Roadrunners and the Changing Environments

New Mexico

Supercomputing Challenge

Final Report

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Table of Contents

Executive Summary

The project we worked on was about roadrunners. We wanted to know how the changing environment would affect the roadrunner population in the future. We wanted to do this because the roadrunner is a native bird to our land. Not only is it important to the state of New Mexico, it also has meaning for the Native Americans in the land. We used the computer software StarLogo to map out the roadrunner environment. StarLogo calculates the number of roadrunner, roadrunner offspring, roadrunner prey, temperature and water supplies. We plugged our research into StarLogo to make our results as accurate as possible.

In testing our model, we expected our roadrunners population to decrease and then increase but ultimately achieve stability. However, the total roadrunner population survived regardless of the amount of insects. The lack of insects simply decreased their available energy to walk and reproduce. But our model was incomplete as to determining the stability of the total roadrunner and the insect population.

Our hypothesis was proven right and wrong in a lot of different ways. We wanted to test the effects of environmental change, and were able to do so. We determined that roadrunners can survive with limited amount of water. Temperature affected roadrunners the most, in that when temperatures were too hot or too cold, roadrunners could not reproduce. This leads us to believe that climate change does indeed have an effect on roadrunner population.

Roadrunners and the Changing Environment

Introduction

In this project, we are modeling roadrunners and the environment they live in. We chose this project because the roadrunner is native to our homelands. The roadrunner has significant meaning to the state of New Mexico and our native religion. We wanted to know what effect the environment will have on the roadrunner population and how are native birds of New Mexico dealing with the changing environment. We based the environment of the roadrunner on the northern Chihuahuan Desert. We used the modeling software StarLogo 2.2 to run our experiment. We found out that temperature and water resources do have an effect on roadrunner population. In addition, it's also important to consider predators and prey in order to achieve stability in the population.

Project Description

In our experiment, we modeled the various environmental effects on roadrunner population. Our questions include: How do changes in the temperature, precipitation, and water resources affect the roadrunners' reproductive rates and life span? How do the number of predators and prey affect roadrunner population?

We expected the roadrunner population to decrease by a huge amount. Then at a point it would gradually increase and stabilize. We expected that the population would increase because the roadrunners would easily adapt to changes in environment, due to the temperature and the precipitation. This is because roadrunners are already highly adapted to the dry desert environment (Famolaro). There would be small fluctuations in the roadrunner population due to the amount of predators and available roadrunner prey. This stabilization of the roadrunner population in their environment is carrying capacity (Sandefur). In our model we tried to determine the effects on carrying capacity due to environment changes and amount of prey.

When studying population dynamics, we found out that the population depends on the period of time, population size and the growth. If we gave them variables, then time= n, population size =u, growth rate= r. The growth rate is determined by births per year minus deaths per year or r = b- d. If we used the dynamic system for population, the equation would be u(n)=(n-1)+ru(n-1) or u(n)==r^n u(o). Then the population grows exponentially until infinity. This is similar to the Malthusian model of population (Sandefur). The Malthusian model predicts that the population will continually grow until the Earth capacity was over flourished. This in reality is impossible for roadrunners because there are limiting environmental factors such as temperature and precipitation, as well as competition with other roadrunners, available prey to provide energy, and roadrunner predators.

In the model, we duplicated the characteristics of the Chihuahuan Desert, such as variables for temperature, reproduction rates for insects and roadrunners, water resources, and time of mating. We gave the roadrunners variables such as age and energy. For example, they're able to reproduce at 2-3 years, and they live up to 8 years (Desert USA). The model also incorporates temperature, as the roadrunner activity is reduced 50 percent during the hot daytime hours. We set the temperature to rise and fall throughout the course of day and night and the time is set in military time. We created an underground freshwater spring to attract insects to provide energy and a mating area. Insects were created given a random age, and when they met another insect, they were able to reproduce. When an insect meets a roadrunner, the roadrunner kills the insect and gains energy by a factor of 1. Roadrunners died when their energy = 0 or their age = 424 weeks.

Results

Compared to our hypothesis, roadrunners weren't affected by water issues like we thought. Roadrunner population was most affected by temperature and amount of available prey, the insects. Roadrunners were sensitive to temperature changes, based on the fact that they couldn't reproduce if the temperature was too hot or too cold. This leads us to believe that climate change can have an effect on roadrunner population by limiting the birth rate.

In addition, available prey had an effect on roadrunner population. When the insects died, it led to a loss of food for the roadrunners, thus decreasing their energy and making them die. Other factors that made the roadrunners lose their energy were walking and reproduction. The most important factor that helps roadrunners gain energy were insects and water.

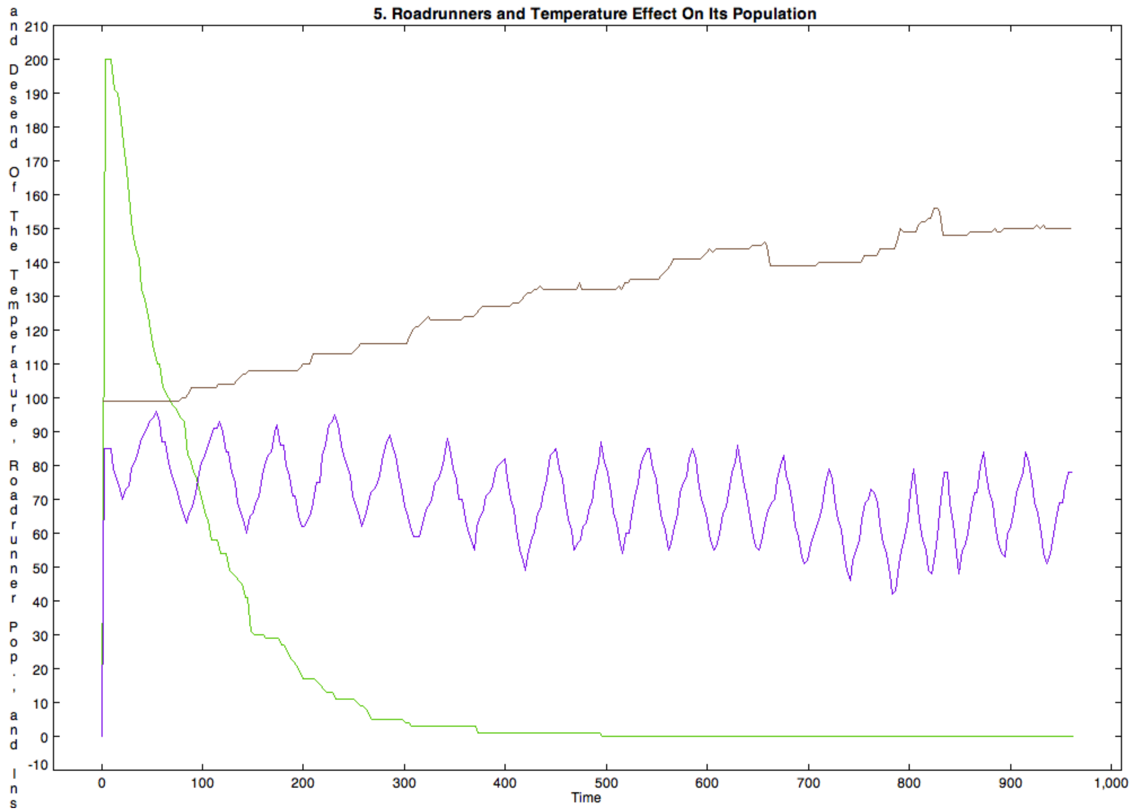

Figure 1: Population after 900 time steps. This shows when the population of the roadrunners begins at 50 and the insects is set to 200. In this graph the population of the roadrunners was too high and you can see the insect line (green) goes down too fast. This is a good example of over population in one habitat. The roadrunner line (brown) was going up gradually and has little lost and then it gains a lot back. Temperature is a little below than what we intended for. We were aiming around at least 100 degrees Fahrenheit.

Ultimately, we couldn't find the stability between roadrunners and insects. Many of the tests that were taken had flaws where either the roadrunner or the insects survived despite the other dying out. Our model was flawed in the fact that we didn't incorporate roadrunner predators. We ran out of time to factor that in, and that could have created stability in limiting the roadrunner population size.

Conclusion

In testing our model, we expected our roadrunners population to decrease and then increase but ultimately achieve stability. However, the total roadrunner population survived regardless of the amount of insects. The lack of insects simply decreased their available energy to walk and reproduce. But our model was incomplete as to determining the stability of the total roadrunner and the insect population. We need more time to include roadrunner predators to limit the roadrunner population size.

Our hypothesis was proven right and wrong in a lot of different ways. We wanted to test the effects of environmental change, and were able to do so. We determined that roadrunners can survive with limited amount of water. Temperature affected roadrunners the most, in that when temperatures were too hot or too cold, roadrunners could not reproduce. This leads us to believe that climate change can have an effect on roadrunner population by limiting the birth rate.

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Appendix A: StarLogo Code

Observer:

```
breeds [roadrunners insects watermaker]
globals [tmp time days weeks]

to setup
ca
create-roadrunners-and-do num
[
setxy random screen-width random screen-height
set shape swan-shape
setc brown
set age (random 424)
set energy 10
set days 0
]
create-insects-and-do incnum
[
setxy random screen-width random screen-height
set shape shape-12
setc green
]
set tmp 85
create-watermaker-and-do 1
[ht]
ask-patches
[set water 0 ]
end

to go
  ask-turtles [repeat 1 [move]]
  set time (time + 1)
  ifelse time >= 6 and time <= 18
  [set tmp (tmp + (random 4) + 1)]
  [set tmp (tmp - 3) ]
  if time >= 24
  [set time 0 set days (days + 1)]
  if days >= 7
  [set days 0 set weeks (weeks + 1)
  ask-turtles [set age age + 1]]
  ask-turtles
  [ if (tmp > 40 and tmp < 70) or ((random 100) < water)
   [reproduce reproduce-insects]]
  change-day
  update-water
```

```
  output-population
end

To change-day
  ifelse time > 6 and time < 18
  [ask-patches [scale-pc cyan water .1 5]]
  [ask-patches [scale-pc brown water .1 5]]
  end

to update-water
  diffuse water 1
   ask-watermaker
  [set water 2]
  change-day
end

to output-population
  type count-roadrunners
  type ","
  type count-insects
  type ","
  ;type weeks
  ;type ","
  ;type days
  ;type ","
  print (weeks * 7 * 24 ) + (days * 24) + time
end
```

Turtles:

```
turtles-own [gender age energy steps]
patches-own [water]

to move
  if breed = watermaker [stop]
  if breed = insects [uphill]
   rt random 180
   lt random 180
   fd 1
   eat
   check-energy
   drink
   check-age-insects
end

to reproduce
   if breed = insects [stop]
```

```
  if (count-roadrunners-here > 1)
  [
     grab one-of-roadrunners-here [
     if (age > 159) and ((age-of partner) > 159)
     [
       hatch
       [
         setc white
         set age 0
       ]
  set energy energy - 4
     ]]
    ]
end

to reproduce-insects
  if breed = roadrunners [stop]
  if (count-insects-here > 1 and count-insects < 200)
  [
     grab one-of-insects-here [
     if (age > 1) and ((age-of partner) > 1)
     [
       hatch
       [
         setc yellow
         set age 0
       ]
     ]]
    ]
end

to eat
 if breed = insects [stop]
 if energy > 20 [stop]
 if count-insects-here > 0
 [grab one-of-insects-here
 [kill partner]
 set energy (energy + 1)]

end

to check-energy
 if breed = insects [stop]
 if energy <= 0 [die]
 set steps (steps + 1)
 if steps >= 100
```

```
  [set energy (energy - 1)
  set steps 0]
  if age = 424 [die]
  if tmp <= 30 [set energy energy - 1]
  ;death-of-all-roadrunners
end

to drink
  if breed = insects [stop]
  if breed = watermaker [stop]
  set energy energy + (.00001 * water)
  set water water - (.00001 * water)
end

to check-age-insects
  if breed = roadrunners [stop]
  if age > 3  [ die ]
end

to uphill
  let [:dir sniff]
  if :dir >= -45 [seth heading + :dir]
end

to sniff
  let [:dir -45
       :best-val water
       :best-dir -100]
  let [:current water-towards :dir 1]
  if :current > :best-val
    [set :best-val :current
     set :best-dir :dir]
  set :dir :dir + 45
  set :current water-towards :dir 1
  if :current > :best-val
    [set :best-val :current
     set :best-dir :dir]
  set :dir :dir + 45
  set :current water-towards :dir 1
  if :current > :best-val
    [set :best-val :current
     set :best-dir :dir]
  output :best-dir
end

todeath-of-all-roadrunners
```

end