GUIDELINES FOR PROTECTING WOOD TURTLES AND THEIR HABITATS IN MASSACHUSETTS

Natural Heritage and Endangered Species Program
Massachusetts Division of Fisheries and Wildlife
Route 135, Westborough, MA 01581
Author: Suzanne Fowle
Last updated: 8 February 2001

INTRODUCTION

The Natural Heritage and Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife (the Division) has developed the following guidelines to assist property owners, land managers, consultants, and Conservation Commissioners with protecting wood turtles (*Clemmys insculpta*) and their habitats. The wood turtle is listed as a Species of Special Concern by the Division in Massachusetts, and activities proposed in or near its habitats are subject to review under Massachusetts laws. The Division intends to apply these guidelines in its review of Notices of Intent, pursuant to the Massachusetts Wetlands Protection Act regulations (310 CMR 10.59). Implementing these guidelines will also help property owners and land managers avoid potential violations of the Massachusetts Endangered Species Act (MGL c. 131A) and its implementing regulations (321 CMR 10.00).

Users of these guidelines are advised that they do not supersede any law, regulation, or official policy of this or any other agency. Rather, these guidelines are intended to complement existing regulatory review processes by providing scientifically based management recommendations. These guidelines include: a summary of life history and habitat requirements of wood turtles; a summary of pertinent laws and regulations; guidelines for avoiding adverse impacts to wood turtles and their habitats; literature cited.

LIFE HISTORY AND HABITAT REQUIREMENTS OF THE WOOD TURTLE

Wood turtles may inhabit a variety of wetland types, including rivers, streams, swamps, bogs, seasonal pools, and wet meadows, and they inhabit uplands adjacent to these wetlands (Table 1) (Harding and Bloomer 1979, Compton 1999). They are most strongly associated with flowing water (streams and rivers) and adjacent uplands. Unlike turtles that inhabit calm, open waters and bask in prominent places, wood turtles are relatively difficult to detect.

Wood turtles are well suited to both aquatic and terrestrial environments, allowing them to spend much of the active season on land – feeding, nesting, and estivating. They return to their wetland habitats in the fall (if they are not already there) and hibernate there (Table 1). Wood turtles emerge from hibernation in March and remain active through late November (Farrell and Graham 1991). However, most of the terrestrial activity of adults takes place from late May to late August (Harding and Bloomer 1979, Ernst 1986, Kaufmann 1992). In Ontario, only 14% of observations of wood turtles in the spring and summer were in aquatic habitats (Quinn and Tate 1991). Adults remain in terrestrial habitats for as many as 33

consecutive days (Kaufmann 1992) and have been found on land as late as October (Farrell and Graham 1991). Adult females tend to spend more time on land than do adult males (Kaufmann 1992).

Movement patterns vary widely among individuals (Quinn and Tate 1991, Kaufmann 1992, Robakiewicz 1993), but most adult wood turtles remain within 300 m of their home wetlands (Kaufmann 1992). However, each individual tends to exhibit the same – or similar – movement pattern from year to year (Harding and Bloomer 1979, Quinn and Tate 1991, S. Parren, unpubl. data).

Wood turtles are capable of long-range movements between wetland habitats and into upland habitats (Table 2). Kaufmann (1992) observed adults moving as far as 600 m away from their home streams in Pennsylvania, and Parren (unpubl. data) has observed a maximum along-stream movement of 1,700 m in Vermont. In Ontario, an adult female moved 3,600 m from her nest site to her late summer range (Quinn and Tate 1991). In the same study, adult home ranges varied from <1 ha to 115 ha, with an average home range of 24 ha (Table 3).

Wood turtles mate in their aquatic habitat, in both the spring and fall (Ernst 1986, Kaufmann 1992). The earliest recorded mating was in late March, in Pennsylvania (Ernst 1986), and while most spring mating occurs in April and May, it can continue into June (Harding and Bloomer 1979). In the fall, mating can occur from late August to early November (Harding and Bloomer 1979, Ernst 1986, Kaufmann 1992), although most fall breeding has been observed in September.

Nesting occurs from late May to early July (Farrell and Graham 1991). Wood turtles lay their eggs on land, up to 110 m away from water (Siart 1999). They lay from 5 to 18 eggs, with most recorded averages at about 8 eggs per clutch (Harding and Bloomer 1979, Farrell and Graham 1991). Wood turtles are not known to lay more than one clutch per year. Most researchers have found nesting wood turtles primarily in forest openings, where soils are exposed and well-drained (Carroll and Ehrenfield 1978, Harding and Bloomer 1979, Farrell and Graham 1991). In Pennsylvania, wood turtles were also found nesting in meadows, corn fields, and hay fields (Kaufmann 1992). Nesting also occurs in natural sand deposits on river and stream banks (S. Parren, unpubl. data).

Hatchlings emerge in the early fall, after an incubation period of approximately 70 days (Farrell and Graham 1991). Emergence takes place from mid August to late October (Harding and Bloomer 1979), varying according to temperature date of egg deposition. Hatchlings reach wetlands after 1 to 24 days of travel over land (Tuttle and Carroll 1999a). Hatchlings are not known to overwinter in their nests.

Movements and habitat use patterns of hatchling and juvenile wood turtles have not been well-studied. Preliminary results suggest that hatchlings and young juveniles remain closer to streams than do adults (Harding and Bloomer 1979, Brewster and Brewster 1991). Brewster and Brewster (1991) found that captive-bred hatchlings and young juveniles remained within 40 m of a channel.

The age at which turtles reach sexual maturity is between 10 and 18 years (Harding and Bloomer 1979, Brooks et al. 1992, Farrell and Graham 1991). The size and age at which wood turtles reach sexual maturity is not well known due to the varied results of different studies. Harding and Bloomer (1979) found that mature turtles were a minimum of 160 mm in carapace length. In Farrell and Graham's (1991) study, the smallest mature male was 139 mm in plastron length, and the smallest mature female was 143 mm in plastron length. Lovich et al.'s (1990) results were similar to Farrell and Graham's: 141 mm in plastron length for males; 136 mm in plastron length for females. These two studies were conducted at similar latitudes, in northern New Jersey and in Pennsylvania.

Since turtle size at sexual maturity tends to increase with increased latitude (Harding and Bloomer 1979, Brooks et al. 1992), we estimate size of sexual maturity to be 145 mm (plastron length) in Massachusetts, for both males and females. These guidelines will be modified according to subsequent information on size of sexual maturity in Massachusetts.

The wood turtle diet consists of both aquatic and terrestrial foods, including green leaves, berries, earthworms, slugs, insects, mollusks, mushrooms, and carrion (Harding and Bloomer 1979, Farrell and Graham 1991, Kaufmann 1992).

Table 1. General Habitats Required by the wood Turtle.

Habitat Type	**Description**	**Habitat functions provided for wood turtles**	**Time of year used by wood turtles (in Mass.)**
Wetland habitat	Usually flowing water. Most freshwater wetland types are potentially used.	Overwintering, breeding, feeding, dispersing, estivating, shelter	Year-round
Upland habitat	Various upland types within 600 m of the wetland's edge.	Feeding, nesting, dispersing, estivating, shelter	Late March to late October, with heaviest use from late May to late August

Table 2. Distances moved by individual adult wood turtles away from home streams. Results are from radio-tracking studies.

Location	Straight-line distance moved (m)			No. of individuals (duration of study)	Source
	minimum	maximum	average		
Pennsylvania	Not reported	600	Not reported[1]	50 (6 seasons)	Kaufmann 1992
West Virginia	Not reported	200	Not reported	4 (<1 season)	Niederberger and Seidel 1999
Maine	Not reported	599	Not reported[2]	37 (4 seasons)	Compton 1999
Vermont	72	271	184	7 (4 seasons)	S. Parren, unpubl. data

1 Ninety-five percent of movements were within 300m of the wetland.
2 Ninety-five percent of movements were within 243m of the wetland.

Table 3. Summary of home-range sizes recorded for wood turtles during radio-tracking studies.

Location	Home range size (ha)		No. of individuals (duration of study)	Source
	Average	Range		
New Hampshire				
Males	5.8	1.60-10.04	5 (1 season)	Tuttle and Carroll, unpubl. data[1]
Females	3.9	2.12-9.16	5 (1 season)	
Juveniles	6.0	1.20-10.12	2 (1 season)	
Ontario				
All adults	24	<1-115	8 (3 seasons)	Quinn and Tate 1991[2]
Pennsylvania				
Males	5.0	1.64-5.00	6 (3-5 seasons)	Kaufmann 1995[3]
Females	3.3	1.92-3.00	4 (3-5 seasons)	
Quebec				
All adults, 1996	20.5	Not reported	20 (2 seasons)	Arvisais et al. 1999[1]
All adults, 1997	17.4		20 (2 seasons)	
Ontario				
Adults & juveniles	Not reported	4.7-152.2	15 (1 season)	Smith and Brooks 1999[1]

1 – unknown method
2 – minimum area method
3 – quadrat summation method

Threats to Wood Turtles – The greatest threats to existing populations of wood turtles are those that increase the mortality (or removal from the wild) of adults and juveniles (Crouse et al. 1987, Congdon et al. 1993, Congdon et al. 1994). While significant and perpetual losses

of eggs and hatchlings can also lead to population decline, only slight increases in adult and juvenile mortality can have the same effect (Doroff and Keith 1990, Brooks et al. 1991, Congdon et al. 1993). The reason why turtles depend on high survival rates is that they – and other long-lived organisms – have evolved to balance their low reproductive rate with a long life span (see Gibbs and Amato 2000). In other words, they require several decades of breeding before they succeed in replacing themselves in their populations.

Turtles that survive their hatchling and early juvenile years (the period when survival rates are naturally low) have traditionally been able to depend on long life spans. By adult size, their shells are an effective defense against most natural predators. However, humans have added – and continue to add – sources of mortality against which turtles cannot defend themselves: cars and trucks, farm machinery and landscape equipment, removal for pets (which is the demographic equivalent of mortality).

These sources of mortality also act as barriers to wood turtle movement, as do obvious physical barriers such as fences, curbs, railroad tracks, and retaining walls. Roads, for example, fragment turtle habitat and make dispersal more difficult or impossible, depending on width, traffic volume, and construction features of the road. Fragmentation may lead to isolation of local populations, and isolation can increase a population's risk of extinction (Saccheri et al. 1998). An isolated population cannot receive dispersing individuals from other populations, a process which may be necessary to maintain genetic diversity and to sustain the population.

The most dense populations of wood turtles tend to occur where habitat diversity – and therefore food source diversity – is high (Kaufmann 1992). Wood turtles have been documented using all upland habitat types (Quinn and Tate 1991, Kaufmann 1992), with a slight preference for dense ground cover, such as shrub habitats, undisturbed meadows, and forest edges (Kaufmann 1992, Tuttle and Carroll 1999b). Cutting or thinning dense ground cover will likely adversely affect wood turtles, as will decreasing the diversity of upland habitats. Removal of the forest canopy in the immediate vicinity of seasonal pools can degrade wetland habitat quality by negatively affecting amphibians (Raymond and Hardy 1991, deMaynadier and Hunter 1999). The eggs and larvae of amphibians that breed in seasonal pools may be an important food source for wood turtles.

Since wood turtles tend to nest and move through open upland habitats when available (Harding and Bloomer 1979, Farrell and Graham 1991, Kaufman 1992), they are vulnerable to activities that typically occur there. Plowing or otherwise excavating upland habitats can destroy nests and kill turtles. Mowing can also kill wood turtles of all ages. Wood turtle nests in stream and river banks and on sand bars are vulnerable to flooding. Dam releases can kill eggs and hatchlings (Compton 1999).

Nest predators, such and skunks and raccoons, threaten wood turtles. Providing attractants to these predators – such as garbage, pet food, shelter – in or near wood turtle habitat can adversely affect wood turtles. Human presence can also easily disrupt nesting activity. A wood turtle is likely to abandon her nest if disturbed before she has started to lay her eggs. Human recreation in wood turtle habitat can have an impact in this way. Recreation (without

education and/or area restrictions) also leaves wood turtles more vulnerable to collection for pets.

MASSACHUSETTS LAWS THAT PROTECT WOOD TURTLES AND THEIR HABITATS

Massachusetts Wetlands Protection Act – The Massachusetts Wetlands Protection Act (WPA) (MGL c. 131 s. 40) protects a variety of wetland "Resource Areas" (and, in some cases, the surrounding uplands) that can support rare, state-listed wildlife. According to the WPA's implementing regulations (310 CMR 10.00), projects that are proposed to occur in a Resource Area or associated 100-foot buffer zone, and that will alter wetland habitat of wood turtles or other rare wildlife, may have "no short or long term adverse effects" on that habitat. Specific protected Resource Areas that wood turtles are likely to inhabit include: Land Under Water Body; Isolated Land Subject to Flooding; Bordering Land Subject to Flooding; Bordering Vegetated Wetlands; and Riverfront Areas (Table 4). These are defined in detail in the WPA regulations.

The Division has prepared an atlas of "Estimated Habitats of Rare Wildlife," including estimated habitats of wood turtles. The atlas is available from the Division and from local conservation commissions. When a proposed project will occur within an Estimated Habitat, a copy of the project proponent's Notice of Intent to the local conservation commission must be forwarded to the Division. Within 30 days of receipt of the Notice of Intent, Division staff determine: 1) whether the proposed project would occur within actual habitat of a rare species; and, if so, 2) whether the proposed project will have any "short or long term adverse effects" on that wetland habitat. The Division submits their opinion to the applicant, the local conservation commission, and the Department of Environmental Protection. The Division's opinion is presumed correct, although it may be rebutted by clear evidence to the contrary.

The important wildlife habitat functions protected under the WPA are: feeding, breeding, migrating, overwintering, and finding shelter. Therefore, adverse impacts to habitats supporting these activities are not permitted. Replicating habitat for wetlands wildlife and moving animals to new habitat are not permitted because adverse impacts to existing habitat still occur. According to the Department of Environmental Protection's rare species policy, "habitat replication, relocation of individual animals, or other proposed measures purported to offset adverse effects shall not be permitted because these activities cannot meet the performance standard of no adverse short or long term effect on the habitat of the local population" (DEP Rare Species Policy 90-2).

Table 4. Resource Areas (pursuant to Massachusetts Wetlands Protection Act) and associated habitat functions provided for wood turtles.

	Life stages associated with habitat functions potentially provided					
Resource Area[1]	**Feeding**	**Breeding** (mating & nesting)	**Migrating**	**Overwintering**	**Shelter**	**Comments**
Land Under Water Body	adults juveniles hatchlings	Adults	adults juveniles hatchlings	adults juveniles hatchlings	adults	A pond and its buffer zone can provide habitat for most life stages.
Isolated Land Subject to Flooding (ILSF)	adults juveniles hatchlings	Adults	adults juveniles hatchlings		adults juveniles hatchlings	ILSF may contain seasonal wetlands used by turtles of all ages, when flooded and when dry.
Bordering Land Subject to Flooding (BLSF)	adults juveniles hatchlings	Adults	adults juveniles hatchlings		adults juveniles hatchlings	BLSF may contain seasonal wetlands used by turtles of all ages, when flooded and when dry.
Bordering Vegetated Wetlands (BVW)	adults juveniles hatchlings	Adults	adults juveniles hatchlings		adults juveniles hatchlings	BVW may provide wetland habitat for turtles of all ages, and its buffer zone may support nests.
Riverfront Area	adults juveniles hatchlings	adults hatchlings eggs	adults juveniles hatchlings	adults juveniles hatchlings	adults juveniles hatchlings	A Riverfront Area can provide various wetland and upland habitats. It can provide all habitat functions.

1 All Resource Areas (except Isolated and Bordering Land Subject to Flooding) include a 100-foot buffer zone in which activities can be regulated if they will adversely affect the Resource Area itself. Riverfront Areas consist of adjacent uplands up to 200 feet from the high water line of a river or perennial stream. The uplands within the Riverfront Area are regulated as part of the Resource Area.

Assessing Impacts Under the WPA – To expedite regulatory reviews of large projects, projects with direct wetland alterations, and projects with significant buffer zone loss, applicants should follow the guidelines below.

- Applicants are strongly encouraged to conduct rare wildlife habitat evaluations prior to filing a Notice of Intent. Such evaluations are more likely to expedite the review process if conducted by a wildlife biologist with proven experience and expertise conducting surveys for the target species, in this case, the wood turtle. The applicant should use the information provided in the evaluation to determine whether his or her project would adversely affect rare species habitat.

- Submit the full Notice of Intent to the Division, including plans, stormwater management forms and supporting data, wetland delineation forms, any wetland assessments, and any

wildlife habitat evaluations. Classifying wetland types according to Cowardin et al. (1979) will help facilitate the Division's review. Alternative analysis reports, as required under the Rivers Protection Act, must be provided.

- Clearly delineate boundaries of proposed work on a U.S.G.S. topographic map. Avoid drawing broad circles or using arrows to indicate the project locus.

- Provide plans that show the entire proposed project on one page, including streets and other landmarks. Plans drawn at a scale of 1:40 are often easiest to interpret. Delineate the limit of clearing on plans and show grading, limit of lawn, and all other project components.

- Delineate wetland Resource Areas, including Riverfront Areas, on plans. Make sure Bordering Vegetated Wetland flag numbers are clearly visible on plans. Delineate wet depressions that may be state or federal wetlands on plans.

- Provide ground-level photographs that characterize wetland types within and near the impact area(s). Label photographs and cross-reference them on 1:40 scale plans. Providing a 1:12,000 scale, color-infrared, aerial photograph (taken when leaves are off trees) with the subject property clearly marked is recommended.

- Provide land-use information for the site and neighboring lands. Include residential and commercial development, roads, agricultural land, and active or abandoned gravel pits. Demarcate these areas on the plans, if possible.

- Include detailed erosion and sedimentation control plans, particularly for sites with steep topography and for projects that will disturb large amounts of upland adjacent to wetlands.

- Submit to the Division any new or revised information presented to the Conservation Commission during the hearing process.

Massachusetts Endangered Species Act – The Massachusetts Endangered Species Act (MESA) (MGL c. 131A) prohibits the "taking" of any species of animal or plant listed as Endangered, Threatened, or Species of Special Concern. For animals, "taking" is defined as: "to harass, harm, pursue, hunt, shoot, hound, kill, trap, capture, collect, process, disrupt the nesting, breeding, feeding, or migratory activity or attempt to engage in any such conduct, or to assist in any such conduct" (321 CMR s. 10.02). This broad definition of "take" allows regulatory protection to be provided to individual wood turtles as well as to their wetland and upland habitats.

Under certain circumstances, the Division may grant a permit allowing the "take" of state-listed species as a result of a development project. Such "Conservation Permits" (321 CMR 10.04(3)) are granted only when there are no reasonable alternatives to the proposed project, when the project has been modified to minimize impacts to rare species and their habitats,

and when the project has been designed in such a way as to provide a "net benefit" to the population(s) of affected species. "Take" can also be allowed for research or educational purposes.

Assessing Impacts Under MESA – The Division may request additional site-specific information to aid in its regulatory review of proposed projects. This will be especially true for requests for Conservation Permits that allow limited take of wood turtles under MESA. Although 1 to 2 years of additional data collection is unlikely to describe all habitats used by a local population of wood turtles, it is likely to contribute information useful to the Division's review process.

In reviewing a project, the Division may request additional information on some or all of the following:

- Relative abundance of wood turtles – This information is obtained by capturing turtles with dip nets, with traps, and by hand. Captured turtles should be individually marked, and the catch per unit effort should be calculated. Capture efforts should occur each month from March 15 to November 15.

- Turtle movements and location of overwintering sites – Radio-track at least 10 adult males and 10 adult females. Track turtles for at least 2 activity seasons: from initial capture to November 15 and from March 15 to November 15 of the second season. Record locations every other day from April 15 to October 15, when turtles are most active on land. Record locations once a week during the rest of the season.

- Home range sizes and lengths – Map each turtle's movements (all radio-tracking locations) on separate 1:12,000 minimum scale air photos (leaves off, color infrared). Calculate the area (in hectares, using minimum convex polygons) and length (maximum distance between 2 outermost locations, in meters) for each turtle.

- Age classes of captured turtles – Turtle age classes are best estimated from shell morphometrics. Measure the following on all turtles when captured and recaptured (in millimeters): carapace length, plastron length, plastron width. Count the number of growth rings on the plastron. The number and percent of turtles with <10 growth rings on the shell, and the number and percent with plastron lengths of <145 mm should be calculated.

The Division issues permits for handling and capturing state-listed species in the field and therefore must be contacted before such activities are attempted.

GUIDELINES TO AVOID ADVERSE IMPACTS

Activities that may have adverse effects on wood turtle habitat and/or may kill or injure adults, juveniles, hatchlings, or eggs include but are not limited to the following.

- Destroying wetland habitats by filling.

- Degrading wetland habitats by increasing erosion and sedimentation or discharging runoff and contaminants into wetlands.

- Altering the hydrology of wetland habitats. Adding impermeable surfaces nearby, such as pavement and buildings, can alter the hydrology of wetlands by increasing runoff. Water detention systems can alter hydrology by decreasing the amount of water that normally reaches the wetland.

- Releasing water from dams. Dam releases can flood nests and kill eggs located in banks and sandbars below dams (Compton 1999).

- Undertaking activities that cause or significantly increase the likelihood of direct mortality to turtles or eggs. Examples include: building roads and parking lots; increasing traffic on existing roads; using machinery for landscaping, forest-cutting, lawn-mowing, and plowing. The probability that mortality will occur will likely increase with increased proximity of these activities to known turtle habitat.

- Construction of barriers to turtle movements, including walls and fences, ditches, curbs, railroads (non-elevated, without underpasses or overpasses), and roads (non-elevated, without underpasses or overpasses).

- Decreasing upland habitat diversity, especially destroying areas with dense ground cover and little or no canopy cover.

- Decreasing habitat diversity within wetlands or decreasing diversity and abundance of wetlands at a landscape level. Disrupting ecological processes that maintain diversity within and between wetlands may adversely impact wood turtles. Altering hydrology by adding impervious surfaces (driveways, houses) or by installing retention basins can disrupt these processes.

- Increasing the amount of human activity in wood turtle habitat, without providing sufficient undisturbed habitat, and without enforcing bans on the collection of wood turtles.

Because wood turtles commonly travel each year between habitat features that are hundreds of meters apart (Tables 2 and 3), the activities listed above have the potential to adversely affect habitat or cause “take” of wood turtles if they occur up to 600 m from documented turtle sightings. However, not all development activities within the range of maximum movement are likely to adversely affect actual habitat areas or to cause a taking. Each proposed project will be reviewed separately by the Division, and consideration will be given to site-specific conditions, the nature and extent of the proposed activity, the extent and quality of local turtle habitat, and knowledge of both the general ecology and local status of wood turtles.

LITERATURE CITED

Arvisais, M., E. Levesque, and J. Bourgeois. 1999. Habitat characterization and selection within the home range of wood turtles (*Clemmys insculpta*). Proceedings of the Canadian Amphibian and Reptile Conservation Network, Quebec.

Brewster, K.N. and C.M. Brewster. 1991. Movement and microhabitat use by juvenile wood turtles introduced into a riparian habitat. Journal of Herpetology 25(3):379-382.

Brooks, R.J., G.P. Brown and D.A. Galbraith. 1991. Effects of a sudden increase in natural mortality of adults on a population of the common snapping turtle (*Chelydra serpentina*). Canadian Journal of Zoology 69:1314-1320.

Brooks, R.J., C.M. Shilton, G.P. Brown, and N. Quinn. 1992. Body size, age distribution, and reproduction in a northern population of wood turtles (*Clemmys insculpta*). Canadian Journal of Zoology 70:462-469.

Carroll, T.E. and D.W. Ehrenfeld. 1978. Intermediate-range homing in the wood turtle, *Clemmys insculpta*. Copeia (1):117-126.

Compton, B.W. 1999. Ecology and conservation of the wood turtle (*Clemmys insculpta*) in Maine. M.Sc. thesis, University of Maine, Orono.

Congdon, J.D., A.E. Dunham and R.C. van Loben Sels. 1993. Delayed sexual maturity and demographics of Blanding's turtles (*Emydoidea blandingii*): implications for conservation and management of long-lived organisms. Conservation Biology 7(4)826-833.

Congdon, J.D., A.E. Dunham and R.C. van Loben Sels. 1994. Demographics of common snapping turtles (*Chelydra serpentina*): implications for conservation and management of long-lived organisms. American Zoology 34:397-408.

Cowardin, L. V. Carter, F. Golet, and E. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service. FWS/OBS-79/31. 103 pp.

Crouse, D.T., L.B. Crowder, and H. Caswell. 1987. A stage-based population model for loggerhead sea turtles and implications for conservation. Ecology 68(5):1412-1423.

deMaynadier, P.G. and M.L. Hunter. 1999. Forest canopy closure and juvenile emigration by pool-breeding amphibians in Maine. Journal of Wildlife Management 63(2):441-450.

Doroff, A.M. and L.B. Keith. 1990. Demography and ecology of an ornate box turtle (*Terrapene ornata*) population in south-central Wisconsin. Copeia (2):387-399.

Ernst, C.H. 1986. Environmental temperatures and activities in the wood turtle, *Clemmys insculpta*. Journal of Herpetology 20(2):222-229.

Farrell, R.F. and T.E. Graham. 1991. Ecological notes on the turtle *Clemmys insculpta* in northwestern New Jersey. Journal of Herpetology 25(1):1-9.

Gibbs, J.P. and J.D. Amato. 2000. Genetics and demography in turtle conservation. Pp. 207-217 in M.W. Klemens (ed.), *Turtle Conservation*. Smithsonian Institution Press, Washington, D.C.

Harding, J.H. and T.J. Bloomer. 1979. The wood turtle, *Clemmys insculpta*: a natural history. Bulletin of the New York Herpetological Society 15(1):9-26.

Kaufmann, J.H. 1992. Habitat use by wood turtles in central Pennsylvania. Journal of Herpetology 26(3):315-321.

Kaufmann, J.H. 1995. Home ranges and movements of wood turtles, *Clemmys insculpta*, in central Pennsylvania. Copeia (1):22-27.

Lovich, J.E., C.H. Ernst, and J.F. McBreen. 1990. Growth, maturity, and sexual dimorphism in the wood turtle, *Clemmys insculpta*. Canadian Journal of Zoology 68:672-677.

Niederberger, A.J. and M.E. Seidel. 1999. Ecology and status of a wood turtle (*Clemmys insculpta)* population in West Virginia. Chelonian Conservation and Biology 3:414-418.

Quinn, N. and D.P. Tate. 1991. Seasonal movements and habitat of wood turtles (*Clemmys insculpta*) in Algonquin Park, Canada. Journal of Herpetology 25(2):217-220.

Raymond, L.R. and L.M. Hardy. 1991. Effects of a clearcut on a population of the mole salamander, *Ambystoma talpoideum*, in an adjacent unaltered forest. Journal of Herpetology 25:509-512.

Saccheri, I., M. Kuussaari, M. Kankare, P. Vikman, W. Fortelius, and I. Hanski. 1998. Inbreeding and extinction in a butterfly metapopulation. Nature 392:491-494.

Siart, L. 1999. An investigation of wood turtle (*Clemmys insculpta*) nest success in southwestern Massachusetts. M.Sc. Thesis, Antioch University, Keene, N.H.

Smith, K. and R. Brooks. 1999. Demography and home ranges of wood turtles, *Clemmys insculpta*, in Algonquin Park, Ontario. Proceedings of the Canadian Amphibian and Reptile Conservation Network, Quebec.

Strang, C.A. 1983. Spatial and temporal activity patterns in two terrestrial turtles. Journal of Herpetology 17(1):43-47.

Tuttle, S.E. and D.M. Carroll. 1999a. Nest-to-water movements and habitat use of hatchling wood turtles. P. 222 in *Program and Abstracts*, 79th Annual Meeting of the American Society of Ichthyologists and Herpetologists. University of Pennsylvania, State College.

Tuttle, S.E. and D.M. Carroll. 1999b. Home range and habitat use of wood turtles, *Clemmys insculpta*, in Southern New Hampshire. P. 222 in *Program and Abstracts*, 79th Annual Meeting of the American Society of Ichthyologists and Herpetologists. University of Pennsylvania, State College.