Assessing Populations of Painted Turtles (*Chrysemys picta*) in Ponds at Black Rock Forest, NY



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May 1, 2012

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Abstract:

Painted turtles (*Chrysemys picta*) are the most widespread turtles in North America and are one of the most studied species of turtles in the world. The ponds of Black Rock Forest (BRF) are the home to several species of turtles, among these is the painted turtle. However, there have been no recent studies on painted turtle populations at BRF. This study examined the population of painted turtles in three of Black Rock Forests' ponds: Upper Reservoir, Aleck Meadow Pond and Sutherland Pond. Turtles were trapped, marked and recaptured for two consecutive summers and the population size, sex ratio, and age structure were determined. Analyses showed that the population for all three ponds has not changed significantly over the years but a slight increasing trend is apparent. In addition, in all three ponds the sex ratio is close to 1:1 and there are significantly more adults than juveniles, as is expected in a painted turtle population. These findings indicate that the populations appear to be healthy. The data collected, as well as the results found will help in future studies and in the management of painted turtle populations in the ponds at BRF.

Introduction:

Population dynamics is the study of changes in population size and age structure over time. Three main topics included in the study of population dynamics are population size, sex ratio, age structure. Understanding the importance these topics is crucial for the study of population dynamics (Gotelli, 2008). Population size is an indicator of the abundance and stability of a population. Populations of some organisms tend to be small; however, if there is a small population of an animal that is expected to live in a large population it may indicate that something is seriously wrong with that particular population (Gotelli, 2008). Sex ratio is important in the process of sexual reproduction since it helps with recruitment of new individuals into the population. In addition, it was found that sex ratio affects population dynamics in general (Ranta et al, 1999). Lastly, age structure also has an impact on the population as a whole. It can be used as an indication of the reproductive capabilities and likelihood of the continuation of a species (Gotelli, 2008). These concepts are important for ecologists because they help in the management and conservation of different species of organisms.

There have been few studies of populations of turtles. The major difficulty in these population studies is acquiring an adequate number of captures and recaptures from which data can be calculated. In addition, these studies require the monitoring of the same populations over an extended period of time (Ernst, 1971). However, turtles play an important part of ecosystems and they can be indicator of the health of that particular ecosystem (Tabor and Aguirre, 2004).

Painted Turtle Biology

Painted turtles are the most widespread turtle species in North America and are the only species whose range spreads across the continent. *Chrysemys picta* is a small turtle with a smooth, flattened and oval carapace, or the dorsal part of the shell (Figure 1a). It has twelve marginal scutes, plates made of keratin that cover the shell, on each side. It is olive to black-colored with yellow or red borders along the seams. The plastron (Figure 1b), or bottom shell, is generally yellow but may have brown or red markings. The body is also olive to black with yellow and/or red markings along the neck, legs and tail. Males are generally smaller in size than females and can be distinguished by their longer nails and their cloaca, which is posterior to the rim of the carapace, whereas female have shorter nails since they are worn down when nesting (Ernst and Lovich, 2009). There are four recognized subspecies of painted turtles in the United States but the one living in the northeastern United States is the eastern painted turtle, *Chrysemys picta picta*. This subspecies ranges from southeastern Canada to Georgia and westward from the Atlantic coastal states into eastern Alabama. However, the subspecies may intergrade or hybridize, especially near range boundaries (Ernst and Lovich, 2009). Because *C. picta* is a semi-aquatic species, individuals of this species prefer slow-moving, shallow bodies of freshwater such as ponds, lakes, marshes and swamps. Painted turtles prefer habitats with soft, muddy bottoms in order to bury themselves and hibernate during the winter, plenty of aquatic vegetation and abundant basking sites, as basking is important for thermoregulation (Ernst and Lovich, 2009).



Figure 1a. Carapace of a painted turtle.



Figure 1b. Plastron of a painted turtle.

Factors That Affect Turtle Populations

The population density of painted turtles has decreased over the years in some locations (Gervais et al., 2009). There are many factors, both natural and anthropogenic, which affect turtle populations and may affect individuals at different life stages. Nest predation by animals such as raccoons, foxes and chipmunks has been shown to affect turtle populations (Christens and Bider, 1987; Snow, 1982). Due to nest predation, there is no juvenile recruitment, disproportionately affecting population growth and thus skews the age structure of the population. Predation can also decrease the population size because as time goes by, old turtles die but few new turtles are born into the population (Snow, 1982). Primary productivity is another factor that affects the density of turtles in a given area (Galbraith et al., 1988). This is expected, as food availability will determine the size of a population in a given area. Interspecific competition is another factor which might

affect the population size. Snapping turtles (*Chelydra serpentina*) are another species of turtles that are quite territorial and might compete with painted turtles for resources (Aengenheyster, 1998). A factor that has been found to affect the density of the turtle populations, specifically at Black Rock Forest, is pH. The acidity levels of the ponds causes the population density to decrease because pH not only affects the turtle's growth rate, but also affects the entire pond community including the plants and other organisms that feed off them, thus affecting the turtle population size that feeds off these other organisms (McKinsey, 1997). However, the factors that have contributed the most to the decline of freshwater turtle populations in recent years are loss of habitat due to development, pollution and wetland changes in areas of rapid development (Steen and Gibbs, 2004; Marchand and Litvaitis, 2004; Gervais et al., 2009). These new developments have driven turtle populations out of their original habitats and have forced them to migrate. Migrating turtles are often forced to find new habitats and in some cases they have to cross roads and highways leading to high levels of road mortality. It is important to note that road mortality not only affects the age structure of a population since it is a leading cause of adult mortality but it also skews sex ratios since many adult females are killed when migrating to find nesting locations (Steen and Gibbs, 2004).

Previous Painted Turtle Studies

There have been a few studies on painted turtles in several different locations in the northeastern United States that can be related to the populations of Black Rock Forest, the study site for this research. One of these studies was conducted near Albany, NY. It was found that the sex ratio was 1.4 males: 1 female and that the juvenile to adult ratio in this

population was 1:5 (Bayless, 1975). Another study done in Southeastern Pennsylvania found that the sex ratio in this location was 1:1 and that the juvenile to adult ratio was 1:4 (Ernst, 1971). Lastly, an 18 year-long study conducted in Long Island, NY found that the male to female sex ratio fluctuated between 0.62:1 and 1.80:1 and that males dominated for 11 of the 18 years that the study took place. In terms of the age structure, the adult to juvenile ratio ranged between 0.45:1 and 6.33:1, with a mean of 2.16:1 and the adults dominated for 14 of the 18 years of the study (Zweifel, 1989). At Black Rock Forest few studies have been done on painted turtles (McKinsey, 1997; Aengenheyster, 1998). Both of these studies show that Aleck Meadow is the pond with the largest population size, followed by Sutherland. However, Upper Reservoir was not included in either study but there are some previous data that can be used for comparison. In addition, both studies at BRF showed that the male to female ratio was 1:2 in Sutherland Pond and 3.2:1 in Aleck Meadow and that the adult to juvenile ratio was 2.14: 1 in Sutherland and 3.3:1 in Aleck Meadow.

Goals and Predictions

No recent studies have been done on the painted turtle populations in the ponds at Black Rock Forest (William Schuster, personal communication). For this reason, this research will examine the population of painted turtles in three of the ponds at Black Rock Forest: Upper Reservoir, Aleck Meadow and Sutherland Pond, in order to assess the population and examine the population dynamics, which will help in future studies and the management of this species.

The goals of this study are to estimate the population size of painted turtles, find the male to female ratio and determine the age structure in each of the three ponds at Black Rock Forest. In addition, the results found from this study will be compared to data from previous years in order to determine if there have been any changes in the turtle populations. Previous studies indicate that Aleck Meadow is the pond with the largest painted turtle population, therefore, it is expected that this pond will continue having the largest painted turtle population. In addition, it is expected that the sex ratio will be slightly skewed since it is only 1:1 in ideal populations and has been found to be skewed in the previous studies that were done at BRF. Finally, since there is not a lot of juvenile recruitment due to predation (Ernst, 1971; Wilbur, 1975; Aengenheyster, 1998) and because painted turtles have a long lifespan (Ernst and Lovich, 2009), it is expected that there will probably be more adults than juveniles at any census.

Methods:

Study Site

Black Rock Forest (BRF) was originally established as a facility for forest management research in 1928 and it is now one of the nation's most active field stations specializing in research and education. Black Rock Forest (Figure 2) is located in the Hudson Highlands in Cornwall, New York, 50 miles north of New York City, and is a 3,800 acre green area. In the forest, there are seven ponds that total about 100 acres. Three ponds were surveyed for this study: Upper Reservoir, Aleck Meadow and Sutherland Pond. Of these ponds, Sutherland is the only natural one and is approximately 12,000 years old. Upper Reservoir and Aleck Meadow are man-made and were constructed as water storage reservoirs for the town of Cornwall between 1920 and 1935. Currently, they provide the town's main water supply. In terms of elevation, Sutherland Pond is the highest at 380m, followed by Aleck Meadow with 314m and Upper Reservoir is the lowest at 298m. Lastly, in terms of surface area, Upper Reservoir is the largest one with a surface area of 6.1 ha, followed by Sutherland with 4.1 ha and Aleck Meadow is the smallest one with a surface area of 3.0 ha (Adirondack Lake Survey, 1987).

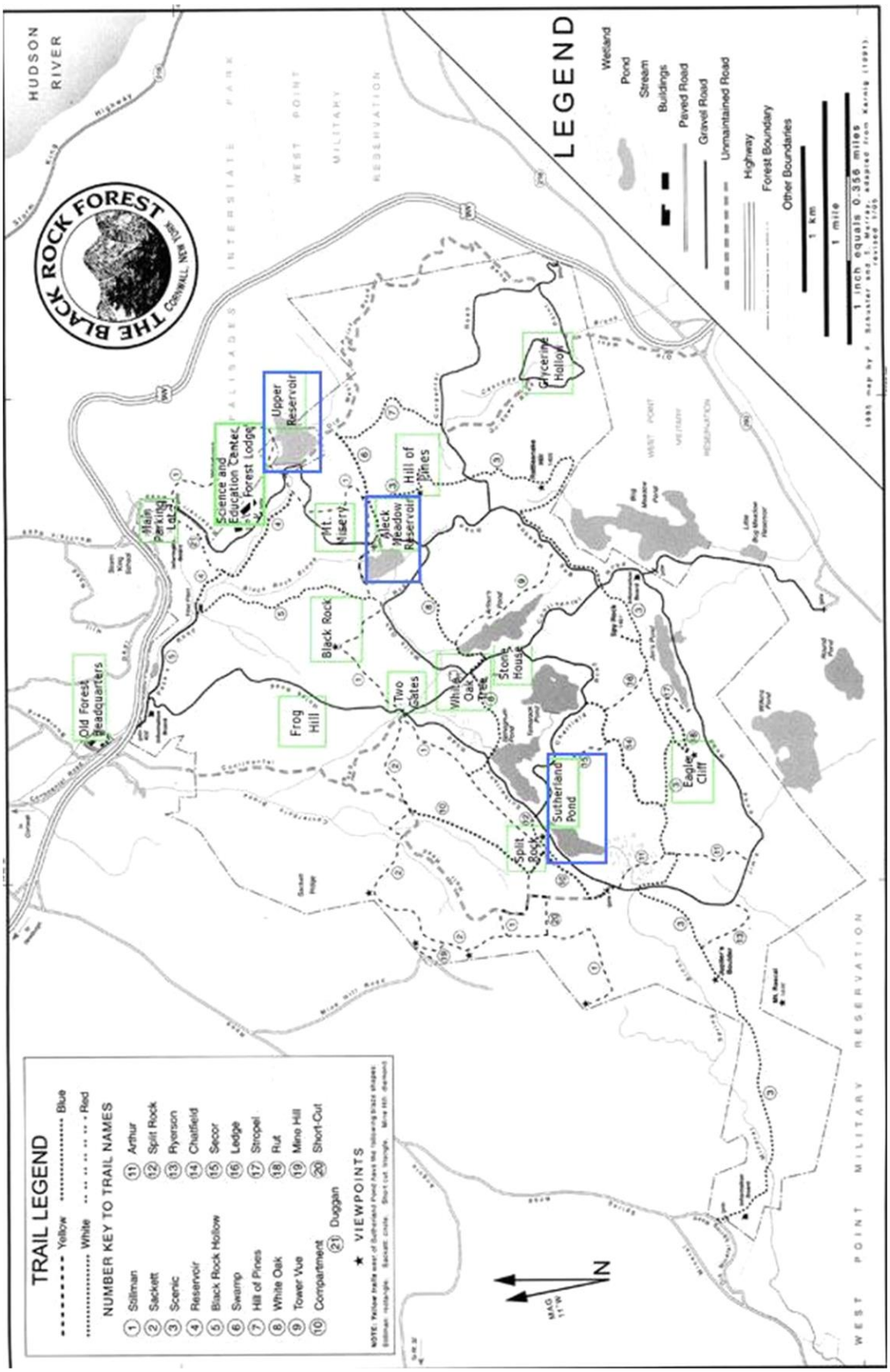


Figure 2. Map of Black Rock Forest with the studied ponds enclosed in blue boxes.

Trapping method

Data collection took place in Upper Reservoir, Aleck Meadow and Sutherland Pond at Black Rock Forest over the summers of 2010 and 2011. Two traps were set in each pond at the beginning of the summer season (Figure 3). These traps were strategically placed near areas where painted turtles were most likely to be found, such as in areas with logs or large stones for basking or in muddy or swampy locations. If no turtles were captured after a few days, the trap was moved to a new location. Painted turtles were trapped daily for 10 weeks by using a hoop trap, a widely used piece of equipment for this purpose (Ream and Ream, 1966; Gamble, 2006). The trap was baited with a can of sardines in oil and it was then placed in the water, pulling the string taut so that trap was completely open and the string was then placed around a stake in the mud. Finally, the trap was slightly buried in the mud so that it didn't move around, making sure that there was an area above water, allowing captive turtles to breathe. The turtle trap was checked the following day and if there were turtles present, the trap was removed from the water and brought to a dry area on land to take their measurements.



Figure 3. A baited hoop trap placed in the water.

Data Recording

Each turtle was taken one by one out of the trap. First, the turtle's right hind leg was placed near the passive integrated transponder (PIT) tag reader to see if it had previously been captured and if it had, the number that appeared on the reader was noted. If a PIT tag was not detected, it was checked for notches on the marginal scutes of the carapace and if it had any, the combination was noted. If it did not have a tag or mark, it was considered a newly captured turtle.

To determine the sex of the turtle, the turtle was flipped over so that the plastron was on top. The tail was gently pulled out until it was completely straight. The turtle was identified as a female if the cloaca was directly in line with the carapace and it was identified as a male if it was farther down from the carapace.

All length, width and height measurements were taken using calipers, in millimeters. The length and width of the carapace were measured at the longest and widest point

respectively. The height of the turtle was measured. The length of the plastron (bottom shell) was measured (Figure 4). The mass of the turtle was measured using a digital scale. The pattern of the lines of the plates was observed to determine the subspecies of the turtles. If they were straight, it was identified as an eastern painted turtle (*Chrysemys picta picta*), and if they were crooked or zigzagged, it was identified as a hybrid between an eastern painted turtle and a midland painted turtle (*Chrysemys picta marginata*) (Ernst, and Lovich, 2009). The approximate age was determined by counting the growth rings on the carapace (Sexton, 1959; Wilson et al., 2003) and if the rings were too worn to count, it was just identified as "worn" and categorized as an adult. However, due to the uncertainty in this method, the plastron length (PL) was also used to determine the relative age of the turtles. If the PL < 100mm, it was classified as a juvenile and if the PL ≥ 100mm, it was classified as an adult (Ernst and Lovich, 2009; McKinsey, 1997).



Figure 4. Measuring the plastron length of a painted turtle with the calipers.

Passive Integrated Transponder (PIT) Tagging Procedure

Turtles that had not been previously captured or marked were marked by PIT tagging them. PIT tags are electronic microchips, about the size of a grain of rice, about 8-14mm long and 2mm in diameter. They are a reliable means of giving individual identification codes to animals (Gibbons and Andrews, 2004).

Turtles were first scanned using a Biomark hand-held reader to make sure that they didn't have a PIT tag. If no tag was located, the area where the tag would be applied (right hind leg) was identified, swabbed with antiseptic Betadine and allowed to dry. The tagging equipment, which included the Biomark MK7 Implanter and the Biomark HPT8 8.4mm tags were sterilized with alcohol prior to being used. The turtle's leg was held firmly so that it didn't move and the tagging needle was inserted at an acute angle approximately ¾ of an inch beneath the skin (Figure 5). The plunger was used to insert the tag through the needle. A piece of cotton or gauze with antiseptic was placed over the needle entry point and the needle was carefully removed. Pressure was applied to the needle entry point for about a minute to make sure the bleeding had stopped and Betadine was applied again to prevent infection. The PIT tag reader was used to read and verify the number.

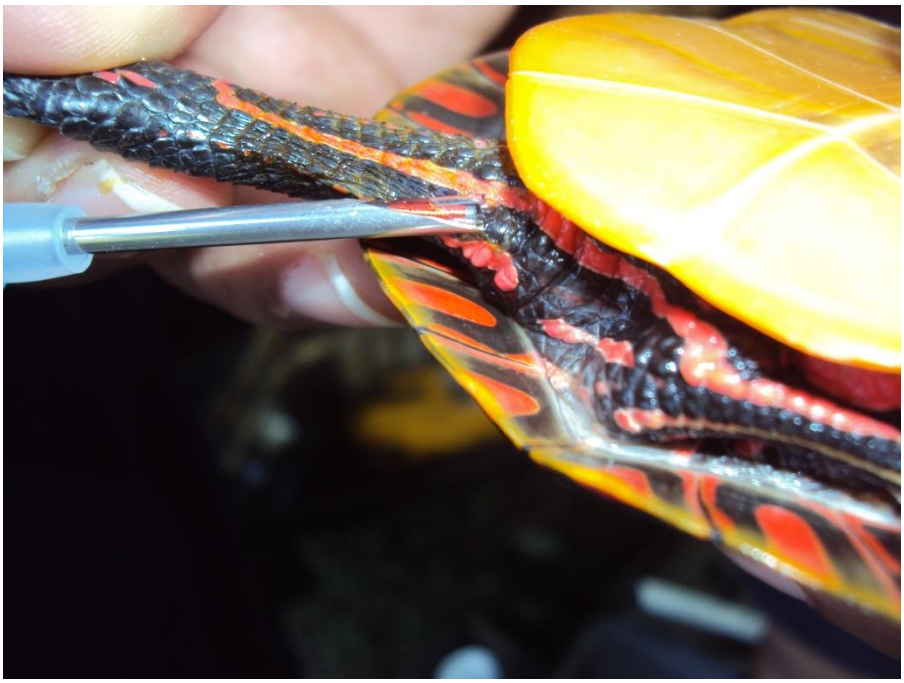


Figure 5. Painted turtle being PIT tagged.

Data Analysis

The mark-recapture (M-R) method is one of the most common ways to study populations and estimate the population size of mobile animals. Populations of large mammals such as grizzly bears (Mowak and Strobeck, 2000) to populations of sea bass (Fritsch et al., 2007) have been studied using this method. The total size of a population is found using the equation ***N=MC/R***, where *N* is the estimated population size, *M* is the total number of marked individuals, *C* is the total number of captures during the second capture period and *R* is the number of marked individuals that were recaptured (Wilbur, 1975) .

However, three basic assumptions are made when using the mark-recapture method to estimate the population size of an organism. The first and most important assumption is that the population is a closed one, meaning that there are no births or deaths and no migration in or out of the population that might cause changes in the

population size. Second, the M-R method assumes that each member of the population has an equal probability of capture. The last assumption made is that the marking must have no effect on the behavior of the animals, meaning that the marked individuals should not easier, “trap-happy”, nor harder, “trap-shy”, to catch after they are marked (Koper and Brooks, 1998; Zippin, 1958).

The data were analyzed using the program MARK, which uses the mark-recapture method to provide population estimates from marked animals when they are reencountered at a later time (White and Burnham, 1999). In order to estimate the total population size in each pond, the data first had to be reformatted to a binary system in which the capture history of each individual was written where 1 represented each time the individual was captured and 0 represented each time that the individual was not captured. This process was repeated for all individuals in all three ponds for both 2010 and 2011. Then, the standard closed capture model was selected in the program MARK and the data were then entered and analyzed.

In addition, the data was graphed using Excel in order to examine the sex ratio and the age structure of each pond. SPSS was then used to statistically analyze the data. A two-way ANOVA test was used to analyze the data using pond and year as factors, to determine the statistical significance of the results in order to be able to compare the findings across ponds and years. Finally, a chi-squared test was used to determine if there was a significant difference between the number of males and females and juveniles and adults in all three ponds for 2010 and 2011.

Results:

Population Size

A summary of the individuals captured, recaptured and percent recaptured for both trapping seasons combined are given in Table 1. Aleck Meadow had the largest number of individuals that were captured as well as recaptured, followed by Upper Reservoir and finally Sutherland Pond.

The pond with the largest apparent population size is Aleck Meadow, since it appears to have the largest estimated number of turtles in all four years, followed by Upper Reservoir, while Sutherland appears to have the smallest population size (Figure 6). The two- way ANOVA result, p= 0.074, indicates that there is no significant difference between the population size in all three ponds for all four years. In addition, even though there are fluctuations in size over the years, overall, there appears to be a slight increase in population over time in all three ponds.

Table 1. Shows the individual painted turtles captured and recaptured in Aleck Meadow, Upper Reservoir and Sutherland Pond in the two trapping seasons combined (2010-2011).

Chrysemys picta Trapping data summary			
	Aleck Meadow	Sutherland	Upper Reservoir
Individuals captured	53	30	38
Individuals recaptured	27	7	17
Percent recaptured (%)	50.9	23.3	44.7

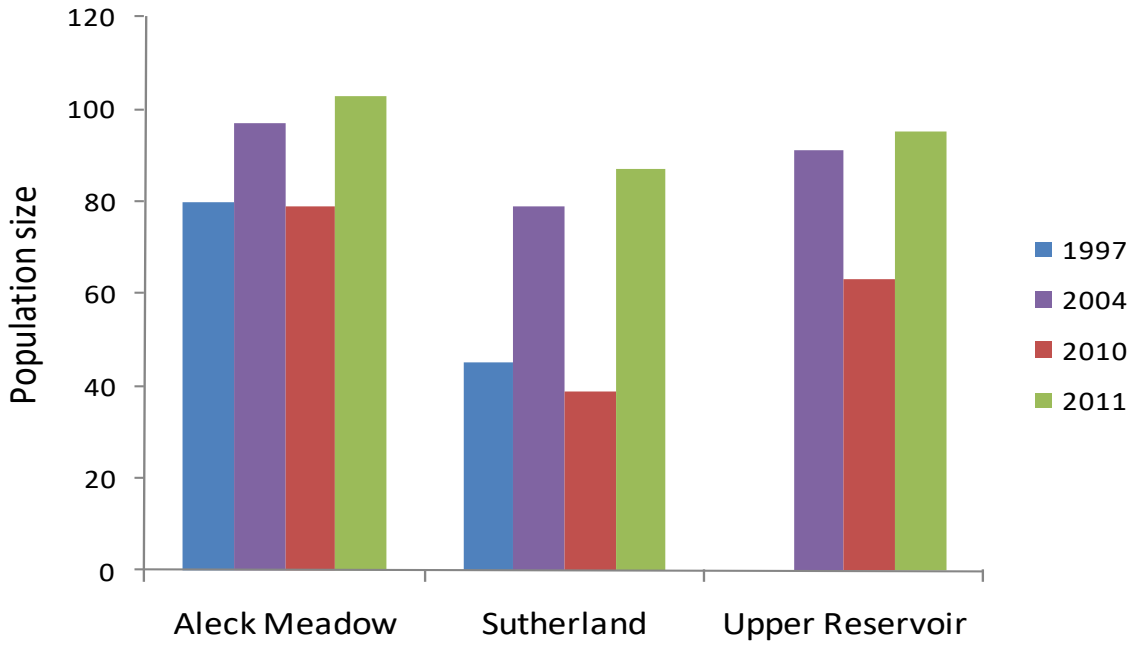


Figure 6. Estimated population size of painted turtles in Aleck Meadow, Sutherland Pond and Upper Reservoir for 1998, 2004, 2010 and 2011.

Sex Ratio

The sex ratio of the turtles for both trapping seasons varies by pond. In 2010, the sex ratio in Aleck Meadow was fairly close to 1:1, there were only 7.1% more females than males (Figure 7a). However, only males were captured in Sutherland Pond and there were twice as many males than females in Upper Reservoir. In 2011, the sex ratio in all three ponds appeared to be closer to the desired 1:1 ratio (Figure 7b). Both Aleck Meadow and Sutherland appear to have more males than females, while Upper Reservoir had more females than males. Aleck Meadow had 37.5% more males than females, while Sutherland had 63.6% more males than females. Upper Reservoir had 18.3% more females than males. In addition the chi-squared tests indicated that there was no significant difference between the number of females a males in all three ponds for both 2010 and 2011 since all p-values are over 0.050.

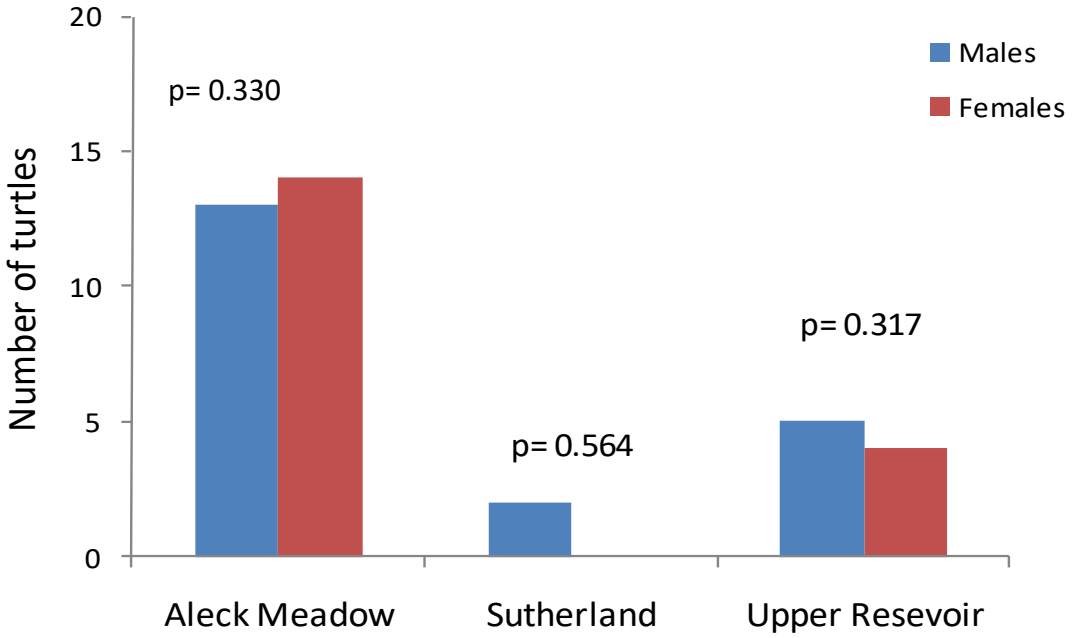


Figure 7a. Number of male and female painted turtles in Aleck Meadow, Sutherland Pond and Upper Reservoir in the 2010 trapping season.

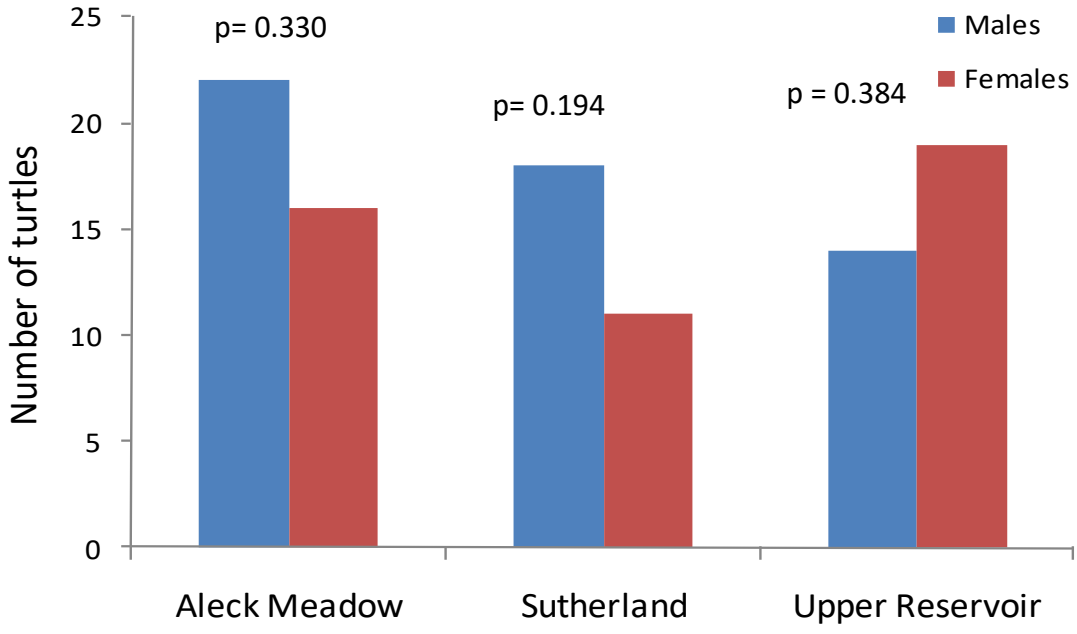


Figure 7b. Number of male and female painted turtles in Aleck Meadow, Sutherland Pond and Upper Reservoir in the 2011 trapping season.

Age Structure

The age structure for all three ponds during both 2010 and 2011 appears to be consistent in that there are more adults than juveniles in all three ponds (Figures 8a and 8b). However, it is important to note that due to the small sample of painted turtles during 2010, only adults were captured in both Upper Reservoir and Sutherland Pond. The chi-squared test showed that there is a significant difference between the numbers of adults and juveniles in all three ponds for both 2010 and 2011, as the p-values indicate ($p<0.050$). However, the only exception to this was Sutherland Pond in 2010 ($p=0.564$) (Figure 8a).

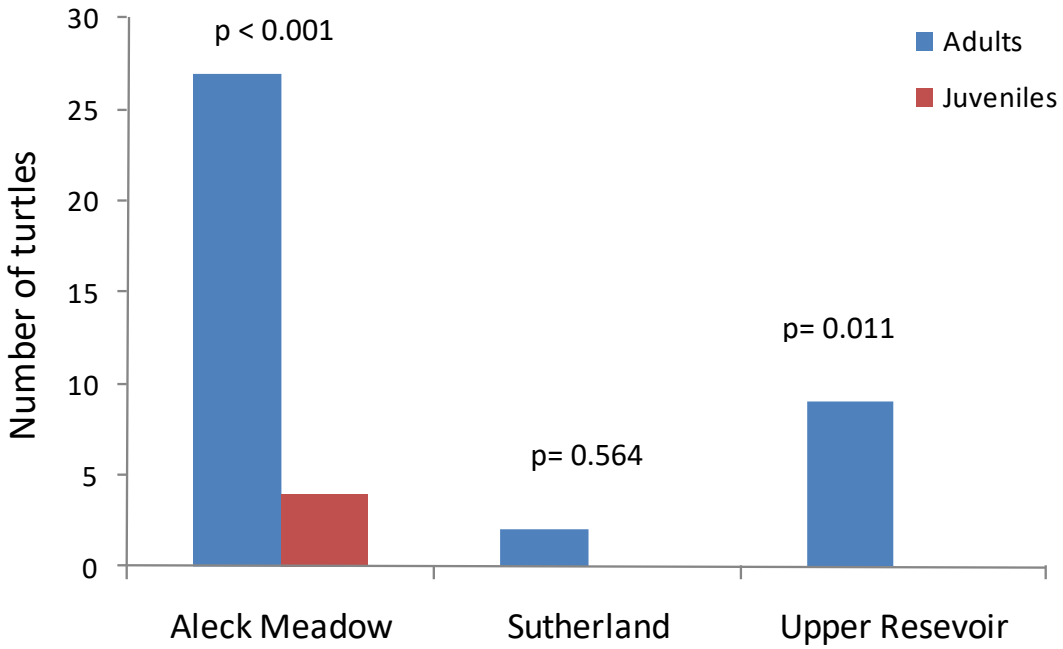


Figure 8a. Number of adult and juvenile painted turtles in Aleck Meadow, Sutherland Pond and Upper Reservoir in the 2010 trapping season.

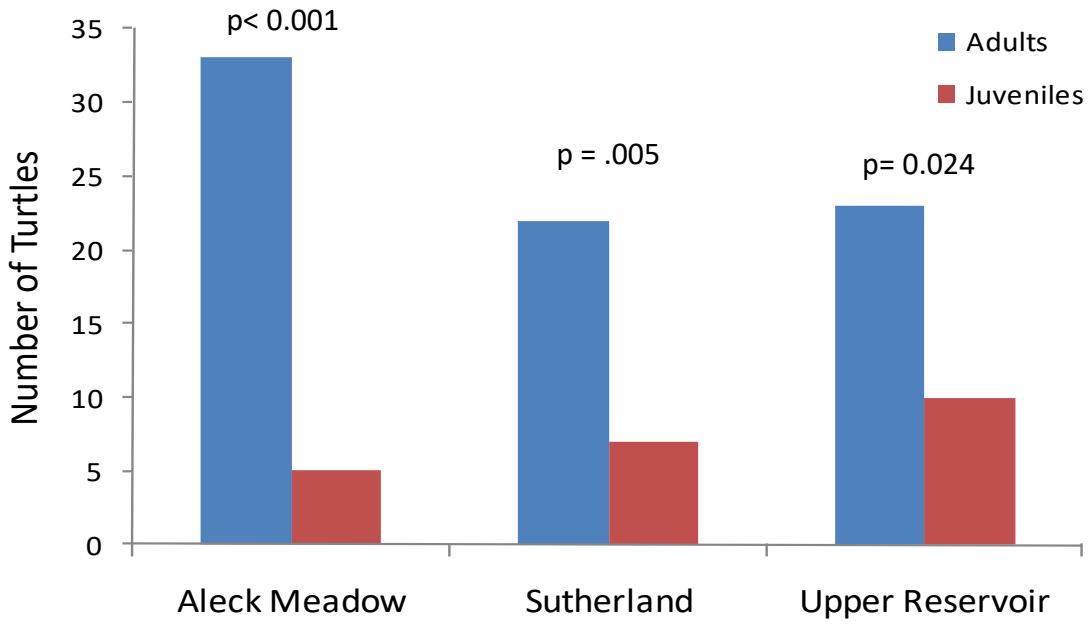


Figure 8b. Number of adult and juvenile painted turtles in Aleck Meadow, Sutherland Pond and Upper Reservoir in the 2011 trapping season.

Discussion:

Population Size

Aleck Meadow had the largest number of individual turtles that were captured, as well as the largest number of recaptures, which initially suggests that this is the pond with the largest painted turtle population. Similarly, since the least number of individual turtles were captured in Sutherland, it suggests that this pond had the smallest painted turtle population. These conjectures were confirmed after analyzing the data using the MARK program since it was estimated that overall, Aleck Meadow had the largest population size, followed by Upper Reservoir and Sutherland Pond had the smallest population size. These results are in agreement with the previous studies done at BRF (McKinsey, 1997; Aengenheyster, 1998), which also found that Aleck Meadow had the largest population size.

There are many factors that can possibly explain these results. Aleck Meadow is known for being one of the best spots in Black Rock Forest for catching painted turtles (William Schuster, personal communication). This is probably due to the suitable habitat, which consists of muddy banks, plenty of basking areas and abundant tree cover. Out of the three ponds, Sutherland probably had the least suitable habitat since it has a rocky bottom, which is not suitable for painted turtles since they require muddy bottoms to bury themselves to hibernate (Ernst and Lovich, 2009).

The presence of other species of turtles is another factor that might influence the population size in these ponds. In addition to painted turtles, snapping turtles (*Chelydra serpentina*) also inhabit these ponds. In Aleck Meadow and in Upper Reservoir there was only one observation of a snapping turtle, whereas in Sutherland Pond there were 6 observations of snapping turtles in both trapping seasons combined. It is possible that

competition for resources between these two species can affect the overall population size of painted turtles (Aengenheyster, 1998).

The population for all three ponds fluctuates during the four years that were examined. The population estimates for 1997 and 2010 are smaller than the ones from 2004 and 2011. These fluctuations in population size are normal since the estimate is dependent on the number of individuals captured each year (Zweifel, 1989). The population estimate for Aleck Meadow and Sutherland from 1997 is not very different from the estimate from 2010 but it is smaller than the population estimate from 2004 and 2011. However, when comparing the population size estimate between 2010 and 2011, an increase in population size can be observed. This might be due to two possible reasons. The first, is that the population actually increased, although this is unlikely since painted turtle populations don't usually increase this fast and there would have had to been more juveniles in 2011, which were not observed in Aleck Meadow. There was an increase in juveniles captured in Sutherland and Upper Reservoir but these cannot be considered the result of an increase in population. The other reason why the population size might seem to be increasing from 2010 to 2011 is because of increased trapping effort. Because few turtles were captured in Sutherland and Upper Reservoir in 2010, there was an increased trapping effort in these two ponds, which means that that the traps were moved to more suitable locations in the case that no turtles were captured after a few days.

Lastly, the p-value obtained from the two-way ANOVA was 0.074, which is larger than p= 0.050, which indicates that there is no significant difference between the population size for all three ponds in all four years. This indicates that the populations in all three ponds have not changed significantly over time and therefore are stable.

Sex Ratio

The sex ratio for 2010 appeared to be even in Aleck Meadow, where there was just one more female than male. The chi-squared test indicated that there was no significant difference between the observed numbers of males and females in the pond since p= 0.847, meaning the sex ratio could very well be 1:1. There were only males in Sutherland, which is very likely due to the very low number of turtles captured. In Upper Reservoir the male to female ratio was 2:1 but this again, might be due to the small sample size in that pond. However, p-values for both ponds were over 0.050, p= 0.564 for Sutherland and p=0.317 for Upper Reservoir, meaning that there was no significant difference between the observed numbers of males and females.

In 2011, the sex ratio for all three ponds changed; they were still pretty close but none of them was exactly 1:1. Aleck Meadow and Sutherland had slightly more males than females with a 1.4: 1 and a 1.6: 1 ratio, respectively. Conversely, Upper Reservoir had more slightly more females than males with 1.4: 1 ratio. However, the difference between males and females in the pond does not appear to be significant since the p-values for all three ponds were greater than 0.05.

These results differ from previous studies at Black Rock Forest. Although no concrete numbers are given, judging from the graphs, it is estimated that in 1997 Aleck Meadow had a 3:1 of females to males and Sutherland had a 2:1. These results indicate that the sex ratio was significantly skewed (McKinsey, 1997).

Age Structure

The age structure is consistent for all three ponds; in both trapping seasons, there are generally more adults than juveniles. The chi-squared test confirmed this since the p-values were over 0.050 in both years for all ponds. The only exception was Sutherland Pond in 2010; however, the large p-value is very likely due to the very small sample size. The reason that there are more adults than juveniles is that painted turtles are considered juveniles until they reach sexual maturity when their plastron length measures over 100mm, which is about when they are approximately 7-9 years old, and since painted turtles live about thirty years (Ernst and Lovich, 2009), it means that they will be in their adult stage for most of their life (Gibbons, 1987). For this reason, it is likely that there will be more adults than juveniles at any given time in the ponds unless there is a significant problem in the population. The only time when this wasn't true was is 2010 when there were no juveniles in both Sutherland and Upper Reservoir but it is very likely due to the small sample size.

Limitations of the Method

The mark-recapture method makes many assumptions about the population, which in turn can lead to error in the population size estimate. The first assumption this method makes is that the study takes place in a closed population. However, migration of painted turtles has been observed, especially in locations where ponds are a short distance from each other (Zweiffel, 1989). Furthermore, a few cases of migration within the ponds at BRF have been observed (personal observation). These observations violate this assumption of a closed population and therefore estimates may be larger or smaller than the actual population, depending whether the migration was in or out of the population.

A second assumption that the mark-recapture method makes is that the markings do not affect the behavior of the animal, thus making it harder or easier to catch after they are marked. However, this assumption was also violated. In this study there were many turtles that were not seen again after they were marked, meaning they had become trap shy. Conversely, there other turtles that were caught repeatedly after being marked, meaning they were trap happy (personal observation). The violation of this assumption can also give an inaccurate population estimate.

The last assumption is that each individual of the population has an equal probability of capture. Failure to meet this assumption has profound effects on population size estimates. However, there have been studies that showed that there are many factors that contribute to the unequal probability of capture. These included type of sampling method such as basking traps, hoop traps or dip nets and location in which the traps were set (Gamble, 2006; Koper and Brooks, 1998; Ream and Ream, 1966).

Implications of This Study

The results found in this study indicate that the populations are slightly increasing, if not, at least stable. The data collected as well as these results will provide crucial groundwork for future turtle studies on painted turtle populations in the ponds at Black Rock Forest. Furthermore, these data can be used for a long term study and possibly a survivorship study on some of the marked individuals. Findings from this study can also be compared to other studies done in similar places in the northeast region of the United States in order to assess the populations of painted turtles of the region in general. Lastly, these findings can be used to assess the overall health of the ecosystem based on the

abundance and condition of the painted turtle populations.

Conclusions:

The results found in this study indicate that the populations of painted turtles in all three ponds appear to be healthy. The populations appear to be increasing slightly, or are at least stable, there is statistically no significant difference between the number of males and females in all of the three ponds, meaning that the sex ratio is 1:1, and there are more adults than juveniles, as is expected in a painted turtle population. Since the populations appear to be healthy, there is not much management needed but monitoring the populations is important in order to prevent a decline in population size.

The study of painted turtles is of importance to ecologists because painted turtles are an ideal model organism; they are fairly common throughout the world, they are easy to study. In addition, findings of these studies can be applied to other species of turtles that are biologically and behaviorally similar. Furthermore, turtles play an important part of ecosystems and their presence or absence can be indicator of the health of that particular ecosystem. Finally, the findings of this study will help with the turtle management of painted turtle populations at BRF and it will provide crucial groundwork for future painted turtle population dynamics studies.

Recommendations:

This study focused mainly on population dynamics and many of its findings are relevant for future studies that can take place at Black Rock Forest. One of these studies would be to study nest predation and find the rate of predation because this is a factor that affects the overall painted turtle population of the ponds. Another possible study would be to examine the population of painted turtles in all seven ponds at BRF to determine if the populations in the other ponds differ from the ones in this study.

Furthermore, the mark-recapture method for estimating population size makes many assumptions, one of which is that there is no migration. However, even though this assumption was made for this study, there are data that supports the assertion that some turtles migrate to other ponds within the forest. Therefore, it would be interesting to study migration and determine the migration rate. In addition, it would be useful to implement a long-term project by installing radio telemetry devices on some turtles to observe their movement patterns and to determine whether they mostly move around the vicinity of their pond or if they make long journeys to find new habitats at other ponds.

Lastly, it would be useful to conduct a study on the interactions of snapping turtles and painted turtles at Black Rock Forest in order to determine if there is competition for resources between these two species of turtles.

Acknowledgements:

I would like to thank Prof. Peter Bower from the Environmental Science department at Barnard College for his mentorship and support, and for providing me with this research opportunity; without him this research project would not have been possible. I would like express my gratitude to my mentor, Dr. Chris Raxworthy from the American Museum of Natural History for his valuable input and help. I would also like to thank my seminar advisor Dr. Elisa Bone from E3B at Columbia University for her advice and for helping me throughout the writing process. Finally, I would like to thank everyone at Black Rock Forest, especially Bill Schuster, Katie Pavlis, John Brady, Matt Munson and my fellow summer interns from both 2010 and 2011 for helping me with the data collection because I would not have been able to conduct my research without their help.

References:

Adirondack Lake Survey. 1987. Black Rock Forest Data. Obtained from William Schuster, Black Rock Forest Director. Cornwall, New York.

Aengenheyster, Kirk H. 1998. Estimating Population in Two Species of Turtle Using the Mark-Recapture Method. Senior Thesis.

Bayless, L. 1975. Population Parameters for *Chrysemys picta* in a New York Pond. The American Midland Naturalist **93**(1)**:**168-176.

Christens, E., and J. R. Bider. 1987. Nesting Activity and Hatching Success of the Painted Turtle (*Chrysemys picta marginata*) in Southwestern Quebec. Herpetologica **43**(1)**:**pp. 55-65.

Fritsch, M. et al.2007. Assessment of Sea Bass (*Dicentrarchus labrax, L.*) Stock Delimitation in the Bay of Biscay and the English Channel Based on Mark-Recapture and Genetic Data. Fisheries Research **83**(2–3)**:**123-132.

Galbraith, D.A. et al. 1988. Factors Affecting the Density of Populations of Common Snapping Turtles (*Chelydra serpentina serpentina*). Canadian Journal of Zoology **66**(5)**:**1233 1240.

Ernst, C. H., and Lovich, J. E. 2009. Turtles of the United States and Canada. 2nd edition. The Johns Hopkins University Press, Baltimore, MD.

Ernst, C. H. 1971. Population Dynamics and Activity Cycles of *Chrysemys picta* in Southeastern Pennsylvania. Journal of Herpetology **5**(3/4)**:**pp. 151-160.

Gamble, T. 2006. The Relative Efficiency of Basking and Hoop Traps for Painted Turtles (*Chrysemys picta*). Herpetological Review **37**(3)**:**308-312.

Gervais, J., Rosenberg, D., Barnes, S. and Stewart, E. 2009. Conservation Assessment For The

Western Painted Turtle in Oregon: (*Chrysemys picta bellii*). U.S.D.A. Forest Service. pp. 4–61. Accessed October 20, 2011. < http://www.fs.fed.us/r6/sfpnw/issssp/ documents/planning-docs/ca-hr-chrysemys-picta-bellii-2009-09.pdf>

Gibbons, J. W. 1968. Population Structure and Survivorship in the Painted Turtle, *Chrysemys picta*. Copeia **1968**(2)**:**260-268.

----------. 1987. Why Do Turtles Live So Long? Bioscience **37**(4)**:**pp. 262-269

Gibbons, J. W., and K. Andrews. 2004. PIT tagging: Simple Technology at Its Best. Bioscience **54**(5)**:**447-454.

Gotelli, N. J. 2008. A Primer of Ecology. 4th edition. Sinauer Associates, Sunderland, MA.

Koper, N., & Brooks, R. J. (1998). Population-Size Estimators and Unequal Catchability in Painted Turtles. Canadian Journal of Zoology, **76**(3)**:**458-465.

Marchand, M. N., and J. A. Litvaitis. 2004. Effects of Habitat Features and Landscape Composition on the Population Structure of a Common Aquatic Turtle in a Region Undergoing Rapid Development. Conservation Biology **18**(3)**:**758-767.

McKinsey, Krista. 1997. Effects of Pond Acidity Levels on Distribution of Turtle Populations at Black Rock Forest, NY. Master's thesis.

Mowat, G., and C. Strobeck. 2000. Estimating Population Size of Grizzly Bears Using Hair Capture, DNA Profiling, and Mark-Recapture Analysis. The Journal of Wildlife Management **64**(1)**:** 183-193.

Ranta, E., Kaitala V., and Linstrom, J. 1999. Sex in Space: Population Dynamic Consequences. Proc.R.Soc.Lond.B **266:**1155-1160.

Ream, C., and Ream, R. 1966. The Influence of Sampling Methods on the Estimation of

Population Structure in Painted Turtles. American Midland Naturalist **75**(2)**:**pp. 325-338.

Schuster, William. Forest director, Black Rock Forest. Personal communication.

Sexton, O. J. 1959. A Method of Estimating the Age of Painted Turtles for Use in Demographic Studies. Ecology **40**(4)**:**pp. 716-718.

Snow, J. 1982. Predation on Painted Turtle Nests: Nest Survival as A Function of Nest Age. Canadian Journal of Zoology **60**(12)**:**3290-3292.

Steen, D. A., and Gibbs, J.P. 2004. Effects of Roads on the Structure of Freshwater Turtle Populations. Conservation Biology **18**(4)**:**1143-1148.

Tabor, G. M. and Aguirre A. A. 2004. Ecosystem Health and Sentinel Species: Adding an Ecological Element to the Proverbial "Canary in the Mineshaft". EcoHealth **1**(3)**:** 275- 283

White, G. C., and Burnham, K. P. 1999. Program MARK: Survival Estimation from Populations of Marked Animals. Bird Study **46**(S)**:**120-139.

Wilbur, H. M. 1975. The Evolutionary and Mathematical Demography of the Turtle *Chrysemys picta*. Ecology **56**(1)**:**pp. 64-77.

Wilson, D. S.,Tracy, C.R. and Tracy, C. R. 2003. Estimating Age of Turtles from Growth Rings: A Critical Evaluation of the Technique. Herpetologica **59**(2)**:**pp. 178-194.

Zippin, C. 1958. The Removal Method of Population Estimation. The Journal of Wildlife Management **22**(1)**:**pp. 82-90.

Zweifel, R., 1989. Long Term Ecological Studies on a Population of Painted Turtles, *Chrysemys picta*, on Long Island New York. American Museum Novates **2952**: pp. 1-155