

## LINNAEUS FUND RESEARCH REPORTS

*Editorial Comment.* — This section presents research reports based on support provided by Chelonian Research Foundation through its annual turtle research awards program, the Linnaeus Fund. Named after CAROLUS LINNAEUS [1707–1778], the Swedish creator of binomial nomenclature, the fund honors the first turtle taxonomist and father of all modern systematics. Linnaeus Fund awards are granted annually to individuals for specific turtle research projects, with either partial or full support as funding allows. Priority is generally given to projects concerning freshwater turtles, but tortoise and marine turtle research proposals are also funded. Priority is generally given to the following general research areas: taxonomy and systematic relationships, distribution and zoogeography, ecology, natural history, and morphology, but a broad range of other topics are also considered. Priority is also given to projects that demonstrate potential relevance to the scientific basis and understanding of chelonian diversity and conservation biology. The generally preliminary and summary reports in this section are not formally peer-reviewed, but are nonetheless subjected to editorial review.

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### Seasonal Movements and Habitat Preferences of Spotted Turtles (*Clemmys guttata*) in North Central Connecticut. Linnaeus Fund Research Report

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The spotted turtle (*Clemmys guttata*) is a small semi-aquatic freshwater turtle of the eastern United States. Its range extends from northern Florida to southern Ontario and Maine through New York, Pennsylvania, Ohio, northern Indiana, Michigan, and northeastern Illinois (Ernst et al., 1994). Spotted turtles can be found in a variety of aquatic habitats including vernal pools, swamps, small streams, bogs, marshes, and meadows. They also utilize upland habitats during part of their seasonal cycle in parts of their range (Ward et al., 1976; Graham, 1995).

Besides the study by Ward et al. (1976) in Maryland, aestivation and terrestrial habitat usage in this species has had little documentation. Klemens (1993) studied spotted turtles in Connecticut and reported that male turtles exhibited terrestrial activity in the spring but during the summer turtles utilized wetland habitats. He noted that there was very little evidence of aestivation for spotted turtles in southern New England. My study was designed to determine the seasonal habitat usage and movements of spotted turtles in north central Connecticut.

It has been well documented that most captures of spotted turtles occur from late March through mid-June (Conant, 1951; Ernst and Barbour, 1972; Lovich, 1988) as this is the time when their seasonal activity cycle is at a peak. During the summer months, spotted turtles are very inconspicuous due to aestivation in muskrat burrows, upland paludal forests, and upland fields (Ernst, 1976; Ward et al., 1976; Graham, 1995; J. Milam, *pers. comm.*).

*Methods.* — In spring 1993, 4 spotted turtles were captured (2 male and 2 female). The study was conducted at a

town-owned park located between Hartford, Connecticut, and the Massachusetts border in the Connecticut River valley. Miniature radio transmitters (AVM; SM 1-H) were affixed to each turtle's carapace with epoxy. Turtles were sexed (by jaw and eye color and plastral concavity), aged (plastral abdominal scute annuli), weighed, and measured. Photographs were taken of each turtle's plastral pattern and unique characteristics and markings were noted. The turtles were released in the exact capture location within 24 hrs.

Movements and behavior were recorded daily until the late fall of 1993 when observations were reduced to three times a week. Data were also collected on habitat type, temperature, rainfall, and distance moved. In late October 1993, 3 additional females were added to the study after being found in a communal hibernaculum with a radioed male.

Tracking was resumed on a daily basis in the spring of 1994 until late fall 1994 when tracking was again reduced to three times a week. In early spring 1995 an additional female was added to the study after being caught by hand in a vernal pool. Tracking resumed daily until completion of the study in September 1995.

The exact location of each turtle was flagged with surveyors' flagging. In a few cases, turtles were located by triangulation. Turtles were recaptured once a year for transmitter replacement. The transmitter signal reflected whether the turtle was swimming or resting even before the turtle was located. Turtles were approached cautiously so that behavior could be recorded. Other spotted turtles captured during the study were marked with paint marker on their carapace.

*Results.* — Eight turtles were included in this study. One was only in the study for 1 month before I failed to locate her and the longest duration was a turtle tracked for 27 months (Fig. 1). One turtle, R2, was lost due to transmitter failure for a period of 4 months before being found again and returned to the study.

Turtles used a variety of habitats including small vernal pools, a permanent bog, upland fields, early successional forests, and older more established woodlands. Most of the turtles were captured in spring in a small vernal pool (<0.5 ha). Males traveled between wetlands more often than females during the spring months when mating took place. Female turtle M4 moved from a vernal pool to an adjacent field and back (Fig. 2). Male turtle J3 moved from the bog to a vernal pool to the field and back to the bog (Fig. 2).

Turtle ID	Sex	Duration (days)	1993												1994												1995											
			May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec				
L1	F	21	[Black bar]																																			
R2	M	276	[Black bar]																																			
R2	M	216	[Black bar]																																			
J3	M	226	[Black bar]																																			
M4	F	548	[Black bar]																																			
T5	F	493	[Black bar]																																			
S8	F	118	[Black bar]																																			
A7	F	493	[Black bar]																																			
E10	F	115	[Black bar]																																			

Figure 1. Duration in study for each turtle. Note that R2 appears twice; data was not recorded on this individual from June to October 1994 due to transmitter failure.

During the first summer, two of the turtles aestivated in upland habitats while one aestivated along the dried edge of a vernal pool. Aestivation was marked by periods of small movements of up to 10 m with occasional movements of up to 50 m by individual turtles in a 24 hr period. Heavy rains and thunderstorms often stimulated movement during aestivation. It was not documented in this study if turtles fed at all during aestivation.

Turtles returned to the wetlands in mid- to late fall even if there was no water in the wetlands. One turtle returned to the sphagnum bog, a permanent water body, but the other two turtles returned to vernal pools where they overwintered just under the ice. The turtle that hibernated in the bog was found to occupy a communal hibernaculum with at least three other spotted turtles. The turtles who hibernated in the bog emerged later than the turtles that hibernated in the vernal pools. During spring of 1994 the two males made several movements of up to 250 m to travel among aquatic habitats. Females usually remained in one wetland but made movements of up to 265 m away from the wetland for nesting. Upland aestivation occurred between 3 and 165 m away from the wetlands for all turtles. Daily movements were typically between 0.5 and 50 m for both males and females when in aquatic habitats.

During summer 1994 most of the turtles aestivated in upland habitat except for one male and one female that aestivated in the bog dug into a sedge tussock. Both of these turtles stayed close to the hibernaculum from the previous year during the summer and again hibernated at that exact site during the winter.

The habitat usage of a male (J3) and a female (M4) for the one year period from spring 1993 through summer 1994 is shown in Fig. 2. Analyses of the movements and habitat usage for all the turtles is presently underway.

**Discussion.** — In the spring months between March and May, male turtles migrated between wetlands possibly to increase their mating opportunities. Male turtles were found to make migrations of up to 250 m in a 24 hr period. The vernal pools were full of wood frog egg masses, salamander egg masses, and aquatic larvae that the turtles were feeding on during the spring months.

All the turtles in this study aestivated in an upland habitat for periods between 1 and 10 weeks at some point during the two year period in the summer months. This behavior is similar to what J. Milam (unpubl. data) found in central Massachu-

setts. Upland habitats varied between overgrown fields that were adjacent to wetlands to early successional paludal woods to older woodland areas within 200 m of the wetlands. Drying wetlands are not the only stimulus for upland aestivation, since turtles left the permanently wet bog and traveled upland to aestivate in forest with a heavy understory.

Aestivation is a period of dormancy punctuated by periods of brief activity. Some of the turtles utilized upland habitats (field and forest) while others aestivated in the mucky substrate on the wetland edges. The summer of 1993 was a notably dry summer with rainfall in August well below the normal amount. This may have stimulated turtles to aestivate upland for longer amounts of time than during a summer with more normal precipitation. The summer of 1994 had a slightly higher than normal rainfall. Some turtles did not leave the wetlands at all during that summer. In 1993 male turtle J3 spent 38 days in upland aestivation but in 1994 he did not leave the bog at all;

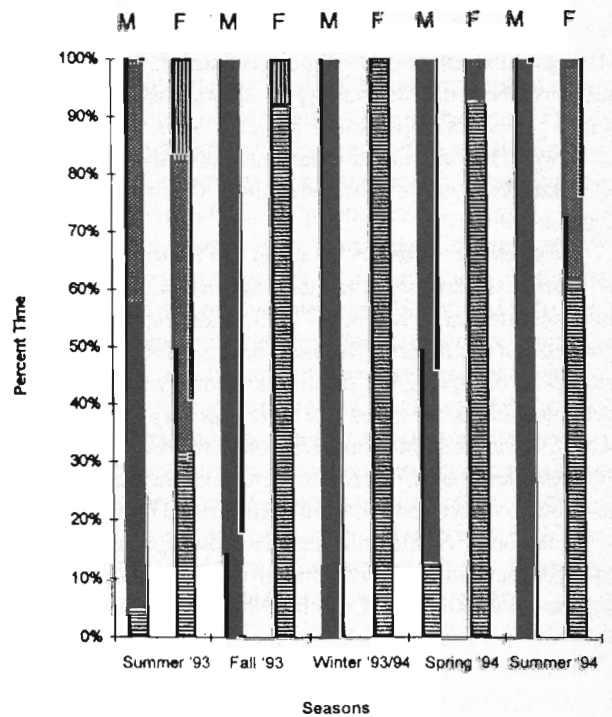


Figure 2. Graph of habitat use showing percentage of time spent in each habitat for a male (M, J3) and a female (F, M4) through 5 consecutive seasons. Horizontal stripes = vernal pool, solid black = bog, gray cross-hatching = field, vertical stripes = forest.

instead utilizing sphagnum-covered hummocks for aestivation.

Some of the turtles showed fidelity to hibernaculum sites. In the communal hibernaculum in the bog, turtles regrouped in the same location for the second year of the study. Communal hibernation may increase chances of early spring mating. All of the turtles demonstrated a seasonal pattern of movement which they repeated during two years of the study. Often turtles could be found in the same exact locations at the same general time of the year within the study time.

When giving consideration to spotted turtles' habitat requirements it should be noted that these turtles utilize a variety of interconnected habitat types within a certain range. Protecting wetlands is critical, but maintaining continuity among wetland sites is integral to preserving populations of spotted turtles. Providing buffer zones of at least 200 m around the wetlands is also necessary to provide adequate protection since turtles are migrating out to aestivate and nest during spring and summer months.

Future research should be focused on microhabitat selection and population studies in New England and throughout the spotted turtle's range. As this species is listed as threatened or of special concern in three of the six New England states where it occurs, documentation of where it occurs now and population abundance should be of high priority for future studies. Studies to determine habitat preferences will be helpful to predict where spotted turtles are apt to occur.

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## Ecology and Natural History of the Wood Turtle (*Clemmys insculpta*) in Southern New Hampshire. Linnaeus Fund Research Report

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An intensive one-year ecological study of the wood turtle (*Clemmys insculpta*) was conducted in New Hampshire from April 1993 to June 1994 at a site where Carroll (1991) previously had observed *C. insculpta*. The wood turtle is distributed throughout New Hampshire (Oliver and Bailey, 1939; DeGraaf and Rudis, 1983), but the species does not appear to be common anywhere in the state (Taylor, 1993). Few population or ecological data have been published on any wood turtle population in northern New England, and quantitative field studies of the wood turtle in New England are scarce. Virtually nothing is known about the early life stages of this species throughout its range. A major goal of this field study was to provide basic life history data to expand our understanding of the wood turtle's ecological variation (Tuttle, 1996).

*Materials and Methods.* — Located in southern New Hampshire in the Merrimack River watershed, the immediate study site includes two converging brooks with a sandy or gravelly substrate and occasional muck-bottomed stretches. Separated by a hayfield, the brooks are bordered by scrub-shrub wetlands, forested wetlands, emergent wetlands, upland mixed forest, and white pine stands.

Sampling was chiefly by hand-capture; turtles were individually marked by carapacial marginal scute notching. Environmental and cloacal temperatures were recorded. Straight-line morphometric measurements of the shell (carapace length, carapace width, plastron length) were taken, and body mass was recorded. Sex was determined by using external features (Harding and Bloomer, 1979). Mean values of all measurement samples are followed by  $\pm 1$  standard deviation (SD).

Ten adult *C. insculpta* (five of each sex) and two juveniles were fitted with external radio transmitters (Model 16M, Advanced Telemetry Systems, Inc., Isanti, Minnesota) on the rear of the carapace using waterproof epoxy. Each turtle was located on alternate days with a portable receiver and hand-held directional antenna. Tracking took place between April 1993 and June 1994. Movements of radio-tagged turtles were mapped by noting their exact locations in the field and plotting them on an enlarged aerial photograph. Using a microcomputer program (McPAAL, National Zoological Park,