PAINTED TURTLE GROWTH IN CORRELATION WITH THE PH OF THEIR ENVIRONMENT

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ABSTRACT

Painted turtles have been captured and measured sporadically within the five local ponds in Black Rock Forest over the past 10 to 15 years. Previous research noted the abundances of turtles within each pond. A correlation between pond health, indicated by pH, and turtle abundance was found. I decided to research whether or not a correlation existed between growth rate and pond health as well. Using hoop nets, I captured turtles in a pond with a neutral pH and a pond with an acidic pH. I compared the turtles' current mass to data recorded from each turtle's previous captures. Turtles from Aleck Meadow (pond with neutral pH) did have a much faster growth rate than those from Sutherland Pond (pond with low pH). The average growth rate for turtles from Aleck Meadow was 0.151 percent mass change per year while for Sutherland pond growth rate was 0.014 percent mass change per year. In Aleck Meadow females grew at a much faster rate than males, while in Sutherland the opposite was true.

While the data was statistically significant, these results are not necessarily accurate in general because there was a lack of data from Sutherland Pond, both recorded in the past and obtained during my research. Only a total of eight turtles could be used to analyze Sutherland's data, as compared to the 40 turtles used from Aleck Meadow pond. If relatively accurate, the data most likely signifies a bleak future for the painted turtles. As smaller in size and generally less abundant, they may have a difficult time surviving in an ever more acidic environment.

INTRODUCTION

ACIDIC WATER

pH is known to be an indirect gauge of pond health. Normally water tends to have a relatively neutral pH hovering around 7. Ponds may be naturally more acidic due to rocks and minerals in their environment, but pH is often lower in bodies of water primarily due to acid rain. Acid rain is precipitation containing levels of nitric and sulfuric acids that are higher than normal. It can be caused naturally by volcanoes, but is most often caused through artificial means. In particular, the burning of fossil fuels emits significant amounts of sulfur dioxide and nitrogen oxides into the atmosphere. These emissions eventually return to earth through precipitation (www.epa.gov, 2008). Black Rock Forest, being only about 60 miles from the densely urban New York City (www.mapquest.com, 2009), has relatively acidic rain with an average pH of 4.30 (www.nadp.sws.uluc.edu, 2004).

Acid rain causes levels of aluminum to increase while it decreases amounts of calcium carbonate within ponds and lakes. Aluminum itself is poisonous to many organisms. The element binds with phosphorus, hindering the uptake of phosphorus by organisms. As a result, invertebrate organisms often have lowered levels of calcium and phosphorus and elevated levels of aluminum in their bodies. As the trophic levels of the food chain increase, animals contain insufficient quantities of phosphorus and calcium and the amount of aluminum is bioaccumulated to rather high levels (Sparling 1990). Multiple studies show that high levels of aluminum have toxic effects on most pond life. In gill-breathing organisms such as fish and invertebrates, excess aluminum causes plasma loss and haemolymph ions, which then leads to osmoregulatory failure. It has been noted that it also reduces gill enzyme activity, which is an important part of the ion uptake process. Researchers also found bioaccumulated aluminum in organisms such as reptiles, mammals, and birds. The aluminum was also found to affect the mycorrhiza and root systems of plants and enters the food chain in that way. (Rosseland, Eldhuset, and Staurnes 1990) Pond acidity has been further been shown to slow the growth rate of the American Black Duck and the Mallard as well as increase the rate of their mortality (Sparling 1990). Elevated aluminum levels in humans and other animals have lead to problems in bone formation, hematopoietic tissue, and kidneys, as well as anemia (Jeffery, Abreo, Burgess, Cannata, and Greger, 1996).

BLACK ROCK FOREST

Painted turtles have been captured and measured in a series of ponds in Black Rock Forest (Cornwall, NY, southeastern New York State) since 1992 by a series of investigators. Data routinely collected includes body mass, sex, age, carapace length, width and height, and plastron length. Captured turtles have had PIT tags implanted subcutaneously in their back right leg and/or notched shell markings to identify them.

Effendy and Karrmann (2004) measured the above-mentioned body parts of painted turtles in Black Rock Forest to determine if mass and length as well as various ratios of shell measurements were correlated with the sex of the turtle. They found that females were distinctively larger in size, had proportionally higher and more domed carapace heights, and weighed more.

Researchers have also noted the abundances of painted turtles in each of the five ponds located within Black Rock Forest as well as collected data on the relationship between sex and size of various features of the turtles. While investigating turtle abundance, pond health was also examined by recording pond pH and temperature. Turtle abundance was weakly related to these indicators of pond health. In ponds comprising of a low pH, there were fewer turtles as well as a more skewed sex ratio and age distribution of the turtles. Of the five tested ponds Alec Meadow Reservoir has the most neutral pH of 6.0 while Tamarack, Sutherland, and Sphagnum ponds are the most acidic with average pHs hovering between 4.8 and 5.3 (McKinsey 1997).

The five ponds of Black Rock Forest are interlinked and connected like a chain. Water flows from Sutherland to Tamarack to Sphagnum to Arthur's to Aleck Meadow, then finally flowing through a local water treatment facility (McKinsey 1997). Even though all ponds receive the same amount and same kind of rain, there still exist differences in pH between the ponds. As the water flows from one pond to another, it has more time to be cleaned and buffered by vegetation along the way, becoming more neutral in pH. Because of this, the first three ponds in the chain are the most acidic, and Aleck Meadow, being last in the chain, is the most neutral.

GROWTH RATE

Limpus and Chaloupka (1997) studied the growth rate of sea turtles living in the southern Great Barrier Reef. They discovered that female sea turtles grow distinctly faster than males. The average age of sexual maturity in sea turtles occurs when they are roughly 40 years old. Chaloupka and Limpus noted that females had their biggest growth spurt at about 9 years of age while males grew fastest when they were 11 years old. At sexual maturity when the sea turtles reach full size, females are larger than males. Females have an average curved carapace length (CCL) of 95-100 cm while males have an average CCL of less than 95 cm. Even though sea turtles are a different species than painted turtles, I anticipate they are related enough for painted turtles to have similar growth patterns, on a smaller scale.

While pH and pond health affect the growth rate and health of many pond dwelling organisms, there have been studies denoting a variety of other factors that affect growth rate specifically on turtles. For example, Gibbons (1967) studied three different populations of painted turtles in southwest Michigan. He found each population to have different growth rates. He attributed these variations in growth rate to differences in age, water temperature, and food availability. In regard to food availability, painted turtles are opportunistic feeders, willing to feed on plants or animals, alive or dead. Their diet includes algae, aquatic plants like Elondea and eelgrass, earthworms, insect larvae, tadpoles, and dead fish (Buhlmann, 2009). Although these turtles are omnivores, they tend to prefer a more carnivorous diet. Aquatic insect larvae make up a significant portion of their diet (Cossel, 1997).

Another experiment conducted by Koper and Brooks (2000) tested whether or not growth rate was correlated with food availability and/or amount of time spent basking. They raised 90 hatchlings in a laboratory setting and permitted the turtles different amounts of basking time and fed them either 100 percent or 60 percent of the amount of food required for satiety. Koper and Brooks found growth to be positively correlated with the amount of time spent basking and no correlation between growth and food quantity available.

Mass change in female turtles is also dependent on the reproductive cycle. Eggs add a significant amount of weight to a female as well as detract mass once they have been laid. In the northern Midwest, most nesting occurs between late May and early July (Cossel, 1997). Females reach sexual maturity roughly at age six or with a carapace length of about 160 mm. Some females live beyond 30 years of age. Each nesting season, females of sexual maturity usually produce two clutches, but many also produce three clutches. The time intervals between internesting is on average 16.4 days and decreases towards the end of summer. Clutches usually contain between 4-20 eggs. Egg size is positively correlated with female size, but the spent body mass of females after nesting stays the same proportional to body mass (Koper and Brooks, 2000). Not only does the female lose the weight of the eggs after completion of nesting, she also weighs less than before pregnancy due to using her stored fat to produce the clutch (Congdon and Tinkle, 1982).

MY RESEARCH

A significant amount of research has been conducted on turtle growth in the hatchling and juvenile stages, mass changes in females during nesting the season, various factors that effect growth rate, the general effects of pH on pond life, as well as the abundance of painted turtles located within the Black Rock Forest ponds. I combined all of these topics to address the question of ‘how is the growth rate of the painted turtle (*Chrysemys picta*) affected by pond “health”, as indicated by pH?’ I hypothesize that, like its affect on abundance, a low pH will negatively affect the growth rate of painted turtles. I expect to see a higher growth rate and bigger sizes among turtles from the more pH-neutral Aleck Meadow rather than from the more acidic Sutherland Pond. Because female turtles are generally larger than males, I also expect females to have a faster growth rate than males.

METHODS

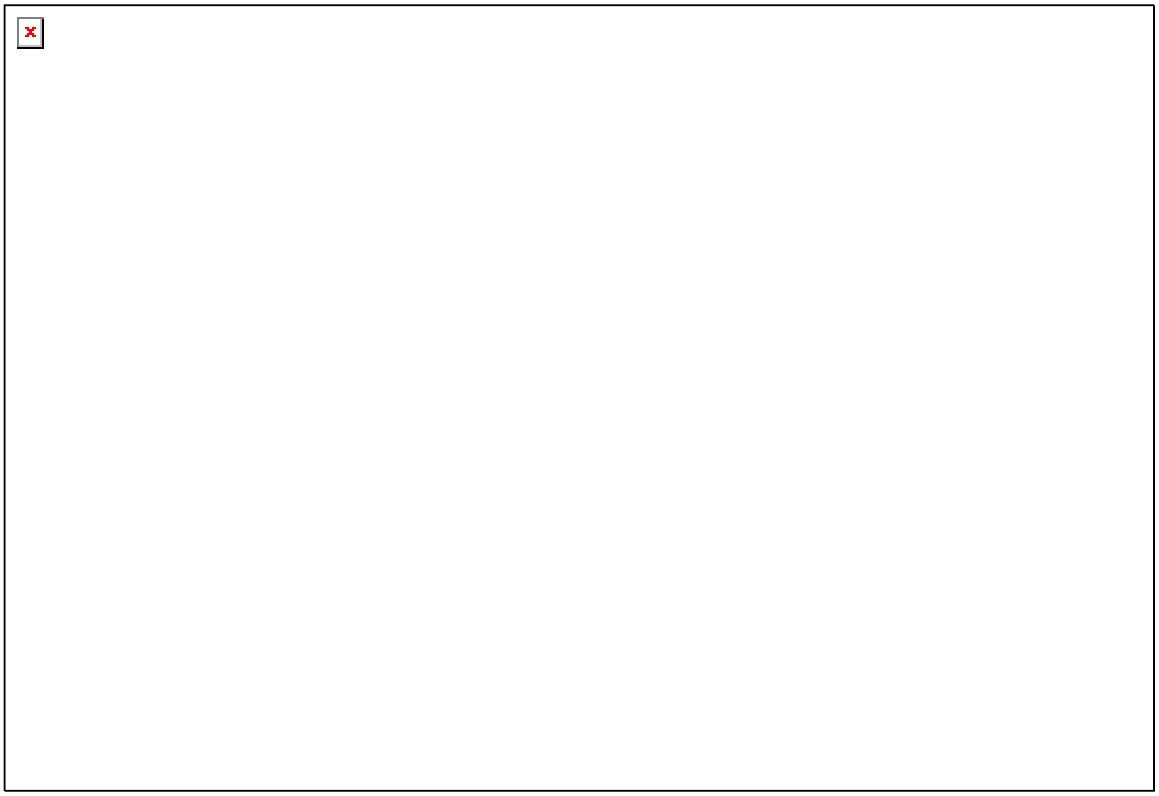
I conducted my trapping at Alec Meadow Reservoir and at Sutherland Pond. I chose these ponds because Aleck Meadow represents a habitat with a relatively neutral pH of 6.0, while Sutherland has a relatively acidic pH of 5.3. I trapped once to several times a week using hoop nets and cat food as bait. I recorded the sex, age, weight, carapace length, width, and height, and plastron length of each turtle. I only used data on turtles that have been previously captured and measured, and did not notch the shell or insert PIT tags into new captures. PIT tags are very small identification chips that have been injected into the back right foot of captured turtles by previous researchers. They are much more accurate in identifying a specific turtle than using the previous method of notching various scoots along the edge of the carapace.

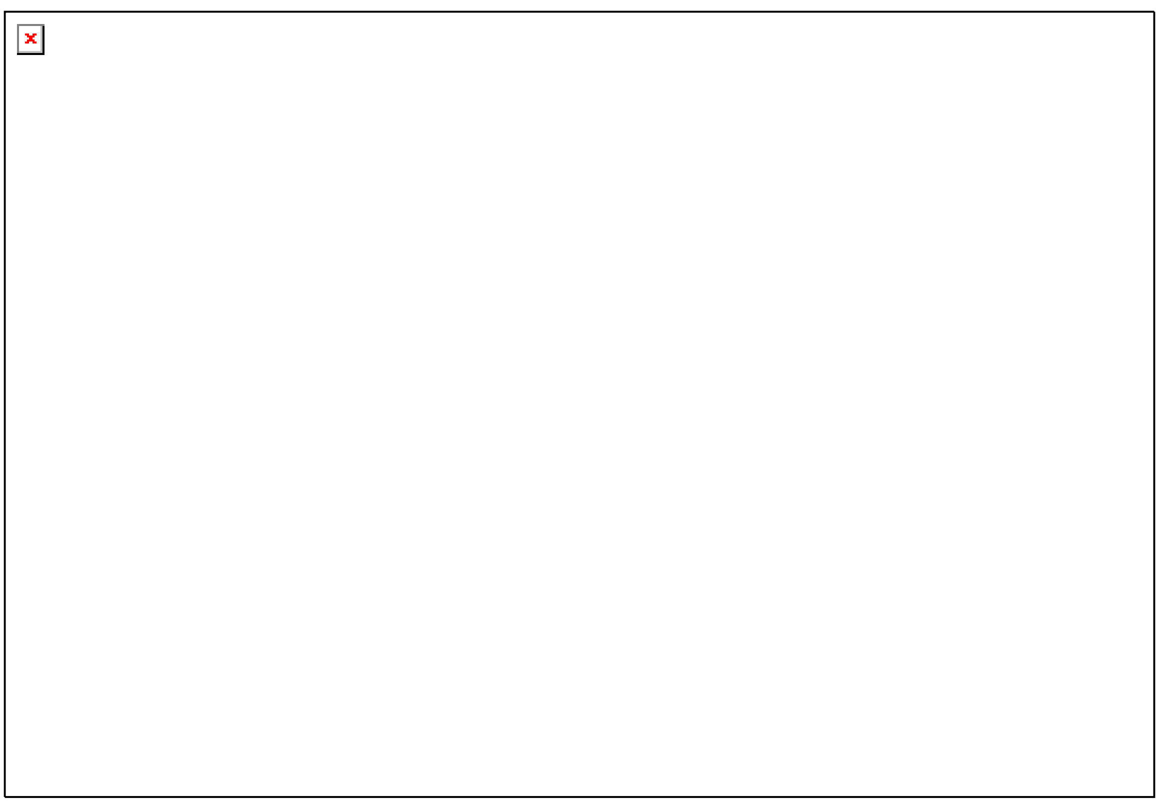
I examined data collected from the past ten to fifteen years and analyzed growth rate patterns of weight over different time periods. I analyzed the data according to categories of turtles based on sex and pond. I used analysis of variance and covariance to test for significant differences in growth between the two ponds. My study does not directly test the impact of pond acidity, and thus will only tests correlations of pH with growth rates.

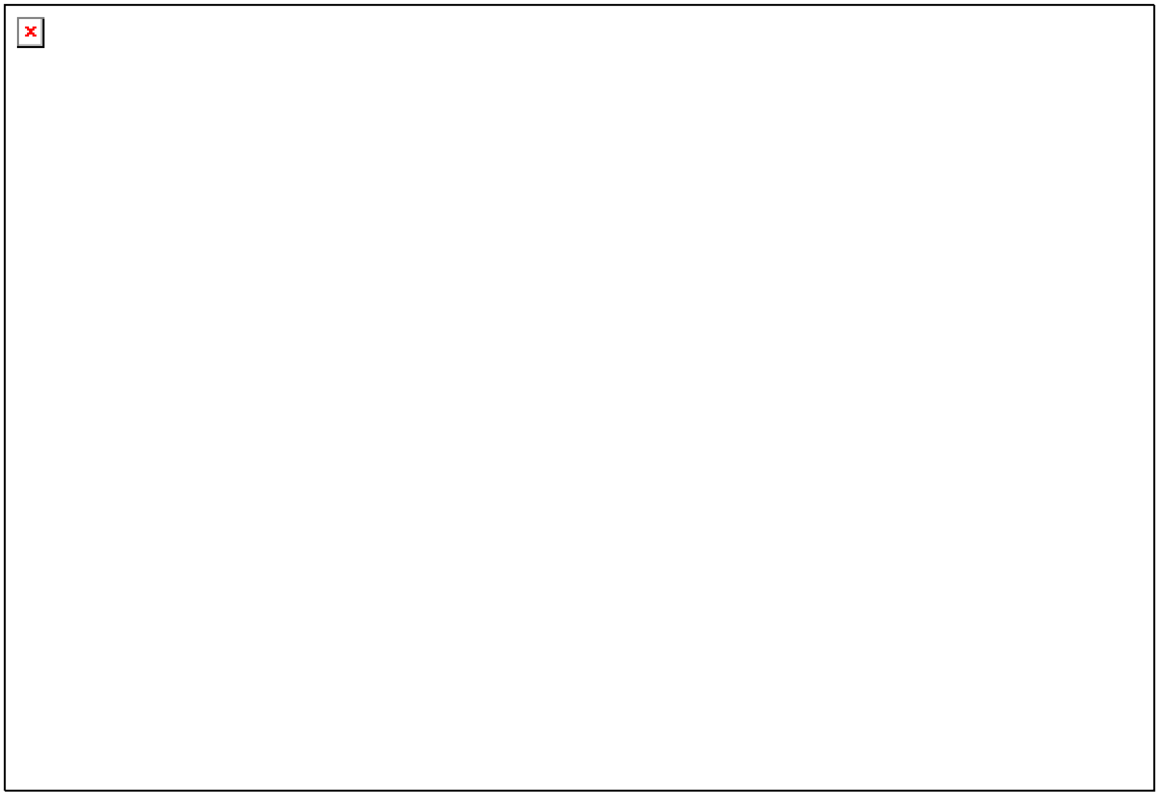
RESULTS

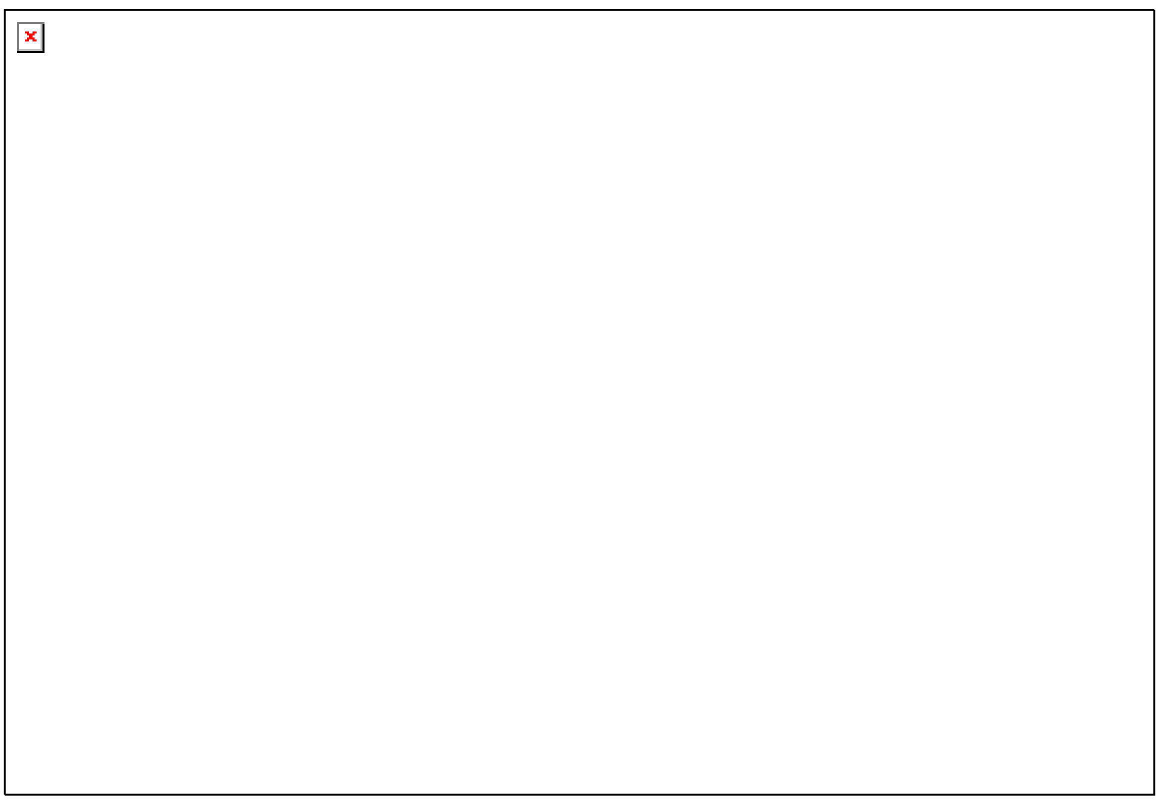
From late June to late July of 2009, 45 tagged painted turtles were caught a total of 79 times. Of these 45 turtles, 40 were found in Aleck Meadow while only 5 were collected from Sutherland Pond. To be able to work with more data from Sutherland, several turtles that were not captured this summer, but that did have several previous recaptures, were also used in the data analysis.

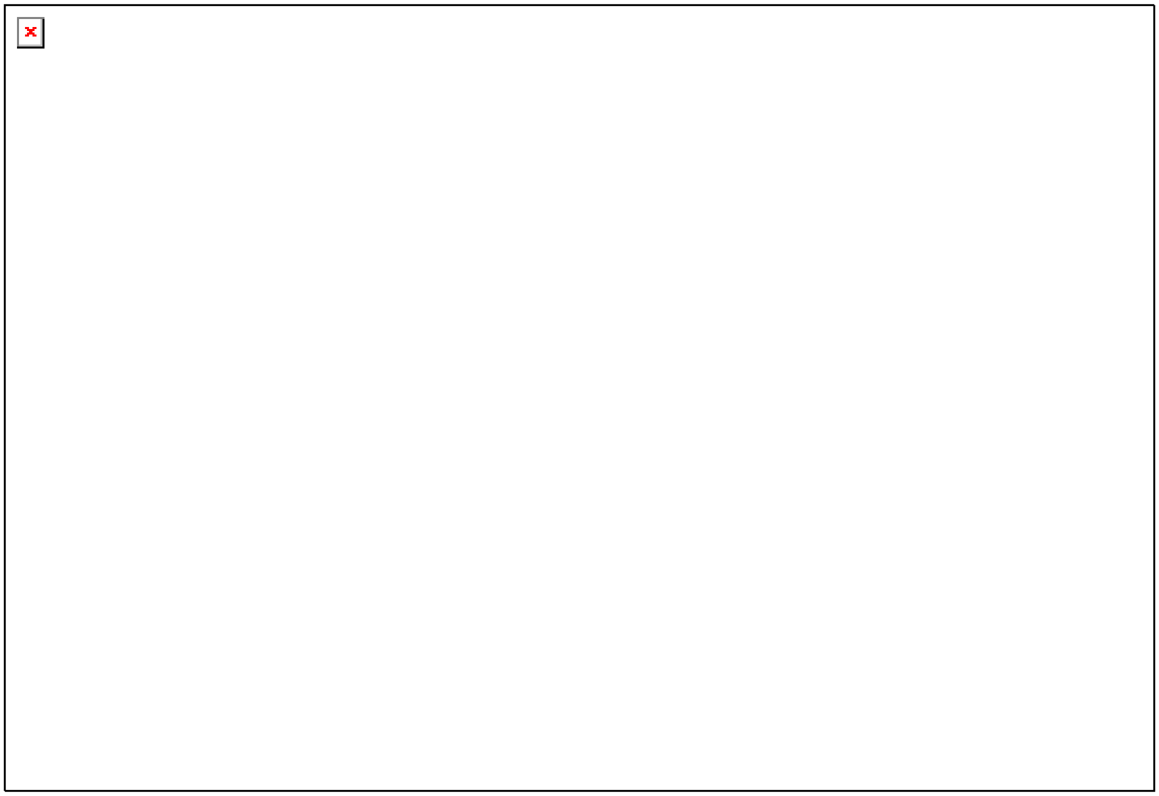
Data for individuals as well as each group as a whole is plotted on the following graphs, along with best-fit linear lines showing the relative slopes of the data. Growth rate of individuals and the mean growth rate are also shown below.

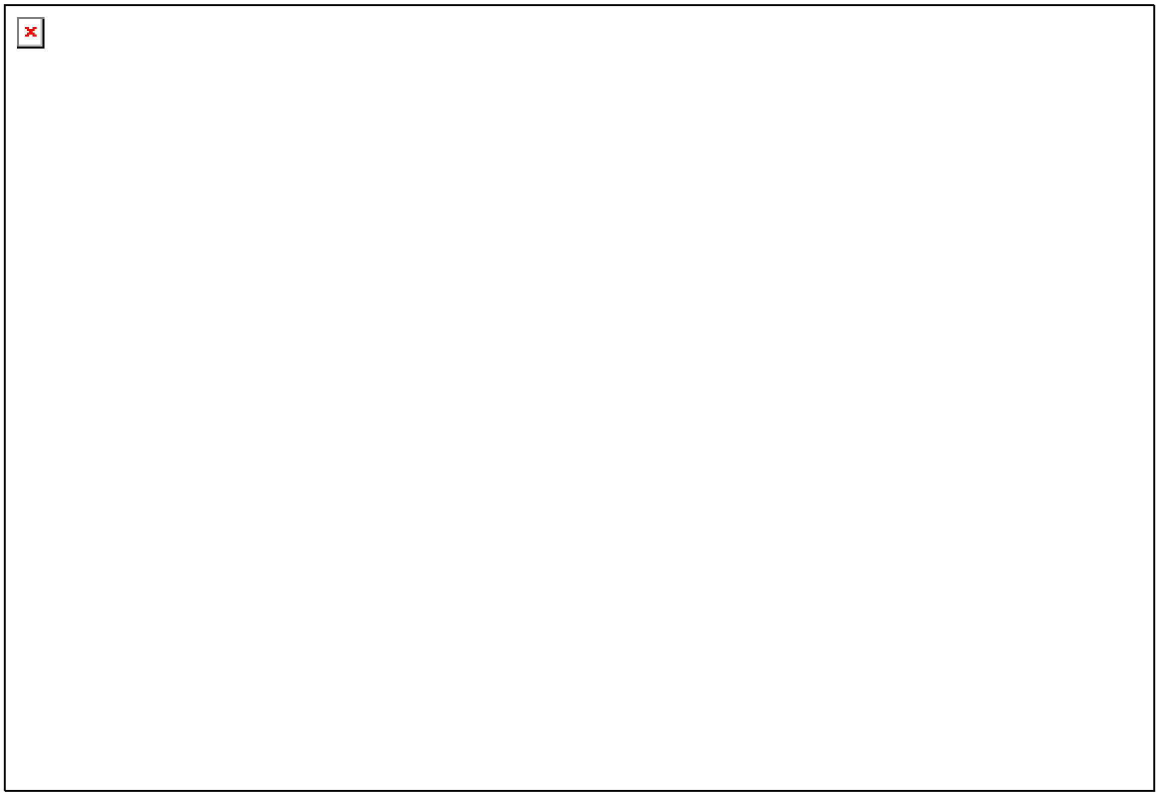


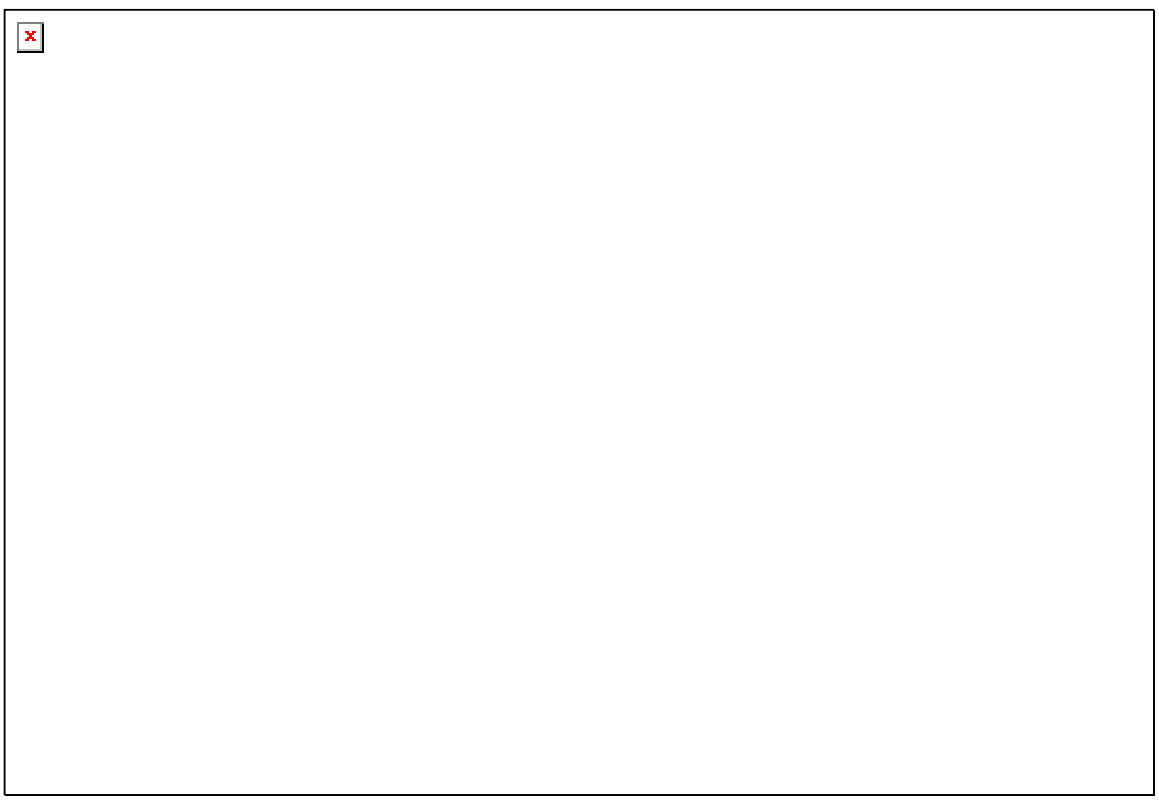












T-test p values:
ALM Females vs. SUT Females: p = 1.08361E-08
ALM Males vs. SUT Males: p = 0.00893
ALM Females vs. ALM Males: p = 0.002961
ALM Females vs. SUT Males: p = 8.62105E-11

Mean Long Term Growth Rate of Painted Turtles in Ponds at Black Rock Forest
(Percent mass change per year)

Location	Mean	Std. Error
Aleck Meadow (ALM)	0.15090672	0.12993946
ALM Females	0.25617147	0.21693424
ALM Males	0.04564197	0.04294467
Sutherland (SUT)	0.01350036	0.02219062
SUT Females	-0.0036712	0.00842185
SUT Males	0.03067192	0.03595939

Individual Long Term Growth Rate of Painted Turtles in Ponds at Black Rock Forest
(Percent mass change per year)

ALM Females	ALM Males	SUT Females	SUT Males
0.04673089	0.00823045	0.01148748	0.05194805
0.01746513	0.07495069	-0.016	0.08955224
0.0160097	0.11764706	0.00433673	-0.0494845
0.02753575	0.0255814	0.00866079	
0.07368893	-0.0128755	-0.0268412	
0.01905823	0.03450895		
0.07384615	0.31538462		
1.24786325	0.02205289		
0.55482815	0.01510417		
1.00621118	0.0083045		
0.09216495	0.0377679		
0.05599566	-0.0365217		
0.04048735	0.00732759		
0.02857143	0.02152466		
0.20470588			
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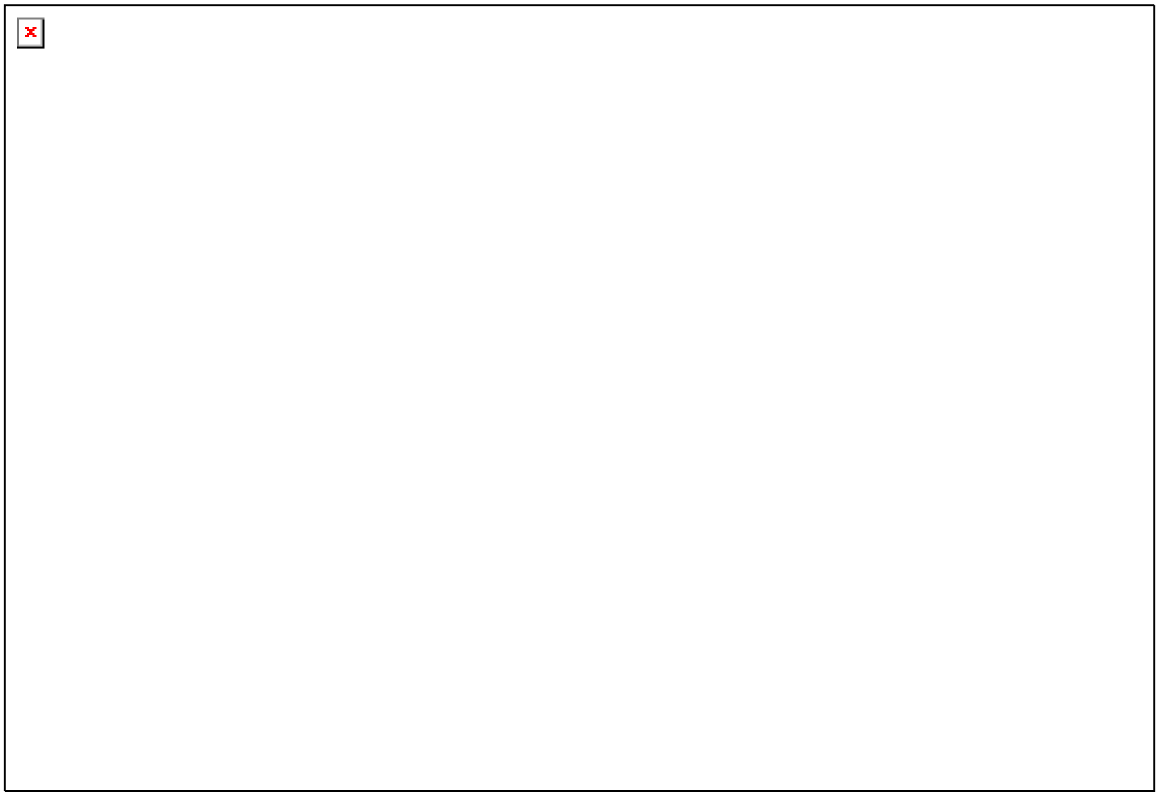

DISCUSSION

My data showed that both female and male turtles from Aleck Meadow have a higher average growth rate than those living in Sutherland Pond. The average growth rate of turtles of the combined sexes from Aleck Meadow is a power of ten larger than that from Sutherland. The growth rate of females in Sutherland was unexpectedly negative, as well as the growth rate of several individuals within each pond. A negative growth rate most likely indicates that an individual is dying, due to sickness, old age, lack of food, etc. The negative growth rate for females in general from Sutherland is most likely due to only a small number of turtles recaptured. If more had been recaptured, the growth rate would most likely be positive as well.

The males from both Aleck Meadow and Sutherland Pond have mean growth rates that are very similar, while the females have drastically different average growth rates. Females from Alec Meadow have a relatively fast growth rate while females from Sutherland Pond have a negative mean growth rate. Previous research has shown that female turtles are significantly larger than male turtles. As the females near or reach sexual maturity, growth rate possibly increases more rapidly than for the males. It is expected that a larger turtle would have a larger growth rate than a smaller turtle. The growth rate of males and females from Aleck Meadow seems to follow this theory. It was unexpected for the females to have a slower mean growth rate than males in Sutherland Pond. Because there was so little data to work with in Sutherland, it is uncertain whether this data is accurate or not. If true, the data signifies that females are more sensitive to an acidic environment than males.

This data is very statistically significant. The p-values comparing males to males and females to females in each pond, as well as males to females of the same pond are all well below 0.05. This shows that there is an actual difference between the growth rates of turtles in different ponds as well as between the different sexes.

Although my results are statistically significant, I do not fully believe my results are a good representation of the growth rate of males or females from Sutherland Pond. To begin with, there are relatively very few painted turtles living in the pond. Unfortunately, of these turtles, there were not many tagged in Sutherland. I caught roughly three times as many untagged as tagged in the pond, many of them being under four years of age. It was interesting to note the amount of juvenile turtles within Sutherland. A future study could compare the number of turtles within certain age ranges in each of the ponds. Possibly the reason why there are so few turtles in Sutherland and that of those few, most of them are juveniles, could be because of the snapping turtle populations within the pond. In Aleck Meadow we did not catch a single snapper while in Sutherland we caught six during my month long trapping period. Snapping Turtles are a predator of the painted turtle. The snapping turtles may have eaten most of the adult, previously tagged painted turtles. Nonetheless, my results may have been much different if there were more than eight turtles to work with.

Examining the data showed that there were both negative growth rates and spikes in growth rate in the long term and short term for some of the turtles. As mentioned earlier, a negative long term growth rate most likely indicates a turtle is dying. On the other hand, there are a variety of factors that can affect a negative or big spike in growth rate for a short term time period. Over the past decade, many different investigators have collected turtle data using different methods to weigh the reptiles. For most of my experiment, we used an electric scale (don't know proper name). Past investigators also used manual hanging scales. Hanging scales generally have an error of 10-15 grams, especially if you have a fidgety turtle. We also learned that some of these scales were not properly calibrated. The variety of scales used throughout this ongoing research definitely leaves some, possibly a large amount of error in the results. In addition to scale variability, short-term drops in mass can be attributed to natural reasons. A few possibilities include scarce food availability, an unusually hot or cold growing season, circumstances leading to not enough time spent basking, or in the case of females, weight loss post-nesting. It would be easier to note technical errors or patterns in weight loss if data was collected less sporadically. With current data, it is difficult to pinpoint reasons for sudden drops or spikes in mass.

Sporadically collected data hindered this investigation in other ways as well. Some turtles have been caught many times throughout their lives and have provided investigators with a great deal of data. Others have only been recaptured once, not allowing me to effectively examine how their mass has changed over time. It would be most beneficial for future scientists if trapping was done every summer at least once a week.

Although it is hard to tell whether my data gives a good representation of the growth rate of turtles in Sutherland Pond, it appears that an acidic environment is not a good habitat for painted turtles. As previous research has shown, the populations of turtles within Black Rock Forest's more acidic ponds are greatly smaller than those in neutral Aleck Meadow. This indicates that in the long-term, not only will there be less turtles living in acidic environments, the turtles will also be smaller than their ancestors. Thanks to current levels of pollution and acid rain, it appears that ponds, streams, lakes, and rivers will only get more acidic with time. This has several important repercussions. Smaller turtles potentially could be weaker competitors in their habitat. They may have a harder time finding food with other, relatively bigger competitors around. They may also be easier to kill and eat if they are generally smaller in size. They would become a more enticing snack for their predators like snapping turtles, snakes, heron, and raccoons. Smaller female turtles would also mean smaller, and possibly fewer eggs laid during nesting. Because of this, the number of painted turtles would most likely diminish in the future; possibly leading to a future endangerment of the species.

If my questionable data is wildly off and painted turtles in acidic conditions have a similar growth rate to those living in neutral water, there would be a much different outcome for the future of the painted turtle. The turtles would maintain the same size and would be no less fit at competing than their ancestors. Over time, they may adapt to the acidic water in that they would become more abundant as well. If this were so, the painted turtles would become more tolerant and adjusted than their predecessors. That could only be plausible if the food sources and habitats of the turtles maintained their current levels, and were not diminished by an acidic environment. Under these conditions, we would not have to worry about the future survival of the painted turtle.

This summer research was a good preliminary experiment. I'd suggest to future researchers to follow this experiment for at least the next three years. It would also be extremely valuable to tag as many new turtles as possible, especially in Sutherland Pond. Even though it did not affect my research, it is unfortunate for future investigators that I was unable to tag the many "new" turtles that I had captured. I believe Black Rock Forest would gain some valuable data if turtles were caught one to four times a week for the next three or more summers. There would be much more data and it would make the patterns and trends more reliable. Most of the tagged turtles at the present were not tagged in the past two or three years, therefore they are more mature. It would also help the data to have additional measurements on more juvenile turtles and to compare their growth rates with those that are older.

CONCLUSION

My results show that turtles living in a pond with a relatively neutral pH do have a higher growth rate than those living in more acidic conditions. The data also shows that females in neutral conditions have a faster growth rate than males, while females living in acidic conditions have a slower growth rate than their male counterparts. This possibly indicates that females are more sensitive to acidic conditions and are more prone to the negative health effects it causes. While the data is statistically significant, the reliability of the data analysis is unsure. Data gathered from Aleck Meadow included 40 turtles while data analysis conducted for Sutherland Pond only included a total of eight turtles for both males and females. This is most likely not a good representation of the painted turtle population within Sutherland as a whole.

Assuming that the data accurately depicts the turtle growth rate in Sutherland Pond, some important conclusions can be drawn. Since the Industrial Revolution, pollution has started to become a major concern for our planet. Acid rain is one of those concerns that especially seems to affect turtles. Our ponds, lakes, and streams have become acidic over time because of the low pH of rain. Even though painted turtles are quite abundant in the United States at the moment, their numbers may significantly decrease in the future. Because pH affects the growth rate of females more than males, fewer eggs may be laid, leading to smaller future populations.

It would be beneficial to this data analysis if this experiment were continued for a few consecutive years to ascertain the accuracy of the Sutherland Pond data. Many more turtles need to be tagged and measurements of their mass taken more regularly in order to gain a better, more reliable perspective on the situation. A few more years of regular, continued research could give Black Rock Forest valuable insights on the growth rate of painted turtles and the direction in which they are headed.

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