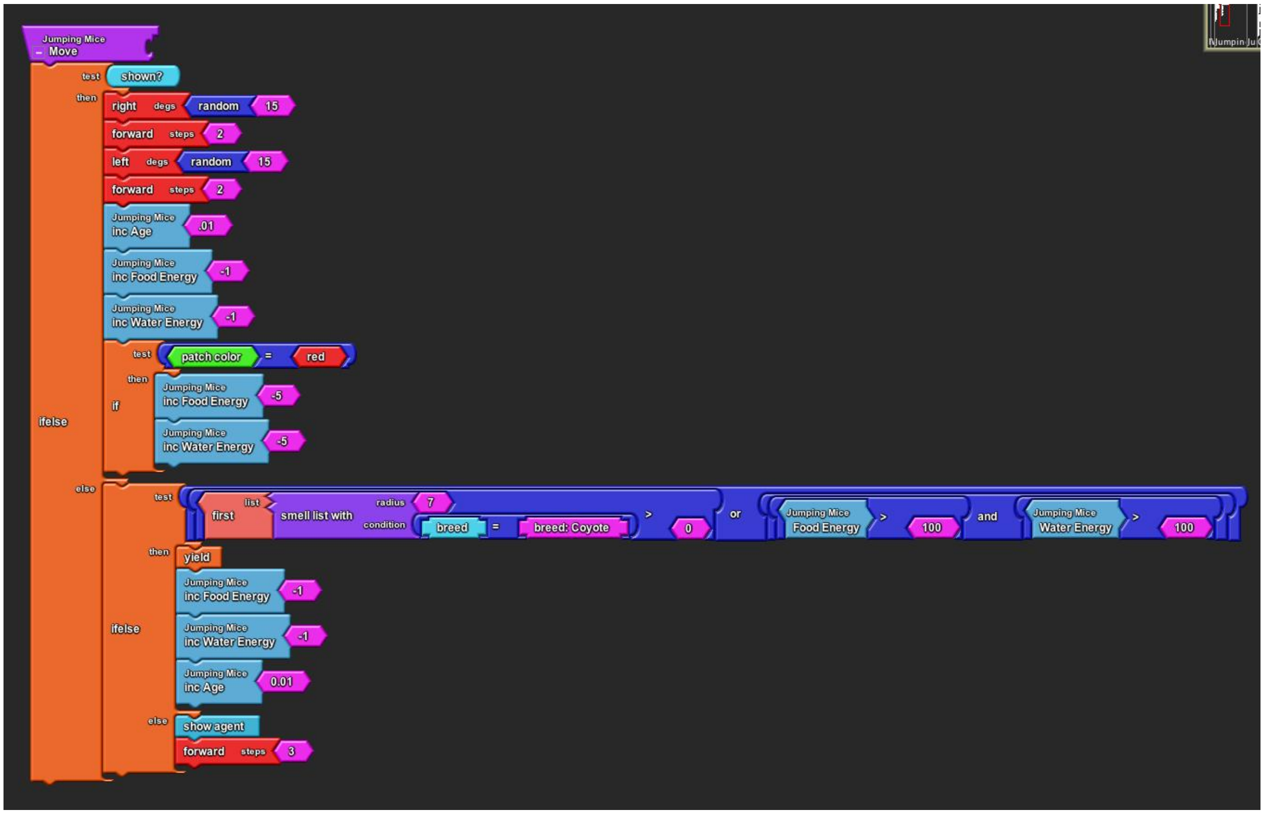
Jumping Mice



Additional Jumping Mice Code

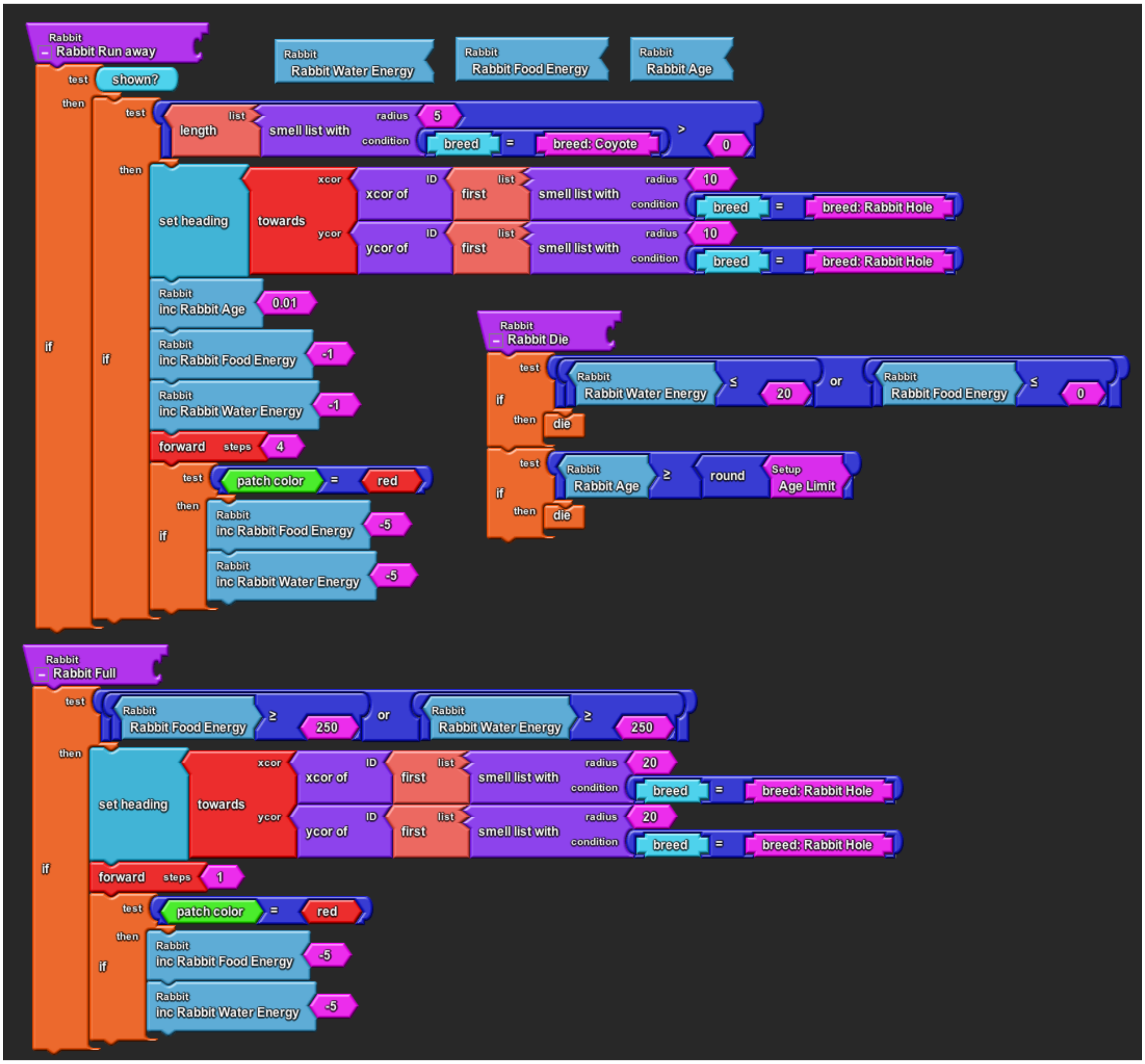


Rabbits

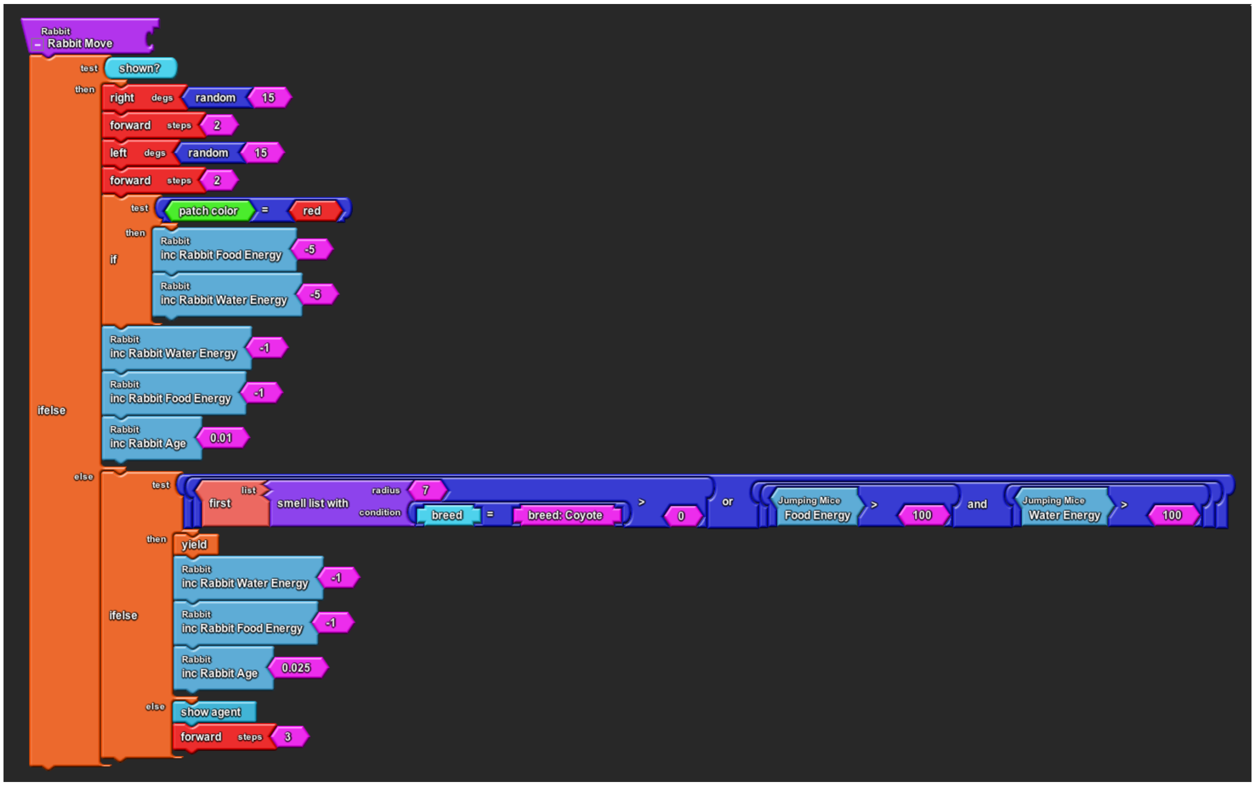


Jumping Mice
Move
test
shown?
then
right
degs
random
15
forward
steps
2
left
degs
random
15
forward
steps
2
Jumping Mice
inc Age
.01
Jumping Mice
inc Food Energy
-1
Jumping Mice
inc Water Energy
-1
test
patch color
=
red
then
if
Jumping Mice
inc Food Energy
-5
Jumping Mice
inc Water Energy
-5
ifelse
else
test
list
first
smell list with
radius
7
condition
breed
=
breed: Coyote
>
0
or
Jumping Mice
Food Energy
>
100
and
Jumping Mice
Water Energy
>
100
then
yield
Jumping Mice
inc Food Energy
-1
ifelse
Jumping Mice
inc Water Energy
-1
Jumping Mice
inc Age
0.01
else
show agent
forward
steps
3

Additional Rabbit Code

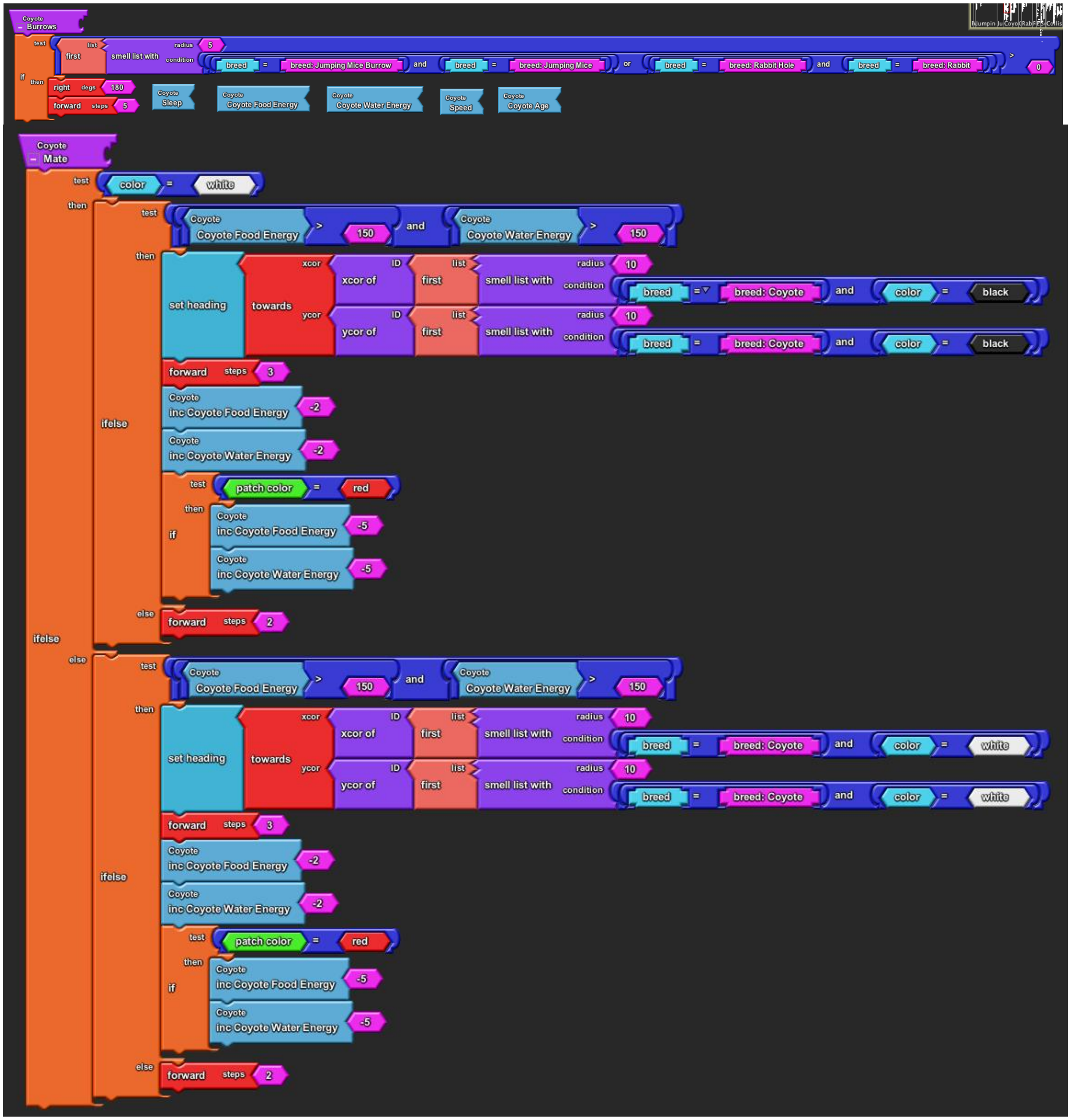


Coyote

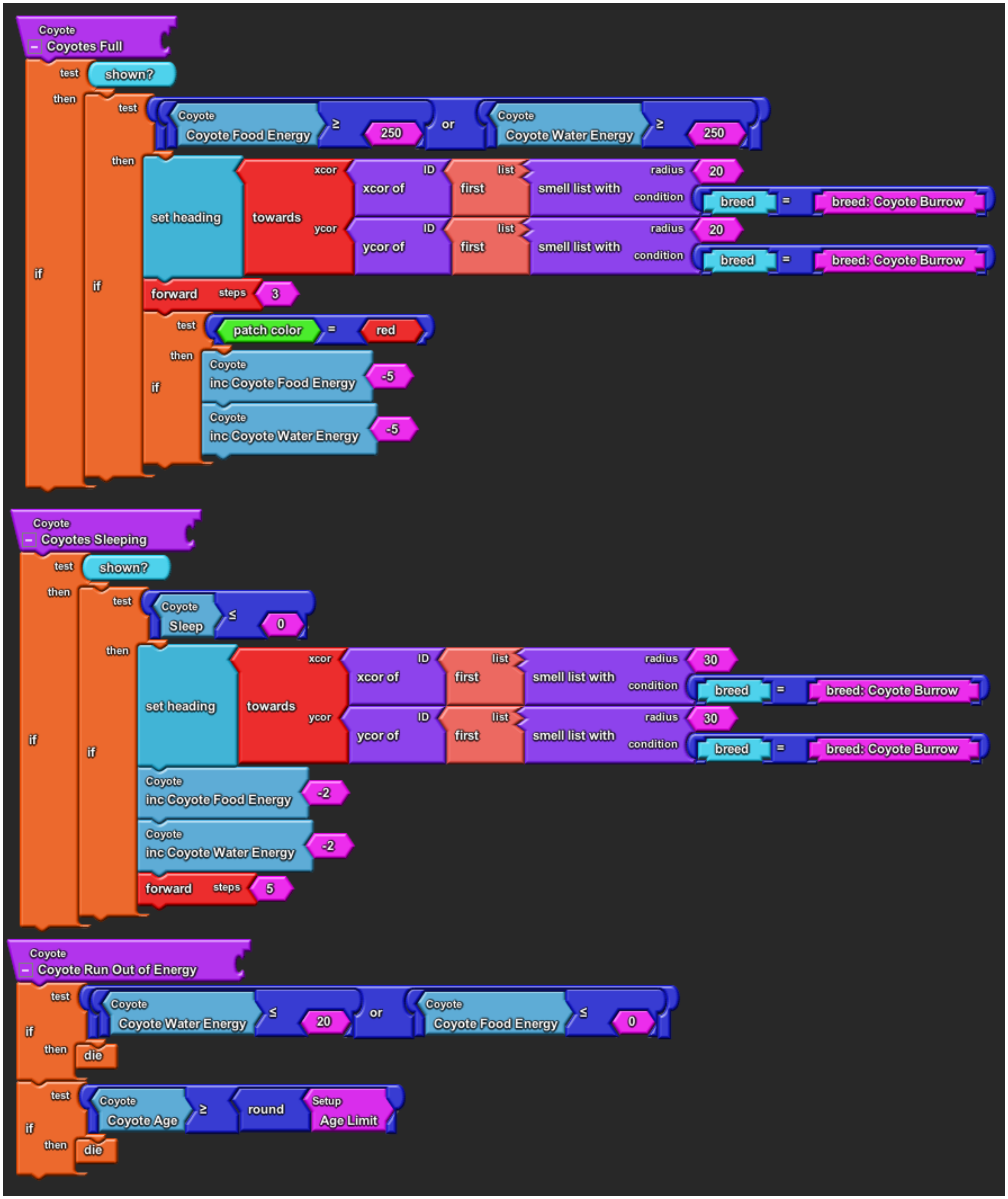


Rabbit
Rabbit Move
test
shown?
then
right
degs
random
15
forward
steps
2
left
degs
random
15
forward
steps
2
test
patch color
=
red
then
if
Rabbit
inc Rabbit Food Energy
-5
Rabbit
inc Rabbit Water Energy
-5
Rabbit
inc Rabbit Water Energy
-1
Rabbit
inc Rabbit Food Energy
-1
ifelse
Rabbit
inc Rabbit Age
0.01
else
test
list
first
smell list with
radius
7
condition
breed
=
breed: Coyote
>
0
or
Jumping Mice
Food Energy
>
100
and
Jumping Mice
Water Energy
>
100
then
yield
Rabbit
inc Rabbit Water Energy
-1
ifelse
Rabbit
inc Rabbit Food Energy
-1
Rabbit
inc Rabbit Age
0.025
else
show agent
forward
steps
3

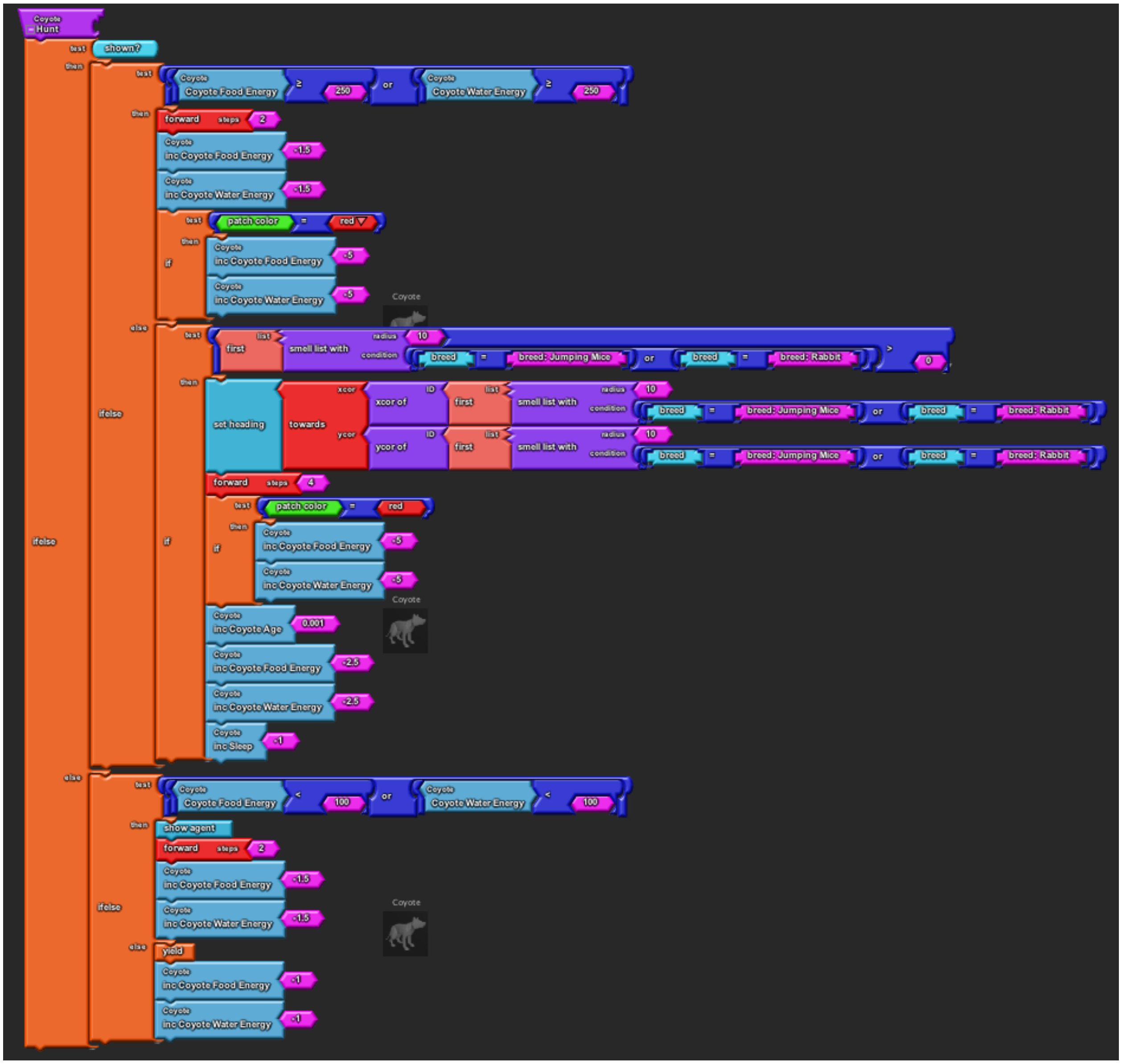
Additional Coyote Code



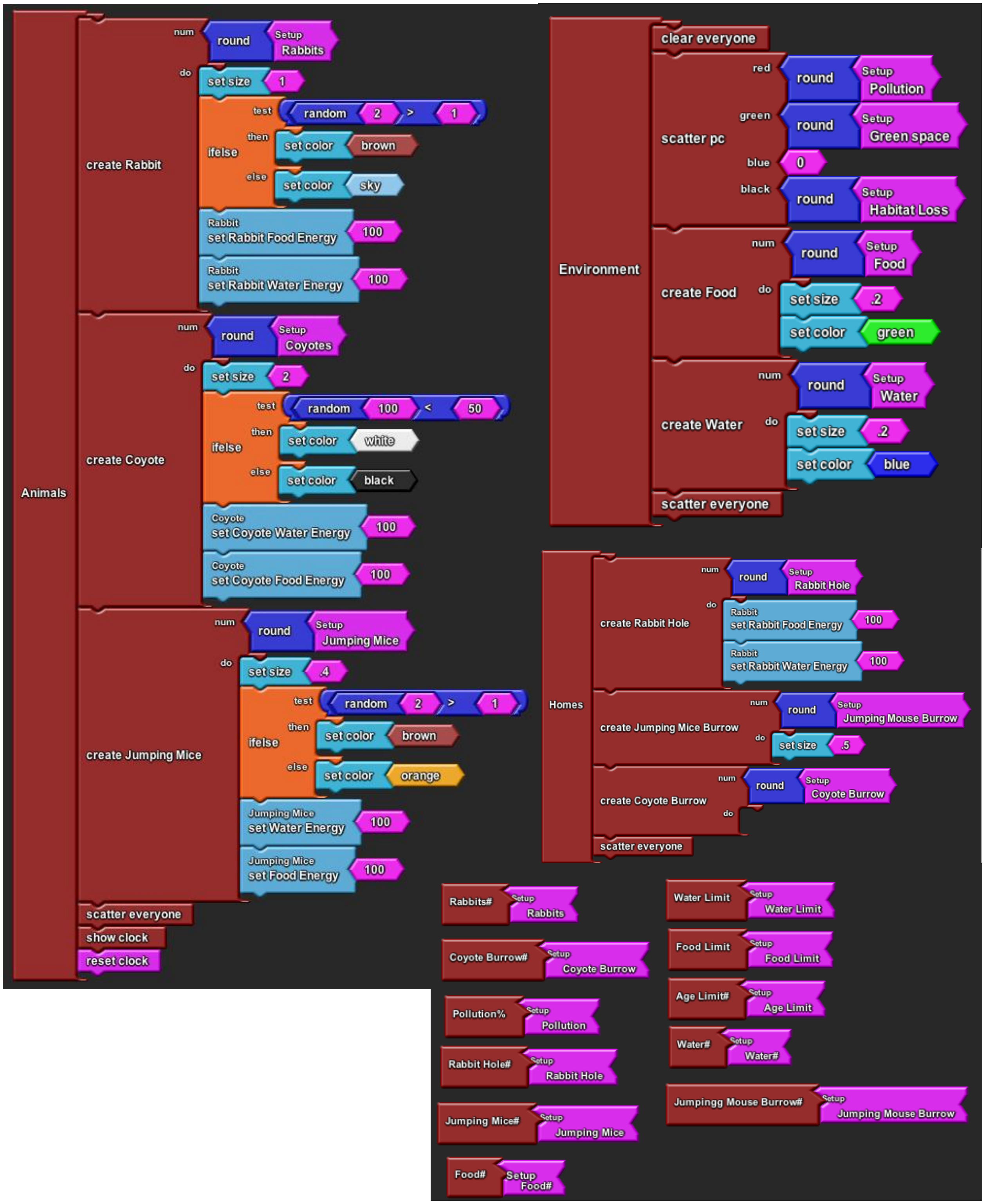
Additional Coyote Code



Appendix B: Setup

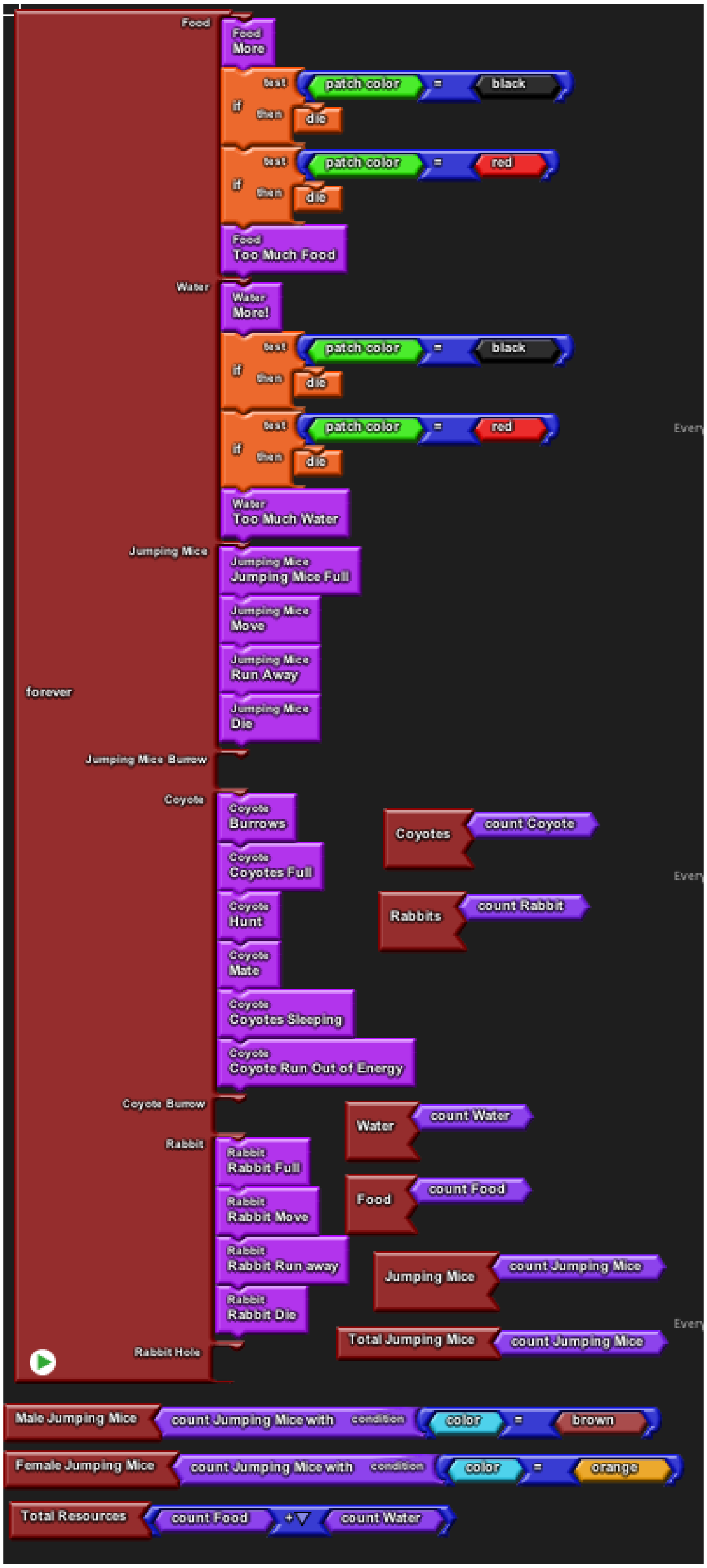


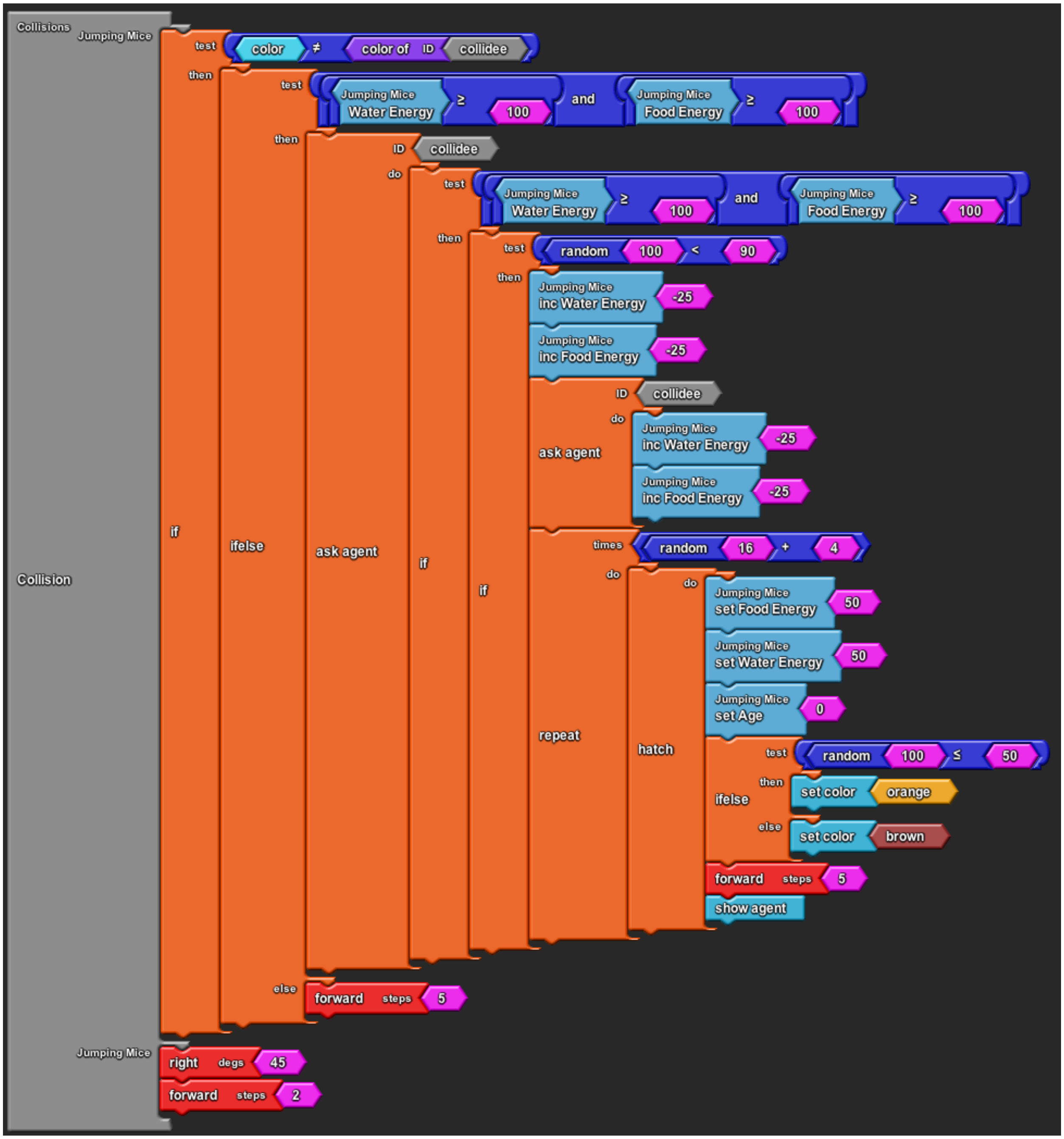
Appendix C: Forever Block

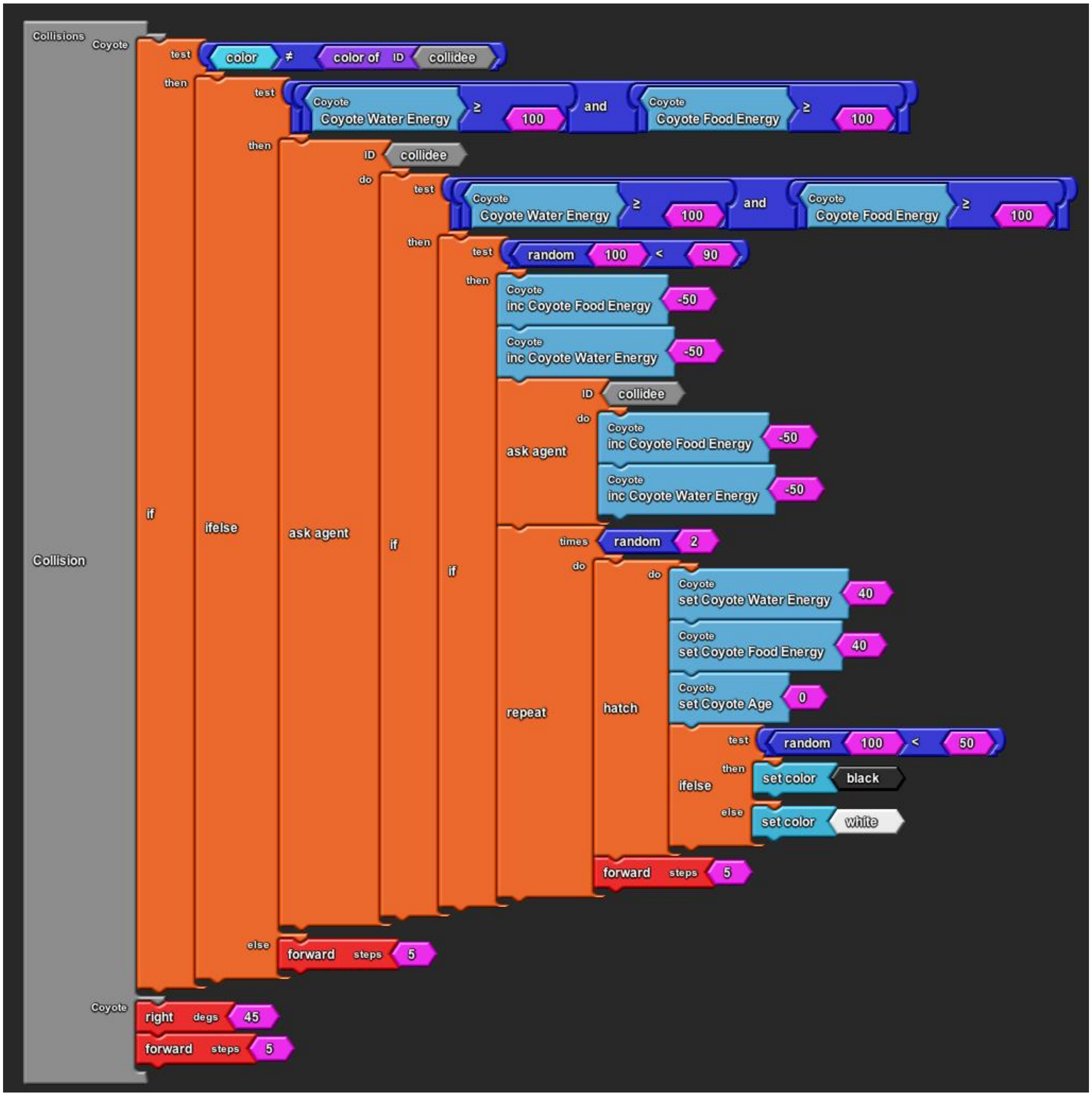


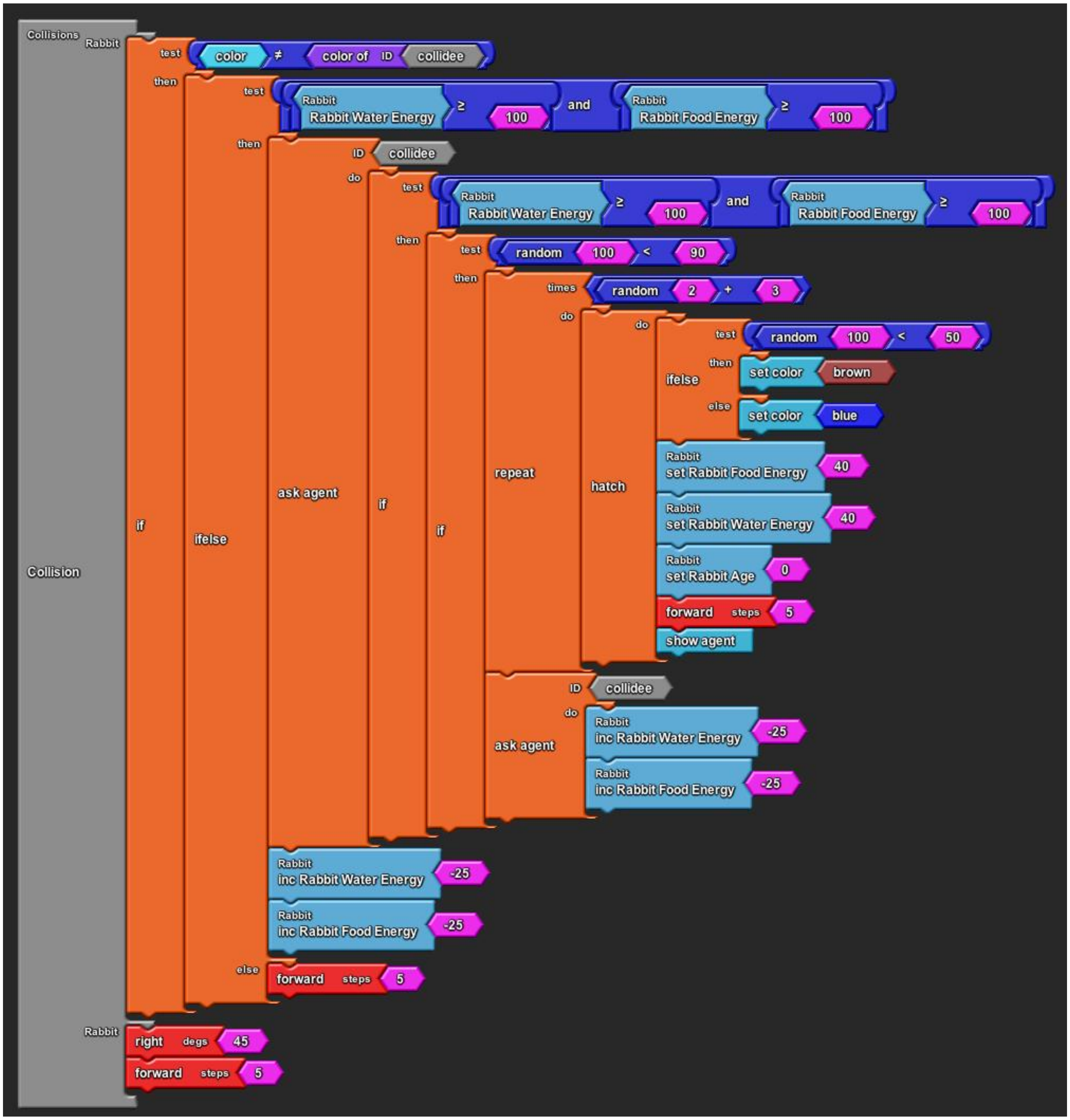
Appendix D: Collisions

Breeding Collisions

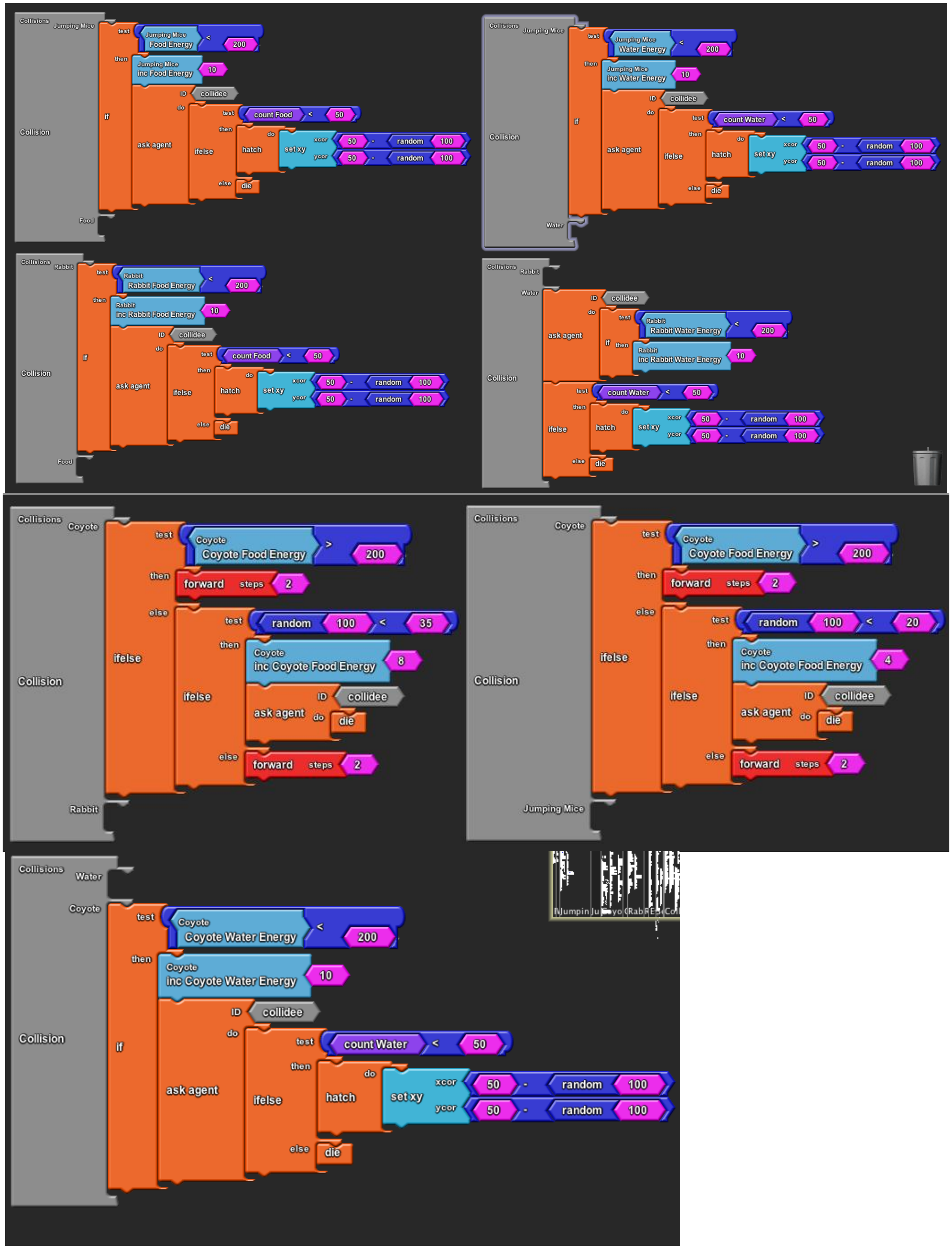



Collisions
Jumping Mice
Collision
if
test
color
≠
color of
ID
collidee
then
ifelse
test
Jumping Mice
Water Energy
≥
100
and
Jumping Mice
Food Energy
≥
100
then
ask agent
ID
collidee
do
if
test
Jumping Mice
Water Energy
≥
100
and
Jumping Mice
Food Energy
≥
100
then
if
test
random
100
<
90
then
Jumping Mice
inc Water Energy
-25
Jumping Mice
inc Food Energy
-25
ask agent
ID
collidee
do
Jumping Mice
inc Water Energy
-25
Jumping Mice
inc Food Energy
-25
repeat
times
random
16
+
4
do
hatch
do
Jumping Mice
set Food Energy
50
Jumping Mice
set Water Energy
50
Jumping Mice
set Age
0
ifelse
test
random
100
≤
50
then
set color
orange
else
set color
brown
forward
steps
5
show agent
else
forward
steps
5
Jumping Mice
right
degs
45
forward
steps
2


Collisions
Coyote
Collision
if
test
color
≠
color of
ID
collidee
then
ifelse
test
Coyote
Coyote Water Energy
≥
100
and
Coyote
Coyote Food Energy
≥
100
then
ask agent
ID
collidee
do
if
test
Coyote
Coyote Water Energy
≥
100
and
Coyote
Coyote Food Energy
≥
100
then
if
test
random
100
<
90
then
Coyote
inc Coyote Food Energy
-50
Coyote
inc Coyote Water Energy
-50
ask agent
ID
collidee
do
Coyote
inc Coyote Food Energy
-50
Coyote
inc Coyote Water Energy
-50
repeat
times
random
2
do
hatch
do
Coyote
set Coyote Water Energy
40
Coyote
set Coyote Food Energy
40
Coyote
set Coyote Age
0
ifelse
test
random
100
<
50
then
set color
black
else
set color
white
forward
steps
5
else
forward
steps
5
Coyote
right
degs
45
forward
steps
5



Food and Water Consumption Collisions


Collisions Jumping Mice
Collision
if test Jumping Mice Food Energy < 200
then Jumping Mice inc Food Energy 10
ask agent ID collidee do
ifelse test count Food < 50
then hatch do set xy xcor 50 - random 100 ycor 50 - random 100
else die
Food
Collisions Jumping Mice
Collision
if test Jumping Mice Water Energy < 200
then Jumping Mice inc Water Energy 10
ask agent ID collidee do
ifelse test count Water < 50
then hatch do set xy xcor 50 - random 100 ycor 50 - random 100
else die
Water
Collisions Rabbit
Collision
if test Rabbit Rabbit Food Energy < 200
then Rabbit inc Rabbit Food Energy 10
ask agent ID collidee do
ifelse test count Food < 50
then hatch do set xy xcor 50 - random 100 ycor 50 - random 100
else die
Food
Collisions Rabbit
Water
Collision
ask agent ID collidee do if test Rabbit Rabbit Water Energy < 200 then Rabbit inc Rabbit Water Energy 10
ifelse test count Water < 50
then hatch do set xy xcor 50 - random 100 ycor 50 - random 100
else die
Collisions Coyote
Collision
ifelse test Coyote Coyote Food Energy > 200
then forward steps 2
else ifelse test random 100 < 35
then Coyote inc Coyote Food Energy 8
ask agent ID collidee do die
else forward steps 2
Rabbit
Collisions Coyote
Collision
ifelse test Coyote Coyote Food Energy > 200
then forward steps 2
else ifelse test random 100 < 20
then Coyote inc Coyote Food Energy 4
ask agent ID collidee do die
else forward steps 2
Jumping Mice
Collisions Water
Coyote
Collision
if test Coyote Coyote Water Energy < 200
then Coyote inc Coyote Water Energy 10
ask agent ID collidee do
ifelse test count Water < 50
then hatch do set xy xcor 50 - random 100 ycor 50 - random 100
else die

Burrow Collisions