Population and Habitat Ecology
of the River Cooter (*Pseudemys concinna*)
in the New River Gorge National River, W.V.

by

Kurt Andrew Buhlmann

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APPROVED:

Michael R. Vaughan, Chairman

James D. Fraser

Dean F. Stauffer

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(ABSTRACT)

During 1984-85 I investigated population ecology and habitat relationships of river cooters (*Pseudemys concinna*) in the New River Gorge National River (NRGNR), West Virginia. Cooter colonies occurred in 3 pool habitats characterized by slow current velocities ($\bar{x}$=0.22m/s), shallow water (0-2m), aquatic macrophyte beds, and basking sites.

The estimated adult population during summer 1985 was 64 individuals. Six, 25%, and 35% of the captures at the three study sites respectively, were juveniles. Most hatchling cooters apparently overwintered in the nest and emerged in April. Juvenile growth was rapid and linear until 6 years of age. Adult female cooters were larger (P=0.03) and heavier (P=0.0004) than males.

Adult cooters consumed mostly eelgrass (*Vallisneria americana*) and elodea (*Elodea canadensis*), although some crayfish remains were found in fecal samples. Juveniles consumed vegetation as well as invertebrates and fish.

Cooters did not move out of the pool habitats in which they were marked. Movements within pool habitats were influenced by basking site

availability and location, which varied with river flow flucuations. Two radio-marked cooters wintered in shallow backwater channels.

Potential factors limiting the population are collecting and high artifical summer flows which scour weedbeds. Addition of basking sites may increase habitat suitability for cooters.

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INTRODUCTION

During 1983-85 some co-workers and I conducted a biological survey of habitats and wildlife in the New River Gorge National River (NRGNR), W.V. The NRGNR was added to the National Park Service system in 1977 "with the purpose of conserving and interpreting its outstanding natural, scenic, and historical values and for preserving it as a free-flowing stream for the benefit and enjoyment of present and future generations" (U.S. Congress 1978). The survey was needed to provide a biological data base to aide Park personnel in making management decisions.

Early in the study, I discovered a species of aquatic turtle (*Pseudemys concinna*) not previously recorded for the NRGNR (Buhlmann and Vaughan 1985). This thesis reports on the ensuing study of *P. concinna* in the NRGNR.

River cooters (*P. concinna*) range throughout the southeastern coastal plain from Virginia to Florida where they inhabit large ponds, lakes, and rivers. They are large, conspicuous baskers. Females may have a carapace length of 320 mm and weigh 3.7 kg; males generally are smaller. The genus *Pseudemys* is the most abundant turtle group in the ponds and streams of the southeast and the Mississippi Valley (Conant 1975). Turtles in this genus are commonly called 'cooters' and/or 'sliders'. The name 'cooter' is derived from 'kuta', a word for turtle in several African dialects (Conant 1975:60).

In 1972 a number of turtles, presumed to be Florida cooters (*P. floridana*), were discovered in Bluestone Reservoir, located on the New

River in southern West Virginia, 8 km upstream from the NRGNR (Bayless 1972). Only a few adults were observed basking on emergent logs, thus Bayless speculated that those individuals may have been transported and released into the reservoir by man. The nearest known populations of cooters were more than 320 km east of Bluestone Reservoir on the Virginia Piedmont in Charlotte and Nelson Counties (Tobey 1985). No further research into the origin of these turtles was conducted until Seidel (1981) captured several individuals in Bluestone Reservoir and by analysis of cranial morphology, identified them as river cooters (P. concinna).

Seidel (1982) predicted that the isolated colony of cooters in Bluestone Reservoir was quite small and that continued survival depended largely on habitat stability and protection from human disturbance. He also found evidence for the presence of P. concinna in the New River system prior to construction of Bluestone Dam. A juvenile specimen located in the University of Michigan Museum of Zoology, had been collected in the Greenbrier River near its confluence with the New in 1934. The Greenbrier River meets the New River directly below Bluestone Dam.

Turtle bones recovered from an archeological site at Bluestone Reservoir were identified as 700-800 year old Pseudemys. Seidel (1982) felt it reasonable to assume that the river cooters in the Bluestone Reservoir represented an endemic population. River cooters probably entered the New River drainage during the late Pleistocene when some tributary streams on the Virginia Piedmont drained to the Teays (New) River. These tributaries have since been captured by the James and Roanoke Rivers (Ross 1969), which drain towards the Atlantic, and are known to support populations of river cooters.

Cooters are reported to range from the Mississippi Valley up the Ohio River only as far as western Kentucky and southwestern Indiana (Minton 1972). Recent collections have expanded the range 150 km eastward in Kentucky (Stephens 1985). Other collections of specimens in 1963 and 1969 indicate that the species may occur in the Kanahwa River near its junction with the Ohio River (Seidel and Green 1982). These specimens bear little resemblance to NRGNR specimens even though they occur in the same drainage. However, the Ohio River and NRGNR populations are separated by Kanahwa Falls, a natural barrier which is known to limit the distribution of fish and mollusc species (Neves 1983). Since cooters are less likely to travel overland than some other species of aquatic turtles, the Falls probably constitute a barrier to their dispersal. The presence of Kanawha Falls and the stream capture theory suggest that cooter populations in the NRGNR and Bluestone Reservoir originated from Atlantic drainage stock.

Because the NRGNR population is located outside of the known continuous range of this species, and is in a different geographical region, a study to collect baseline data was conducted. The results of the study are presented in two papers. The first paper discusses the population ecology and characteristics of cooter populations in the NRGNR and also discusses sampling and study techniques for aquatic turtle populations. The second describes habitat associations, diet, and movement patterns of cooters in the New River Gorge National River.

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CHAPTER 1

POPULATION ECOLOGY OF RIVER COOTERS IN THE NEW RIVER GORGE NATIONAL RIVER, WEST VIRGINIA

INTRODUCTION

River cooters (*Pseudemys concinna*) range throughout the southeastern coastal plain from Florida to Virginia, where they inhabit large ponds, lakes, and rivers. They are large, aquatic turtles and conspicuous baskers. Females may have a carapace length of 350 mm and weigh 3.7 kg; males generally are smaller.

During summer 1984 I surveyed the entire New River Gorge National River (NRGNR), West Virginia, and encountered *P. concinna* in three separate pool habitats (Buhlmann and Vaughan 1985), located downstream of the Bluestone Reservoir population described by Seidel (1981).

I suspect that cooter populations in the New River, West Virginia may be Pleistocene relicts. They are isolated from populations in the James and Roanoke river drainages on the Virginia Piedmont. These populations are located at the highest elevations recorded for this species (427 m), and the NRGNR population is near the northern edge of the species range.

During 1984-85 I investigated the population ecology of cooters in the NRGNR. Specific objectives were 1) determine distribution; 2) estimate population structure and size; 3) investigate selected life history parameters; and 4) recommend management actions for maintaining this species as part of the biota of the NRGNR.

STUDY AREA

The 84 km NRGNR between Hinton and Fayetteville, WV is located in the Appalachian Plateau physiographic region (Figure 1). The area consists of Pennsylvanian and Mississippian sandstones, shale, and coal seams (Fuerst 1981). Mean elevation at river level is 427 m. The NRGNR is a sixth order stream consisting of riffles, runs, and pools. Pool habitats, as well as riparian floodplains, exist in the southern section of the Gorge, near Hinton.

River flows are regulated by Bluestone Dam, a flood control facility located 4.8 km upstream and by Claytor Lake Dam, a hydroelectric facility, located 75 km upstream in Virginia. The presence of a flood control facility creates stability in the river, with natural low summer flows increased and winter flows reduced (Petts 1984).

The climate is mild with an average annual temperature of 11°C and 109-114 cm of precipitation per year. Mean summer (Jun-Aug) and winter (Dec-Feb) temperatures are 20.0°C and 2.2°C, respectively (Fuerst 1981:32). Winter and summer water temperatures range from

0.0-3.9°C and 18.0-26.5°C, respectively. Ice forms on the slower moving pools in mid-January.

Vegetation along the river is deciduous with sycamore (Platanus occidentalis), river birch (Betula nigra), black willow (Salix nigra), and silver maple (Acer saccharinum) constituting most of the canopy.

Emergent aquatic vegetation includes water willow (Justica americana), and lizard tail (Sauruus cernuus). Submergent aquatic vegetation includes elodea (Elodea canadensis), pondweed (Potomogeton crispus), and eelgrass (Vallisneria americana).

METHODS

Field techniques

During 1984 I captured basking cooters in basket traps constructed from poultry netting (Ream and Ream 1966, Sexton 1959, Morreale et al. 1983). Traps were attached to the undersides of basking logs and turtles dropped into the mesh baskets when approached by a researcher. The top edges of the baskets were bent inward to prevent captured turtles from climbing out.

During 1985, I used unbaited hoop net traps constructed of three galvanized hoops, 91 cm in diameter, with one fingered throat (Memphis Net and Twine, Memphis, Tenn.). A leader net attached to the front of each hoop net completed the fyke net trap (Vogt 1980).

Leader nets were constructed of 0.64cm mesh, were 15 m long, 1.3 m tall and had floats on the top and lead weights on the bottom. Hoop nets were set in shallow water (<91 cm) so that captured turtles could reach the surface to breathe.

Captured turtles were marked individually, by notching marginal scutes (Bury and Luckenback 1977). Square, rather than V-shaped cuts were made, since they take longer to grow out (M.E. Seidel, pers. comm.).

Straight line carapace length, plastron length, shell height, and weight were recorded for each captured turtle. Turtles were classified as mature male, mature female, juvenile, or hatchling. Juvenile yearly ages were estimated by counting the number of plastral annuli on the right abdominal scute. Hatchlings displayed only a birth annulus. Mature males were differentiated from mature females by secondary sex characteristics, such as elongated front nails, and thick tails. Females characteristically had shorter tails, higher domed shells, and were heavier (Jackson 1970).

Turtles with carapace lengths greater than 14.2 cm were marked with 3.3 cm diameter Petersen disc tags (Floy Tag Mfg., Seattle, WA). Turtles smaller than 14.2 cm could not swim properly with the large tags. Tags were attached by drilling holes through the ninth or tenth marginal scute and securing with galvanized wire. Two tags (one on each side of the carapace) were attached to each mature turtle.

Tag colors were unique to each study site and differed for males and females. Juveniles were marked with only one tag. Smaller juveniles (< 14.2cm) were affixed with 1.3 cm diameter tags that were unique in color, making individual identification possible.

I used observations of tagged turtles to calculate marked-to-total ratios and to determine if turtles moved upstream or downstream to other pool habitats in the river.

Tagged cooters were observed with binoculars or spotting scope while they were basking on logs or floating at the water's surface. Basking frequency was calculated as the number of tagged turtles basking divided by the total number of marked turtles in the population.

Population estimation

Adult spring population size for each of the 3 pools was estimated using Schnabel and Lincoln-Petersen estimators (Seber 1973). Schnabel estimates were calculated 14, 14, and 8 times at Sites 1, 2, and 3, respectively, between 21 April and 15 July 1985. The Lincoln-Petersen estimate was calculated using 21 April through 31 May as the marking period and 1 June through 15 July as the recapture period. The bounded counts method was also used to estimate population size from observations of basking cooters during the same time period (Overton 1971:426). A fall population estimate was attempted in September 1985, but low river flows and cool temperatures limited the number of cooters captured.

RESULTS

Population size

I captured 17 adult cooters 27 times, 15 adult cooters 25 times, and 13 adult cooters 22 times at Sites 1,2, and 3, respectively. I took the mean of the three separate population estimates as my best estimate of population size at each site (Table 1). Adult river cooter colony size at Sites 1, 2, and 3 was 22, 19, and 14, respectively. Resulting densities were 2.2/ha, 0.6/ha, and 1.2/ha, respectively. Densities were based only on water surface area at each site.

I also captured musk (*Sternotherus odoratus*), painted (*Chrysemys picta*), and snapping (*Chelydra serpentina*) turtles in the fyke net traps and estimated their relative abundance from captures/trap night (Table 2). At each study site river cooters were the least abundant and musk turtles were the most abundant species.

Basking frequencies

I found no differences in basking frequency between males and females during April, May, June, or July (*t*-test, Wilcoxon rank sum, Table 3). During August and September, males basked more frequently than females (*P* = 0.006 and 0.007, respectively) (Table 3). Female basking decreased steadily throughout the summer (Jonckheere test for ordered alternatives, *JS* = 2.08, df = 4, *P* = 0.019).

Size and Growth

Mature females (N=14) had longer carapaces than mature males (N=26) (*t* = 2.19, df = 38, *P* = 0.0341), longer plastrons, (*t* = 3.10, df = 37, *P* = 0.0036), greater shell height, (*t* = 4.88, df =38, *P* = 0.0001), and weighed more, *t* = 3.92, df = 38, *P* = 0.0004) (Table 4). The smallest mature male examined had a carapace length of 19.75cm, while the smallest female had a carapace length of 22.75cm.

Growth in adult cooters recaptured between April and September 1985 varied with capture interval (Table 5). Mean percent increase per day was 0.008cm ± 0.000009 (0.24cm/30 days) for females (N=4) and 0.02cm ± 0.000012 (0.60cm/30 days) for males (N=3). One male captured 17 June 1985 had recently lost a leg, was weak, and appeared in poor health. Ninety-two days later the stump had healed and his weight had increased by 163 g (1.9%).

Based upon carapace length, I found that juvenile growth through 6 years of age was linear (N =20, r^2=.908, Y= 3.82 + 1.85X, Table 6, Figure 2). Beyond 6 years of age, growth apparently declines but the rate is incalculable because growth rings are no longer visible. The largest juvenile cooter aged was 6 years old and had a carapace length of 16.5 cm.

Hatchling cooters were first observed in mid-April 1985. During April-June I captured 6 hatchlings that ranged in size from 3.2cm to 4.2cm (Table 7). Hatchlings were easily identified by unique plastal patterns. One hatchling, recaptured in October 1985 after 139 days had an increased carapace length from 3.2cm to 6.2cm (97%).

Sex ratios

Male:female sex ratios at Sites 1, 2, and 3 were 1.1:1.0, 2.0:1.0, and 4.5:1.0, respectively. The overall sex ratio for the NRGNR population was 1.9:1.0. At Sites 1, 2, and 3, juveniles accounted for 6%, 35%, and 25% of the total captures, respectively.

Courtship and Nesting

One instance of copulation was observed on 29 April 1985 and one female palpated on 17 June carried hard-shelled eggs. No nesting females were observed even though intensive searches were conducted. Likely nesting areas were inspected three times daily (8:00AM, Noon, and 6:00PM) between 15 May and 15 July 1985.

DISCUSSION

Basking behavior

Morreale et al.(1984) reported higher activity levels in female yellow-bellied sliders (Pseudemys scripta) during April and May. They speculated that females bask more in the spring in order to attain body temperatures necesssary for courtship behavior and the development of eggs.

I observed cooters in the NRGNR basking between 8:15 AM and 5:15 PM, with most activity occurring around midday. Pritchard and Greenwood (1968) found florida red-bellied turtles (Pseudemys nelsoni), florida cooters, and river cooters in Florida to bask between 7:30 AM and 4:45 PM, with most basking activity also occurring around midday.

Cagle (1950) reported that basking keeps the skin free of leeches and other parasites. Wind has been noted to decrease basking behavior, probably as a result of increased water loss and cooling (Boyer 1965).

The earliest recorded basking date for cooters in the NRGNR was 4 March 1985. The air temperature was 22.5°C and the water temperature was 8.5°C. Ernst (1971c,1972) reported inactivity in painted turtles when water temperatures were less than 10°C; feeding did not occur when water temperatures were below 15°C. Ernst (1972) also found active spotted turtles (Clemmys guttata) when water temperatures were between 8.5 and 32°C, but again, feeding did not occur below 15°C. I observed painted and musk turtles, but not cooters, moving about in water at 7°C.

Basking cooters were observed throughout the study season on sunny days when air temperatures were between 18.2 and 31.9°C. Water temperatures during this period ranged from 8.5 °C to 25 °C. Throughout the study, air temperatures were always warmer than water temperatures when cooters were observed basking.

During 17-23 September 1985, I detected a change in basking behavior and attributed it to air temperature (15°C) dropping below water temperature (20°C). For the first time, cooters were observed basking on top of elodea beds in very shallow water (0-1m) whereas before they always basked on rocks or log snags. Several cooters were captured by hand during this time, a method that is usually not successful with this species. Water temperatures taken in the elodea beds ranged between 23 and 28°C. Throughout this 7 day period, air temperatures ranged between 15 and 22°C, main channel temperatures between 19-22°C, and elodea beds between 22-28°C. However, on any given day when cooters basked in elodea beds, air temperature was less than main channel temperature which was less than elodea bed temperature. This behavior continued until air temperature rose to 22-23°C, which was warmer than main channel waters. Elodea beds remained warmer than the air, but cooters returned to basking logs. I suspect that cooters were seeking a minimum temperature of 22°C and utilized areas normally avoided to attain it. Because I observed this behavior and also found cooters to become active when air temperatures rose to 22.5°C in the month of March, I believe that 22°C may represent the minimum environmental temperature for activity in New River cooters.

Preferred thermal maximum and minimum temperatures of cooters is not reported in the literature, but peak activity range for painted and musk turtles is 20.7-22.4°C; minimum/maximum temperatures are 10/34°C for musk and 8/32°C for painted (Hutchison et al. 1966). In the NRGNR, both of these species were observed to be active both earlier and later in the season than river cooters.

Population size and structure

I estimated a total population of 64 mature cooters. However, cooter density varied considerably (3.7-fold) between pools (Table 1). Densities for river cooters are not reported elsewhere in the literature, but there is substantial variation in the densities of other freshwater turtles. Snapping turtle density in South Dakota was 1.3/ha (Hammer 1969). Gibbons (1970d) in South Carolina reported 89 yellow-bellied sliders per ha, and Ernst (1971c) reported 600 painted turtles per ha in Pennsylvania.

A cooter population exists upstream of the NRGNR in Bluestone Reservoir (Seidel 1981), and I have received scattered reports of large basking turtles upstream of the reservoir in Virginia (Seidel per. comm.). However, it appears that the population in the NRGNR is isolated from these others. Further, it appears that the sites I identified are the only areas where colonies of cooters exist in the

NRGNR. Downstream of Site 3, the river becomes narrower and swifter, floodplain habitat is replaced by sandstone boulders, and riffles and rapids replace pools as the dominant habitat (Fig. 1).

Site 1, with the highest cooter density, probably represented the best available habitat. It had large amounts of aquatic vegetation (1.1 ha), water depths of <2 m (95%), slow currents, backwaters, and sandbars. Site 2, with the lowest density, occupied the largest area, was slightly deeper (82%, < 2 m), had substantial aquatic vegetation (0.6 ha), but no sandbars or backwaters. Site 3 had the deepest water (39%, < 2 m), swiftest currents, and least aquatic vegetation (0.1 ha) of the three sites.

The sex ratio at Site 3 was strongly skewed towards males (4.5:1.0), yet the greatest juvenile proportion was also found at this site (35%). Jackson (1970) reported a 1.0:1.0 sex ratio (47% females) in a Florida river cooter population. I speculate that dispersing juveniles from Sites 1 and 2 stop at Site 3 and remain or disperse into 'non-habitat' downstream. The large numbers of males at this site may be a result of their tendency to range farther than females. MacCullock and Secoy (1983) reported this to be the case with western painted turtles (*Chrysemys picta belli*), and Morreale et al. (1984) found the same with yellow-bellied sliders. This may account for the higher density of cooters at Site 3 than at Site 2.

If cooters do not disperse upstream and Site 1 is regarded as the site from which dispersal originates, Site 3 would be expected to recieve males from Sites 1 and 2, whereas Site 2 would only receive males from Site 1. This may explain why the proportional number of males increases farther downstream. Also, this leads to speculation that Site 1 is the older site, with the other colonies having been established later. Since completion of Bluestone Dam, dispersal from colonies upstream of Site 1 has been shut off. This may be detrimental to long term survival of the NRGNR population.

Sex ratios reportedly vary with the temperature at which the eggs were incubated. Brooks et al. (1985) experimented with snapping turtle eggs in Canada and found that those incubated constantly at 20, 30, and 32°C produced only females, while those incubated at 24 and 26°C produced only males. Those eggs incubated at 22 and 28°C produced both sexes. Morreale and Gibbons (1985) stated that variations in climate and nest microhabitat may contribute to observed differences in adult sex ratios. Since cooter nests were not found during this study, I was unable to record temperatures. However, since Site 1 had a 1:1 sex ratio and dispersal of males was assumed to occur, the hatching sex ratio may favor males.

Differences in sex ratios may also result from predation on nesting females (Moll and Legler 1971), but I have no evidence indicating that predation pressure on nesting females would vary between sites.

Juvenile growth

Early growth in hatchlings is rapid (Cagle 1946, Webb 1961). I recaptured one hatchling that increased in body length 97% between 22 May and 8 October 1985 (139 days). Hatchlings may double in length and weight during the first growing season (Bury 1979:584).

First year growth in hatchlings is determined in part by time of emergence from the egg. Generally, eggs laid in early summer produce late summer hatchlings, whereas eggs laid later overwinter in the nest, hatch in the spring, and have a longer first growing season.

Gibbons and Nelson (1978) speculated that delayed spring emergence of turtles in temperate regions involves a cost/benefit assessment, where hatchlings may wait for cues that signal favorable environmental conditions. The cooter population in the NRGNR is at the northern limit of the species range and an at an elevational high, thus the growing season is shorter than in the southern extent of the range. Since cooter eggs take from 65 days @30°C to 114 days @25°C to develop (Jackson 1970), hatchling cooters may enhance their chances of finding food and suitable temperatures by remaining in the nest until spring.

Graham (1971) collected a gravid female red-bellied turtle (*P. rubriventris*), a closely related species, that laid 17 eggs on 30 June 1969. These eggs were incubated at 25°C and took 73-80 days to hatch. Seidel (1981) incubated 8 eggs from a Bluestone Reservoir cooter at 30-35°C. The eggs were laid between 10-21 July and 3 hatched 45-56 days later on 4 September. Carapace lengths (3.8, 3.6, and 4.0 cm), were similiar to hatchlings found in April during this study.

If I consider Seidel's (1981) laying date of 15 July for Bluestone Reservoir cooters to be the average date, incubate the eggs at 25°C, and assume they will develop in approximately 75 days, the earliest hatch day would be 28 September. That is late in the season for hatchling cooters to find food and favorable climatic conditions. Therefore, it is likely that cooters in the NRGNR overwinter in the nest. Graham (1985) found red-bellied turtle hatchlings to overwinter in the nest in Massachusetts.

In April and May 1985 I captured 6 hatchling cooters that had only birth annuli. This, and a dessicated hatchling found on a ball field 6 June provide evidence for overwintering in the nest. In addition, I captured one juvenile on 6 May 1985 that had a carapace length of 5.5cm and displayed a first year annulus. Since this individual was smaller than hatchlings that had lived for a full growing season, I suspected this individual emerged from the egg in autumn of 1984.

Growth from birth to age six appeared to be linear (Fig. 2). Gibbons (1969) noted near constant growth rates until the onset of maturity in the chicken turtle (Deirochelys reticularia). Because juveniles were captured between April and October, I added a correction factor to their ages (see footnote, Table 6).

Age at maturity varies among turtle species and northern individuals of a species mature later than their southern counterparts

(Bury 1979:576). Tinkle (1958) reported that musk turtles mature between their second and third years. Snapping turtles mature around their seventh year (Hammer 1969). Cagle (1952) reported wide differences (males at age 3, females at age 6) in the attainment of sexual maturity in diamondback terrapins (Malaclemmys terrapin). Mitchell (1985) reported that Virginia populations of painted turtles reach maturity in their sixth or seventh year. Graham (1971b) found both male and female Plymouth red-bellied turtles to reach maturity around 9 years of age in Massachusetts. Jackson (1970) found that cooters in Florida reached maturity when the males had plastron lengths of 14.5cm and females 17.0cm. The smallest mature male found in the NRGNR had a plastron length of 18.5cm and the smallest female was 20.75cm.

Growth rate has been reported to decrease at the age of maturity (Gibbons 1969, Webb 1961). If this conclusion is valid for New River cooters, then age of maturity probably occurs between age 7 and 8. Clark and Gibbons (1969) speculated that a switch from carnivorous to herbivorous diets when turtles mature might account for the slower rate of growth. Jackson (1970) and Graham (1971b) found declines in growth rates to be associated with size.

Survivorship

Recruitment in aquatic turtle populations may be adversely affected by a variety of factors including cold temperatures, predation, and flood conditions. Mink (*Mustela vision*), green-backed herons (*Butorides virescens*), snapping turtles, and smallmouth bass (*Micropterus dolomieui*) probably prey on hatchling cooters in the NRGNR. Also, assuming that hatchling cooters emerge from the nest in April, early survival may be related to the severity of flooding during that first month. I did not capture any juveniles from the 1983 cohort, and April flows in that year were higher (54,000 cfs) than in any other year (Table 8). High flows also scour weedbeds which are used for food and cover,and may affect hatchling survival.

Few data are available on the long-range population dynamics of any turtle species (Bury 1979:600), and determining adult survivorship would require a long term study. During 1984, 11 adult cooters were captured and marked. During 1985, 9 were recaptured. All were in the same pools that they had occupied one year before. This indicates an annual survival rate of at least 82%. Both animals not recaptured in 1985 were males from Site 3.

SUMMARY AND MANAGEMENT IMPLICATIONS

River cooters are endemic to the New River in West Virginia. The populations appear to be small and continued survival may depend on stability in the system. Flow alterations, such as those expected if Bluestone Dam is converted to a hydro-electric facility, may endanger the continued existence of this species in the NRGNR. River cooters are highly dependent on log snags for basking, an activity that regulates their feeding and reproductive behavior. Reptiles are poikilotherms and must bask in order to raise their body temperature to a level which allows feeding and reproductive activity. Inundation of log snags during times of the day which are important for basking turtles could have adverse effects on the population. Low water levels caused by the dam could also prevent turtles access to basking sites. Water temperature changes at certain times of the year are known to adversely affect fish populations, and probably could affect cooters as well.

River cooters, like other turtles, lay hard-shelled eggs which are deposited in holes dug by the females. The nest sites selected are well-drained, with sandy or loam soil. High water discharges from a hydro-electric facility could inundate those sites, resulting in fatalities of the developing embryos.

River cooters are primarily herbivorous. It is possible that water flucuation may also alter the productivity of aquatic weed beds, most notably eelgrass and elodea.

Human disturbance may also limit the numbers of cooters in the New River Gorge. In the past, basking turtles have been used for rifle practice and collected for food.

Further study is needed on reproductive success and survival among adults and juveniles, especially in relation to man-made flow alterations to the river system. West Virginia DNR has listed the river cooter as a species of 'special concern' in the State. Those agencies charged with management of the New River need to be aware of this turtle population and consider the impacts that management decisions may have. Since the population is small, it is recommended that collecting be discouraged.

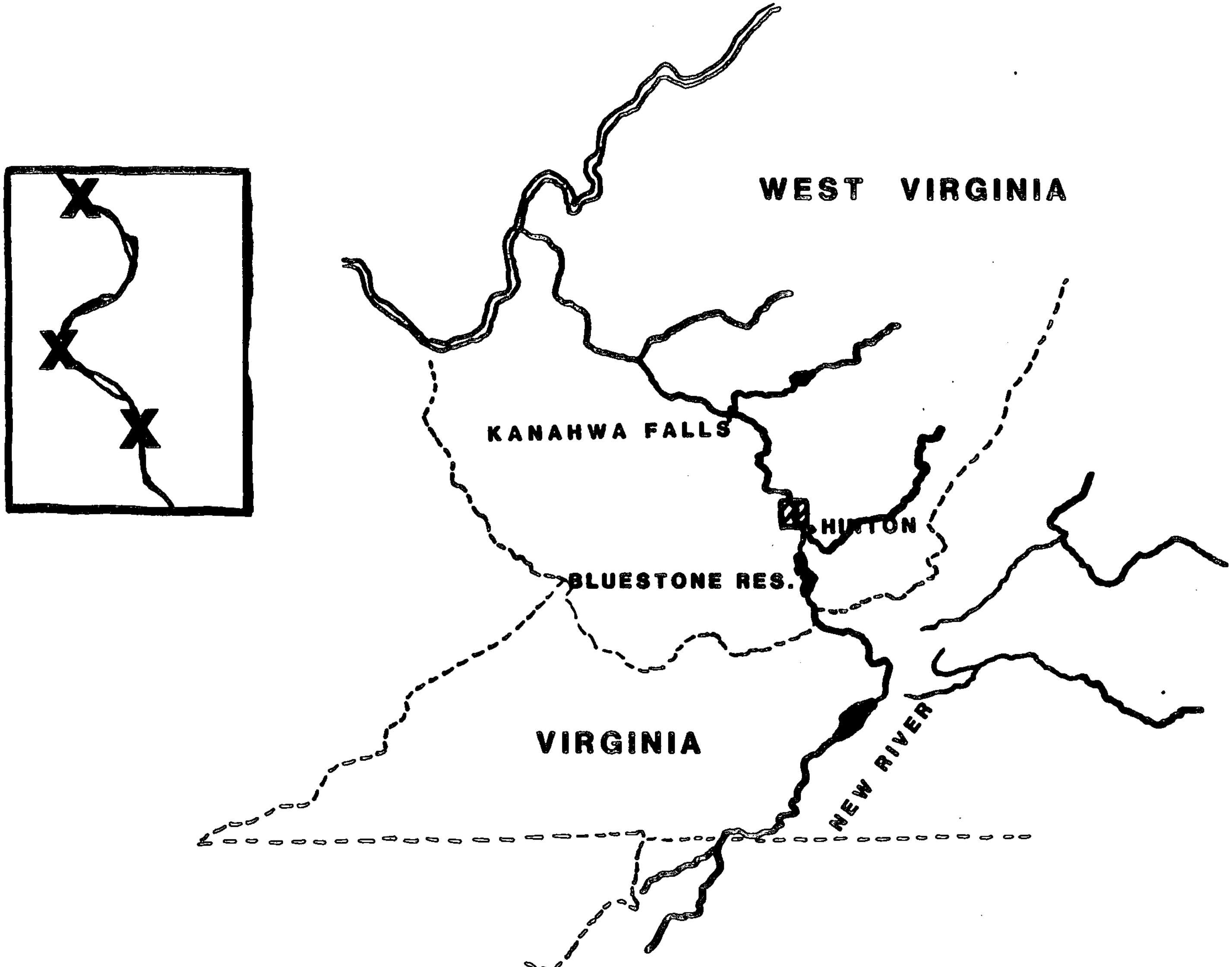

Figure 1. Map of the New River Gorge National River (NRGNR), showing river cooter study sites near Hinton, W.V. 1985.

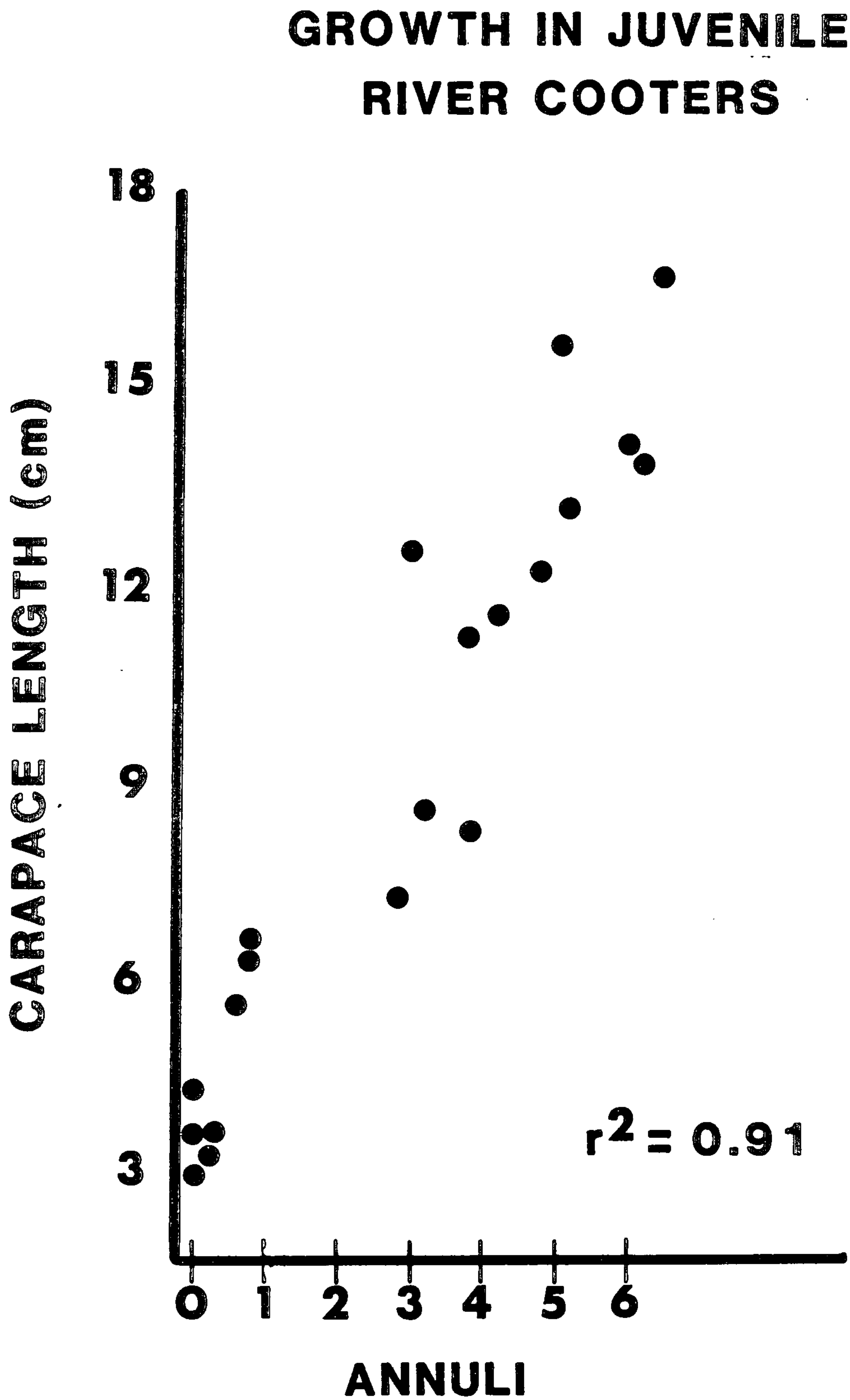

Figure 2. Regression of growth in juvenile river cooters with carapace length plotted against number of plastral annuli.

TABLE 1. POPULATION ESTIMATES FOR ADULT RIVER COOTERS IN THE NEW RIVER GORGE NATIONAL RIVER, W.V. 21 APRIL-15 JULY 1985.

LOCATION	SCHNABEL	LINCOLN-PETERSEN	BOUNDED COUNT	$\bar{X}$	DENSITY/ha
SITE 1	N = 23	N = 22	21	22	2.2
95% C.I. =	17 < 23 < 26	= 17 < 22 < 31			
SITE 2	N = 21	N = 21	16	19	0.6
95% C.I. =	15 < 21 < 28	= 15 < 21 < 37			
SITE 3	N = 14	N = 17	10	14	1.2
95% C.I. =	13 < 14 < 20	= 13 < 17 < 30			
BROOKS *			5		
SANDSTONE *			4		

* represent areas between Site 2 and Site 3 where a few basking cooters were observed.

TABLE 2. ESTIMATED NUMBERS OF THREE TURTLE SPECIES ASSOCIATED WITH RIVER COOTERS IN THE NEW RIVER GORGE NATIONAL RIVER, W.V. 1985.

LOCATION	MUSK (Sternotherus odoratus)	PAINTED (Chrysemys picta)	SNAPPING (Chelydra serpentina)	COOTER (Pseudemys concinna)	TOTAL TURTLES	DENSITY PER HECTARE
SITE 1	190 (6.0)	84 (2.6)	52 (1.6)	23 (0.7)	349	34.6
SITE 2	460 (9.0)	-- (0.0)	40 (1.0)	21 (0.0)	521 *	16.5
SITE 3	243 (4.0)	70 (1.2)	51 (0.9)	14 (0.2)	378	31.3

* painted turtles occurred at Site 2, however none were captured.
Estimated numbers of other turtles based on a ratio of total captures of each species/X to the number of captured cooters/cooter population estimate.
Values in ( ) represent mean captures per trap night.

TABLE 3. MEAN MONTHLY BASKING FREQUENCIES* FOR MALE AND FEMALE RIVER COOTERS, NRGNR, 1985.

MONTH	N ◊	MALES	FEMALES	P-value
APRIL	16	17.2%	24.6%	0.5754
MAY	15	15.5%	27.1%	0.2541
JUNE	24	20.1%	21.8%	0.8263
JULY	4	16.0%	6.3%	0.3721
AUGUST	3	21.0%	0.0%	0.0063
SEPTEMBER	10	15.6%	1.3%	0.0073

* Basking frequencies were calculated by determining the % of marked turtles of each sex basking during a survey and averaging over all surveys for that month. ◊ Number of times that basking surveys were conducted.

TABLE 4. BODY MEASUREMENTS OF MATURE COOTERS, NRGNR, W.V. 1984-85.

	N	$\overline{X}$	RANGE	P *
WEIGHT				
MALES	26	1.6 kg	0.8-2.6 kg	
FEMALES	14	2.6 kg	1.1-4.0 kg	0.0004
SHELL HEIGHT				
MALES	26	8.1 cm	6.5- 9.3 cm	
FEMALES	14	9.9 cm	7.3-12.0 cm	0.0001
PLASTRON				
MALES	25	23.9 cm	18.5-27.3 cm	
FEMALES	14	26.9 cm	20.8-31.5 cm	0.0036
CARAPACE				
MALES	26	26.6 cm	19.8-30.3 cm	
FEMALES	14	28.9 cm	22.8-35.5 cm	0.0341

* t-test.

TABLE 5. BODY MEASUREMENTS OF RECAPTURED ADULT COOTERS, NRGNR, W.V. 1985.

TURTLE #/SEX	DATES CAPTURED	DAYS ELAPSED	CARAPACE LENGTHS	GROWTH(cm) (cm/day)	%	WEIGHT(g)	WEIGHT CHANGE(g) (g/day)
1 M	4/21/85		29.50	.25		2428.3	-23.3
	6/23/85	63	29.75	(.004)	0.9%	2405.0	--
14 F	4/26/85		30.25	.25		3105.4	-23.3
	9/20/85	143	30.50	(.0017)	0.8%	3082.1	--
22 M	4/28/85		28.25	.75		1889.7	23.4
	9/10/85	135	29.00	(.0056)	2.7%	1913.1	(.17)
2 F	4/29/85		30.25	.50		3058.7	93.4
	9/15/85	139	30.75	(.004)	1.7%	3152.1	(.67)
27 F	5/5/85		30.25	.25		2918.6	70.1
	9/7/85	125	30.50	(.002)	0.8%	2988.7	(.56)
3 F	5/6/85		32.50	.25		3922.6	23.4
	9/19/85	136	32.75	(.002)	0.8%	3946.0	(.17)
44 M	6/17/85		25.75	.50		1494.4	163.4 *
	9/17/85	92	26.25	(.005)	1.9%	1657.8	(1.78)

* this turtle had recently lost a foot when first captured, stump had healed by second capture.

TABLE 6. BODY MEASUREMENTS AND PLASTRAL ANNULI OF JUVENILE RIVER COOTERS IN THE NRGNR, W.V. 1984-85.

TURTLE NUMBER	DATE	CARAPACE LENGTH (cm)	WEIGHT (g)	ANNULI	ADJUSTED ANNULI *
21	4/21/85	15.75	443.6	5	5.10
26	4/29/85	14.25	326.9	6	6.10
36	5/22/85	12.50	186.8	3	3.10
5	9/13/84	7.25	70.1	2	2.75
	6/17/85	8.75	105.1	3	3.25
40	6/17/85	11.75	256.8	4	4.25
9	9/14/84	12.40	210.1	4	4.75
	6/23/85	13.25	245.2	5	5.25
46	7/11/85	14.00	303.5	6	6.25
48	7/30/85	16.50	490.3	6	6.50
49	9/7/85	8.35	93.4	3	3.75
50	9/7/85	6.55	46.7	<1	.75
52	10/8/85	11.20	186.8	3	3.75

Growing season is approximately April 15 - October 15.
* Annuli are adjusted by time of capture in the growing season.
April 15-May 29=.10; May 30-July 14=.25; July 15-Aug 31=.50; Sept 1-Oct 15=.75

TABLE 7. BODY MEASUREMENTS AND CAPTURE DATES OF HATCHLING RIVER COOTERS IN THE NRGNR, W.V. 1985.

TURTLE NUMBER	DATE CAPTURED	CARAPACE LENGTHS (cm)	WEIGHT (g)	ANNULI	ADJUSTED ANNULI
H1	4/29/85	3.55	-	0	.10
H2	5/19/85	4.20	-	0	.10
H3(53)	5/22/85	3.15		0	.10
	10/8/85	6.20 @	35.1	<1	.75
H4	6/3/85	3.33	-	0	.25
H6	6/5/85	5.50	23.4	1	.50*
H5	6/13/85	3.60	-	0	.25

* last fall's hatchling, others are delayed spring emergence.
@ represents a 3.05cm increase in 139 days= 97% growth increase.

TABLE 8. AGE CLASSES OF JUVENILE RIVER COOTERS CAPTURED IN THE NRGNR, W.V. 1985, AND MAXIMUM FLOW LEVELS (CFS) AND MINIMUM WATER TEMPERATURES (C) DURING APRIL 1979-85.

AGE CLASS	NUMBER CAPTURED	YEAR OF HATCHING	MAXIMUM FLOW	MINIMUM TEMP
0	6	1985	8900	____
1	1	1984	38700	____
2	0	1983	54300	8.5
3	4	1982	19100	9.5
4	1	1981	16800	10.0
5	2	1980	45900	9.5
6	3	1979	30600	10.5

APPENDIX 1. SCHNABEL ESTIMATE CALCULATIONS FOR ADULT RIVER COOTER COLONY SIZE AT SITE 1, NRGNR, W.V. 1985.

DATE	TURTLES EXAMINED A	TURTLES MARKED	TURTLES MARKED IN AREA B	PRODUCT (A)(B)	SUM OF (A)(B)	RECAP-TURES m	SUM OF RECAP-TURES C	POP EST SUM(A)(B) / SUM(C)+1
4/21	4 (4,1,12,13)	4	0	0	0	0		
4/26	4 (14,15,16,17)	4	4	16	16	0		
4/29	2 (2,12)	1	8	16	32	1	1	16
5/6	1 (3)	1	9	9	41	0	1	20.5
5/18	2 (32,10)	2	10	20	61	0	1	30.5
5/19	1 (3)	0	12	12	73	1	2	24.33
5/20	2 (15,12)	0	12	24	97	2	4	19.4
5/23	1 (37)	1	12	12	109	0	4	21.8
5/24	1 (38)	1	13	13	122	0	4	24.4
	SECOND MONTH							
6/3	1 (10)	0	14	14	136	1	5	22.67
6/23	1 (4)	0	14	14	150	1	6	21.43
6/25	1 (12)	0	14	14	164	1	7	20.5
7/15	5 (11,32,3,38,47)	2	14	70	234	3	10	21.27
7/30	1 (48)	1	16	16	250	0	10	22.73
	FALL ESTIMATE							
9/10	1 (48)	0	17	17	267	1	11	22.25
9/15	1 (2)	0	17	17	284	1	12	21.85
9/19	2 (3,11)	0	17	34	318	2	14	21.2
9/20	1 (14)	0	17	17	335	1	15	20.94
9/23	1 (12)	0	17	17	352	1	16	20.71
10/8	1 (54)	1	17	17	369	0	16	21.71
			18					

Numbers in ( ) are identification numbers of marked turtles.

APPENDIX 2. SCHNABEL ESTIMATE CALCULATIONS FOR ADULT RIVER COOTER COLONY SIZE AT SITE 2, NRGNR, W.V. 1985.

DATE	TURTLES EXAMINED A	TURTLES MARKED	TURTLES MARKED IN AREA B	PRODUCT (A)(B)	SUM OF (A)(B)	RECAP-TURES m	SUM OF RECAP-TURES C	POP EST SUM(A)(B) / SUM(C)+1
4/26	2 (18,19)	2	0	0	0	0		
4/27	2 (20,21)	2	2	4	4	0		
4/28	3 (22,23,24)	3	4	12	16	0		
4/29	3 (25,26,21)	2	7	21	37	1	1	18.5
5/5	1 (27)	1	9	9	46	0	1	23.0
5/6	1 (28)	1	10	10	56	0	1	28.0
5/8	2 (30,19)	1	11	22	78	1	2	26.0
5/16	1 (31)	1	12	12	90	0	2	30.0
5/19	1 (23)	0	13	13	103	1	3	25.75
5/20	1 (18)	0	13	13	116	1	4	23.20
	SECOND MONTH							
6/3	1 (30)	0	13	13	129	1	5	21.5
6/4	1 (39)	1	13	13	142	0	5	23.67
6/20	1 (39)	0	14	14	156	1	6	22.29
7/11	5 (24,28,39,30,46)	1	14	70	226	4	10	20.55
	FALL ESTIMATE							
9/7	1 (27)	0	15	15	241	1	11	20.08
9/10	1 (22)	0	15	15	256	1	12	19.69
10/8	1 (25)	0	15	15	271	1	13	19.36

Numbers in ( ) are identification numbers of marked turtles.

APPENDIX 3. SCHNABEL ESTIMATE CALCULATIONS FOR ADULT RIVER COOTER COLONY SIZE AT SITE 3, NRGNR, W.V. 1985.

DATE	TURTLES EXAMINED A	TURTLES MARKED	TURTLES MARKED IN AREA B	PRODUCT (A)(B)	SUM OF (A)(B)	RECAP-TURES m	SUM OF RECAP-TURES C	POP EST SUM(A)(B) / SUM(C)+1
5/6	2 (29,6)	2	0	0	0	0		
5/19	5 (33,34,35,29,6)	3	2	10	10	2	2	3.3
5/22	1 (36)	1	5	5	15	0	2	5.0
	SECOND MONTH							
6/4	1 (34)	0	6	6	21	1	3	5.25
6/17	6 (40,41,42,43,44,29)	5	6	36	57	1	4	11.40
6/18	5 (35,36,41,43,45)	1	11	55	112	4	8	12.44
6/19	1 (42)	0	12	12	124	1	9	12.40
6/23	1 (9)	1	12	12	136	0	9	13.60
	FALL ESTIMATE							
9/17	2 (44,51)	1	13	26	162	1	10	14.73
9/24	1 (51)	0	14	14	176	1	11	14.67

Numbers in ( ) are identification numbers of marked turtles.

APPENDIX 4. River cooters (males=M, females=F, juveniles=J, hatchlings=H) marked in the NRGNR, W.V. 1984-1985, and the sites at which they were captured.

SITE 1			SITE 2			SITE 3		
1	M	+	5	J	+	6	F	+
2	F	+	19	F		7	M	*
3	F	+	20	M		8	M	*
4	F	+	21	J		9	J	+
10	F	+	22	M		33	M	
11	M	+	23	F		34	M	
12	M		24	M		35	M	
13	M		25	M		36	J	
14	F		26	J		40	J	
15	F		27	F		41	M	
16	M		28	M		42	F	
17	M		30	M		43	M	
32	F		31	M		44	M	
37	M		39	F		45	M	
38	M		46	J		51	M	
47	F		49	J		(53)H3	J	
48	J		50	J		H6	H-J	
54	M		52	J				
H5	H		H1	H				

* Turtles captured in 1984 only.
+ Turtles captured in both 1984 and 1985.
All others captured in 1985 only.
Petersen disc tag colors: Site 1- males red, females white; Site 2- males orange, females yellow; Site 3- males pink, females blue.

APPENDIX 5. Maximum monthly flow discharges in the New River Gorge National River for the period 1974-1985.

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
74-75	14200	9100	20300	32700	44600	55900	35800	27900	27800	6680	6250	22100
75-76	40100	17400	10100	49100	20300	12200	24200	12300	34600	6990	3530	3860
76-77	56100	14300	31700	5800	38400	39400	53800	10300	6500	4650	4250	6320
77-78	15900	52100	29900	50400	38600	51300	48300	30800	9240	7850	14300	3370
78-79	2340	3690	15700	50400	43200	56500	30600	34200	24400	9060	7350	41200
79-80	25000	29000	19300	38500	13700	40800	45900	21600	9230	14300	8670	2870
80-81	4560	7060	5410	3230	17800	11600	16800	42600	33000	8300	2570	7640
81-82	15200	3850	18600	44000	55400	39100	19100	13000	56700	8280	6790	5100
82-83	5800	32800	36600	10000	36900	45500	54300	25200	9460	6100	3180	2330
83-84	20200	13600	29800	13900	62500	45000	38700	48200	8840	6950	31900	11200
84-85	6100	17200	13300	29300	33300	16700	8900	32400	5120	5500	24500	5050

APPENDIX 6. Minimum monthly temperatures in the New River Gorge National River for the period 1977-1985.

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
77-78	11.5	5.0	3.0	1.0	0	1.5	10.0	12.0	22.0	23.5	25.5	22.0
78-79	12.5	8.0	3.5	2.0	1.0	4.5	10.5	13.0	18.0	20.5	24.0	19.5
79-80	9.0	7.5	4.0	3.5	1.5	2.0	9.5	11.0	21.0	24.0	26.5	21.0
80-81	11.5	7.5	3.0	2.0	2.0	5.5	10.0	14.5	18.5	24.0	22.5	17.5
81-82	13.0	6.0	2.0	2.0	2.0	5.5	9.5	14.0	18.0	25.0	23.5	10.5
82-83	--	9.0	5.0	1.5	3.0	5.0	8.5	14.5	19.0	24.5	26.0	19.5
83-84	--	--	--	--	--	--	--	--	--	--	--	--
84-85	--	--	--	--	--	--	--	--	--	--	--	--

APPENDIX 7. Trapping techniques used for river cooters in the New River Gorge National River, W.V. 1984-85.

Fyke nets were most effective for capturing cooters. They captured turtles at night, on cloudy or rainy days, and were most effective near the entrances to coves or backwater channels during periods of rising water. During low water, cooters avoided these areas and remained out in the main river channel. Main channel sets worked best on the downstream end of sandbars. Hoop traps baited with meat were ineffective because river cooters were primarily herbivorous. I did not bait traps with vegetable matter.

Fyke nets were unbiased in sampling the population. Basking traps were unbiased in sampling the sex ratio during the spring months (i.e. basking frequencies did not differ by sex), but may have been biased toward adult captures.

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CHAPTER 2

HABITAT, FOOD HABITS, AND MOVEMENTS OF RIVER COOTERS

IN THE NEW RIVER GORGE NATIONAL RIVER, WEST VIRGINIA.

INTRODUCTION

During July 1984 I discovered a population of river cooters (Pseudemys concinna) in the New River Gorge National River (NRGNR), W.V. (Buhlmann and Vaughan 1985). A population located 8 km upstream of the NRGNR in Bluestone Reservoir was reported by Bayless (1972) and described by Seidel (1981). I also received reports stating that cooters occur upstream of the reservoir in Virginia. The next nearest populations of river cooters are in the Roanoke River drainage, more than 322 km southeast in the Virginia Piedmont. It is possible that cooters in the New River system represent a Pleistocene relict population which managed to invade the New River through Piedmont tributaries which once drained to the New, but the tributaries have since been captured by the Roanoke and James Rivers, which flow to the Atlantic (Ross 1969).

Archeological sites near the New River Gorge have produced Pseudemys sp. bones which have been dated at 800 years old, ruling out the likelihood of an introduction by man.

Most studies of aquatic turtles have provided only qualitative habitat descriptions; here I quantitatively describe habitat of river cooters in the NRGNR, W.V.

STUDY AREA

The 84 km NRGNR lies between Hinton and Fayetteville, W.V. (Figure 1). The New River is a sixth order stream; the section designated as the NRGNR consists of riffles, runs, and pools. More pool-like conditions, as well as riparian floodplains, exist in the southern section of the Gorge, near Hinton.

The river flows are regulated by Bluestone Dam, a flood control facility completed in 1946, and by Claytor Lake Dam, a hydro-electric facility, located 75 km upstream in Pulaski County, Virginia. The presence of a flood control facility creates stability in river level, with natural low summer flows increased and winter flows reduced (Petts 1984).

The climate is mild with an average annual temperature of 11°C and 109-114 cm of precipitation per year. Mean summer (Jun-Aug) and winter (Dec-Feb) temperatures are 21.0°C and 0.0°C, respectively (Fuerst 1981:32). Water temperatures range from 0.0-3.9°C in winter to 18.0-26.5°C in summer.

Geology consists of Pennsylvanian and Mississippian sandstones, shale, and coal seams. The NRGNR is in the Appalachian Plateau physiographic province. Near the study sites, mean elevation at river level is 427 m; ridgetops reach 671 m (U.S.G.S. 1976).

Colonies of cooters occurred within three pool habitats in the NRGNR located 8.2, 13.4, and 19.4 km downstream from Bluestone Dam (Buhlmann and Vaughan 1985) (Fig. 1). This section of the river has a relatively wide channel, riparian floodplains, and pool habitats which are separated by riffles and runs. Downstream of the third location, stream gradient increases, the river channel narrows, riffle habitats become prominant, and floodplain forests are replaced by sandstone talus.

Riparian vegetation along the river is deciduous with sycamore (Platanus occidentalis), river birch (Betula nigra), black willow (Salix nigra), and silver maple (Acer saccharinum.) composing the majority of the canopy.

Emergent aquatic vegetation includes water willow (Justica americana), and lizard tail (Sauruus cernuus). Submergent aquatic vegetation includes elodea (Elodea canadensis), pondweed (Potomogeton crispus), and eelgrass (Vallisneria americana).

METHODS

Habitat measurements

I mapped total areas of the three pool habitats from aerial photographs. Pools were bounded by riffle habitats at both ends. I divided each pool into used and unused portions based on the locations of cooter captures and basking observations. I compared physical characteristics between used and unused portions of the three pools and between used portions and a riffle habitat (Site X) unused by cooters.

In each pool I established transects crossing the river perpendicularly at 50 m intervals and marked them with flagging on each bank. I also established 3 equally spaced lengthwise transects in each pool. I measured physical characteristics along each transect using a fish-finding chart recorder (Lowrance Eagle Mach1 Computer Graph) mounted in a 14 ft. motor powered john boat. I recorded depth, boundaries of aquatic vegetation, and obtained a rough idea of substrate type in areas where water depth and/or clarity precluded direct observation of the bottom. I classified depth at 1 m intervals. All transects in which the boat and chart recorder were used were run at a constant rate during the entire length of the transect to facilitate accurate plotting of the habitat variables on cover maps.

In areas that were too shallow to use the boat, I measured distances with a measuring tape and waded areas to record depth and substrate. I transcribed data onto habitat maps and identified areas of uniform depth, presence and size of aquatic vegetation beds, and bottom substrate type. Transects were run during August when water levels remained relatively constant and river flows were stable at 2500 cfs.

I recorded current velocities at three equally spaced points along every other transect in each of the three pools and at Site X. Distance between points varied with river width. Measurements were obtained with a Price-type current meter mounted 70cm from the side of a canoe. Due to equipment limitations, I measured only surface current velocities. In moving water bodies, surface velocities are the fastest (Orth 1984: 70).

Substrate was classified as boulders (> 256 mm), cobble (64-256 mm), gravel (2-64 mm), and sand/silt (< 2 mm) (Cummins 1962).

I counted the number of basking sites available to cooters in each pool at a variety of flow regimes. Flow discharge (cfs) on the New River was recorded daily at 8:00AM. (U.S. Army Corps of Engineers).

Movements

Cooter movements were determined using radio telemetry (Telonics Inc, Mesa, Az.). Transmitters (75 g) were secured with galvanized wire passed through two holes drilled in the ninth and tenth posterior carapace marginals. Silicone sealing was used to mold the square transmitter to the turtle's carapace and to streamline the configuration to prevent intanglement with vegetation and debris. Radio locations enabled me to determine hibernation locations and movement patterns. Radio fixes were obtained at least twice per day.

Cooters were also marked with Petersen disc tags (Chapter 1). All mature cooters received two 3.3 cm colored tags, which were wired to a posterior carapace marginal on each side. Turtles from each pool received different colored tags as did males and females in each pool. Large juvenile turtles, with greater than 14.2 carapace length were marked with only one tag, indicating the females's color for a particular site. Juveniles with less than 14.2 cm carapace length were marked with 1.3 cm disc tags in a combination that permitted individual identification. Swimming ability in turtles smaller than 14.2 cm was hindered by the larger tags. All turtles also were marked by notching a combination of carapace marginals with a hacksaw (Bury and Luckenback 1977).

I estimated minimum convex polygon home range size (Mohr 1947) and maximum observed distance travelled for cooters captured 3 or more times and I recorded maximum observed distance travelled for cooters captured twice.

Food item analysis

I attempted to obtain stomach contents from all turtles captured during April-September 1985 using a modified stomach flushing technique (Legler 1977). My stomach flushing board was modeled after one constructed by Graham (1981). Because of limited success I opted to hold captured turtles in captivity until they defecated. Droppings were preserved in 10% formalin for later macroscopic analysis and comparison with a reference collection. I identified major food items in terms of frequency of occurrence (Bowen 1983: 329).

RESULTS

Site description

Aquatic habitats in the New River were categorized as pools, runs, riffles, or rapids (Bisson et al. 1982). River cooters only inhabited pool habitats within the river. An abundance of aquatic vegetation, most notably elodea and eelgrass was associated with cooter habitat. Surface current velocities in cooter inhabited pools ranged from 0.22 - 0.28 meters/second (m/s) (Table 1). Current velocities in elodea beds were often 0 m/s.

Pool depths ranged to 5 m. Elodea beds usually occurred at depths of 0-1 m on sand or mud substrates, while eelgrass beds normally occurred at depths of 1-2 m on gravel substrates.

Although depths varied between pool, the used portions of all three pools were more shallow than the unused portions (Table 2). Mean surface current velocities between used ($\bar{x}$ =0.24m/s) and unused ($\bar{x}$=0.36m/s) portions of Site 1 were not different (ANOVA, N=36, F = 1.65, df=34, P = 0.2071), but were different between used ($\bar{x}$=0.28m/s) and unused ($\bar{x}$=0.46m/s) portions of Site 2 (N=67, F = 8.14, df=65, P = 0.0058) and used ($\bar{x}$=0.22m/s) and unused ($\bar{x}$=0.47m/s) portions of Site 3 (N=26, F = 3.39, df=24, P = 0.0782).

Site X, a riffle habitat, had a cobble and boulder substrate that precluded growth of elodea, but eelgrass was present. Mean surface current velocity was greater ($\bar{x}$=0.97m/s) than at any of the pool sites (ANOVA, N=138, F = 24.90, df=132, P = 0.0001). Cooters were not found at Site X.

Basking site availability

All used sites had a similiar number of basking sites but availability varied with different flows (Figures 2,3,4). Sites 1 and 2 had basking sites available throughout a wide range of flows, while Site 3 basking sites were only available at flows less than 3500 cubic feet per second (cfs).

Surface water level was a linear function of cfs discharge between 1260 and 18300 cfs (N=17, Y=-8916.5 + 5658.9X, df=15, r^2=0.96) (Appendix 1). An increment of 4000 cfs was equivalent to a 30.5 cm change in surface water level.

Movements

I recorded the range of flows (cfs) at which cooters utilized each basking site. Each time a cooter(s) was observed at a certain basking site the flow level (cfs) was recorded. Therefore, a list of flows was compiled indicating the range of availability for each basking site. Basking locations of cooters differed with mean flow discharge at Sites 2 (ANOVA, N=29, S.E.=300.1, F=28.33, df=27, P = 0.0001) and 3 (N=47, S.E.=150.2, F=14.21, df=42, P = 0.0001) (Table 3). Cooters at Site 1 responded to flows under 3500 cfs, by moving out of backwater areas and returning to the main river channel. When flows increased, cooters often moved into backwater areas to access basking sites. I was not able to demonstrate this statistically because some cooters remained trapped in backwater areas when the water receded and other cooters remained in the main channel during high flows (ANOVA, N=26, S.E.=270.1, F = 0.35, df=24, P = 0.5584). Cooters at Sites 2 and 3 travelled, in response to flow levels, from one side of the river to the other (distance=574m and 186m, respectively) to access available basking sites.

I detected no daily movement patterns in NRGNR cooters.

Two adult cooters with radios (1 male, 1 female) were monitored at Site 1 between 13 October 1984 and 15 July 1985. Both hibernated in different backwater channels with silt substrates and water depths classified as 0-1 m. However, they wintered in small pockets 1-2m deep. Both cooters entered these backwater areas in early November and remained there until 3 March. On 4 March, the male was observed basking, and the female had moved to another area. During the period of inactivity, ice frequently covered the backwater areas. I did not detect movement of the cooters during this time. No attempts were made to locate these turtles underwater, so I do not know if they buried into the substrate or remained on top.

My home range estimates are based on fyke and basking trap captures. At Site 1, average minimum home range size (MHRS) for females and males was .72 ha (N=2) and .79 ha (N=1), respectively. Average maximum observed distance travelled (MODT) for females and males was 126 m (N=5) and 198 m (N=1), respectively. MHRS of radio-marked cooters (female: 1.2 ha, 52 locations; male: 1.6 ha, 50 locations) was greater than disc-tagged cooters; MODT for female and male was 358 m and 321 m, respectively.

At Site 2, one male had a MHRS of 7.4 ha. Average MODT for females, males, and juveniles was 650 m (N=2), 625 m (N=4), and 115 m (N=1), respectively.

Only one female was recaptured at Site 3 (MHRS=.32 ha, MODT=171 m). Average MHRS for males was .28 ha (N=4); average MODT was 154 m (N=8). MHRS for juveniles (1.6 ha, N=3) was larger than adults

(t = 2.52, df=7, P = 0.045) and average MODT by juveniles (285 m, N=3) was greater (t = 1.84, df=10, P = 0.099).

Diet analysis

Filamentous algae appeared in 100% of the samples in April (Table 4). Elodea and eelgrass were co-dominant in the May-September samples (Table 4). Three mature cooters (2 females, 1 male) ingested whole crayfish. Other miscellaneous items identified included mussel shell fragments (unidentified sp.), asiatic clam (*Corbicula fluminea*), leaves and seedpods of river birch and slippery elm (*Ulmus rubra*), and sand grains (Tables 4 and 5).

Eelgrass was present in 71% of the samples (N=14) from Site 1, but only 33% (N=9) and 22% (N=9) for Sites 2 and 3, respectively (Table 5). Elodea occurred in 100% of the samples at Site 3, but only 21% and 33% from Sites 1 and 2, respectively (Table 5).

Juveniles and hatchlings consumed insects and other meat items in their diet (Table 6). Juveniles (N=3) consumed filamentous algae (67%), elodea (33%), and eelgrass (33%), but were also found to consume crayfish (33%), tricopterans (33%), and fish (33%). Two captive juvenile cooters presented with eelgrass and elodea, consumed the eelgrass completely, before the elodea was consumed. Hatchling cooters (N=3) consumed the same aquatic plants as adults and juveniles, and also consumed crayfish (33%), tricopterans (33%), flying insects (67%), and log perch (*Percina caprodes*)(33%).

DISCUSSION

Habitat Requirements

Cooters in the NRGNR required the following habitat components: 1) basking sites available over a wide range of flow conditions, 2) elodea weedbeds for cover and food in 0-1m of water on silt/mud substrates, 3) eelgrass for food in 1-2m of water on gravel substrates, and 4) slow surface current velocities, averaging 0.22-0.28 m/s.

Site 1 provided the best habitat for river cooters in the NRGNR and had the highest density of river cooters (Chapter 1). It had slow current velocities, more elodea and eelgrass than the other sites, and wide-ranging availability of basking sites.

Site 2 had adequate basking sites, but since pool size was large, distances between them were greater than at Sites 1 and 3. This accounts for the greater MODT values at this site. I do not know what effect these distances may have on cooter selection of habitat. At Site 2, 38% of the total area was in the 0-1m depth range, yet most of this was on bedrock substrate. Although 3 times as large, Site 2 had half the elodea as Site 1 (Table 1). Small clumps of eelgrass were distributed throughout the site, and were not likely limiting.

Site 3 was likely marginal habitat for cooters. No colonies were located downstream of this site. Cooters from Site 3 ingested eelgrass, (probably free-floating) but I did not find eelgrass growing there. Only 14% of this area was in the 1-2 m depth range and 61% of the total area was at depths greater than 2 m. Basking sites were limiting, since they were not available during flows greater than 3500 cfs. Thus, the opportunity was limited for cooters to bask during the spring months when body temperatures need to be raised for courtship and reproductive activities. This site may be a sink for dispersing individuals from the upstream colonies (Chapter 1).

Movements

I did not observe cooters moving to different pools during 1985. Also, 11 of 13 cooters initially captured in 1984 were recaptured in the same pools in 1985; 2 were never recaptured.

Cooter movements were related to flow regime (Table 4). At Site 1, radio-marked turtles moved into backwater areas during flows greater than 3500 cfs, but returned to the main river channel when flows decreased (Figs 5,6). I believe that cooters moved into backwaters to access basking sites which were available only at the greater flows and because those available elsewhere at low flows were no longer available.

Cooters at Sites 2 and 3 traveled across the river, with changes in flow, to access available basking sites. Basking sites were available during a wide range of flows at Sites 1 and 2, but not at Site 3 (Figures 2,3,4). Thus, basking site availability at Site 3 may limit cooter densities. Two heavily used basking sites at Site 2 were 574 m apart. Marchand (1945a) reported that the activity range of the florida cooter (P. floridana), a related species, did not exceed 300 m. Possibly, distance between basking sites may limit population density.

I could not detect any differences in movements between adult males and females within pool habitats. A juvenile (carapace=117mm) traveled the longest observed distance at Site 3 (494 m). Bury (1979:595) reported that juvenile turtles may go through a dispersal phase and wander farther than adults.

Adult and juveniles often traversed areas 3-5 m deep to access basking sites. Using SCUBA, I discovered a male cooter on the bottom of Site 3 in 5m of water among boulder and cobble substrate. I do not believe that cooters find food or cover in these deep water habitats, but pass through them to reach other areas.

My river cooter minimum home range size estimates (MHRS) probably underestimate the area used, since 1) the average number of relocations was 4, and 2) a number of captures were made with basking traps or were visual observations of tagged, basking cooters. My data from radio-marked turtles indicate cooters are submerged in elodea beds when they are not basking and I did not locate them in deep (>3 m) open water. River cooter home ranges and distances travelled varied between sites and were probably responses to basking site and aquatic weedbed locations.

Diet

Adult cooters in the NRGNR were primarily herbivorous, feeding on algae, elodea, eelgrass, and pondweed. Eelgrass appeared to be consistently favored where available, although elodea was the dominant submergent plant at the three study sites (Table 1). The dominance of elodea in the diet at Site 3 (Table 6) was likely due to the lack of available eelgrass (Table 1). Algae appeared to be an important component of the diet during the early spring months, when cooters were active but macrophytes were not available. Several whole crayfish were found in adult feces, although it is not known whether they were incidentally ingested while the turtles foraged in vegetation or were actively pursued and captured. Stephens and MacGregor (pers. comm.) reported observing adult cooters feeding on dead fish in Lake Cumberland, Kentucky.

Hatchlings and juveniles consumed various insects and crayfish in addition to vegetation. Clark and Gibbons (1969) noted that juvenile red-eared sliders _P. scripta_ tend to be carnivorous, but shift to a herbivorous diet with maturity. They suggested that the carnivorous habits of juveniles enable them to obtain more protein and grow at a faster rate than adults. This may aid in shell hardening, thus making them less susceptible to predation. A decrease in rate of growth at age of maturity may be attributed to a change in diet (Webb 1961).

Conclusions and management implications

River cooters are adapted for life in large, naturally flucuating river systems. However, artifical flows, such as those produced from flood control dams or hydro-electric facilities may impact cooter populations. Unusually high flows during summer months scour away aquatic vegetation (Petts 1984: 159), thereby limiting food and cover. Nest sites may be inundated. Channelization projects reduce the diversity of depths and substrates, and also increase current velocities (Petts 1984). Removal of riparian vegetation reduces the chance that trees will fall into the water and become basking sites.

The addition of log snags at certain sites may be a viable management action which will increase the habitat suitability for cooters.

The cooter population in the NRGNR is small and close attention needs to be paid for its continued existence.

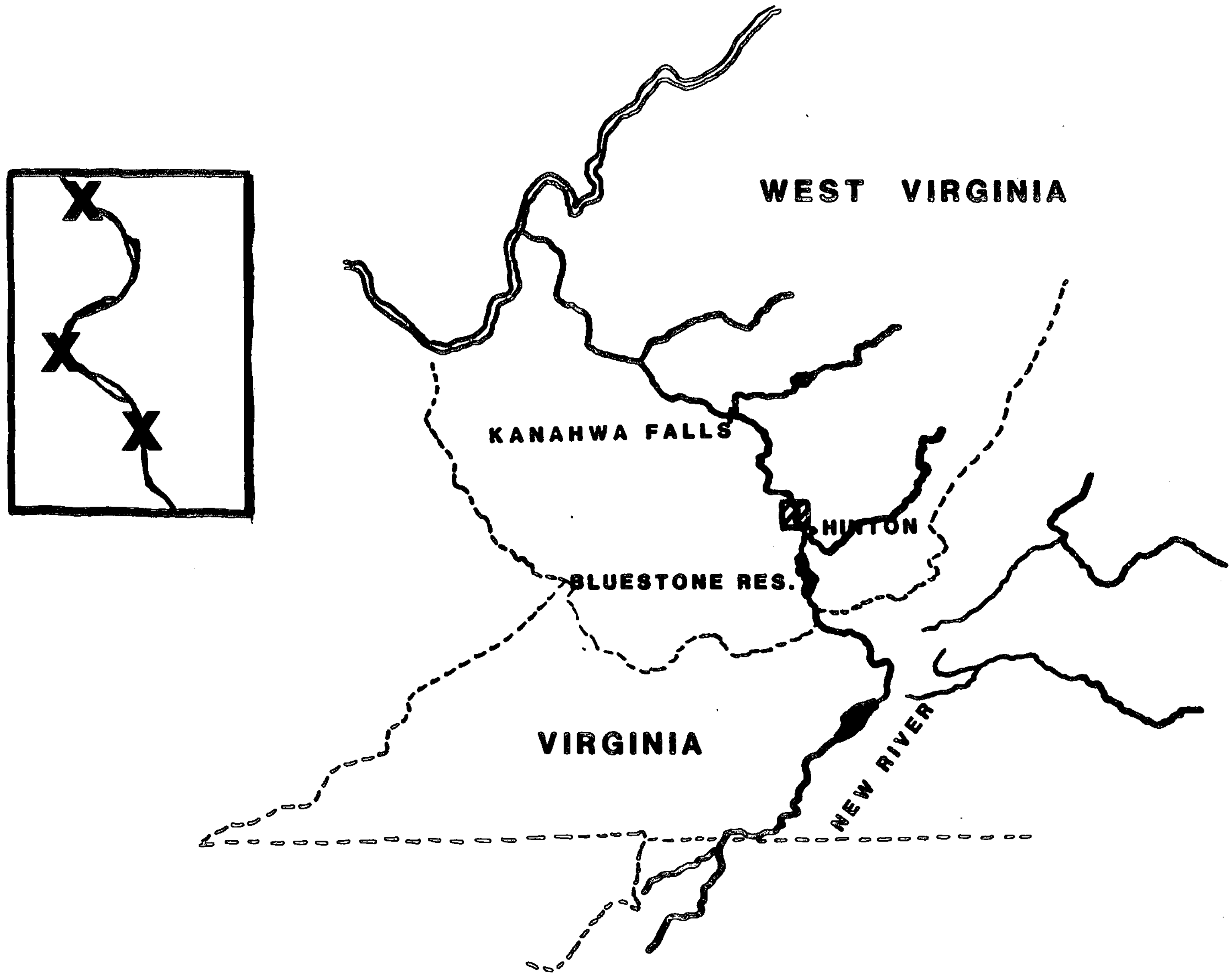

Figure 1. Map of the New River Gorge National River (NRGNR), showing river cooter study sites near Hinton, W.V. 1985.

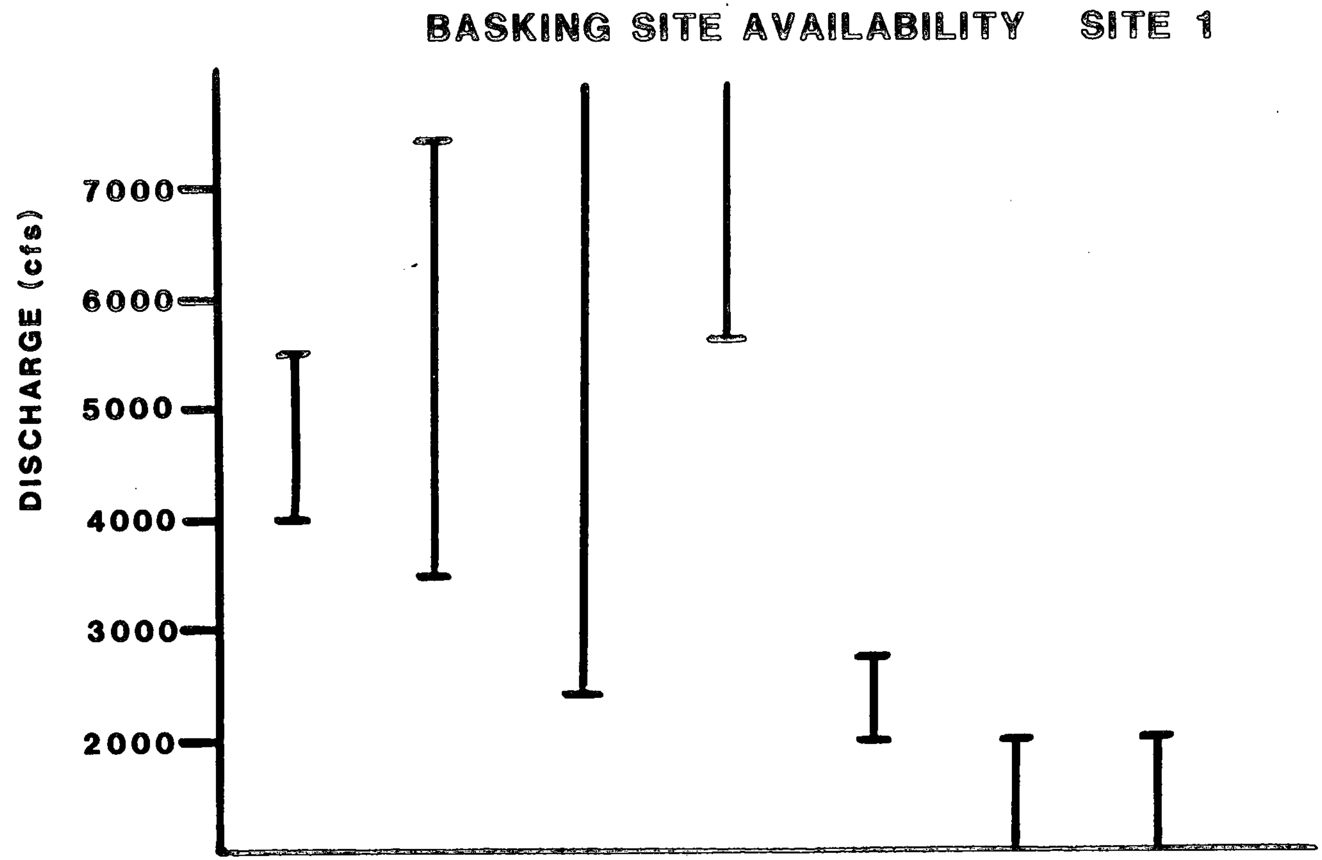

Figure 2. Basking site availability in relation to cfs discharge at Site 1, NRGNR, W.V. 1985.

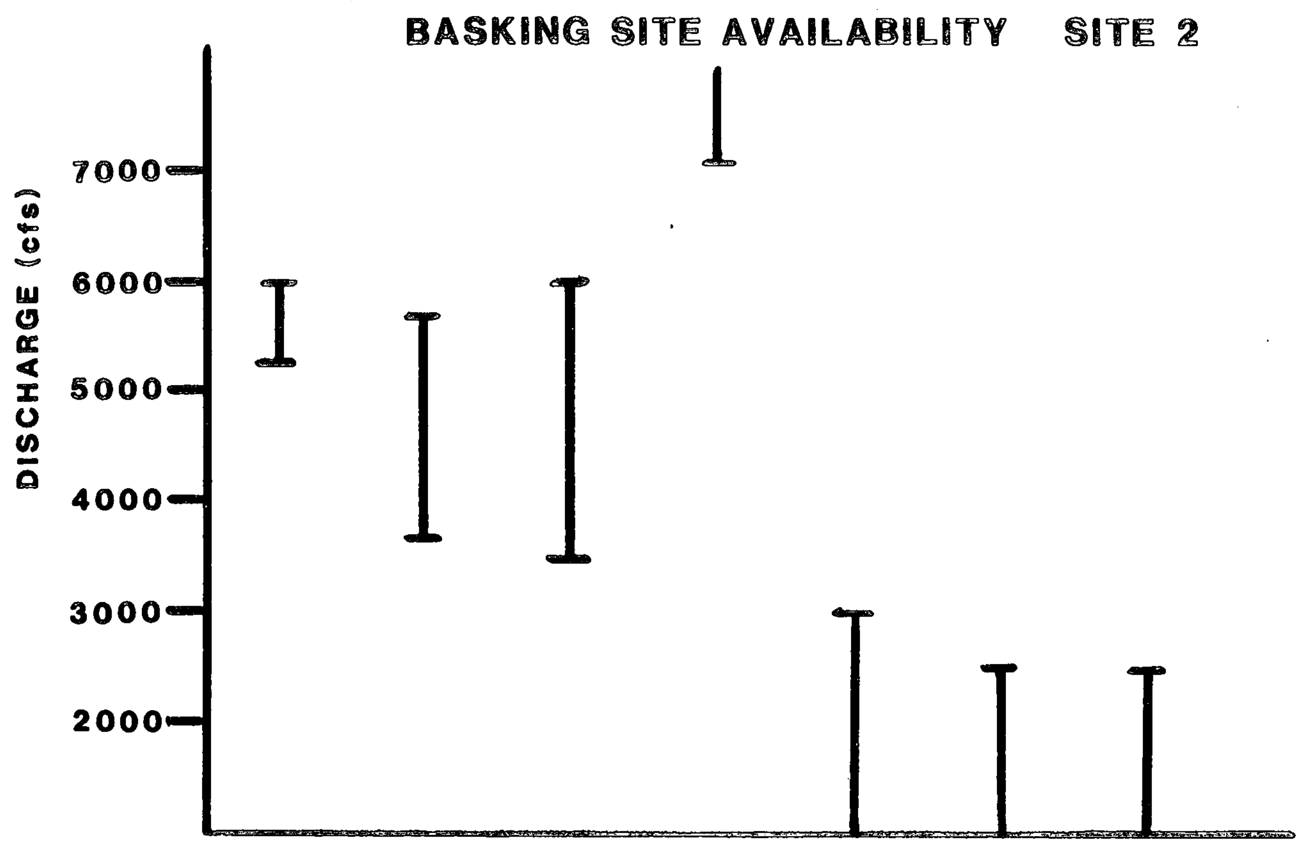

Figure 3. Basking site availability in relation to cfs discharge at Site 2, NRGNR, W.V. 1985.

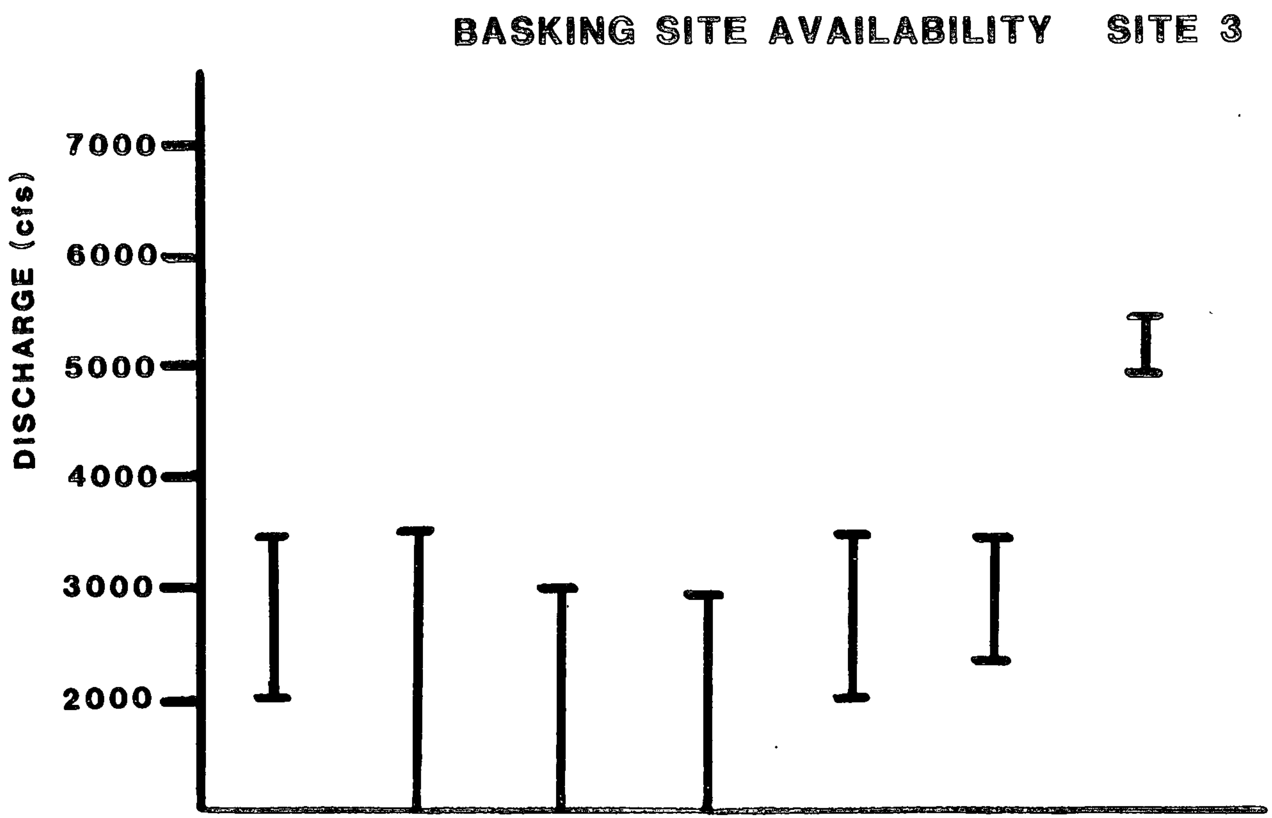

Figure 4. Basking site availability in relation to cfs discharge at Site 3, NRGNR, W.V. 1985.

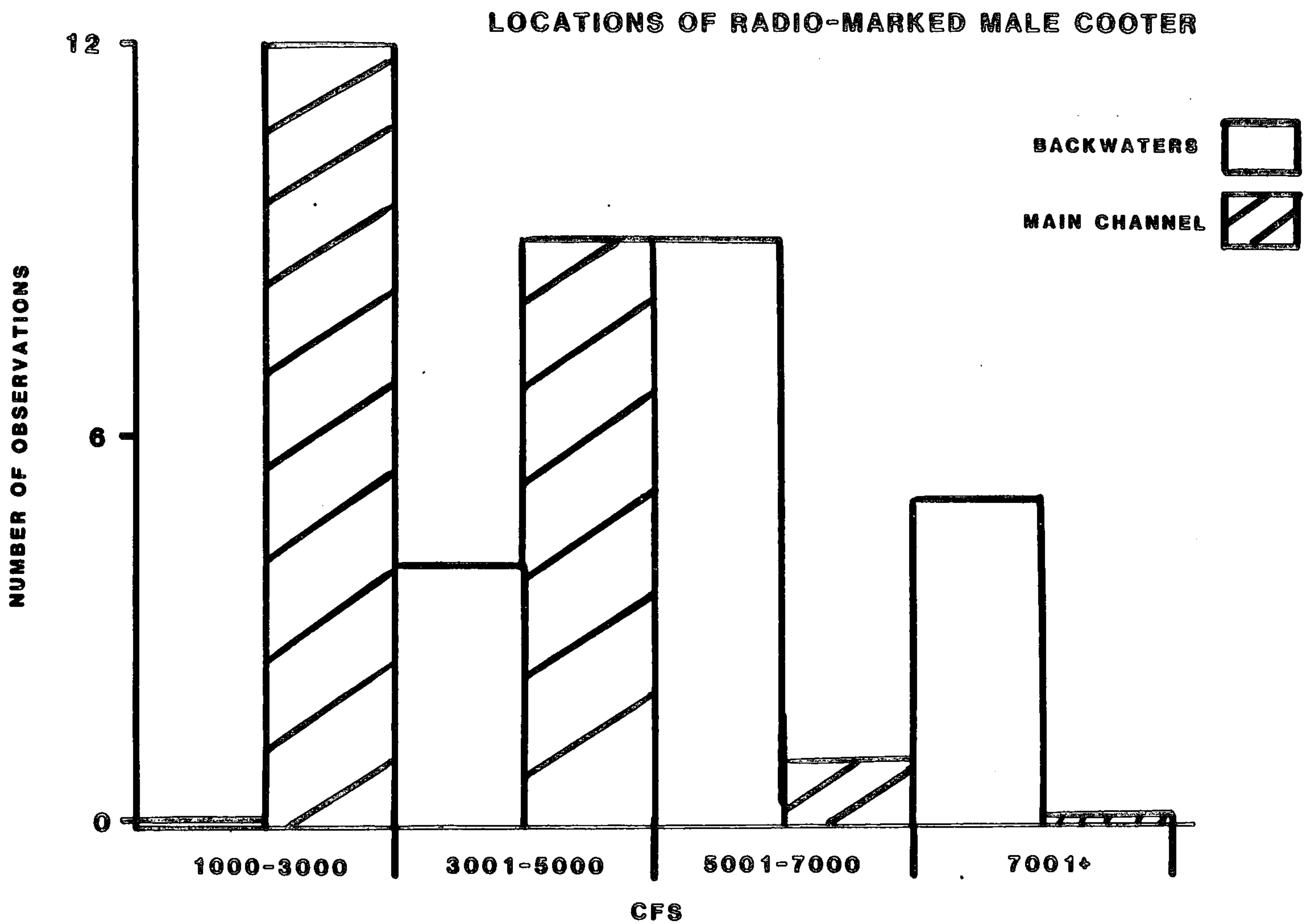

Figure 5. Locations of radio-marked male cooter in relation to flow level (cfs) at Site 1, NRGNR, W.V. 1984-85.

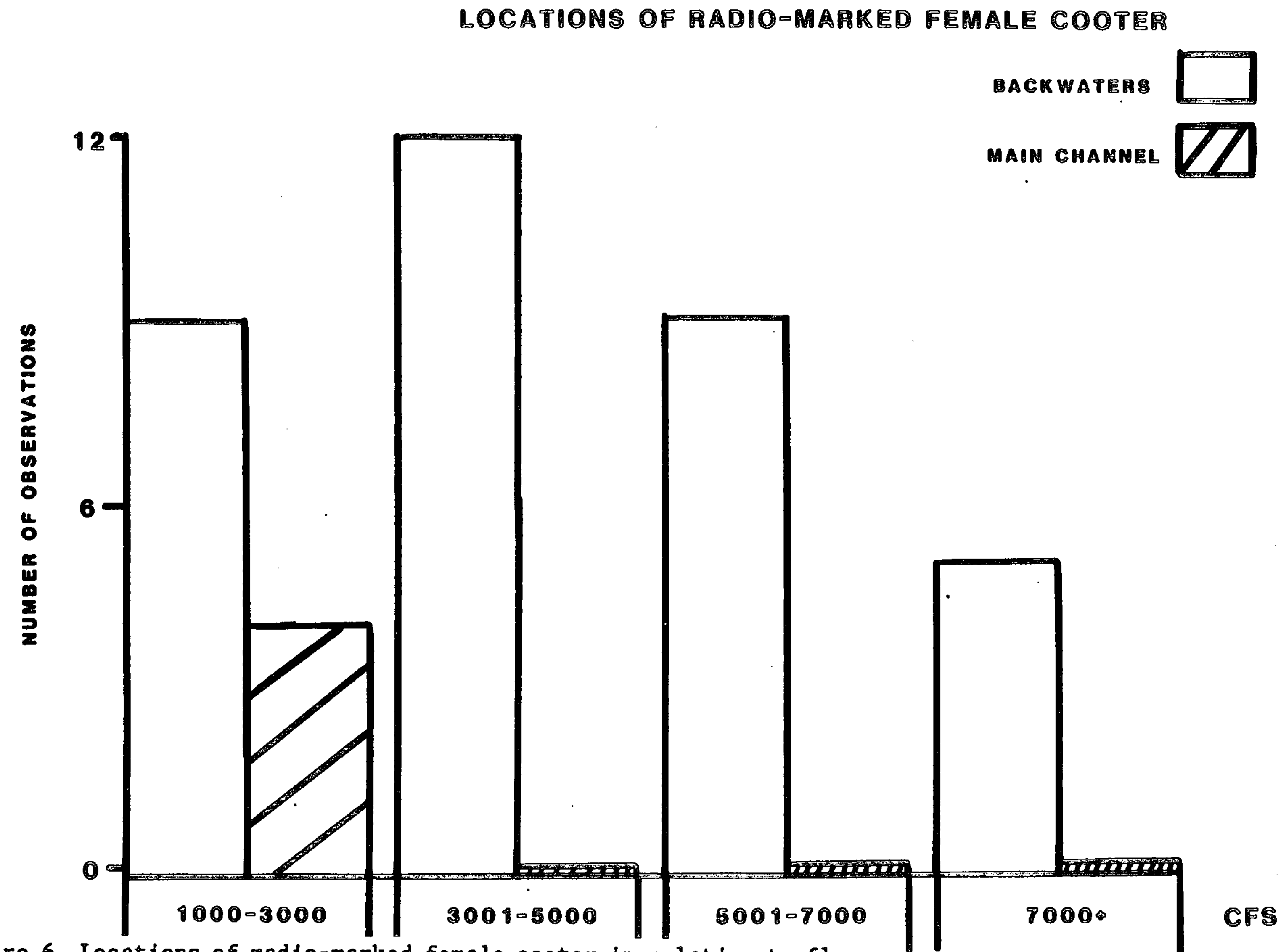

Figure 6. Locations of radio-marked female cooter in relation to flow level (cfs) at Site 1, NRGNR, W.V. 1984-85.

TABLE 1. Habitat characteristics of used portions of pools (Sites 1,2,3) inhabited by cooters and a riffle habitat (Site X) not inhabited by cooters, NRGNR, W.V. 1985.

	POOL AREA(ha)	ELODEA	EELGRASS	ISLANDS ⌐	MEAN CURRENT VEL.	COOTER DENSITY
SITE 1	10.08	.99 ha (9.8%)	.10 ha (1.0%)	5.5 ha	0.24 m/s	2.2/ha
SITE 2	31.57	.58 ha (1.8%)	*	0.03 ha	0.28 m/s	0.6/ha
SITE 3	6.61	.14 ha (2.1%)	#	0.03 ha	0.22 m/s	1.2/ha
SITE X	11.10	0	*	0	0.97 m/s	0

⌐ Island areas are in addition to entire pool hectares.
* Eelgrass present in scattered clumps within the 1-2m depth range
# Eelgrass not found

TABLE 2. Water depth (% of area) at each of 4 study sites in the NRGNR, WV, 1985.

	TOTAL AREA (ha)	very shallow 0-1m	shallow 1-2m	mod. deep 2-3m	deep 3-4m	very deep 4-5m
SITE 1						
used	10.08	62	33	5	0	0
non-used	8.50	48	18	21	11	2
SITE 2						
used	31.57	38	44	16	2	0
non-used	15.10	18	56	26	0	0
SITE 3						
used	6.61	25	14	44	15	2
non-used	5.46	14	26	28	23	9
SITE X	11.10	84	16	0	0	0

TABLE 3. Locations and mean flows at which cooters were observed within pool habitats, NRGNR, W.V. 1985.

	$\bar{X}$ flow (cfs)		P
SITE 1			
backwater	4398		0.5584
main channel	4044		
SITE 2			
main snag	4604		0.0001
upstream snag river left	2145		
SITE 3			
outside island	5380	+	0.0001
sandbar/behind island	3157	+	
rock rapid	2609	| +	0.0028 *
downstream snag	2398	+ |	
rocks under bridge	2063	+	

+ values connected by bars were not different from each other; Duncans multiple range test.
* level of significance excluding 'outside island' group

TABLE 4. Time specific food habits (% frequency of occurrence) of adult river cooters in the NRGNR, W.V. 1985.

Ingested material	N=7 April	N=7 May	N=6 June	N=6 July	N=6 Sept
Filamentous algae	100.0	14.2	83.3	16.6	66.7
Eelgrass	--	57.0	50.0	83.3	50.0
Elodea	--	57.0	100.0	16.6	66.7
Pondweed	--	14.2	16.6	16.6	33.3
Terrestrial leaves	14.2	14.2	--	16.6	--
Crayfish	--	14.2	16.6	--	16.6
Mussel shell	--	--	--	16.6	--
Asiatic clam	--	--	--	16.6	--
Sand	14.2	--	--	--	--

TABLE 5. Site specific food habits (% frequency of occurrence) of adult river cooters in the NRGNR, W.V., April-September 1985.

Ingested material	N=14 SITE 1	N=9 SITE 2	N=9 SITE 3
Algae	50.0	77.8	44.4
Eelgrass	71.4	33.3	22.2
Elodea	21.4	33.3	100.0
Pondweed	14.2	11.1	22.2
Terrestrial leaves	14.2	11.1	--
Crayfish	14.2	11.1	--
Mussel shell	7.1	--	--
Asiatic clam	7.1	--	--
Sand	7.1	--	--

TABLE 6. Age and sex specific food habits (% frequency of occurrence) of river cooters in the NRGNR, WV, April-September 1985.

Ingested material	N=13 FEMALE	N=19 MALE	N=3 HATCHLING	N=3 JUVENILE
Algae	69.2	47.4	66.7	66.7
Eelgrass	61.5	36.8	66.7	33.3
Elodea	38.5	52.6	66.7	33.3
Pondweed	23.1	10.5	--	--
Terrestrial leaves	15.4	5.3	66.7	--
Crayfish	15.4	5.3	33.3	33.3
Mussel shell	--	5.3	--	--
Asiatic clam	--	5.3	--	--
Sand	--	5.3	--	33.3
Unidentified invert.	--	--	33.3	--
Insect wing	--	--	66.7	--
Tricopteran	--	--	33.3	33.3
Fish	--	--	33.3	33.3

APPENDIX 1. Cubic feet per second discharge (cfs) from the New River at Hinton, W.V. and corresponding water surface level readings on U.S. Geological Survey staff gauges. Data are representative of flow flucuations experienced by river cooters during 1985, NRGNR, W.V.

CFS	GAUGE HEIGHT *
18300	4.44
16700	4.41
11100	3.61
7700	3.03
7010	3.02
6420	2.89
6040	2.74
5570	2.72
5000	2.60
4520	2.50
4070	2.36
3470	2.24
3080	2.12
2410	1.91
2080	1.80
1850	1.72
1260	1.51

* Gauge height is recorded in feet.

APPENDIX 2. Mean monthly flow discharges (cfs) on the New River at Hinton, W.V. for 1984 and 1985 water years.

MONTH	OCT 83-SEPT 84	OCT 84-SEPT 85
October	4392	2889
November	5408	4960
December	12820	6314
January	6383	7884
February	19430	10954
March	16080	8268
April	20150	5379
May	16250	6704
June	4879	2815
July	4700	2389
August	6439	5022
September	2637	2144

APPENDIX 3. Temperatures (C)in the New River at Hinton, W.V., 1984-1985.

MONTH	DATE	1984	1985
October	7	15.1	17.0
	21	18.3	--
November	7	11.6	--
	21	5.2	--
December	7	3.7	--
	21	--	--
January	7	--	--
	21	--	0.2
February	7	--	1.4
	21	--	3.5
March	7	--	7.0
	21	--	--
April	7	--	10.3
	21	--	17.0
May	7	--	17.2
	21	--	19.8
June	7	--	25.0
	21	23.3	21.0
July	7	22.8	--
	21	23.6	--
August	7	24.5	--
	21	21.5	--
September	7	20.9	--
	21	19.6	20.5

APPENDIX 4. Home range estimates (ha) and maximum observed moved distances (m) of river cooters at Site 1 in the NRGNR, W.V. 1985.

TURTLE #	SEX	NUMBER RELOCATIONS	HOME RANGE	MAXIMUM OBSERVED DISTANCE MOVED
2	F	5	.90	200m
3	F	4	.53	142m
14	F	2	--	91m
15	F	2	--	72m
10 *	F	52	1.20	358m
12	M	5	.79	198m
11 *	M	50	1.60	321m
48	J	3	--	91m

* indicates radio-marked turtles, which were tracked for 10 months. other turtles were observed over a 6 month period.

APPENDIX 5. Home range estimates (ha) and maximum observed distances moved by river cooters at Site 2 in the NRGNR, W.V. 1985.

TURTLE #	SEX	NUMBER RELOCATIONS	HOME RANGE	MAXIMUM OBSERVED DISTANCE MOVED
27	F	2	--	726m
39	F	3	--	574m *
30	M	4	7.40	777m
24	M	2	--	574m *
28	M	2	--	574m *
22	M	2	--	574m *
21	J	2	--	115m

* All of these cooters made trips across the river between the same two basking sites.

APPENDIX 6. Home range estimates (ha) and maximum observed distances moved by river cooters at Site 3 in the NRGNR, W.V. 1985.

TURTLE #	SEX	NUMBER RELOCATIONS	HOME RANGE	MAXIMUM OBSERVED DISTANCE MOVED
6	F	3	.32	171m
29	M	4	.32	171m
33	M	2	--	39m
34	M	3	.43	220m
35	M	3	.19	194m
41	M	3	--	173m
43	M	3	--	61m
44	M	3	.16	147m
51	M	2	--	226m
36	J	7	1.40	176m
9	J	4	.48	184m
40	J	7	2.90	494m

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CONCLUSIONS

Range and Occurrence

Coastal plain physiographic regions comprise most of the river cooter's range and most members of the genus Pseudemys are found in the southeastern U.S. River cooters in the New River and NRGNR are isolated and at the northernmost extent of the range. The continuous range of this turtle reaches approximately the same latitude in southwest Indiana and Illinois (Conant 1975, Minton 1972).

River cooters have been an overlooked component of the New River system. Historically, cooters probably inhabited parts of the New River from near Radford, VA to Site 3 in the NRGNR. For cooters to have colonized the New River, certain Virginia Piedmont streams which now drain to the Atlantic, must have drained westward to the Teays (New) River, providing a dispersal route. Ross (1969) described a Pliocene river, known as the Fincastle, which drained west from the present headwaters of the Roanoke River, near Roanoke, VA, and entered the New River in the Radford/Christiansburg area. In the early Pleistocene, the young Roanoke River pirated the Fincastle River from the Teays, thus forming the Greater Roanoke River and isolating a population of river cooters in the Teays River.

Reports of large basking turtles (probably cooters) in the New River have come from Rich Creek, VA and Shanklin's Ferry, WV. A population of cooters is known to exist in Bluestone Reservoir

(Bayless 1972, Seidel 1981). The population described in this thesis is located 8-19 km downstream of Bluestone Dam in the NRGNR. It is unlikely that cooters occur in the New River farther downstream due to lack of pool habitats.

Population

River cooter colonies were found in 3 pools in the NRGNR. The total number of mature animals in 1985 was estimated to be 64. Several cooters were observed in 2 other pools between the study sites, but these were judged not to represent colonies, but single individuals. The population estimate includes these individuals. Probable emigration to downstream sites occurs from the Site 1 colony, 8.4 km downstream from Bluestone Dam. This colony had a 1:1 sex ratio, but few juveniles. Downstream, at Sites 2 and 3, the proportion of males and juveniles increases, probably from upstream dispersers. During this study (1984-85) I did not observe marked cooters to move between sites. Possibly, dispersal occurs during unusually high flooding or summers of extreme low water.

Growth in cooters is rapid until they reach maturity. Juvenile cooters also consume insects, benthic invertebrates, and fish. These food sources are higher in protein and vitamins than the aquatic vegetation consumed by adults, and probably account for the faster rate of growth. Predation is likely to be reduced, once a juvenile's shell hardens.

Habitat

Cooters selected pool habitats with growths of aquatic macrophytes, slow currents, sandbars, islands, and backwaters. They were not found in riffle habitats, and therefore are unlikely to be found farther downstream of Site 3 in the NRGNR. Cooters require basking sites. These may be rocks, log snags, or occasionally an exposed sandbar. Since cooters live in an aquatic system with naturally flucuating water levels, basking sites may be inundated or left high and out of reach. Optimum cooter habitat has a sufficient amount of basking sites, and some are always available no matter what the level of the river. It is possible that the addition of log snags may increase the habitat suitability for cooters at some sites.

Predictions for future survival

I feel that for long-term survival, this population of river cooters requires further study and protection. I only heard one account of local residents capturing and eating cooters. They are edible, and probably would have been exterminated by now had they been easy to catch. Being herbivorous, cooters do not respond to meat baits and are not captured with light tackle or trotlines, as are snapping turtles. Although I never saw it happen, I suspect that basking cooters as well as musk and painted turtles are victims of rifle target practice at the hands of local residents.

Cooter reproduction in the New River appears to be low. I never found many juveniles at the study sites, and overall adult population density is lower than within their continuous range in the southeastern United States.

Cooters are the least common turtle species in the New River. Cooter eggs probably take longer to develop in northern areas than in southern climes. This may result in a short first growing season, if any at all. Indeed, I found evidence suggesting that cooters overwinter in the nest and emerge in April of the following year. Survival of hatchlings may be influenced by flood situations, both man-made and natural. If time of hatching coincides with unusually high flood waters, survival is probably lessened.

The success of cooter nests would also affect recruitment into the population. Although I did not find any nests during this study, likely nesting sites were subjected to human disturbance. These sites included a high school football and baseball field (Site 1), gardens and backyards of riverbank residents (Site 2), and the roadgrade and construction area of Interstate highway 64 (Site 3). I found nests of 3 other turtle species in the NRGNR including 1 snapping turtle on 7 June, 3 painted on 23 June, and 1 musk on 26 June. It is likely that nesting by cooters occurs within this time range as well.

Overall survival of the population may depend on immigration of new individuals and genes into the population. This can not occur in the NRGNR population because Bluestone Dam is a barrier to downstream dispersal. Artifical flows from this dam such as high summer flows scour aquatic vegetation, notably elodea and eelgrass, which are used for food and cover. Presence of the dam may put the long term survival of this population at considerable risk.

Future Study

More information is needed to maintain this turtle as part of the natural biota of the New River. No information has been collected concerning nesting sites or dates, incubation time, or clutch size. A study of sex ratios at birth may shed some more light on the skewed adult sex ratio situation. Growth, survival, and dispersal of juveniles should be followed through several years. Manipulation of cooter habitat, such as the addition of basking sites may help to maintain populations in the New River.

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