

REVIEW OF THE ECOLOGY AND CONSERVATION OF THE BOG TURTLE, *CLEMMYS MUHLENBERGII*

GREAT SMOKY MTS. NTL. PARK
GATLINBURG, TENN.
RECEIVED

MAY 2 '79

✓	Supt.	RB 9/4
✓	Asst. Supt.	AS 7
	Staff Pat. Spec.	
	Adm. Officer	
✓	Chief Ranger	Dunlop
	Chief of Interp.	
	Chief of Mnt.	
	E/C Coord.	
	Safety Mgr.	
✓	Research Coord.	LS
	Center Director	



UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Special Scientific Report—Wildlife No. 219

Library of Congress Cataloging in Publication Data

Bury, R. Bruce.

Review of the ecology and conservation of the bog turtle, *Clemmys muhlenbergii*.

(Special scientific report—wildlife; no. 219)

Supt. of Docs. no.: I 49.15/3:219

1. Bog turtle—Ecology. 2. Wildlife conservation—United States. 3. Reptiles—Ecology. 4. Reptiles—United States—Ecology. I. Title. II. Series.
SK361.A256 no. 219 [QL666.C584] 636'.9'08s [639'.97'813] 79-607014

REVIEW OF THE ECOLOGY AND CONSERVATION OF THE BOG TURTLE, *CLEMMYS MUHLENBERGII*

By R. Bruce Bury



UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Special Scientific Report—Wildlife No. 219
Washington, D.C. • 1979

Review of the Ecology and Conservation of the Bog Turtle, *Clemmys muhlenbergii*

by

R. Bruce Bury

U.S. Fish and Wildlife Service
National Fish and Wildlife Laboratory
1300 Blue Spruce Drive
Fort Collins, Colorado 80524

Abstract

The bog turtle (*Clemmys muhlenbergii*) is variously considered to be secretive, uncommon, or threatened with extinction. It has a disjunct distribution in the eastern United States, and populations are restricted to wetlands such as bogs and swamps. The turtle appears to be an omnivore. It is most active in the spring, and the eggs (usually three to five) are laid in late spring or early summer. Sexual maturity in both sexes probably occurs at a plastral length of about 75 mm, when the turtles are 6 to 8 years old. Bog turtles apparently have small home ranges (about 1.3 ha or smaller). Other population features are poorly known. There is concern for the plight of the bog turtle because of the continual loss of wetland habitat and irresponsible collecting. A thorough survey is recommended to delineate the occurrence and abundance of the remaining populations of the species throughout its range.

The North American bog turtle (*Clemmys muhlenbergii* Schoepff, 1801) has remained among the most poorly known freshwater species because of its uncommon and discontinuous occurrence. The literature on the species consists mostly of numerous reports of its discovery at new localities in the eastern United States, and extensive descriptions based on scanty field data. Several people have suggested that it is threatened with extinction, whereas others have reported that some populations are large.

Nomenclatural history, systematics, technical description, fossil records, relationships, and pertinent life history literature of the bog turtle were reviewed by Ernst and Bury (1977) and Bury and Ernst (1977). The present paper summarizes the literature on behavior, ecology, habitat, and management problems. This information is offered to resolve contradictions about the abundance of the species, to indicate gaps in the information available about it, and to provide a perspective for its management and conservation.

Description

The bog turtle is clearly distinguishable in the field (Fig. 1). The shell of adults is small, measuring 75-110 mm long; most adults are 75 to 90 mm long. The shell and body are brown to black. There is a large, bright

orange, yellow, or red blotch on each side of the head at the tympanum.

Males have concave plastrons and long, thick tails, and the vent is beyond the carapacial margin; females have high carapaces, flat plastrons, relatively short tails, and the vent is beneath the carapace edge.

Distribution

The bog turtle has a spotty distribution, extending from upper New York and eastern Pennsylvania southward to the Appalachian Mountains in North Carolina (Fig. 2). There are no verified records for West Virginia, southern Maryland, or northern Virginia, and a large gap separates the northeastern populations from colonies in the southern Appalachians (Babcock 1919; Barton and Price 1955; Nemuras and Weaver 1974a; Nemuras 1975; Ernst and Bury 1977).

There are numerous reports on its distribution: *Rhode Island* (Babcock 1917); *Connecticut* (Robinson 1956; Nemuras 1975); *New York* (Fisher 1887; Wright 1918a, 1918b; Bishop 1923; Davis 1928; Myers 1930; Stewart 1947; Ashley 1948; Kauffeld 1949; Benton and Smiley 1961; Zappalorti 1976); *Delaware* (Arndt 1972, 1975, 1977); *Pennsylvania* (Surface 1908; Netting 1927; Roddy 1928; Burger 1933; Cramer 1935, 1941; Heilman 1951; Swanson 1952; Hudson 1954;



Fig. 1. Adult bog turtle (photograph by J. Weaver).

Behler 1970; Nemuras and Weaver 1974b); *New Jersey* (Fowler 1907; Conant and Bailey 1936; Grant 1966; Bloomer and Bloomer 1973); *Maryland* (McCauley and Manseuti 1943; McCauley 1945; Cooper 1949; Reed 1956; Campbell 1960; Nemuras 1965, 1966a, 1966b; Schwartz 1967; Anon. 1973; Harris 1975); *Virginia* (Barton 1960; Hutchinson 1963; Nemuras 1974a); and *North Carolina* (Dunn 1917; Brimley 1943; Nemuras 1974b; Zappalorti 1975).

Habitat

Bog turtles live in bogs and wet meadows where sun penetration is great and humidity high in warm weather (Barton and Price 1955). Major descriptions of the turtle's habitat were given by Carr (1952), Barton and Price (1955), Nemuras (1967), Ernst and Barbour (1972), Nemuras and Weaver (1974b), Zappalorti (1976), Ernst and Bury (1977), and Arndt (1977).

The species may live from sea level to 1,280 m. It usually occurs below 245 m in the northern portion of its range, but inhabits areas from 645 to 1,280 m in the

Appalachians. A few populations are known from 215 to 275 m in the Piedmont region of North Carolina (Nemuras 1974a, 1974b, 1976; Zappalorti 1975).

The bog turtle occurs in standing or slow-moving water that has a mucky substrate, but it is not fully aquatic. It inhabits shallow water, and often is found with its feet wet but its carapace dry. Tryon and Hulsey (1977) reported that captives preferred to be either totally or partly submerged most of the time.

Bog turtles are associated with undisturbed bogs, swamps, ponds, and wetlands that support moisture-loving plants (Carr 1952; Campbell 1960; Nemuras 1965, 1966c; Eglis 1967; Ernst and Barbour 1972; Nemuras 1974b) such as sphagnum mosses (*Sphagnum* spp.), club mosses (*Lycopodium* spp.), skunk cabbage (*Symplocarpus foetidus*), sedges (*Carex* spp.), bulrushes (*Scirpus* spp.), cattail (*Typha latifolia*), speckled alder (*Alnus rugosa*), swamp-bay magnolia (*Magnolia virginiana*), and swamp honeysuckle (*Rhododendron viscosum*). An abundance of grassy or mossy cover is characteristic of most areas where bog turtles are found (Barton and Price 1955). Inasmuch as

these habitat conditions occur in areas of the eastern United States where no bog turtles are present (Nemuras 1974a), other factors apparently restrict the distribution of the species.

Food

Bog turtles apparently forage both on land and under water during the day in warm or hot weather (Surface 1908; Barton and Price 1955; Campbell 1960; Eglis 1967; Ernst and Barbour 1972; Nemuras and Weaver 1974b; Nemuras 1967, 1974b, 1976). Zappalorti (1976) reported that they are aggressive predators.

The diet consists principally of insects but includes some plants and carrion. The contents of two stomachs examined by Surface (1908) consisted of 80% insects and 20% berries. Barton and Price (1955) found the following (in order of abundance) in two adults from Pennsylvania: Lepidoptera larvae, Coleoptera adults, seeds of pondweed (*Potamogeton*) and sedge, several caddis fly larval cases, cocoons of a parasitic hymenopteran or dipteran, snails, millipede pieces, and a crane fly wing. The feces of some adult turtles caught in mid-August contained the exoskeletons of Japanese beetles (*Popillia japonica*).

Numerous other foods of bog turtles have been reported: watercress and skunk cabbage (Zappalorti 1975, 1976), pondweed (Nemuras 1976), earthworms (Nemuras and Weaver 1974a; Nemuras 1976), crayfish (Zappalorti 1975, 1976), snails (Campbell 1960, Nemuras 1974b; Zappalorti 1975, 1976), slugs (Zappalorti 1975, 1976), aquatic insects (Nemuras 1976), field crickets (Zappalorti 1975), butterfly larvae (Campbell 1960), tadpoles (Nemuras 1974b, 1976; Nemuras and Weaver 1974a), bullfrogs, green and wood frogs (Zappalorti 1975, 1976), pickerel frog (Campbell 1960), water snake (Robotham 1963), and nestling birds (Zappalorti 1975, 1976).

Information is inadequate to describe seasonal changes or age differences in feeding habits. There are no detailed quantitative studies of diet. A stomach pump would enable examination of ingested food without killing the turtles (for technique, see Legler 1977).

Seasonal Activities and Migrations

A. J. Barton (*in* Eglis 1967) described a migratory pattern of bog turtles in a Pennsylvania population: in April or May the turtles moved upstream to feeding and egg-laying sites in areas of shallower water, and near the end of August they returned to hibernation areas where the water is deeper. One turtle moved at

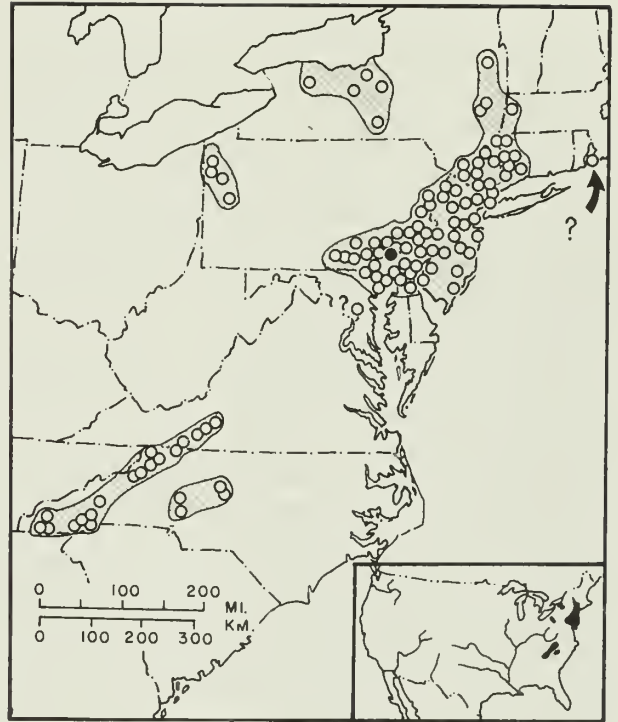


Fig. 2. Distribution of the bog turtle in the eastern United States (from Ernst and Bury 1977, based on Nemuras 1975).

an average rate of 17 m a day over a distance of 185-215 m.

Most activity occurs from April to June and in September (Campbell 1960; Nemuras 1967, 1974b; Nemuras and Weaver 1974a, 1974b; Ernst and Barbour 1972; Zappalorti 1976). In Pennsylvania, Ernst (1977) found turtles active from late March to late September; most activity was in May. The latest recorded activity was in October. In Delaware, Arndt (1977) also found that most activity was in May. The turtles apparently hibernate for about 6 months, from mid-autumn to early spring. When they emerge from hibernation, they spend much time basking. They are often found basking in spring and early summer, and seemingly are less active in midsummer, when the soggy habitat becomes drier. Barton and Price (1955) reported that the species is active in midsummer, but McCauley and Mansueti (1943), Ernst and Barbour (1972), and Nemuras and Weaver (1974a) wrote that it may estivate then. Overnight and during cool, cloudy spells, the turtles bury themselves in the soil or marshland (Barton and Price 1955). In North Carolina, Nemuras (1974b) reported seeing turtles roaming about in the rain.

Daily Activities

In Pennsylvania, Ernst and Barbour (1972) saw the bog turtle only during the warmer parts of the day (1100-1600 h), and Barton and Price (1955) stated that it rarely becomes active before 1000 h, even in mid-summer. In North Carolina, Nemuras (1974b) observed basking until dusk. Zappalorti (1975, 1976) found turtles to be active as early as 0700 h and as late as 1800 h in June and July. In Delaware, Arndt (1977) reported that activity occurred between 0830 and 1840 h with most records from 1200 to 1700 h.

Several workers have suggested that bog turtles remain active at higher temperatures than other northeastern turtles (Cramer 1935; Barton and Price 1955; Eglis 1967; Ernst and Barbour 1972), but recent evidence does not support this contention. Zappalorti (1975) found individuals in North Carolina active at all times of the day when air temperatures were above 18 C but less than 30 C. Body temperatures ranged from 18 to 24 C in basking turtles and from 24 to 28 C in active turtles. In Delaware, Arndt (1977) reported that the body temperature of turtles (N = 12) in the field ranged from 17.0 to 35.0 C; 10 individuals found sunning had temperatures that ranged from 24.0 to 35.0 C (\bar{X} = 28.6). Ernst (1977) reported that active bog turtles (N = 98) he found in Pennsylvania had cloacal temperatures ranging from 16.2 to 31.0 C (\bar{X} = 20.2 \pm 2.29). Those basking (N = 37) had the highest temperatures, ranging from 22.0 to 31.0 C (\bar{X} = 25.3 \pm 2.07). These data do not indicate that the bog turtle is active at temperatures higher than those reported for other species of freshwater turtles (Brattstrom 1965). Evidence provided by Ernst (1977) suggests that basking elevates the body temperature—which is the primary reason for basking in other turtles (Boyer 1965; Moll and Legler 1971; Bury 1972; Auth 1975). Ernst (1977) reported that bog turtles avoid summer heat by burrowing into the soft substrate of waterways, crawling under sedge tussocks, or entering muskrat bank burrows.

Movements

Little is known about the spatial relations of the species. One male studied in Pennsylvania moved only an average of 12 m between three recapture sites in the same month; when it was displaced 0.4 km away it returned to the capture area in 1 day (Ernst and Barbour 1972). This limited evidence suggests that the turtle has homing ability. Zappalorti (1975) recaptured three turtles 39-72 m from the place of first capture after 1-5 weeks, which indicates that these turtles have a small activity area.

Ernst (1977) calculated the mean home range of 19

Pennsylvania turtles to be 1.30 \pm 0.39 ha—1.33 \pm 0.49 ha for 11 males and 1.26 \pm 0.30 ha for 8 females. A. J. Barton (*in* Ernst 1977) found home ranges to be 0.008 to 0.121 ha for males and 0.086 to 0.943 ha for females.

Behavior

Details of intraspecific competition, dominance (subordination), aggregation, or other behavioral interactions of the bog turtle are poorly known. Zappalorti (1976) observed threats and attacks between males in the wild and in captivity. Ernst (1977) found two or more males aggregated together in the field, but he did not observe any aggressive behavior.

Bog turtles frequent wet, soggy terrain also inhabited by spotted turtles (*Clemmys guttata*) and wood turtles (*C. insculpta*) in the northeastern States. In deeper standing water are painted turtles (*Chrysemys picta*), snapping turtles (*Chelydra serpentina*), mud turtles (*Kinosternon subrubrum*), and stinkpots (*Sternotherus odoratus*); and box turtles (*Terrapene carolina*) are nearby on land (Barton and Price 1955; Nemuras 1966c; Ernst 1971, 1976). Ernst (1976) reported that in Pennsylvania bog turtles sometimes shared basking and feeding sites with spotted and painted turtles, and that spotted and bog turtles occupied the same muskrat burrows. The habits and habitats of the spotted turtle are most similar to those of the bog turtle, but no information exists on possible competitive interactions where these two species are sympatric.

Reproduction

Mating occurs from late April to early June and nesting is in June, July, and occasionally August (Barton and Price 1955; Campbell 1960; Nemuras 1967, 1976; Ernst and Barbour 1972; Zappalorti 1976). Although females have been reported to remain secluded during the breeding season (Cramer 1935; Ernst and Barbour 1972; Nemuras 1976; Zappalorti 1975, 1976), recent studies by C. H. Ernst (personal communication) indicate that females are as active as males in the breeding season.

Zappalorti (1976) described courtship as occurring in three phases: sexual recognition, aggressive biting, and mounting. Males mount females by biting or nipping at the female's neck and by hooking the claws of all four feet to her shell (Cramer 1935; Barton and Price 1955; Campbell 1960; Ernst and Barbour 1972; Zappalorti 1976; Arndt 1977). Mating occurs both in shallow water and on land (Barton and Price 1955; Campbell 1960; Nemuras and Weaver 1974b; Zappa-

lorti 1976). Nemuras (1974*b*) observed turtles in south-west Virginia mating during rainy weather.

Several workers who have described the nesting habits of bog turtles (Barton and Price 1955; Nemuras 1965, 1967, 1974*a*; Eglis 1967; Zovickian 1971*a*, 1971*b*; Arndt 1972; Ernst and Barbour 1972; Nemuras and Weaver 1974*b*; Sachsse 1974; Zappalorti 1976), have reported that females dig the nest in open and elevated ground in areas with moss, grassy tussocks, or moist earth. Clutch size varies from one to five eggs; the normal complement is three to five. It is not known whether more than one clutch of eggs is laid each year.

Incubation time in captivity ranges from 6 to 10 weeks, and mostly from 7 to 8 weeks (Campbell 1960; Eglis 1967; Nemuras 1969; Nemuras and Weaver 1974*b*; Zappalorti 1976; Arndt 1977; Tryon and Hulsey 1977). Barton and Price (1955) reported a hatchling emerging from a nest in early September under natural conditions. Overwintering of eggs deposited in late summer or fall is unconfirmed, although expected. There is no parental care of the young.

Growth and Sexual Maturity

Hatchling bog turtles are 25 to 30 mm long (Zovickian 1971*a*, 1971*b*; Arndt 1972; Nemuras 1974*a*; Sachsse 1974). Arndt (1977) reported that 17 hatchlings in captivity were 24.4-26.2 mm long ($\bar{X} = 25.5$). A yearling in Pennsylvania was 38 mm long (Ernst and Barbour 1972). In captivity, a turtle 2 years old and 53 mm long grew 31 mm in 2 years (Barton and Price 1955).

Ernst (1977) reported that Pennsylvania bog turtles averaged 22.9 mm (range, 17.2-28.5 mm) in plastral length as hatchlings. Growth closely resembled that of the spotted turtle, in that there was a gradual reduction in growth rate with age. Further, he reported that the bog turtle apparently has a slower growth rate than the sympatric spotted turtle or painted turtle.

Female bog turtles may be sexually mature when 75 mm long and about 5 years old (Barton and Price 1955). For Pennsylvania bog turtles, Ernst (1977) stated that sexual maturity is probably attained by both sexes at a plastral length of 70 mm—a length reached by some in the 6th year, but not by most until the 8th year.

Population Dynamics

Natality, mortality, immigration, and emigration rates of natural populations of bog turtles are unknown.

Of 226 turtles reported in the literature, there were

93 males, 122 females, and 11 juveniles (Barton and Price 1955; Nemuras 1965, 1967; Zappalorti 1975; Ernst 1977; Arndt 1977). Data are insufficient to enable one to estimate the reproductive span of adults or the sex ratio of any population. In general, most freshwater turtles have a sex ratio of 1:1, and are long-lived (Bury 1979).

Density estimates vary from a low of 5 per ha where commercial collectors sifted whole bogs, to an estimated high of about 125 individuals per ha (Eglis 1967). The numbers found at seven North Carolina bogs varied from 1 to 26 at each site (Zappalorti 1975). In Maryland, Campbell (1960) located 21 turtles in a swamp about 120 m long and 9 to 18 m wide (about 0.15 ha), which represents a density of about 140 turtles per ha.

At a Pennsylvania study area, the bog turtle represented only 0.8% of the turtles (10 of 1,218) captured over a 3-year period (Ernst 1971). Zappalorti (1975) reported collecting 54 bog turtles in seven North Carolina bogs during 225 h of search (1 turtle per 4.2 h). In Delaware, Arndt (1977) found 44 turtles during 81 h of search (1 turtle per 1.8 h).

Predation

Nests, young, and adults of bog turtles are prey of raccoons, skunks, dogs, foxes, and other large predators (Campbell 1960; Ernst and Barbour 1972; Nemuras 1974*b*, 1976).

The bog turtle is relatively small and has a drab-colored shell (often covered with mud); consequently, when it is motionless it often is well concealed in nature. It sometimes plunges or actively digs into the mud substratum to escape (Cooper 1949; Barton and Price 1955; Nemuras 1965, 1967; Ernst and Barbour 1972; Nemuras and Weaver 1974*a*, 1974*b*). It sometimes uses the burrows and trails of muskrats and meadow mice as travel routes and for cover (Bishop 1923; Arndt 1972; Ernst and Barbour 1972; Arndt 1977).

Responses to Habitat Change and Collecting

Urbanization is a serious threat to the survival of the bog turtle, particularly in the northeastern States. In recent years, the species has apparently disappeared from Staten Island (Nemuras and Weaver 1974*a*; Zappalorti 1976).

Bog turtle sites have been destroyed by several kinds of urban developments (Barton and Price 1955; Robotham 1963; Nemuras 1965; Nemuras and Weaver 1974*a*), such as shopping centers, a golf course, a sewage disposal plant, a city park, and a playground.

Road construction also has disrupted populations of the turtle (Robotham 1963; Nemuras 1974*a*, 1974*b*; Nemuras and Weaver 1974*b*) and mortality on highways may be significant (Arndt 1977).

Habitat is destroyed by landfills and by the draining of swampy areas to control mosquitoes or for industrial development (Robotham 1963; Eglis 1967; Nemuras 1967, 1974*a*). Scrap-dumping activities and mining at quarries have filled in parts of bogs inhabited by the species (Campbell 1960; Nemuras 1965). Drainage and development of deep bogs for muck farming has eliminated habitat (Nemuras 1967). The draining of soggy pastures (sometimes accompanied by burning of sedge tussocks) and trenching through bogs and marshes in dairy farm areas have also greatly reduced the area of habitats for the bog turtle (Nemuras 1966*a*, 1974*b*; Nemuras and Weaver 1974*b*; Zappalorti 1976). Livestock grazing in pasture habitats (tussock areas) could injure some turtles (Nemuras and Weaver 1974*b*).

The invasion of marsh habitats by purple loosestrife (*Lythrum salicaria*) has greatly altered the character of many wetlands in New York (Smith 1964). The dominance and persistence of this aggressive Eurasian weed is possibly a threat to northern populations of the bog turtle.

Wright (1918*b*) stated that the species was vanishing with the drying up or draining of sphagnum bogs and "feather-bed" swamps. Ernst and Barbour (1972) reported that the draining of the habitat has nearly eliminated the species over most of its original range. On the other hand, some populations have been flooded when waters were impounded (Nemuras 1974*a*).

Collecting for the pet trade is a serious problem for small, isolated colonies; unrestricted or illegal collecting is encouraged by the commercial value of bog turtles in Europe—\$75-\$150 apiece (Eglis 1967; Salazar 1967; Nemuras 1969, 1974*a*, 1974*b*, 1976; Behler 1971; Weaver 1972; Campbell 1974; Zappalorti 1976; Arndt 1978). There is also a high demand for this turtle in the United States due to its presumed rarity. Clandestine collecting is a serious threat to natural populations. Occasionally bog turtles are shot (Nemuras 1974*b*; Nemuras and Weaver 1974*b*).

Conservation and Management

Scientific and esthetic interest in the species is high. It is the smallest of the four species of the genus *Clemmys*, a North American group, and has a relictual distribution. Collecting for scientific study has little impact on the species; most current workers mark and release animals at the site of capture.

The rarity or plight of the bog turtle has been dis-

cussed by many authors: Babcock (1917, 1919), Wright (1918*b*), Netting (1927), Cramer (1935), Ditmars (1936), Pope (1939), McCauley and Manseuti (1943), McCauley (1945), Carr (1952), Barton and Price (1955), Campbell (1960, 1974), Robotham (1963), Nemuras (1965, 1966*a*, 1966*b*, 1966*c*, 1967, 1969, 1974*a*, 1974*b*, 1976), Eglis (1967), Pritchard (1967), Salazar (1967), Schwartz (1967), Behler (1970, 1971), Zovickian (1971*a*, 1971*b*), Arndt (1972, 1975), Ernst and Barbour (1972), Weaver (1972), Anonymous (1973), Bloomer and Bloomer (1973), Nemuras and Weaver (1974*a*, 1974*b*), Sachsse (1974), Conant (1975), Harris (1975), Zappalorti (1975, 1976), and Ernst and Bury (1977). Ernst and Barbour (1972) reported that this species has been considered as the rarest turtle in North America for more than 50 years.

Tryon and Hulsey (1977) reported that bog turtles bred and laid eggs in captivity. They contended that a substantial captive-bred population is essential to alleviate the effects of disasters to natural populations and habitats. I contend that these efforts are unlikely to succeed in producing surplus animals for restocking. Further, it is important that captive breeding avoid mixing native stocks, lest genetic differences be lost.

Conservation efforts should focus on natural populations to reveal the present abundance of the species and the prime habitat areas that need to be protected. The bog turtle seems to be present in many disjunct wetlands. Nemuras (1975) found about 260 localities for the turtle; most (59%) were in New Jersey and Pennsylvania. Several new localities are known in North Carolina (Zappalorti 1975) and recent studies by the State of Maryland (Anonymous 1978) indicated that the turtle occurred at 130 sites in three counties. Arndt (1978) proposed that the bog turtle is not rare, but rather is secretive, and that lack of previous interest and effort to find it was the reason for its "rarity." There is encouraging evidence that the bog turtle is not depleted in all parts of its range. Still, its wetland habitat is in danger of being altered by man's activities and many populations are near expanding urban and industrial areas in the northeastern United States.

The bog turtle now has some protection in New York, Connecticut, Pennsylvania, New Jersey, and Maryland (Weaver 1972; McCoy 1974; Nemuras and Weaver 1974*a*), and is a species of special concern in North Carolina. Private reserves for the turtle have been set aside in New Jersey (Nemuras and Weaver 1974*a*, 1974*b*), and one area is being considered by New York for a reserve, principally for the bog turtle. The Pennsylvania Game Commission manages two bog turtle reserves: Middle Creek Wildlife Management Area, Lebanon County, and Pymatuning Wild-

life Management Area, Crawford County. A few bog turtle populations occur on U.S. Forest Service lands in North Carolina, where the turtles are in no immediate danger unless roads are constructed in the habitat (Zappalorti 1975) or the bog areas are disrupted.

The species is included in the Red Book (U.S. Department of the Interior 1973), but it is not officially listed as an endangered or threatened species under the Endangered Species Act of 1973. The bog turtle is on Appendix II of the International Convention of Trade in Endangered Species of Wild Fauna and Flora; an export permit is required before the animal may be sent out of the United States.

Discussion

The bog turtle apparently is uncommon over much of its range. It is a secretive animal and many populations may not be found without special effort. Some populations have been destroyed by man's activities. The location and size of other populations have not been reported for fear that they would be raided by collectors.

The biology of the turtle remains poorly known. Only four substantive studies on the ecology of this species have been published (Barton and Price 1955; Ernst 1977; Zappalorti 1976; Arndt 1977), and not all aspects of its ecology have been considered. Further research is needed to determine its habitat requirements and adaptive strategies throughout its range. Also, the species has many reproductively isolated populations and geographic variation in this species should be examined.

More literature has been published on the plight of the bog turtle than on that of any other North American freshwater turtle. Most of the authors have concluded that protection of the species is necessary because of its rarity, spotty distribution, specialized habitat requirements, and unique appeal. Habitat loss appears to be the most serious problem for remaining populations. Irresponsible collecting also threatens remaining populations.

I believe that an objective review of the present distribution and abundance of the bog turtle in each State within its range is warranted. I suggest that the most critical need is to determine the amount of habitat and size of the populations that remain, and then, if necessary, to consider it as a threatened species under the Endangered Species Act.

Acknowledgments

I thank K. T. Nemuras, J. A. Weaver, and R. T. Zappalorti for providing distributional and bib-

liographic information. C. H. Ernst, C. J. McCoy, and G. R. Zug offered helpful comments on earlier versions of this report.

References

- Anonymous. 1973. Endangered amphibians and reptiles of Maryland: a special report. Bull. Md. Herpetol. Soc. 9(3):42-100.
- Anonymous. 1978. Eagle, fox squirrel top Maryland's Endangered Species agenda. Endangered Species Tech. Bull. 3(2):4-6.
- Arndt, R. G. 1972. Additional records of *Clemmys muhlenbergi* in Delaware, with notes on reproduction. Bull. Md. Herpetol. Soc. 8(1):1-5.
- Arndt, R. G. 1975. Meet our turtles. Del. Conserv. 19(1):11-14.
- Arndt, R. G. 1977. Notes on the natural history of the bog turtle, *Clemmys muhlenbergi* (Schoepff), in Delaware. Chesapeake Sci. 18(1):37-76.
- Arndt, R. G. 1978. The bog turtle . . . an endangered species? Del. Conserv. 22(2):18-21, 25.
- Ashley, H. R. 1948. Muhlenberg's turtle in southern New York. Copeia 1948(3):220.
- Auth, D. L. 1975. The behavioral ecology of basking in the yellow-bellied turtle, *Chrysemys scripta scripta* (Schoepff). Bull. Fla. State Mus. Biol. Sci. 20(1):1-45.
- Babcock, H. L. 1917. An extension of the range of *Clemmys muhlenbergii*. Copeia 42:32.
- Babcock, H. L. 1919. The turtles of New England. Mem. Boston Soc. Nat. Hist. 8(3):323-431.
- Barton, A. J. 1960. Deletion of Virginia from the known range of *Clemmys muhlenbergi*. Herpetologica 16(2):120.
- Barton, A. J., and J. W. Price, Sr. 1955. Our knowledge of the bog turtle, *Clemmys muhlenbergi*, surveyed and augmented. Copeia 1955(3):159-165.
- Behler, J. L. 1970. The bog turtle (*Clemmys muhlenbergi*) in Monroe County, Pennsylvania. Bull. Md. Herpetol. Soc. 6(3):52-53.
- Behler, J. L. 1971. Bog turtle *Clemmys muhlenbergi*. Anim. Kingdom 74(1):33.
- Benton, A. H., and D. Smiley. 1961. Some noteworthy records from eastern New York. Herpetologica 17(2):142.
- Bishop, S. C. 1923. Notes on the herpetology of Albany County, New York, III. Copeia 125:117-120.
- Bloomer, T. J., and D. Bloomer. 1973. New Jersey's bog turtle . . . destined to extinction? Bull. N.Y. Herpetol. Soc. 9(3-4):8-12.
- Boyer, D. R. 1965. Ecology of the basking habit in turtles. Ecology 46(1-2):99-118.
- Brattstrom, B. H. 1965. Body temperatures of reptiles. Am. Midl. Nat. 73(2):376-422.
- Brimley, C. S. 1943. Reptiles and amphibians of North Carolina. Carolina Tips 6(1):2-3.
- Burger, J. W. 1933. A preliminary list of amphibians of Lebanon County, Pennsylvania, with notes on habits and life history. Copeia 1933(2):92-94.
- Bury, R. B. 1972. Habits and home range of the Pacific pond turtle, *Clemmys marmorata*, in a stream community. Ph.D. Thesis. Univ. of California, Berkeley. 205 pp.
- Bury, R. B. 1979. Population ecology of freshwater turtles. In M. Harless, and H. Morlock, eds. Turtles: research and perspectives. John Wiley & Sons Inc., New York. In press.
- Bury, R. B., and C. H. Ernst. 1977. *Clemmys*. Cat. Am. Amphib. Reptiles. Pages 203.1-203.2.
- Campbell, H. W. 1960. The bog turtle in Maryland. Md. Nat. 30(1-4):15-16.

- Campbell, H. W. 1974. Turtles at the brink: our endangered species. *Bull. Md. Herpetol. Soc.* 10(1):1-7.
- Carr, A. 1952. Handbook of turtles. Comstock Publishing Associates, Ithaca, N.Y. 522 pp.
- Conant, R. 1975. A field guide to reptiles and amphibians of eastern and central North America. Houghton Mifflin Co., Boston. 429 pp.
- Conant, R., and R. M. Bailey. 1936. Some herpetological records from Monmouth and Ocean counties, New Jersey. *Univ. Mich., Occas. Pap. Mus. Zool.* 328. 10 pp.
- Cooper, J. E. 1949. Additional records for *Clemmys muhlenbergii* from Maryland. *Herpetologica* 5(3):75-76.
- Cramer, W. S. 1935. Lancaster County turtles. *Pa. Angler* 4:15.
- Cramer, W. S. 1941. Little turtle of the swamp. *Nat. Mag.* 34:189-190.
- Davis, W. T. 1928. Natural history records from the meetings of the Staten Island nature club. *Proc. Staten Island Inst. Arts Sci.* 4:116-123.
- Ditmars, R. L. 1936. Reptiles of North America. Doubleday, Doran, Garden City, N.Y. 476 pp.
- Dunn, E. R. 1917. Reptile and amphibian collections from the North Carolina mountains with especial reference to salamanders. *Bull. Am. Mus. Nat. Hist.* 37:593-634.
- Eglis, A. 1967. *Clemmys muhlenbergi* rarest of North American turtles. *Anim. Kingdom* 70(2):58-61.
- Ernst, C. H. 1971. Population dynamics and activity cycles of *Chrysemys picta* in southeastern Pennsylvania. *J. Herpetol.* 5(3-4):151-160.
- Ernst, C. H. 1976. Ecology of the spotted turtle, *Clemmys guttata* (Reptilia, Testudines, Testudinidae), in southeastern Pennsylvania. *J. Herpetol.* 10(1):25-33.
- Ernst, C. H. 1977. Biological notes on the bog turtle, *Clemmys muhlenbergii*. *Herpetologica* 33(2):241-246.
- Ernst, C. H., and R. W. Barbour. 1972. Turtles of the United States. The University Press of Kentucky, Lexington. 347 pp.
- Ernst, C. H., and R. B. Bury. 1977. *Clemmys muhlenbergii* (Schoepff). *Cat. Am. Amphib. Reptiles.* Pages 204.1-204.2.
- Fisher, A. K. 1887. Muhlenberg's tortoise (*Chelopus muhlenbergii* Schweigger) at Lake George, N.Y. *Am. Nat.* 21(7):672.
- Fowler, H. W. 1907. Amphibians and reptiles of New Jersey. *Annu. Rep. N.J. State Mus.* 1906:23-250.
- Grant, R. R. 1966. Revisions to the distributional survey II, the coastal plain of New Jersey. *Bull. Phila. Herpetol. Soc.* 14(2):18-22.
- Harris, H. S. 1975. Distributional survey (Amphibia/Reptilia): Maryland and the District of Columbia. *Bull. Md. Herpetol. Soc.* 11(3):73-170.
- Heilman, R. A. 1951. A list of the amphibians and reptiles of Lebanon County, Pennsylvania. *Proc. Pa. Acad. Sci.* 25:44-46.
- Hudson, R. G. 1954. An annotated list of the reptiles and amphibians of the Unami Valley, Pennsylvania. *Herpetologica* 10(1):67-72.
- Hutchison, V. H. 1963. Record of the bog turtle, *Clemmys muhlenbergi*, in southwestern Virginia. *Copeia* 1963(1):156-157.
- Kauffeld, C. F. 1949. Staten Island turtles. In *Animalland* 16(2):4.
- Legler, J. M. 1977. Stomach flushing: a technique for chelonian dietary studies. *Herpetologica* 33(3):281-284.
- McCauley, R. H., Jr. 1945. The reptiles of Maryland and the District of Columbia. R. H. McCauley, Jr., Hagerstown, Md. 194 pp.
- McCauley, R. H., Jr., and R. Manseuti. 1943. *Clemmys muhlenbergii* in Maryland. *Copeia* 1943(3):197.
- McCoy, C. J. 1974. Pennsylvania protects the bog turtle. *Herpetol. Rev.* 5(2):44.
- Moll, E. O., and J. M. Legler. 1971. The life history of a neotropical slider turtle, *Pseudemys scripta* (Schoepff), in Panama. *Bull. Los Ang. County Mus. Nat. Hist. Sci.* 11:1-102.
- Myers, G. S. 1930. Amphibians and reptiles observed in the Palisades Interstate Park, New York and New Jersey. *Copeia* 173:99-103.
- Nemuras, K. T. 1965. The bog turtle in Maryland. *Bull. Phila. Herpetol. Soc.* 13(1-4):14-17.
- Nemuras, K. T. 1966a. Some records for *Clemmys muhlenbergi* in Cecil County, Maryland. *Bull. Md. Herpetol. Soc.* 2(2):1-2.
- Nemuras, K. T. 1966b. Bog trotting in Maryland. *Md. Conserv.* 18(3):7-10.
- Nemuras, K. T. 1966c. Genus *Clemmys*. *Int. Turtle Tortoise Soc. J.* 1(1):26-27, 39, 44.
- Nemuras, K. T. 1967. Notes on the natural history of *Clemmys muhlenbergi*. *Bull. Md. Herpetol. Soc.* 3(4):80-96.
- Nemuras, K. T. 1969. Survival of the Muhlenberg. *Int. Turtle Tortoise Soc. J.* 3(5):18-21.
- Nemuras, K. T. 1974a. The bog turtle. Profile of an endangered species. *Va. Wildl.* 35(6):7-9.
- Nemuras, K. T. 1974b. The bog turtle. *Wildl. N.C.* 38(2):13-15.
- Nemuras, K. T. 1975. Distribution of the bog turtle. 14 pp. (Unpublished report on file at the National Fish and Wildlife Laboratory, Ft. Collins, Colo.)
- Nemuras, K. T. 1976. Vanishing bog turtle. Populations diminished by climatic changes are being wiped out by man. *Defenders Wildl.* 51(1):38-39.
- Nemuras, K. T., and J. A. Weaver. 1974a. The bog turtle: synonym for extinction? *Natl. Parks Conserv. Mag.* 48(6):17-20.
- Nemuras, K. T., and J. A. Weaver. 1974b. The bog turtle. A little reptile with big problems! *Pa. Angler* 43(7):15-18.
- Netting, M. G. 1927. Muhlenberg's turtle in western Pennsylvania. *Ann. Carnegie Mus.* 17(3-4):403-408.
- Pope, C. 1939. Turtles of the United States and Canada. Alfred A. Knopf, New York. 343 pp.
- Pritchard, P. C. H. 1967. Living turtles of the world. T. F. H. Publications, Inc., Jersey City, N.J. 288 pp.
- Reed, C. F. 1956. The herpetofauna of Harford County, Maryland. *J. Wash. Acad. Sci.* 46(2):58-60.
- Robinson, D. C. 1956. *Clemmys muhlenbergi* in western Connecticut. *Copeia* 1956(4):257.
- Robotham, R. G. 1963(1964). The bog turtle, a gift of responsibility. *Bull. Phila. Herpetol. Soc.* 11(3-4):68-70.
- Roddy, H. J. 1928. Reptiles of Lancaster County, and the State of Pennsylvania. Publications of the Department of Natural History, Franklin and Marshall College, Lancaster, Pa. 53 pp.
- Sachsse, W. 1974. Zum Fortpflanzungsverhalten von *Clemmys muhlenbergii* bei weitgehender Nachahmung der natürlichen Lebensbedingungen im Terrarium. *Salamandra* 10(1):1-14.
- Salazar, M. B. 1967. The disappearing Muhlenberg, *Clemmys muhlenbergii*. *Int. Turtle Tortoise Soc. J.* 1(5):37-39.
- Schwartz, F. J. 1967. Maryland turtles. *Educ. Serv. Md. Dep. Res. Educ.* 79:1-38.
- Smith, R. H. 1964. Experimental control of purple loosestrife (*Lythrum salicaria*). *N. Y. Fish Game J.* 11(1):35-46.
- Stewart, G. D. 1947. A record for Muhlenberg's turtles. *Copeia* 1947(1):68.
- Surface, H. A. 1908. First report on the economic features of the turtles of Pennsylvania. *Zool. Bull. Div. Zool., Pa. Dep. Agric.* 6:105-196.
- Swanson, P. L. 1952. The reptiles of Venango County, Pennsylvania. *Am. Midl. Nat.* 47:161-182.

- Tryon, B. W., and T. G. Hulsey. 1977. Breeding and rearing the bog turtle *Clemmys muhlenbergii* at the Fort Worth zoo. *Int. Zoo Yearb.* 17:125-130.
- U.S. Department of the Interior. 1973. Threatened wildlife of the United States. U.S. Bur. Sport Fish. Wildl., Resour. Publ. 114. 289 pp.
- Weaver, J. 1972. *Clemmys muhlenbergii*, or the bog turtle. A compilation of data. 58 pp. (Unpublished report on file at the Division of Amphibians and Reptiles, National Museum of Natural History.)
- Wright, A. H. 1918a. Notes on *Clemmys*. *Proc. Biol. Soc. Wash.* 31:51-58.
- Wright, A. H. 1918b. Notes on the Muhlenberg's turtle. *Copeia* 52:5-7.
- Zappalorti, R. T. 1975. The status of the bog turtle *Clemmys muhlenberhi* (sic) in North Carolina. 22 pp. (Unpublished progress report, National Audubon Society.)
- Zappalorti, R. T. 1976. The amateur zoologist's guide to turtles and crocodilians. Stackpole Books, Harrisburg, Pa. 208 pp.
- Zovickian, W. H. 1971a. Captive nesting of bog turtles. *Int. Turtle Tortoise Soc. J.* 5(4):14-15, 37.
- Zovickian, W. H. 1971b. Humidity as a growth factor in hatchlings of *Clemmys muhlenbergi*. *Bull. Md. Herpetol. Soc.* 7(4):93-95.

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.



UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
EDITORIAL OFFICE
AYLESWORTH HALL, G5U
FORT COLLINS, COLORADO 80523

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF THE INTERIOR
INT 423



SUPERINTENDENT G10011
GREAT SMOKY MOUNTAINS
NATIONAL PARK
GATLINBURG
TN 37738

NOTE: Mailing lists are computerized. Please return address label with change of address.