New Mexico

Supercomputing Challenge

Final Report

April 1, 2017

Los Lunas High-2

Los Lunas High School

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Executive Summary

Rattlesnake hunting has been going on in New Mexico for decades. Many are captured and turned over for rattlesnake roundups. When captured, snakes are used for a variety of purposes such as their meat for food and their skin for bags and boots.

To look at the impact of rattlesnake hunting on rattlesnake populations, we created a computer model demonstrating an abstract rattlesnake environment with rattlesnake hunters using the software NetLogo. This model was heavily based around personal research and raw data collected by the late state herpetologist Charles W. Painter during the years of 1995-2005.

Based on the raw data, this model became specifically centered on western diamondback rattlesnakes in the southwestern corner of Chaves County.

Once the model was complete, we used the NetLogo feature BehaviorSpace to test our model. The model was run five times for each hunter number and minimum length of harvest. The totals were then averaged and placed on a pivot table. Later, the values were placed into charts for a better visual representation.

Our initial expectation was that rattlesnake hunting would show a negative impact on the overall rattlesnake population. In analyzing our data, we saw that our range of hunters produced a decrease in population between 32-61% of its original population.

Purpose and Introduction

The purpose of our project was drawn from the fact that rattlesnake hunting exists in an unregulated manor. In a book written by Charles Painter, it states:

> "Rattlesnakes in New Mexico are increasingly threatened by unregulated commercial exploitation such as "rattlesnake roundups." These events support a commercial industry based on the value of rattlesnake skins for cowboy boots and other articles of fashion apparel. The potential impacts of this unregulated harvest have not been investigated, though most herpetologists feel that the practice is ecologically unsound and may lead to localized reductions of rattlesnake populations" (Amphibians & Reptiles of New Mexico, 340).

As previously mentioned in the Executive Summary, to look at the extent of how much rattlesnake hunting truly affects the population of rattlesnakes in New Mexico, we created a computer model simulating a rattlesnake environment. The basic idea of the model is that the snakes will be moving around and the hunters will capture them as they run into each other's paths.

The model consists of two independent variables that affect the rattlesnake population: the number of hunters and the minimum length of harvest (the minimum length the rattlesnake has to be in order to be captured). The purpose of having two independent variables was to use them in order to help create a regulation to stabilize the rattlesnake population. The number of hunters would translate into the maximum number of hunting licenses to be given out and the minimum length of harvest would translate into a regulation for how long a snake has to be in order to be captured—much like specific fish have minimum lengths they have to be in order to be captured.

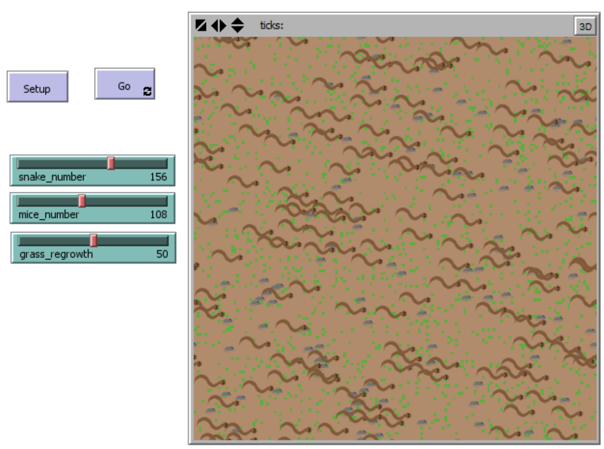
Computational Model

To reach our current model, fifteen versions were created. In deciding how to best model the rattlesnake environment, our team went through a process of abstraction. Our team also scaled the model to match a specific area in New Mexico.

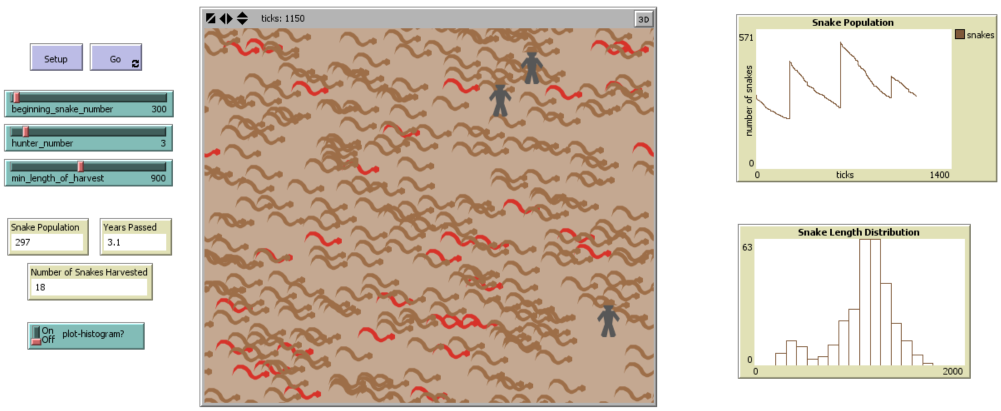
<u>Abstraction of the Model</u>

Originally, we decided to abstract the following ideas into our model: the rattlesnakes moving around, eating prey, growing, reproducing, getting captured, aging, and dying.

From versions 0.0 to 0.2, a rattlesnake environment based on our original abstraction idea was created. The model had rattlesnakes, mice, and grass. A small food chain was established in which the rattlesnakes ate the mice and the mice ate the grass. As the model ran, the grass would regrow and as the snakes and mice ate, they would gain a certain amount of energy. If they reached a certain energy amount, they would reproduce.

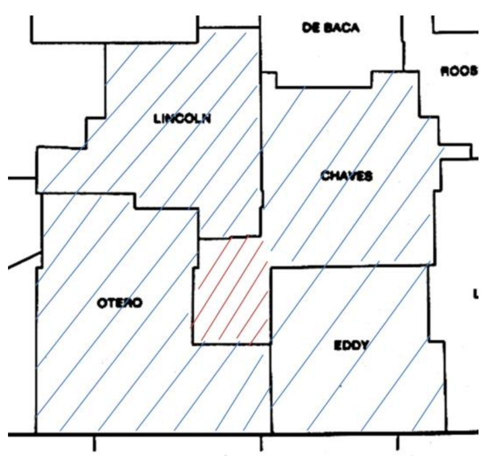


However, as we looked at the model, we decided that having energy levels for both the snakes and mice would become difficult to keep track of. It would be challenging to find the right amount of energy that they would gain from eating, the right amount of energy they would lose from moving, and the right amount of energy they would reproduce at that would have the population oscillate. Therefore, we decided to abstract the food chain and energy levels out of our model. From versions 1.0 to 7.1, we then focused on the rattlesnakes only moving around, growing, reproducing, getting captured, aging, and dying.



Scaling the Model

The next biggest change implemented into the model was modeling it around a specific area in New Mexico. Based on the raw data collected by Charles Painter, most of the rattlesnakes he collected data on came from Lincoln, Chaves, Otero, and Eddy County. Because of this, we decided to model the center of that area (the Southwestern corner of Chaves County).



The approximate area was $1200mi^2$ but we decided to scale it down by a factor of ten. Therefore, the area in the model is $120mi^2$. Based on our personal research we found that a “rancher in Texas in clearing brush killed 60 rattlers per square mile” (Klauber, 560). Using that number as a reasonable estimate on how many rattlesnakes there are per square mile, we decided to multiply the area by sixty rattlesnakes in order to get the total amount of rattlesnakes in that area (7200).

Code

Setup

To set up the world, snakes and hunters are created based on a slider value the user is able to manipulate. The parameters of the snakes are based on personal research as well as the raw data collected by Charles Painter.

Below are snippets of the raw data collected by Charles Painter (the first snippet is the beginning of the data and the second is the end of the data):

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	No.	Year	Sp	Sx	SVL (mm)	Tail (mm)	Total (mm)	Mass (g)	Locality	Collector	Gravid (Y/N)	# Follicles	# Rattles (complete only)	Comments
2	40	2000	ca	m	485	31	516	58	Deming (Florida Mts)		y	4		
3	202	1999	ca	f	510	32	542	89	Hagerman				4	
4	199	2005	ca	f	530	30	560	99	Artesia	Creamer			6	
5	31	1999	ca	f	540	33	573	80	Deming				5	batch in generally poor condition
6	296	1999	ca	m	555	52	607	124	Artesia					
7	201	1999	ca	m	560	48	608	100	Hagerman				5	
8	176	1996	ca	M			610	658						
9	246	2000	ca	m	585	36	621	97	Roswell (gassed batch??)		y	5		
10	26	2000	ca	m	590	35	625	101	Deming (Florida Mts)		y	5		
11	200	1999	ca	m	580	49	629	115	Hagerman				5	
12	199	1999	ca	m	580	50	630	127	Hagerman				5	
13	55	1995	ca	M			660	159						
14	61	1995	ca	F			660	331						
15	174	1996	ca	M			660	862						
16	250	1995	ca	M			673	848						
17	198	1999	ca	m	620	58	678	182	Hagerman				5	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
3726	14	1999	cv	m	910	82	992	474	Deming					batch in generally poor condition
3727	374	2005	cv	f	940	53	993	548	Artesia	Davis	y	14		
3728	139	1999	cv	m	915	82	997	503	Roswell					
3729	193	2000	cv	m	920	80	1000	485	Carlsbad (batch 3)					blood sample for ATH
3730	141	1999	cv	m	925	79	1004	422	Roswell					
3731	442	2005	cv	m	930	75	1005	532	Hagerman	Pilley				
3732	306	2001	cv	m	946	69	1015	420	E of Dexter/Hagerman (E of Pecos River)					retained for ESP/MSB skeleton; ESI Skeleton; ESP 7641 Skin
3733	373	2005	cv	m	956	76	1032	498	Artesia	Davis				
3734	423	2005	cv	m	955	85	1040	635	Hagerman	Pilley				
3735	219	1999	cv	m	960	83	1043	509	Carlsbad					
3736	278	2000	cv	m	960	83	1043	471	Roswell (gassed batch??)					blood sample for ATH
3737	358	2005	cv	m	1013	73	1086	763	Hope	Fletcher				
3738	182	2002	cv	m	1010	85	1095	675	Artesia (Loco Hills)					large C. viridis; retained for MSB spe 7865, measured 941 + 83 mm TL de
3739	192	2000	cv	m	1038	82	1120	673	Carlsbad (batch 3)					blood sample for ATH
3740	69	2005	cv	m				85	S.E. New Mexico; Mixed lot from Artesia and Carlsbad	Holman and Ward mixed lot				
3741	101	2005	cv	m				267	S.E. New Mexico; Mixed lot from Artesia and Carlsbad	Holman and Ward mixed lot				
3742	252	2005	cv	f				312	Artesia	Fowler, Levario, Tilton	y	6		

Snake Length Distribution

When the snakes are created, each snake needs to start out with a specific length. The code breaks up the snakes into ‘adult snakes’ and ‘baby snakes.’ The differentiation of ‘adult snakes’ to ‘baby snakes’ was defined by whether the snake was sexually mature or not.

To assign lengths to each adult snake, NetLogo's "random-normal" function was used. To use the random normal function, a mean and standard deviation number was required. To get those numbers, Painter's data for the total length of each snake was analyzed in Excel which produced a mean number of 1118 and a standard deviation of 195. Those numbers were inputted into the code.

```
create-snakes round (beginning_snake_number * 0.9)
[
  set shape "snake"
  set color brown
  setxy random-xcor random-ycor
  set snake_length round random-normal 1118 195
```

To assign lengths to each baby snake, Painter's data combined with personal research was used. Based on personal research, it was found that when rattlesnakes are born, they are around 228-343mm long. Looking at Painter's data, it was seen that the shortest length that a snake was found to be gravid (carrying eggs) was 516mm. Therefore, we assumed that a baby snake would be between the lengths 228-516mm and coded the lengths for the baby snakes to be a random number between 228-516mm.

```
create-snakes round (beginning_snake_number * 0.1)
[
  set shape "snake"
  set color brown
  setxy random-xcor random-ycor
  set snake_length  (228 + random 288)
```

Reproduction Year

Furthermore, based on personal research, it was found that Western Diamondback Rattlesnakes reproduce every other year. To have rattlesnakes not only reproducing the second year the model is run, but also reproducing with the first year the model is run, 'reproduce years' was created to have half the snakes begin to reproduce the first year and the other half reproduce the second year. In addition, to let the hunters know whether the snakes can be captured or not, if the snake meets the minimum length of harvest (as set by a slider), the snake turns red.

```
ifelse random 2 = 0
[
  set reproduce-year 0
]
[
  set reproduce-year 1
]
if snake_length >= min_length_of_harvest
[
 set color red
]
```

The setup also includes the creation of a set number of hunters based on a slider number who are randomly distributed around the world.

Go

The 'Go' procedure is broken up into the following sub-procedures: move, reproduction, harvest, one year of growth, update years, update hunting season, natural death, and predator death.

Move

The move procedure for the snakes and hunters tells them to move around in a random direction. However, for the hunters, they will only hunt and move around during hunting season. Every tick represents a day, and the hunters will harvest during Spring (days/ticks 45-75).

```
  ask hunters
  [
   if hunting_season >= 45 and hunting_season <= 75
   [
   right random 50
   left random 50
   forward 1
   ]
   ]
end
```

Reproduction

The reproduction procedure has the snakes reproduce. However, the snakes have to meet certain requirements. The snakes have a 25% chance of reproducing (half are female, and females have a 50% chance of reproducing). If the snakes meet this percentage and are sexually mature (3 years old based on personal research), are in their reproduction year, and the time is late summer (reproduction season based on personal research), they will reproduce and hatch between 5-10 snakes (research states that snakes usually reproduce anywhere from 10-20, but we cut this number down because half of these snakes will die due to the harsh winter). When the snakes are born, they will have a random length between 228-343mm (based on personal research).

```
to reproduction
  ask snakes
  [
   set reproduce? one-of [0 1 2 3]
   if age >= 3 and reproduce? = 1 and reproduce-year = 1 and time = 237
   [
    hatch (5 + random 6)
   [
    set snake_length  (228 + random 115)
    set age 0
    set reproduce-year 0
    set color brown
   ]
   ]
  ]
end
```

Update Years

The update years procedure updates the variable ‘time’ to keep track of the years passed. Because each tick represents one day, to find the number of years passed, the total number of ticks is divided by 365 (days).

Update Hunting Season

The update hunting season procedure updates the variable ‘hunting season.’ Hunting season correlates with the tick number. With each tick, the hunting season increases by 1. When hunting season reaches 365, it resets to zero. This way the hunters will know when it is hunting season (45-75).

Harvest

The harvest procedure tells the hunters to look for any red (harvestable) snakes within the patch they are on. If there are any red snakes on the patch, the hunter will look at each of them one at a time. If the snake meets a certain percentage chance of being captured, it will die. The snake has to meet that percentage chance of being captured because it is unrealistic for a hunter to capture all the snakes he/she sees. Therefore, adding a certain percentage chance of the snake being captured makes the model more realistic.

```
to harvest
  ask hunters
  [
    if ( count snakes-here with [color = red] > 0 ) and ( hunting_season >= 45 and hunting_season <= 75 )
    [
     let temp-counter 0
     let temp-pop count ( snakes-here with [color = red] )
     while [(temp-counter < temp-pop) and (count snakes-here with [color = red] > 0) ]
     [
     if random 1000 <= 70
     [
      ask one-of snakes-here with [color = red]
      [
       set harvest? harvest? + 1
       die
      ]
       ]
     set temp-counter temp-counter + 1
     ]
    ]
  ]
end
```

Predator Death and Natural Death

The snakes have 2 different ways to die. The first way is by predator death. There is a random chance that a snake will die from predators in their lifetime. The second way is by natural death. A snake lives for an average of 20 years (based on personal research). Once a snake reaches 20 years old, there is a 90% chance that the snake will die. For each additional year, there is a one percent chance increase of death from 90 (max age 30).

```
to natural-death
  ask snakes
  [
   if age >= 20
   [
    if (70 + age) > random 100
    [
     die
    ]
   ]
  ]
end

to predator-death
  ask snakes
  [
   if random 712 = 0
   [
    die
   ]
  ]
end
```

Validation

For the purposes of trying to conserve the rattlesnake population, we believe that this is a valid model. This model utilizes two variables that the New Mexico Game and Fish Department can implement: a minimum harvest length as well as a restricted number of hunting licenses to be given out.

We furthermore believe that the use of those two variables can be used as a reasonable determination to base what effects rattlesnake hunting has on rattlesnake populations.

Verification

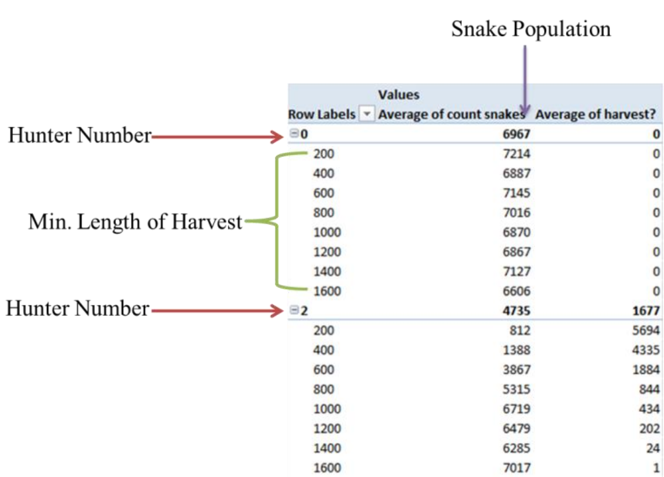
Two discrepancies have been found in our model. The first has to do with the sub-procedure ‘One Year of Growth.’ In our code, each snake is shown to be growing linearly which is inaccurate. Instead of being linear, the snake growth should be faster in the beginning and taper off towards the end as the snake reaches its average lifespan.

The second discrepancy is the starting population numbers for adult and baby snakes. The starting population for adult snakes in the model is currently 90% and 10% for baby snakes. This is inaccurate. Based on personal research after finding this inaccuracy, the numbers are closer to 79% for adults and 21% for baby snakes.

Results

We gathered the data for our model by running it through Behavior Space. In Behavior Space we went through each possible combination for each independent variable and organized it into a pivot table. We ran the hunter variable in increments of 2 (2 hunters then 4 hunters then 6 hunters, etc.) all the way up to 30 hunters and ran the minimum length of harvest in increments of 200mm all the way up to 1600mm. Each combination was run 5 times over the course of 60 years (2-3 generations of rattlesnakes). For example, for two hunters at a regulation of 200mm, we ran it five times and averaged the rattlesnake population for the five runs. It was then run 5 times for two hunters at a regulation of 400mm. Once the regulation has been run up to 1600mm, the hunter number will change to the next increment (in this case 4 hunters) and the process will repeat again.

Below is a snippet of the pivot table:



Row Labels	Values: Average of count snakes	Average of harvest?
⊟0	6967	0
200	7214	0
400	6887	0
600	7145	0
800	7016	0
1000	6870	0
1200	6867	0
1400	7127	0
1600	6606	0
⊟2	4735	1677
200	812	5694
400	1388	4335
600	3867	1884
800	5315	844
1000	6719	434
1200	6479	202
1400	6285	24
1600	7017	1

The control group that will be used to compare how the hunter number and length regulation affect the population of rattlesnakes will be the rattlesnake population with zero hunters.

With the addition of hunters into a regular snake environment, the population decreased a range of 32-61%.

Original Population of Rattlesnakes at Zero Hunters		**6967**	
Average Population Declines Based on Number of Hunters:			
Hunter Number	**Population Number**	**% of Original Population**	**% Decreased From Original Population**
2	4735	68	32
4	4283	61	39
6	3941	57	43
8	3757	54	46
10	3577	51	49
12	3375	48	52
14	3347	48	52
16	3205	46	54
18	3199	46	54
20	3020	43	57
22	2982	43	57
24	2924	42	58
26	2827	41	59
28	2994	43	57
30	2736	39	61

The rattlesnake population decreased an average of 32% with the addition of only 2 hunters into the environment. At our maximum of 30 hunters (the maximum amount of hunters estimated to be found in Chavez County) the population declines 61%.

Below is a snippet of the pivot table at eight hunters:

⊟8	**3757**	**2543**
200	0	6393
400	5	5272
600	793	3917
800	3902	2506
1000	4828	1451
1200	6348	713
1400	7219	89
1600	6958	5

We can see that at eight hunters with no regulation (200mm for the minimum length of harvest) the population for rattlesnakes has reached zero.

Conclusion

Based on our results, it can be determined that rattlesnake hunting causes a direct negative impact on rattlesnake populations. Determining the best course of action to take in conserving the rattlesnake population is difficult. However, our model suggests that at eight hunters with no regulation, there will be no rattlesnakes left in the area. Therefore, we can conclude that if no minimum length requirement will be set for rattlesnakes, we must at least limit the number of hunters to less than eight to keep the rattlesnake population alive.

We also understand that the accuracy of our program is not 100%. However, due to the limited amount of published research on the population densities of Western Diamondback Rattlesnakes, it is difficult to compare the results we obtained to the real-world. We have however looked at a published research article about a study on the provision of resources to rattlesnakes in order to increase rattlesnake populations. The study discovered “little evidence that managers should be concerned that provisioning birds or other wildlife with water or seed is likely to concentrate adult rattlesnakes” (Nowak, 357). In other words, using indirect methods such as providing more food for rattlesnake prey in order to increase prey concentrations for rattlesnakes will not affect rattlesnake populations. This suggests that our model is reasonable in saying rattlesnake hunting directly impacts rattlesnake populations because rattlesnake hunting is more direct than the provision of food for rattlesnake prey.

Overall, we believe our model can be used to get an idea for the impact rattlesnake hunting has on rattlesnake populations.

Acknowledgements

Mr. Creighton Edington

We would like to thank our mentor Mr. Edington for giving us the idea for this project. We would also like to thank him for steadily guiding and supporting us.

Mr. James Taylor

We would like to thank Mr. Taylor for helping us input the natural snake length distributions for our model. We would also like to thank him for advising us on our code and helping us with our data.

Ms. Anne Loveless

We would like to thank our Computer Science teacher Ms. Loveless for supporting us throughout our project.

Mrs. Annette Hatch

We would like to thank Mrs. Hatch for helping us incorporate research and mathematical data into our model.

Mr. Nick Bennet

We would like to thank Mr. Bennet for looking over our model and advising us on the ways that would best optimize our program.

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