The Invasive Russian Olive

New Mexico
Supercomputing Challenge

Final Report
April 5, 2006

Team 97
Shiprock High School

Team members:
1. Martha Hughes
2. Polito Walters
3. Andrew Yazzie

Teachers:
1. Mary Herrmann
2. Vernetta Noble

Project Mentors:
1. Gary Hathorn
2. Irene Lee

Table of Contents

Executive Summary

Russian Olives are an invasive species in the Four Corners as well as the rest of New Mexico. These trees were originally planted for their hardiness but are now replacing native plants and soaking up valuable water.

These plants are very difficult to eradicate due to being able to reproduce both sexually and asexually. We wanted to create a computer model using the best treatment to see how long it would take to eradicate them. Focusing on the cut-stump method which cuts the tree to allow herbicides to be applied to the trunk, we created a computer model using Starlogo. As the model runs the trees grow and birds disperse the seeds. Cut-stump can treat and kill either young or mature trees.

We ran three experiments each five times to average the results. We found that it takes an average of 25 months with two mature and three young cut-stump treatments to eradicate an area with a starting number of 50 trees and 50 birds. With this many treatments it would cost about $10,500. We also discovered that running an experiment with more birds increased the number of trees treated, money spent, and time to eradicate the trees.

We look forward to have others use our study to learn that invasive species must be dealt with, using specific planning. In order to achieve the most efficient use of time, effort and money computer modeling can be used.

Introduction

In the Four Corners, *Eleagnus angustifolia*, more commonly known as Russian Olive is becoming a problem. This invasive plant was first introduced to the United States in the late 1800's as an ornamental or wind-breaking shrub that helped with erosion control. It was favored for its hardiness and self-sustaining nitrogen fixed roots. Now, however, it is rampantly taking over.

In our hometown of Shiprock, New Mexico our water source is the San Juan River. It provides water for drinking, farming, and recreation. Whenever we view it it is choked with Russian Olives. These trees have out-competed many native species like Cottonwood as well as soaked up valuable water near irrigation canals. In addition it of no benefit to farmers or livestock owners. For these reasons it is rated as a Class C noxious weed in New Mexico. (Class C meets definitions of a noxious weed and are of some concern but not federally recognized.)

Unfortunately, Russian Olives are difficult and expensive to eradicate. They can reproduce both sexually and asexually, reducing treatment options. Any part of the tree left in the ground could re-sprout. The most effective treatments involve the use of herbicides, which are expensive and labor intensive.

At the start of our project we wanted to test different eradication methods to see which were most effective and cost efficient. We soon discovered that the methods would all give us similar results. We then decided to focus on one method, cut-stump. This treatment cuts a tree's trunk allowing a herbicide to be sprayed onto the stump.

Our project will create a starlogo model to show how long it would take to eradicate Russian Olives on a riparian (wet) area. The model will show a river with Russian Olives and birds. It will represent how Russian Olives grow and how birds distribute its seeds. This simplification helps us narrow our scope and get better results.

We hope our project will be used to show that there are no quick solutions for eradicating invasive species. Time, effort, and money must be spent efficiently to restore an ecosystem's balance.

Project Description

To start our project we researched extensively on Russian Olives and its behavior. Soon we contacted Gary Hathorn and Jessie Owens from The San Juan County Extension Office for more information. We were lucky enough to go out and map Russian Olives with Ms. Owens to get an idea of how many trees to put in our model. Mr. Hawthorne gave us information on eradication methods he's researched and worked with such as the cut-stump, basal bark, and foliar application methods.

We chose to use Starlogo for our model because it works well for modeling environments and creates a visual aid. In our model, the environment consists of a river to which birds and Russian Olives are added. Both the starting number of Russian Olives and birds are controlled by sliders. When the setup button is pressed the trees (random ages) will grow on a places three patches or closer to the river.

Once the "go" button is pressed, the Russian Olives gain age and energy while the birds fly around randomly. Bird steps are used to measure time. Ten bird steps equals a month. Russian Olives mature at three years of age. Once mature they can produce fruit. In the program it takes a tree 360 steps to mature. A tree's energy equals it's age until it reaches an energy of 1200 where it will discontinue its increasing energy.

When a bird lands on a mature tree it can pick up a seed to be planted. After 10 steps (a month) the bird will drop the seed. If the seed lands on a fertile patch (3 or less patches away from river), it may grow. As the model runs more trees are planted, they mature, and birds disperse more seeds.

The eradication method we chose, as mentioned before, is the cut-stump method. This method can be applied to either young or mature trees with a button. Only 94% of the trees will be treated due to cut-stump's success rate according to Mr. Hawthorne. Once trees are affected, their shape changes to that of a sick tree (red and green) and after each step 20 energy units are decreased from the tree. Decreasing energy helps make the project more realistic because it allows the young trees with less energy to die more quickly like when real trees are treated. If trees have been sick for a random amount of time in a year or more, they may become well, turning into a young tree. This is very much like real life while Russian Olives may send up new sprouts even after being treated. Once a tree's energy level is less than or equal to zero it will die.

To determine how long it takes to eradicate all the Russian Olives in our environment we conducted three experiments. We ran each experiment 5 times to average the results. Different variables were used to explore different results.

Experiment 1-

Starting number of Russian Olives- 50 (Random mature and young to be recorded)

Starting number of birds - 50

The program is run for one year before the first treatment. The first treatment is mature to limit the production of new trees. Three months is allotted for space between treatments. The next treatment is for young trees. Again there is a three month wait and the next mature or young treatments are applied as needed until all the trees are dead.

Experiment 2-

Starting number of Russian Olives - 50

Starting number of birds- 100

The program is run the same as experiment 1 above.

Experiment 3-

Starting number of Russian Olives - 100

Starting number of birds- 50

The program is run like experiments 1 and 2.

With the first experiment we chose to keep the number of Russian Olives and birds the same to view the outcome. Letting the program run for a year before the applying the treatments allows the environment to become settled and running. Three months is allotted between treatments because real eradicators cannot be treating trees constantly. Three months is enough time to let some trees die or catch ones that need additional treatment. For the second experiment we increased the number of birds to 100 to see whether the birds have a significant impact on the results. The same goes for the third experiment where the Russian Olives were 100 and the birds 50.

The data was collected for the 15 runs and averaged out by experiments. The data that is collected can be seen in Appendix.

According to Mr. Hathorn with the cost of herbicide and labor, it costs about $2000 per acre to perform the cut-stump treatment. With about 20 trees per acre it costs about $100 per tree. This will be used to figure the cost for applying the treatments.

Results

After our experiments were run we averaged the five tests for each experiment:

Experiment 1	**Average**
Starting # of Russian Olives-	50
Mature trees	41.4
Young trees	8.6
Starting # of birds -	50
# of mature treatments-	2
total # of mature trees treated-	44.2
#of young treatments-	3
total # of young trees treated-	60.8
Amount of time to eradication- steps	250
Eradication time in months	25
Money spent-	$10,500.00

Experiment 2	**Average**
Starting # of Russian Olives-	50
Mature trees	38.8
Young trees	11.2
Starting # of birds -	100
# of mature treatments-	2
total # of mature trees treated-	43.8
#of young treatments-	3.4
total # of young trees treated-	83.6
Amount of time to eradication- steps	266.4
Eradication time in months	26.6
Money spent-	$12,740.00

Experiment 3	**Average**
Starting # of Russian Olives-	100
Mature trees	82.4
Young trees	17.6
Starting # of birds -	50
# of mature treatments-	2.8
total # of mature trees treated-	88.8
#of young treatments-	3.4
total # of young trees treated-	126.6
Amount of time to eradication- steps	292
Eradication time in months	30.2
Money spent-	$21,540.00

All of the data may be seen in Appendix C. The plots from the experiments are located in Appendix A and a graph is in Appendix B

From experiment 1 to experiment 2 the average number of mature trees to start out with decreased from 41.4 to 38.8. In experiment 3 the starting number of mature trees increased to 82.4 trees due to a higher number of starting trees.

In experiment 1 the average starting number of young trees was 8.6. This number increased to 11.2 in experiment 2 averages. Experiment 3 had a higher starting number of young trees of 17.6 due to a higher number of starting Russian Olives.

The average number of times the cut-stump treatment was applied to mature trees were the same for both Experiment 1 and 2 at two treatments. The average number of mature treatments for Experiment 3 was 2.8

The average number of times the young trees were treated increased from three times in Experiment 1 to 3.4 times in Experiment 2. The average number of young treatments for Experiment 3 were the same as Experiment 2.

The total average number of mature trees treated in Experiment 1 was 44.2 trees. This number decreased to 43.8 in Experiment 2. The average number of mature trees treated in Experiment 3 was 88.8.

The total average number of young trees treated in Experiment 1 was 60.8. It was increased to 83.6 in Experiment 2. Experiment 3's total number of young trees treated further increased to 126.6

To eradicate the Russian Olives in Experiment 1 it took an average number of 25 months. In experiment 2 the time increased to 26.6 months. The time further increased in Experiment 3 to 30.2 months.

The average amount of money spent for the treatments was $10,500. In Experiment 1. The amount of money increased to $12,140. In Experiment 2. In Experiment 3 the cost increased to $21,540.

Conclusions

We were very pleased with the numbers we received from Experiment 1 and Experiment 2. All of the numbers from the five runs were similar within the experiments, showing the results would be accurate when averaged. Experiment 3 however we will not include in our conclusions because all the results were based on it having a much larger starting number of Russian Olives than the other two experiments.

The starting number of mature and young trees was random, so it is of no significance that the number of mature trees decreased from the first experiment to the second. This is also the case with the young trees increasing from Experiment 1 to 2. The reason the computer model generated more mature trees than young in the beginning was because it randomly chooses an age for the tree and since there are fewer numbers below 360 than above, there are less young trees.

The fact that the total number of mature trees treated in Experiment 1 decreased in Experiment 2 was surprising. The total number of young trees treated in Experiment 1 increased in Experiment 2. If the number of young trees increased we thought the number of mature trees would have increased as well. This data does support why the number of treatments applied for mature treatments were the same for both treatments but increased in Experiment 2 for the young treatments however.

To eradicate Russian Olives on a riparian area with a starting number of 50 trees and 50 birds it takes an average of 25 months, two mature cut-stump treatments and three young tree cut-stump treatments costing a total of $10,500.

To eradicate Russian Olives on a riparian area with a starting number of 50 trees and 100 birds, it takes an average of 26.6 months, two mature treatments and 3.4 young treatments, costing a total of $12,740.

With these results, it shows that with a higher number of birds in the model it takes longer, needs more treatments, and more money to eradicate the Russian Olives. This is because more birds produce more new trees. This produces a continuous cycle as the Russian Olives provide both food and shelter for the birds.

In order for the eradication of this invasive species, we suggest that using the cut-stump treatments consistently as well as using nets to prevent birds from distributing seeds to be the most efficient

We consider our greatest accomplishment to be the fact that we were able to get so many real-life variables into the computer model. The variables of trees only being planted near the river, trees being able to get better, and energy being decreased by the cut-stump really made our results possible for real-life modeling.

We hope that others will recognize how important our results are for the thought of invasive species and being able to eradicate them. Computer modeling can be a great tool to experiment with different treatments before applying them in real life. This could save much time, energy and money.

Recommendations

If this project were to be improved we would change a few things. First, more real-life variables could be added to the model. Secondly, Experiment 3 would be changed.

One new variable we would add would be native species. This would change where the Russian Olives could be planted to effect how they reproduce. The project would also become more realistic if we gave the birds more characteristics or activities that would happen in life such as reproduction or death. Having the trees consume water would also add information on how they reduce water for other uses.

We were not pleased with Experiment 3 because most of the results were different based on the starting number of Russian Olives being higher than the other two Experiments, not the fact that there were fewer birds than Russian Olives. To improve this we would have the starting number of birds equal 25. That way the Russian Olives would have the same starting numbers but there would be fewer birds affecting the model.

Acknowledgments

We would like to thank Jeannie Benally, Gary Hathorn, and Jessie Owens from the San Juan County Extension Office for giving us information on Russian Olives and invasive species as well as helping us map Russian Olives. Next we would like to acknowledge Frank Archuleta from the Shiprock Soil and Water Conservation District for giving us information on Russian Olives and their treatment methods. We owe a multitude of thanks to Irene Lee, Aly Pesic, and Roger Critchlow Jr. for their help with our StarLogo Program. We wouldn’t have been successful without you!

References

"Alien Invasion." National Geographic 1998:

Archuleta, Frank. Personal interview. 11/23/05.

Benally, Jeannie. Personal interview. 9/11/05.

de Wit, H. C. D.. Plants of the World - The Higher Plants II. New York: E.P. Dutton and Co. Inc., 1967.

Haber, Erich. Russian-olive – Oleaster Elaeagnus Angustifolia L. Oleaster Family – Elaeagnaceae. Invasive Exotic Plants of Canada Fact Sheet No. 14. National Botanical Services, Ottawa, ON, Canada. April 1999

Hathorn, Gary. Invasive Weeds of San Juan County. New Mexico State University. 11/23/05 <www.sanjuanweeds.com>.

Hathorn, Gary. Telephone interview 1/12/06, 3/20/06

"Oleaster." The New Encyclopaedia Britannica Volume 8. 2002.

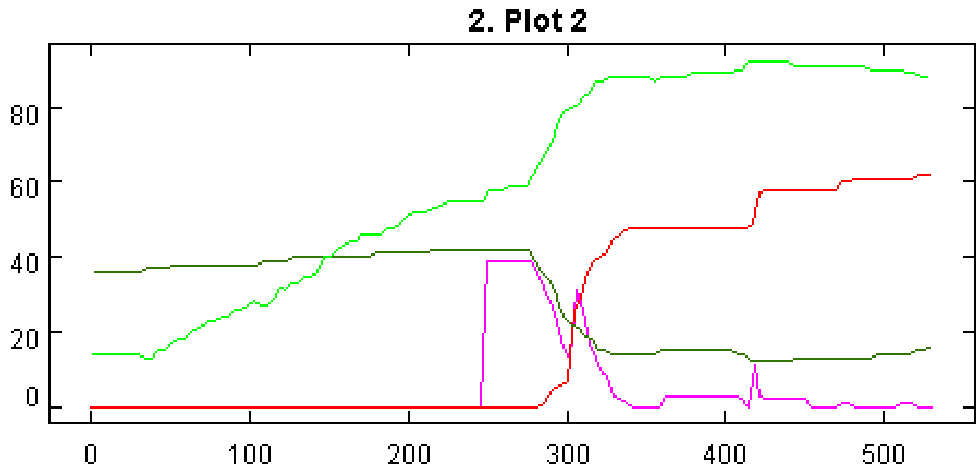
Owens, Jessie. Personal interview. 11/23/05.

Plants Profile. USDA. 11/16/05 <www.http://plants.usda.gov/cgi_bin/plant_profile.cgi?earl=plant_profile.cgi&symbol=ELAN>.

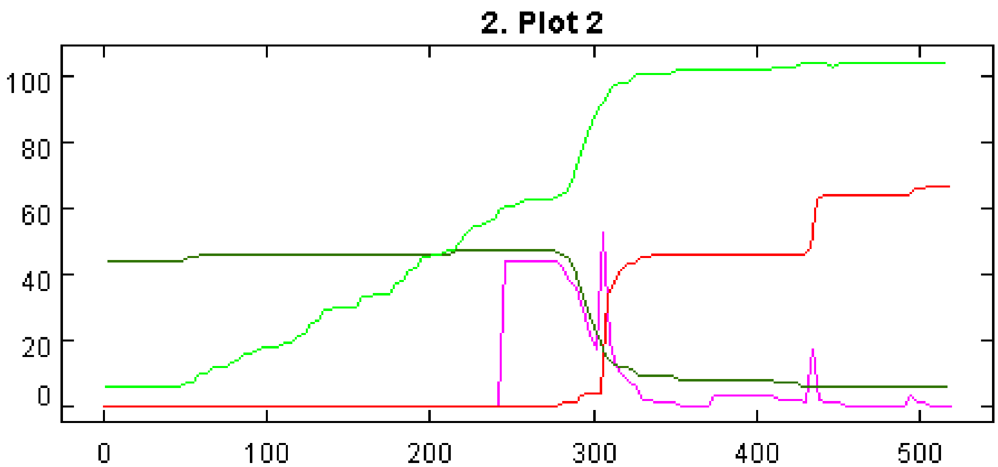
Williams, Eddy. Email Interview. 3/12/06

Appendix A

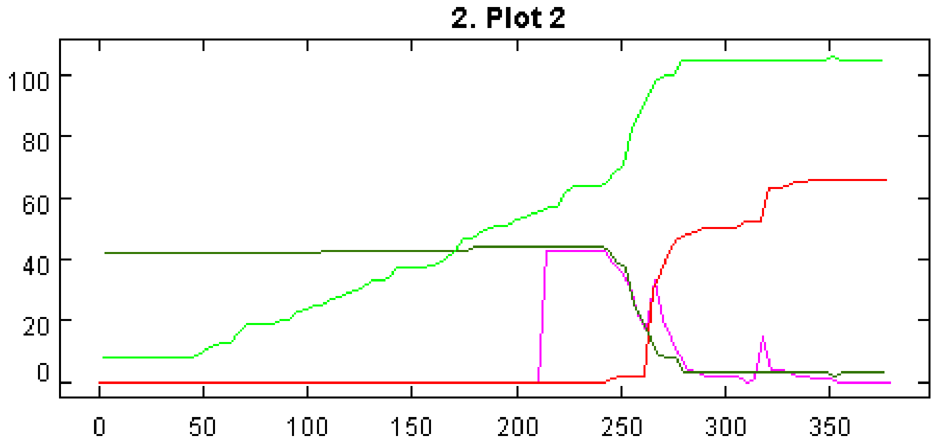
Experiment 1.1



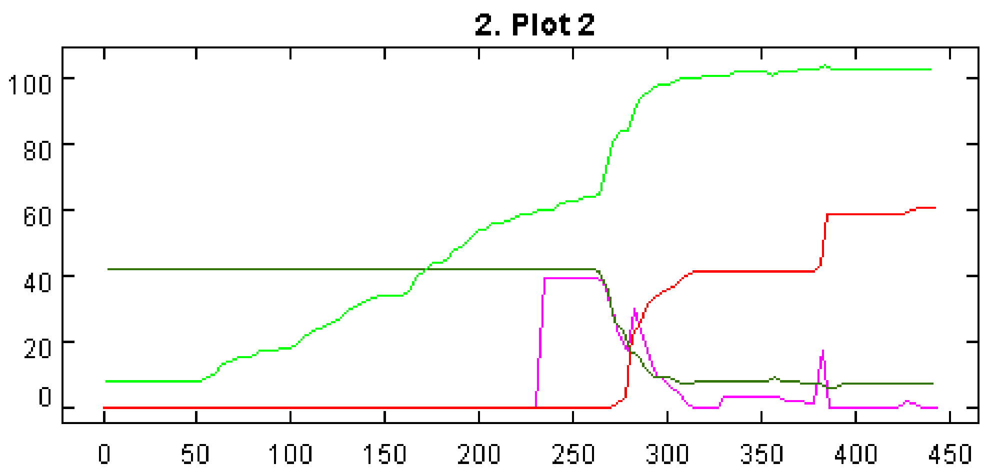
Experiment 1.2



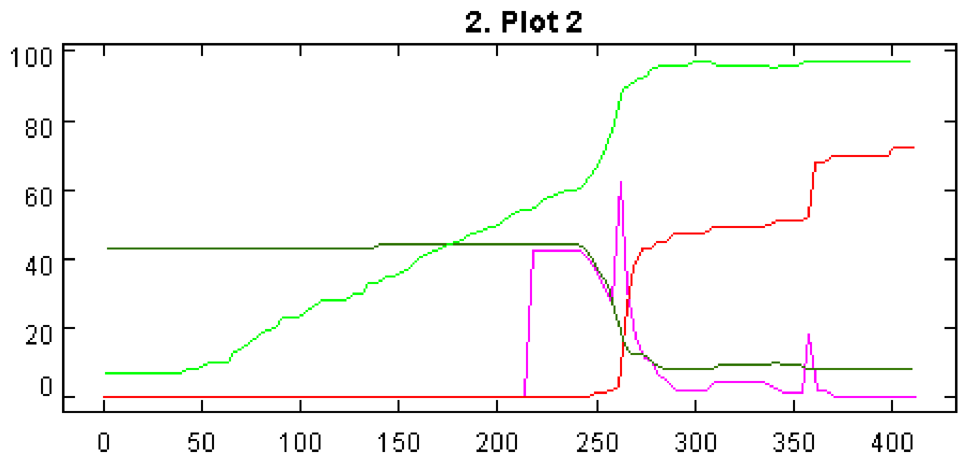
Experiment 1.3



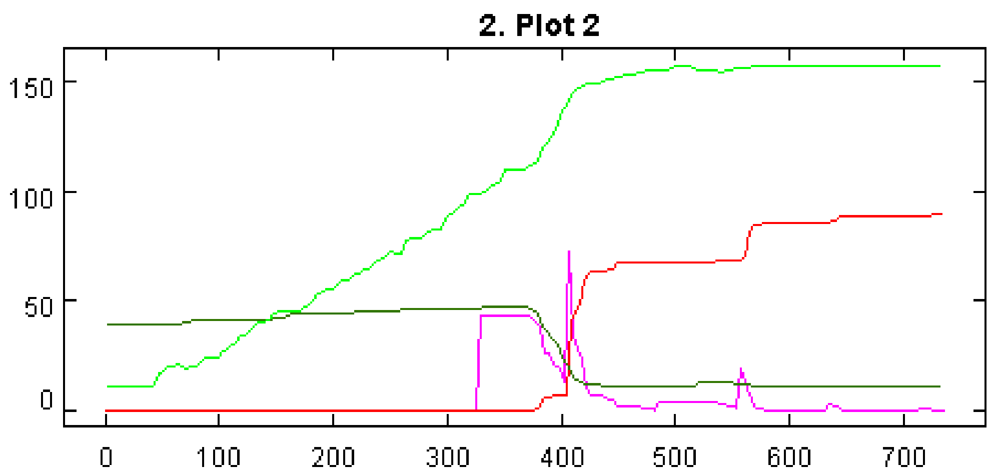
Experiment 1.4



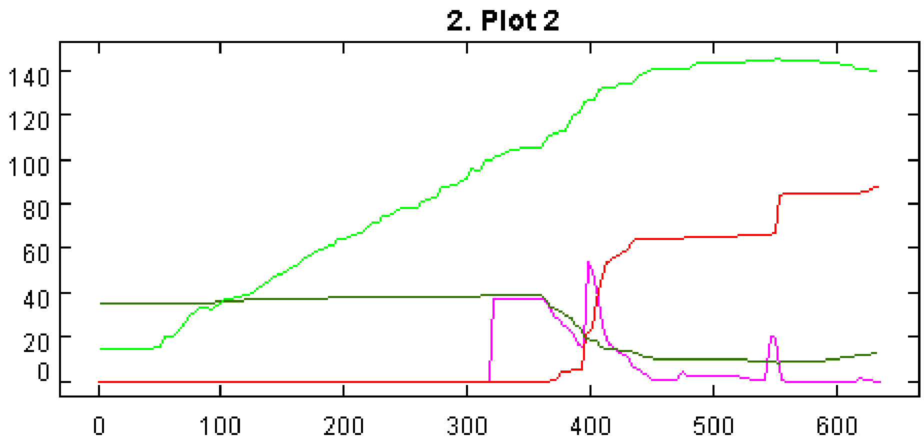
Experiment 1.5



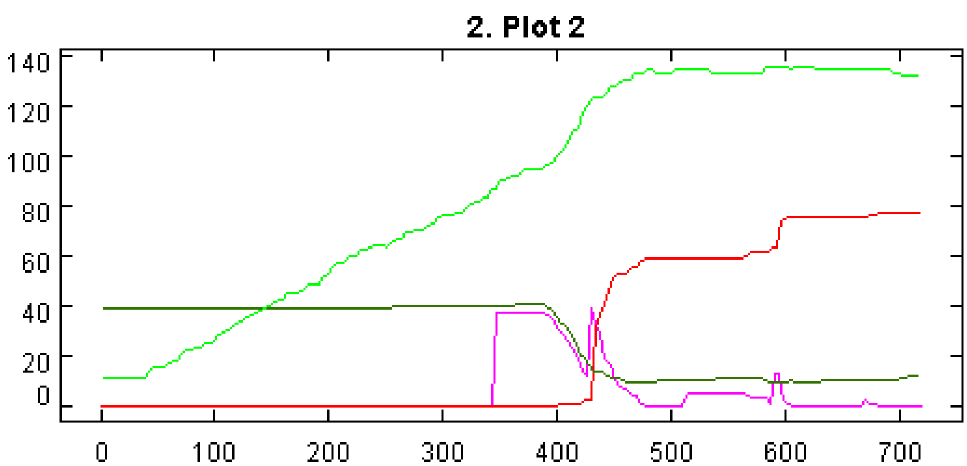
Experiment 2.1



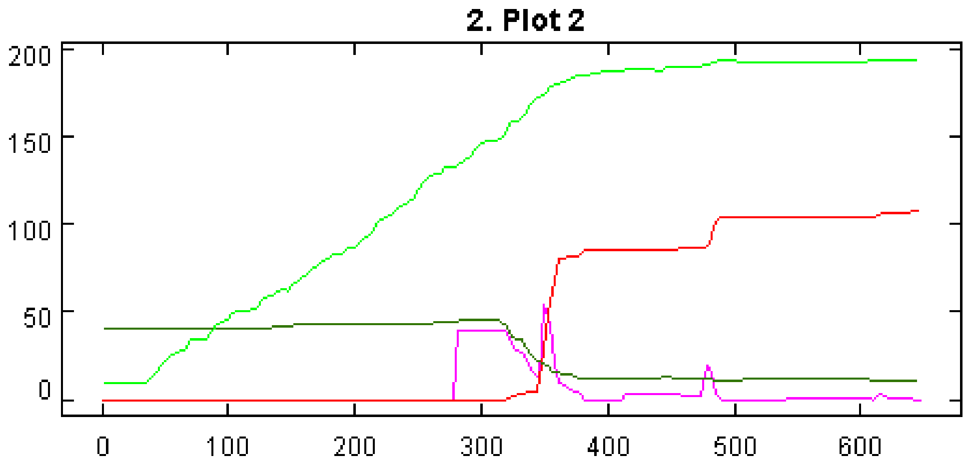
Experiment 2.2



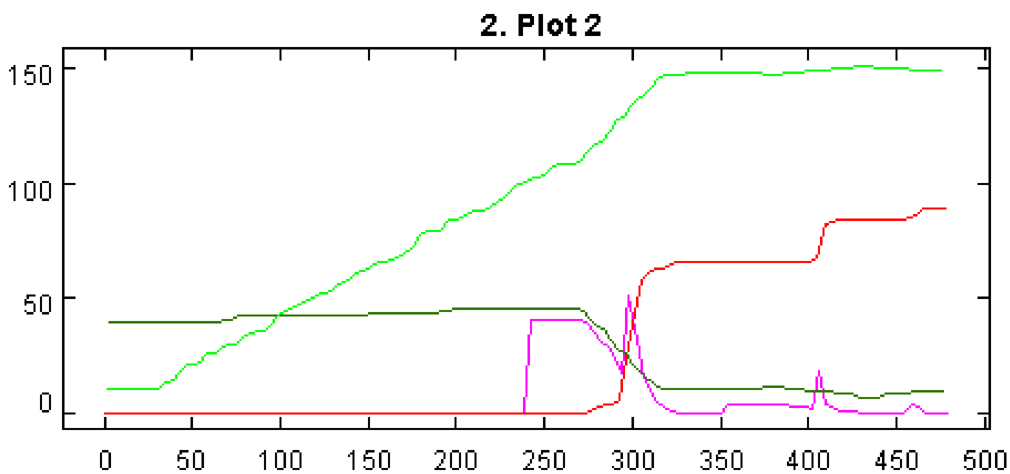
Experiment 2.3



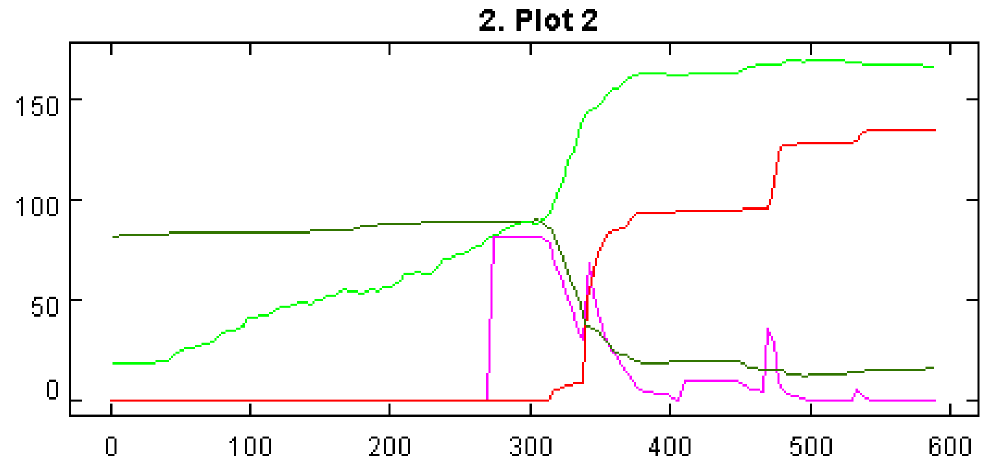
Experiment 2.4



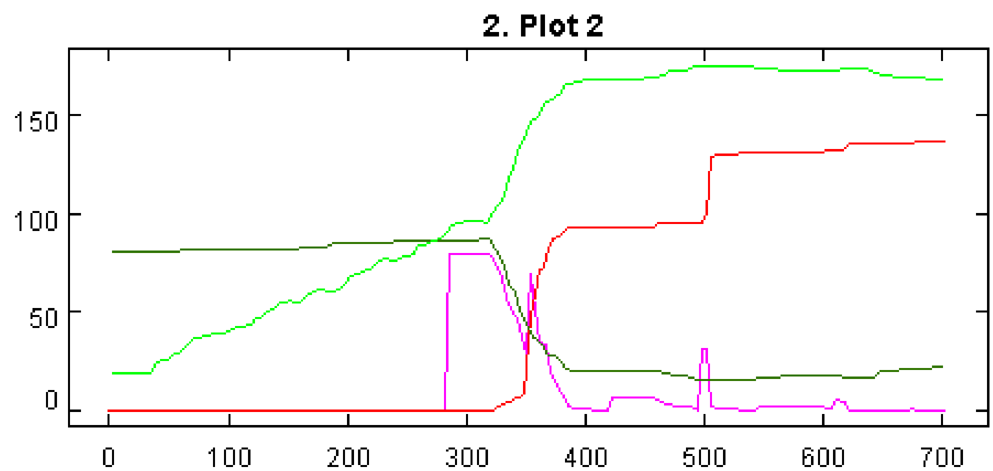
Experiment 2.5



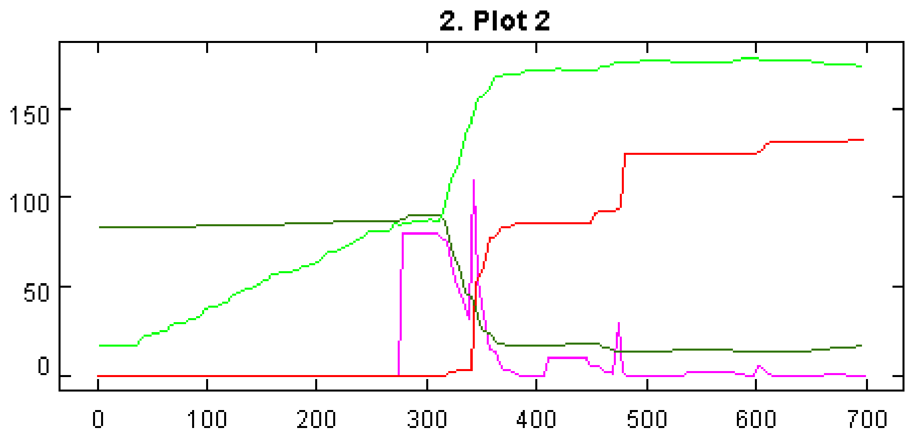
Experiment 3.1



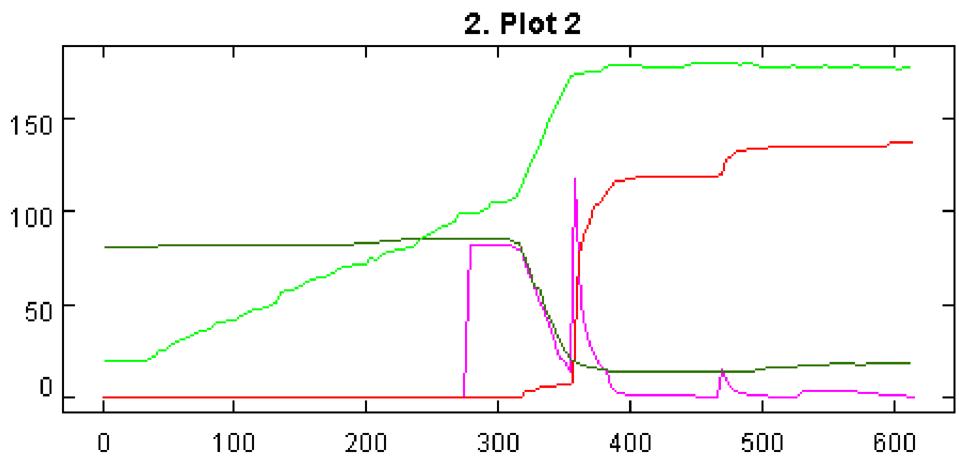
Experiment 3.2



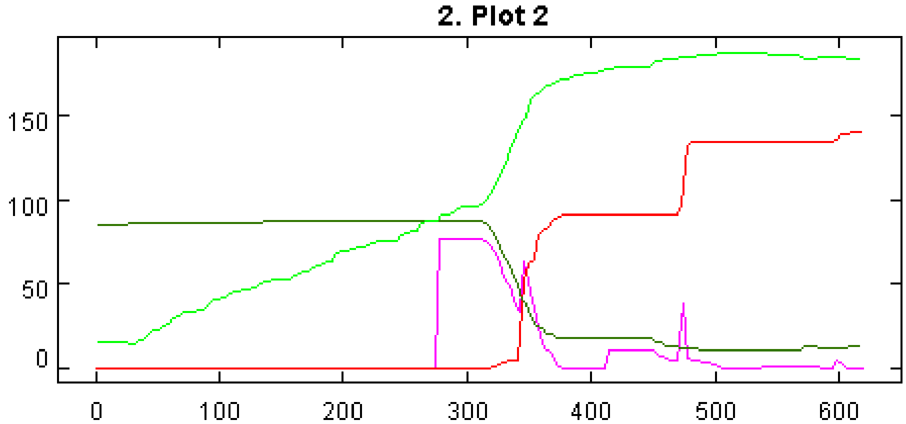
Experiment 3.3



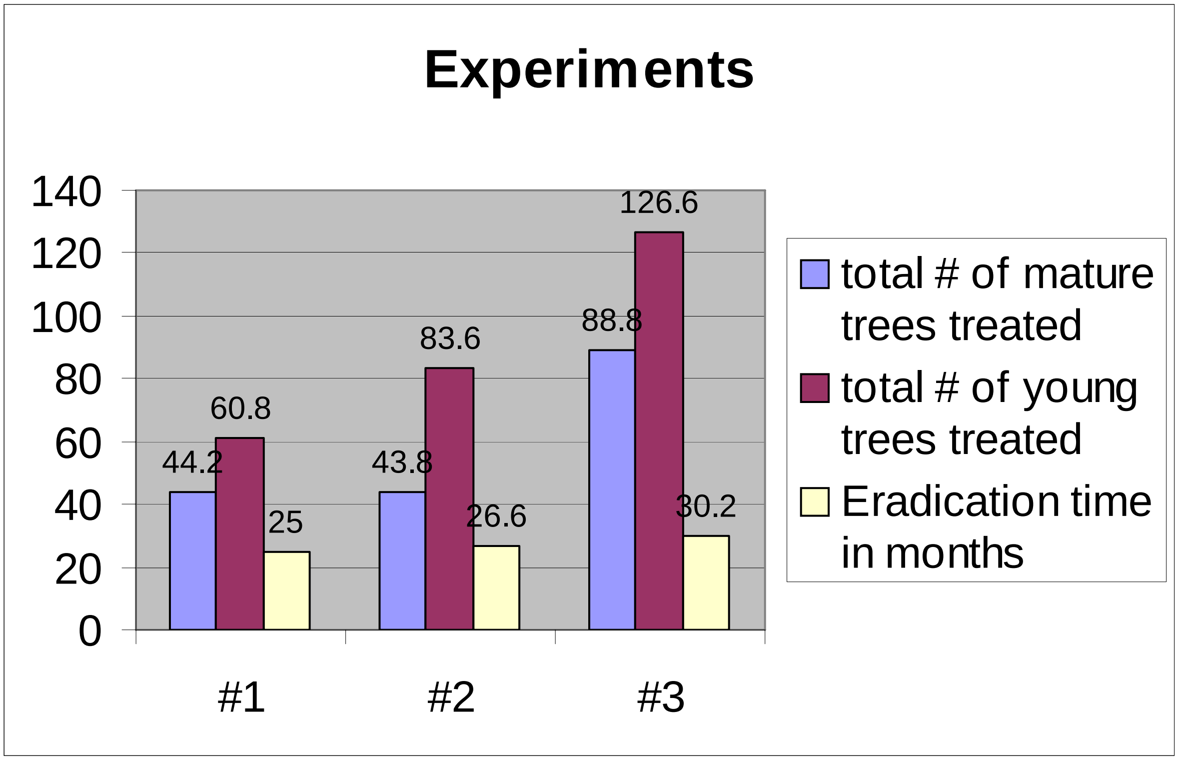
Experiment 3.4



Experiment 3.5



Appendix B



Experiments
140
120
100
80
60
40
20
0
44.2
60.8
25
43.8
83.6
26.6
88.8
126.6
30.2
#1
#2
#3
total # of mature trees treated
total # of young trees treated
Eradication time in months

Appendix C

Experiment 1	1.1	1.2	1.3	1.4	1.5	Average
Starting # of Russian Olives-	50	50	50	50	50	50
Mature trees	36	44	42	42	43	41.4
Young trees	14	6	8	8	7	8.6
Starting # of birds -	50	50	50	50	50	50
# of mature treatments-	2	2	2	2	2	2
total # of mature trees treated-	42	47	44	42	46	44.2
#of young treatments-	3	3	3	3	3	3
total # of young trees treated-	54	62	64	58	66	60.8
Amount of time to eradication- steps	272	252	226	251	249	250
Eradication time in months	27	25	23	25	25	25
Money spent-	$9,600.00	$10,900.00	$10,800.00	$10,000.00	$11,200.00	$10,500.00
Experiment 2	**2.1**	**2.2**	**2.3**	**2.4**	**2.5**	**Average**
Starting # of Russian Olives-	50	50	50	50	50	50
Mature trees	39	35	39	41	40	38.8
Young trees	11	15	11	9	10	11.2
Starting # of birds -	100	100	100	100	100	100
# of mature treatments-	2	2	2	2	2	2
total # of mature trees treated-	47	40	42	45	45	43.8
#of young treatments-	4	3	3	4	3	3.4
total # of young trees treated-	84	80	71	100	83	83.6
Amount of time to eradication- steps	281	247	259	291	254	266.4
Eradication time in months	28	25	26	29	25	26.6
Money spent-	$13,100.00	$12,000.00	$11,300.00	$14,500.00	$12,800.00	$12,740.00
Experiment 3	**3.1**	**3.2**	**3.3**	**3.4**	**3.5**	**Average**
Starting # of Russian Olives-	100	100	100	100	100	100
Mature trees	82	81	83	81	85	82.4
Young trees	18	19	17	19	15	17.6
Starting # of birds -	50	50	50	50	50	50
# of mature treatments-	2	3	3	3	3	2.8
total # of mature trees treated-	90	88	92	86	88	88.8
#of young treatments-	3	4	4	3	3	3.4
total # of young trees treated-	128	123	121	128	133	126.6
Amount of time to eradication- steps	265	315	319	280	281	292
Eradication time in months	27	32	36	28	28	30.2
Money spent-	$21,800.00	$21,100.00	$21,300.00	$21,400.00	$22,100.00	$21,540.00

Appendix D

```
turtles-own [age sick  bird-steps-w-seed tree-near-water energy]    ; diff conditions for agents

to place-by-river
   let [:found-water false]                              ; code to place ro correctly
   setxy random screen-width random screen-height
   set tree-near-water true
   if count-ro-here >= 1 [ set :found-water false]
   if (pc-towards 0 3) = blue  [set :found-water true]
   if (pc-towards 45 3) = blue  [set :found-water true]
   if (pc-towards 90 3) = blue  [set :found-water true]
   if (pc-towards 135 3) = blue  [set :found-water true]
   if (pc-towards 180 3) = blue  [set :found-water true]
   if (pc-towards 225 3) = blue  [set :found-water true]
   if (pc-towards 270 3) = blue  [set :found-water true]
   if (pc-towards 315 3) = blue  [set :found-water true]
   if pc = blue [ set :found-water false ]

   if :found-water = false  [ place-by-river ]
end

to trees-age
   if tree-near-water = true [
      set age age + 1                         ; in program, 10 steps= a month
      if ( (age > 360) and (shape = young-tree) ) [
        setshape mature-tree                        ; trees mature after 3 years or 360 steps
      ]
  ]
end

to trees-energy
    if ( (shape = mature-tree) or (shape = young-tree) ) [   ; after energy is 1200, energy does not
increase
    ifelse age < 1200 [
      setenergy age
          ][
      setenergy 1200
          ]  ]
end

to birds-move
    rt random 90                              ; controlls bird movements- random
    lt random 90
```

```
     fd 1
     set bird-steps-w-seed bird-steps-w-seed + 1
    if shape = bird-shape [ find-seed ]
    if shape = bird-with-seed [ drop-seed ]

end

to find-seed
     grab one-of-ro-here [                                    ; code for birds to pick up seeds
             if (shape-of partner) = mature-tree  [
                      setshape bird-with-seed
                      set bird-steps-w-seed 0
             ]
     ]
end

to drop-seed
    if ( (bird-steps-w-seed = 10) ) [                   ;code for birds to plant ro
               hatch [
                   setbreed ro
                   setshape seed-shape
                   setage 0
                   set tree-near-water false
                   check-for-water
               ]
     setshape bird-shape
     set bird-steps-w-seed 0
    ]
end

to check-for-water
    let [:found-water false]                                  ; code for ros to check for water
    if (count-ro-here >= 1) [set :found-water false]
    if (pc-towards 0 3) = blue  [set :found-water true]
    if (pc-towards 45 3) = blue  [set :found-water true]
    if (pc-towards 90 3) = blue  [set :found-water true]
    if (pc-towards 135 3) = blue  [set :found-water true]
    if (pc-towards 180 3) = blue  [set :found-water true]
    if (pc-towards 225 3) = blue  [set :found-water true]
    if (pc-towards 270 3) = blue  [set :found-water true]
    if (pc-towards 315 3) = blue  [set :found-water true]
    if pc = blue [ set :found-water false ]
    if :found-water = true [
                set tree-near-water true
                setshape young-tree
    ]
end
```

```
to ro-death          ; death comes when energy is 0 or less
  if ( (sick >= 1) and (energy <= 0) and (shape != seed-shape) ) [
  setshape dead-tree
  setsick 0
    ]
end



to make-ro-sick
  if ( (shape != seed-shape) and (breed = ro) and ((random 100) < 93) )[   ; makes tree shape sick
    setsick 1
      setshape sick-tree
       ]
end

to reduce-energy      ; reduces energy if sick
  if sick >= 1 [
     setsick sick + 1
     setenergy ( energy - 20 )
 ]
end

to make-young-tree-sick
  if ( (shape = young-tree) and (breed = ro) and ((random 100) < 93) )[   ; makes young trees sick
w/ button
    setsick 1
      setshape sick-tree
   setyoung-treatment young-treatment + 1
       ]
end

to make-mature-tree-sick
  if ( (shape = mature-tree) and (breed = ro) and ((random 100) < 93) )[ ; makes mature trees sick
w/ button
    setsick 1
      setshape sick-tree
  setmature-treatment mature-treatment + 1
       ]

end

to make-better
```

```
  if sick >= ((random 120) + 18) [     ; makes trees better if they've been sick for a while
    setsick 0
    setage 0
    setshape young-tree
    ]
end



globals [ counter young-treatment mature-treatment ]  ; each time we go through the main loop
we add 1 to the counter
patches-own [ saved-river water plant seeds ]  ; different types of patches
breeds [ro bird] ; diff breeds

 to setup
   ct

   ;; Irene added this
   set counter 0
   set mature-treatment 0
   set young-treatment 0
   clearplots
   ;;

   restore-river
   create-trees
   create-birds
end

to create-trees                       ; creating trees, pop is controlled by slider
    create-ro-and-do ro-pop [
       setage random 2000
       setshape young-tree
       ifelse age < 1200 [
            setenergy age
              ][
            setenergy 1200
             ]
  place-by-river
    ]
end

to create-birds                              ; bird pop controlled by slider
    create-bird-and-do bird-pop [
    setshape bird-shape
    setxy random screen-width random screen-height ]
end
```

```
to save-river
   ask-patches [ setsaved-river pc  ]        ; selected river pattern is saved so that it can be restored
below
end

to restore-river
   ask-patches [
         setpc saved-river
  ]
end


; this is what we used to create a new river
to old-create-river
   create-and-do 1 [
         setxy (( random screen-width ) - screen-half-width ) screen-half-height
         seth 180
         repeat screen-height [
             fd 1 stamp blue
             ask-patch-at xcor ycor [ set water 100 ]
             ifelse (random 100) < 50 [
                       rt 90 fd 1 stamp blue lt 90
             ]
                          [
                       lt 90 fd 1 stamp blue rt 90
             ]
             ask-patch-at xcor ycor [ set water 100 ]
          ]
  ]
end


 to go                              ; sets the counter to control time
    setcounter counter + 1
    ask-ro [ trees-age trees-energy reduce-energy ro-death make-better ]
    ask-bird [ birds-move ]  ; later add birds fly towards water or trees
 end
```