

A Study of the Box Turtle, *Terrapene carolina carolina* (L.), Population in Allee Memorial Woods.¹

ELIOT C. WILLIAMS, JR., Wabash College

As part of a general long-range ecological study of Allee Memorial Woods, the population of the Common Box Turtle, *Terrapene carolina carolina* (L.), has been under study since 1958. This report summarizes the findings during the period 1958-60.

Allee Memorial Woods is a 180 acre wooded tract located along the eastern side of Sugar Creek in Parke County, Indiana, about two miles northwest of the town of Annapolis. This area of partially virgin forest was acquired during his lifetime by the late Dr. Warder C. Allee. Dr. Allee's heirs gave the tract to Wabash College as a biological preserve.

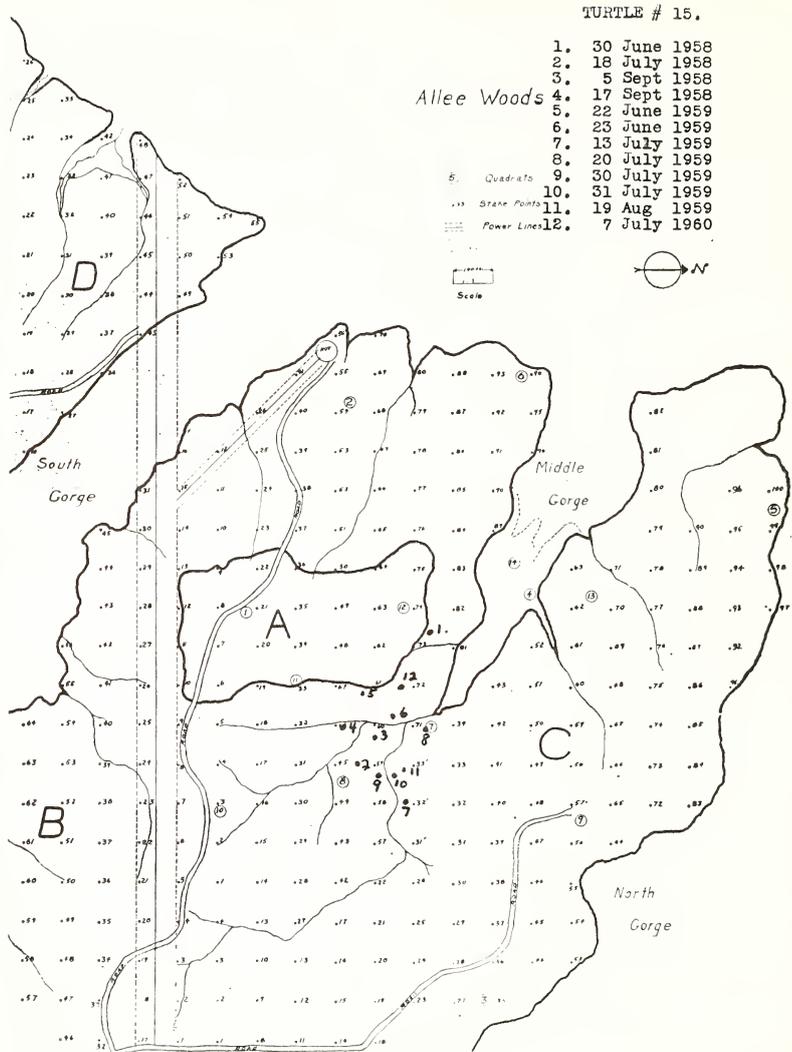
The box turtle is a fairly abundant, permanent resident of Allee Woods. In view of their size, long life span, and relatively slow movement, it was felt that these organisms offered excellent material for a specific population study. Studies on populations of the Common Box Turtle (*T. carolina carolina*) have been made in New York by Nicho's (4) and by Stickel (5) in Maryland. Gould (1) made a study of the homing tendencies in this species. The work of Stickel was very extensive and involved the use of techniques similar to those employed in this study. Legler (2) gives a very complete report on the natural history of the Ornate Box Turtle (*Terrapene ornata ornata* Agassiz) in Kansas. He includes data on population size and home range.

Starting in June 1958, each box turtle seen was marked and released at the point of marking after taking certain measurements and determining the sex of the specimen. Date and time of capture as well as location of the organism were also recorded. The location was taken in terms of known land marks or permanent quadrats early in the summer, but later in 1958 topographic maps of the area were obtained and a numbered grid was made on the map, dividing the area into hectares, and locations of captures were indicated in terms of this grid. Early in the summer of 1959 an 85 acre tract at the south end of the preserve was surveyed and stakes were placed at 100-foot intervals in a grid pattern. With the completion of the staked-out grid, it was possible to pin-point the location of each capture by pacing the distance from the point of capture to the nearest stake and taking a compass reading of the azimuth of the line from the stake to the turtle. Marking the capture on the map by use of a protractor and ruler gives a very close indication of the actual point of capture. The printed map is scaled so that one millimeter on the map is equal to ten feet on the ground. A sample of the pattern of recovery for turtle 15 is given in Map 1.

During the first year of this study (1958) the turtles were marked by drilling holes in the marginal scutes. Each of the scutes was assigned a number and the number designating any particular specimen is determined by the sum of the numbers designated by drilling.

Starting in 1959 a numbered monel metal tag was placed at the rear of the carapace to the right of the tail. This necessitates drilling only one hole and eliminates the possibility of misreading the number.

1. Supported by A. E. C. Contract AT(11-1)547.



Map 1

Portion of the Allee Memorial Woods used in the turtle study. Dots show the location of consecutive captures of Turtle No. 15. Dates of these captures are given above.

In the three-year period 255 turtles have been marked in the 85 acre grid area. In 1958, some turtles were marked in the area north of the study grid, but since that time the work has been confined to the grid area. All the figures on captures given below are based on turtles in the grid area.

In 1958, 138 turtles were marked. In 1959, 66 new turtles were marked and 46 turtles marked in 1958 were recovered at least once. In 1960, 51 new turtles were marked and 65 turtles marked the two previous

years were captured at least once. Thus, 41 per cent of the individuals captured at least once in 1959 had been marked in 1958, and 56 per cent of those captured at least once in 1960 had been marked during the preceding two years.

Taking into account multiple captures, in 1958, when there were 193 actual captures, 28.4 per cent of the captures were of marked turtles. In 1959, when there were 172 actual captures, 61.6 per cent of the captures were of marked turtles. In 1960, when there were 180 actual captures, 71.6 per cent of the captures were of marked turtles.

Combining the record of captures and recaptures for the three-year period 1958-1960, gives the results indicated in Table 1.

TABLE 1
Cumulative Turtle Captures, 1958-1960

No. of Captures	No. of Individuals
1	125
2	59
3	42
4	10
5	4
6	5
7	5
8	1
9	2
10	0
11	0
12	1
13	1
	255

Total Captures = 545

In the three-year period 255 individual turtles have been captured and marked in the study area. Taking into account multiple captures, there have been 545 total captures. Thus in the three-year period, 51.3 per cent of the turtle captures have been recoveries of marked turtles.

Table 2 gives the data on the distance between captures for 291 cases in which turtles were captured more than once within the study area. The median distance travelled is slightly more than 150 feet, since 149 of the 291 cases fall within that range. Based on the range of distances used in the table, the average distance travelled between captures was 228 feet. Since these data are based on captures over a three-year period with 87 cases of turtles captured in more than one year, it seems to represent a reasonable picture of turtle movements. It is quite interesting that the figures for the two-year period 1958 and 1959 were: median distance between captures, 162 feet; and average distance, 253 feet.

Another indication of the movement of turtles is shown in Table 3, which gives the diameter of a circle including all captures for an individual turtle. This table is based on 130 turtles which have been captured at least twice. The median home range for these turtles falls in the 275-299 foot range. This corresponds with the median value of 150 feet for dis-

TABLE 2
Distance Between Consecutive Captures for
Turtles Captured More Than Once

Distance Between Captures, in feet	No. of Cases
0-49	53
50-99	46
100-149	40
150-199	32
200-249	26
250-299	20
300-349	11
350-399	15
400-449	14
450-499	7
500-549	2
550-599	4
600-649	6
650-699	1
700-749	3
750-799	0
800-849	2
850-899	2
900-949	0
950-999	1
1000-1049	0
1050-1099	2
1100-1149	0
1150-1199	0
1200-1249	1
1250-1299	0
1300-1349	0
1350-1399	2
1750-1799	1

Average distance between consecutive captures = 228 feet

Median distance between consecutive captures = 150 feet

tance between consecutive captures, since movement of 150 feet in opposite directions would give a diameter of home range of 300 feet. The average home range is 375 feet. That these figures are quite indicative is again borne out by comparison of the similar figures for the two-year period, 1958-59, in which the median value for home range diameter was 250 feet and the average home range diameter was 368 feet. Stickel (5) found in her studies of box turtles in Maryland that the average home range for males was 330 feet and for females 370 feet. Legler (2) found that the Ornate Box Turtle, a species characteristic of open grassland areas as opposed to the woodland habitat of the Common Box Turtle, had a home range with an average radius of 278 feet. This would be a range with a

TABLE 3
Apparent Diameter of Home Range

Home Range Diameter in feet	No. of Individuals
1-100	16
101-200	25
201-300	23
301-400	17
401-500	16
501-600	10
601-700	9
701-800	4
801-900	4
901-1000	1
1001-1100	2
1101-1200	1
1401-1500	1
1701-1800	1

Average Diameter of Home Range = 375 feet
Median Diameter falls in the 275-299 foot range

diameter of 546 feet, somewhat larger than the ranges reported here and those reported by Stickel (5). It may well be that the Ornate Box Turtle, primarily a prairie species, requires a larger area for the satisfaction of its natural requirements.

Estimation of the total turtle population was made by use of the so-called Lincoln Index (Lincoln, 3) in which the following formula was used.

$$\frac{\text{Total \# in the Population}}{\text{Total \# Marked Animals in the Population}} = \frac{\text{\# Animals in Second Sample}}{\text{\# Marked Animals in the Second Sample}}$$

When the number of animals marked in 1958 is taken to be the first sample (138) and the 1959 season's collection is taken as a second sample (112 collected including 46 previously marked turtles) the estimated population value for the study tract is 336. When the number of animals marked in 1958-1959 is taken to be the first sample (204) and 1960 season's collection are taken to be the second sample (116 collected including 65 previously marked turtles) the population estimate is 364. A further check on these estimates is provided in the collections made on October 14, 1960, when 38 members of the author's Ecology class spread out over the entire area and hunted for turtles during a three-hour period. On that day 14 turtles were observed, of which 10 had been previously marked. Using the Lincoln formula with the total number of turtles marked prior to October 14, 1960, as the first sample, the population estimate is 357. Since a sample of 14 is certainly a very small one, the close correlation with the other two figures seems to be significant. An estimated adult population of around 360 turtles is a reasonably close one for the 85-acre study tract. Very few juvenile turtles have been collected and this is

probably due to the fact that very small turtles could be easily overlooked. It is often quite by chance that the mature turtles are observed. In some cases one becomes aware of their presence only when they are stepped on.

The time span over which turtles were captured is an important factor in assessing the validity of population estimates. Table 4 gives the infor-

TABLE 4
Time Span of Turtle Captures

Years in Which Captured at Least Once	No. of Individuals
1958	67
1958, 1959	22
1958, 1960	25
1958, 1959, 1960	24
1959	47
1959, 1960	19
1960	51
Total	255

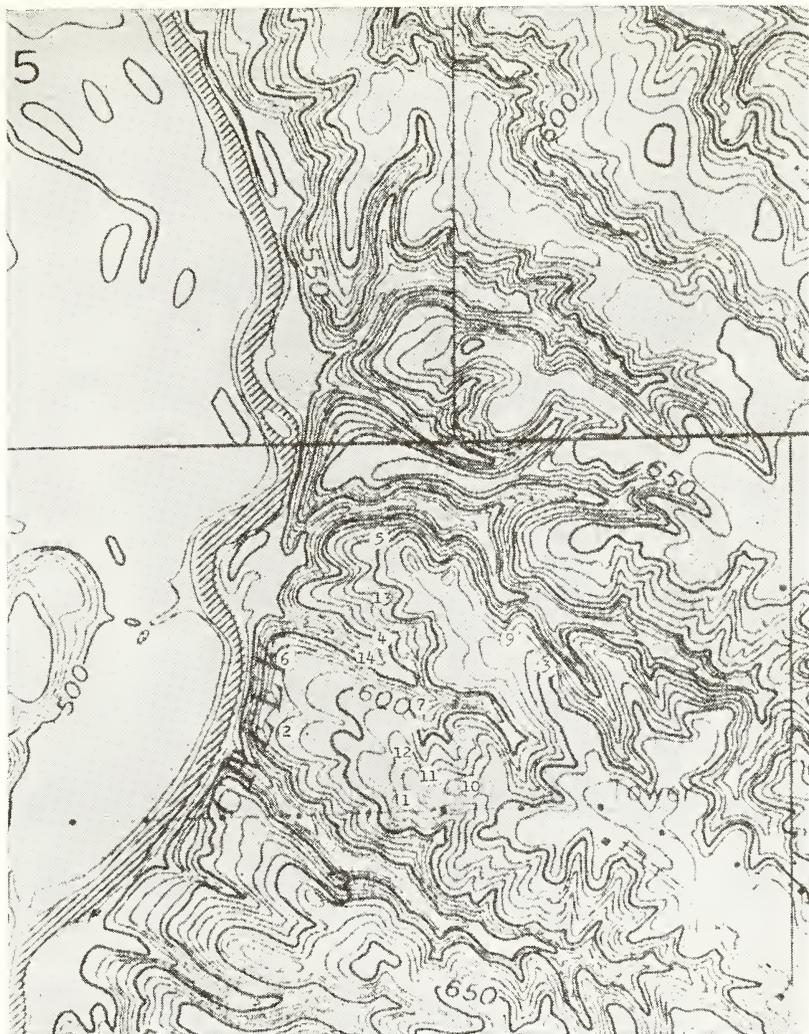
mation relative to this factor. The recapture of 25 turtles in 1960 which were originally marked in 1958 and not taken at all in 1959, indicates that our assumption that most of the marked turtles are still in the area is not unreasonable. As Map 2 shows, the study area has a very much dissected topography with two large, deep gorges and numerous ravines leading into them. Innumerable brush piles, fallen logs, and other natural shelters give the turtles adequate resting places in which they are not easily observed. For obvious reasons, the area is not disturbed in turtle searching and most captures are of turtles which are abroad in their normal daily activities.

Since very few dead turtles have been found and the life span of the box turtle is believed to be in excess of fifty years, mortality has not been taken into account in the population estimates. Turtle #15, whose distribution is indicated on Map 1, has some initials and the date 1911 carved on its plastron. Assuming that the turtle was at least several years old when it was originally marked, this turtle is well over 50 years old.

Another factor which has not been assessed is that of transient turtles which may move through the area. There is no real way of knowing how many of the captures fall into this category. The assumption is that the number is probably not large. The only evidence bearing on this conclusion is the fact that there have been no recaptures of turtles in the study area which were marked in the portion of the preserve north of the 85-acre grid area. There are 45 turtles in this category and it seems logical to assume that any major tendency for the turtles to range over a wide area would have resulted in the capture of at least a few of these individuals.

The population density of adult turtles based on an estimate of 360 turtles in the study area of 85 acres is 4.23 turtles per acre.

The problem of overlap in range from areas adjacent to the study area does not seem to be significant in the case of the north and west boundaries since these are both very steep slopes with a deep gorge below. There are few cases in which a turtle moved down into a gorge and up the other



Map 2

Topographic Map of the study area. The study grid is in the lower portion of the map where the numbers indicate the location of permanent quadrats used for collection of climatic data and other studies.

side. However, on the south and east, they may be some overlap. To the east the wooded area extends a short distance beyond the study area and then one finds cultivated fields. To the south there is a deep gorge for part of the boundary, but the rest of the contiguous area is wooded and a suitable habitat for the box turtle. Taking the average figure for diameter of home range of 375 feet, one can include half of this distance as a strip around the portions of the south and east borders which have readily available and suitable habitats contiguous to the study area. This strip adds about 15 acres to the total area, giving a total of 100 acres for

calculation of adjusted population densities. Using this adjustment, the population density based on an estimate of 360 turtles becomes 3.6 turtles per acre.

These figures can be compared with those of Stickel (5) who found a population density of box turtles at the Patuxent Research Refuge, Maryland, of between four and five turtles per acre. Legler (2) reports somewhat lower population densities for the Ornate Box Turtle. He gives a value of .88 turtles per acre for the entire study area. The area given for the Damm Farm, which was the site of his population studies, is approximately 220 acres. The value of .88 turtles per acre seems to have been obtained by the use of the actual number of turtles captured and marked in his study. If one takes the estimated total population obtained by the use of the Lincoln Index (286 turtles), the value for the population density becomes 1.3 turtles per acre. This figure is a more satisfactory one to use for comparison with that for Allee Woods (3.6 turtles per acre) and those of Stickel (4-5 turtles per acre). Although certain parts of the Damm Farm provided less suitable habitats than others, the same can be said for the study grid in Allee Memorial Woods. It is probable that there were also differences in the study area used by Stickel. It therefore seems clear that the Common Box Turtle, a woodland species, is somewhat more abundant in its normal habitat than the Ornate Box Turtle, a grassland species.

Literature Cited

1. GOULD, E. Orientation in box turtles, *Terrapene c. carolina* (Linnaeus). 1957. Biological Bulletin 112(3) : 336-348.
2. LEGLER, J. M. Natural history of the Ornate Box Turtle, *Terrapene ornata ornata* Agassiz. 1960. Univ. of Kansas Pub. Mus. of Nat. Hist. 11, No. 10, 527-669.
3. LINCOLN, F. C. Calculating waterfowl abundance on the basis of banding returns. 1930. U. S. Dept. Agric. Circ. 118, 4 pp.
4. NICHOLS, J. T. Range and homing of individual box turtles. Copeia, 1939 (3) : 125-127.
5. STICKEL, LUCILLE F. Populations and home range relations of the Box Turtle, *Terrapene c. carolina* (Linnaeus). 1950. Ecol. Monog., 20 : 351-378.