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Of Deadwood and Map Turtles (*Graptemys*): An Analysis of Species Status for Five Species in Three River Drainages Using Replicated Spotting-Scope Counts of Basking Turtles. Linnaeus Fund Research Report

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Map turtles (*Graptemys*) are the most speciose turtle genus in North America north of the Rio Grande, with 12 species recognized (Ernst et al., 1994). Species richness stems from the restriction of these turtles to large rivers and lakes of riverine origin, resulting in drainage-basin endemism within major Gulf Coastal river drainages (including the Mississippi drainage). Many rivers are occupied by a broad-headed, molluscivorous species of *Graptemys* in sympatry with a narrow-headed species exhibiting little molluscivory. Two narrow-headed species, *G. oculifera* of the Pearl River drainage (Fig. 1) and *G. flavimaculata* of the Pascagoula River drainage (Fig. 2), are listed as Threatened under the U.S. Endangered Species Act (ESA) of 1973, and as Endangered by the International Union for the Conservation of Nature (IUCN). Reasons for decline of these two species are thought to include anthropogenic removal of deadwood from river channels, channel modification, water-quality degradation from municipal and industrial effluents, overexploitation for the pet trade, and wanton shooting (U.S. Fish and Wildlife Service, 1988, 1993).

Graptemys are among the most habitual baskers among turtles, and can be seen in great numbers on logs and branches on warm sunny days (Boyer, 1965; Lindeman, 1997b). Feeding studies and anecdotal observations suggest that narrow-headed *Graptemys* graze upon algal/invertebrate communities that occupy submerged deadwood, while broad-headed *Graptemys* are primarily molluscivorous, at least in the case of adult females (Sanderson, 1974; Moll, 1976; Shealy, 1976; Vogt, 1981; Shively and Jackson, 1985; Kofron, 1991; Seigel and Brauman, 1994; Lindeman, 1997b). *Graptemys* also cling to the underwater portions of basking sites as nocturnal resting sites (Chaney and Smith, 1950).

While abundance of deadwood may be an important habitat variable in *Graptemys* ecology, with anthropogenic removal believed to be related to declines in *G. oculifera* and

Figure 1. Adult female *Graptemys oculifera* from the upper Pearl River near Ratliff Ferry, Mississippi. Photograph by P.V. Lindeman.

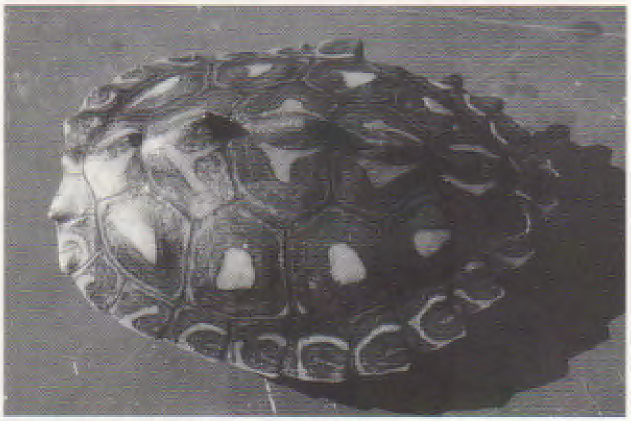

Figure 2. Adult female *Graptemys flavimaculata* from the lower Pascagoula River near Vancleave, Mississippi. Photograph by P.V. Lindeman.

G. flavimaculata, few studies have addressed the importance of deadwood abundance directly. Pluto and Bellis (1986) and Fuselier and Edds (1994) found basking-site abundance to be an important indicator of *Graptemys* abundance locally. In a radiotelemetry study, Jones (1996) found that areas with high deadwood abundance were frequented by *G. flavimaculata*.

In 1994 and 1995, I conducted spotting-scope surveys of five species of *Graptemys* in three river drainages. I quantified the basking densities of the two federally-listed species at a variety of sites within their geographic ranges in the Pearl (*G. oculifera*) and Pascagoula (*G. flavimaculata*) drainages, and compared these densities with basking densities of three unlisted species of *Graptemys*. The unlisted species included *G. gibbonsi*, which is sympatric with the two listed species, and *G. ouachitensis* and *G. pseudogeographica*, which inhabit the lower Tennessee drainage, including Kentucky Lake reservoir, in western Kentucky. I analyzed the relationship between turtle basking density and deadwood density. Here I present data on turtle basking densities for *Graptemys* and other turtle species in the three drainages, in hopes they may serve as baseline data for later comparisons. I also briefly discuss the results of the basking density vs. deadwood density analyses.

Methods. — Basking counts were conducted with a spotting scope with 22–60x zoom magnification at 61 total sites (20–21 sites per river drainage) which were visited eight times each during May and June 1994–95. Maps of the study areas are presented elsewhere (Lindeman, 1996, for the Pearl and Pascagoula drainages; Lindeman, 1997a, for the lower Tennessee drainage). Methods for counting basking turtles and determining densities were as previously described (Lindeman, 1996, 1997a). Emergent deadwood was also counted through the spotting scope, and each potential basking substrate was categorized as a log, branch, tangle, stump, or tree crown. For each type of basking substrate in each drainage, proportion of total substrates occupied by turtles and mean number of turtles per occupied substrate was quantified. These figures were multiplied by the total number of substrates of the category observed at a site (over all eight counts), and the five products were summed to generate an index of deadwood density for each site within each drainage. Pearson correlation coefficients were calculated using either the index of deadwood density or the total number of potential basking substrates observed at a site as the x variable, and the basking densities of individual species of *Graptemys*, total *Graptemys*, total emydids, or of all turtles as the y variable. Analyses were conducted separately using mean basking densities over eight counts, and maximum densities observed at each site.

Results and Discussion. — Predominant species observed in the Pearl drainage, in order of their relative abundance in basking counts, were *G. oculifera*, *Pseudemys concinna*, and *G. gibbonsi*. Together these three species constituted 86% of all turtles observed basking in the Pearl drainage (Table 1). *Graptemys oculifera* was seen at especially high densities and relative abundance upstream from the Ross Barnett Reservoir near the major metropolitan area of Jackson, Mississippi, and was seen at low abundance in tributary streams and three sites on the Ross Barnett Reservoir. The overall basking density of all species in the Pearl drainage was 3.32 turtles/100 m.

Predominant species observed in the Pascagoula drainage were *G. flavimaculata*, *G. gibbonsi*, and *P. concinna* (92% of all turtles observed; Table 2). Basking densities of *G. flavimaculata* and of all turtles were highest in the mainstem Pascagoula River and two sites on the Bowie River, a tributary of the Leaf River. Lower densities were observed on the Leaf and Chickasawhay rivers and the other smaller tributaries. The overall basking density of all species for the Pascagoula drainage was 1.53 turtles/100 m, less than half the density observed in the Pearl drainage.

Predominant species observed in the Tennessee drainage were *Trachemys scripta*, *G. ouachitensis*, and *G. pseudogeographica* (85% of all turtles observed; Table 3). Basking densities on Kentucky Lake reservoir were considerably higher than basking densities at five sites on the Tennessee River below Kentucky Lake Dam, and overall density (9.17 turtles/100 m) was almost 3x higher than on the Pearl drainage and 6x higher than on the Pascagoula drainage.

Table 1. Basking densities and relative abundance of turtles in portions of the Pearl River drainage, Mississippi and Louisiana. Pearl River sites are divided based on whether they are north or south of the Ross Barnett Reservoir. *Go = Graptemys oculifera, Gg = G. gibbonsi, Pc = Pseudemys concinna, Ts = Trachemys scripta, Gsp.* = unidentified *Graptemys, Esp.* = unidentified Emydidae, *Am = Apalone mutica, As = A. spinifera, Kc = Kinosternon carinatum.* Sites = total number of sites surveyed, km = total km surveyed.

Drainage	Sites	km	Basking density, turtles per 100 m (% of all turtles) *Go*	*Gg*	*Pc*	*Ts*	*Gsp.*	*Esp.*	*Am*	*As*	*Kc*	Total
Pearl River N	5	11.68	5.16	0.18	0.21	0.01	0.27	0.09	0.00	0.02	0.15	6.08
			(85)	(3)	(3)	(<1)	(5)	(1)	(0)	(<1)	(2)	
Pearl River S	6	12.93	2.04	0.51	0.21	0.07	0.10	0.05	0.01	0.05	0.36	3.40
			(60)	(15)	(6)	(2)	(3)	(2)	(<1)	(1)	(10)	
Ross Barnett Reservoir	3	6.85	0.58	0.03	0.45	0.06	0.00	0.12	0.00	0.01	0.00	1.26
			(47)	(2)	(36)	(5)	(0)	(9)	(0)	(1)	(0)	
Mayes Lake	1	2.00	2.00	0.00	0.40	0.55	0.00	0.05	0.00	0.00	0.10	2.00
			(65)	(0)	(13)	(18)	(0)	(2)	(0)	(0)	(3)	
Yockanookany River	1	1.10	0.64	0.09	0.18	0.00	0.00	0.09	0.00	0.00	0.00	1.00
			(64)	(9)	(18)	(0)	(0)	(9)	(0)	(0)	(0)	
Strong River	2	3.95	0.30	0.18	0.10	0.03	0.00	0.05	0.00	0.03	0.20	0.89
			(34)	(20)	(11)	(3)	(0)	(6)	(0)	(3)	(22)	
West Pearl River	1	1.58	0.25	0.06	0.57	0.25	0.00	0.25	0.00	0.00	0.00	1.40
			(18)	(4)	(41)	(18)	(0)	(18)	(0)	(0)	(0)	
Bogue Chitto River	1	2.20	1.23	0.23	0.09	0.05	0.00	0.09	0.00	0.00	0.09	1.77
			(69)	(13)	(5)	(3)	(0)	(5)	(0)	(0)	(5)	
Total	20	42.28	2.36	0.24	0.26	0.07	0.11	0.08	0.01	0.02	0.18	3.32
			(71)	(7)	(8)	(2)	(3)	(2)	(<1)	(1)	(5)	

Table 2. Basking densities and relative abundance of turtles in portions of the Pascagoula River drainage, Mississippi. Major tributaries are the Leaf and Chickasawhay rivers. *Gf = Graptemys flavimaculata, Gg = G. gibbonsi, Pc = Pseudemys concinna, Ts = Trachemys scripta, Gsp.* = unidentified *Graptemys, Esp.* = unidentified Emydidae, *Am = Apalone mutica, As = A. spinifera, Asp.* = unidentified *Apalone, Kc = Kinosternon carinatum, Km = K. minor.* Sites = total number of sites surveyed, km = total km surveyed.

Drainage	Sites	km	Basking density, turtles per 100 m (% of all turtles) *Gf*	*Gg*	*Pc*	*Ts*	*Gsp.*	*Esp.*	*Am*	*As*	*Asp.*	*Kc*	*Km*	Total
Pascagoula River	3	6.73	3.23	0.45	0.10	0.06	0.12	0.01	0.01	0.00	0.00	0.04	0.00	4.04
			(80)	(11)	(3)	(1)	(3)	(<1)	(<1)	(0)	(0)	(1)	(0)	
Leaf River	5	10.20	0.29	0.16	0.05	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.56
			(53)	(28)	(9)	(0)	(0)	(0)	(5)	(5)	(0)	(0)	(0)	
Bowie River	2	3.60	0.94	0.25	1.94	0.03	0.06	0.00	0.00	0.00	0.00	0.00	0.00	3.22
			(29)	(8)	(60)	(1)	(2)	(0)	(0)	(0)	(0)	(0)	(0)	
Tallahala Creek	1	1.93	0.21	0.05	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
			(58)	(14)	(28)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	
Chickasawhay River	8	16.85	0.27	0.40	0.24	0.01	0.01	0.02	0.03	0.02	0.01	0.02	0.01	1.03
			(26)	(39)	(23)	(1)	(1)	(2)	(3)	(2)	(1)	(2)	(1)	
Chunky River	1	2.33	0.00	0.39	0.04	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.47
			(0)	(83)	(9)	(0)	(0)	(9)	(0)	(0)	(0)	(0)	(0)	
Black Creek	1	0.60	0.33	0.67	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.17
			(28)	(57)	(15)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	
Total	21	42.23	0.79	0.32	0.30	0.01	0.03	0.01	0.02	0.02	0.01	0.02	0.01	1.53
			(52)	(21)	(20)	(1)	(2)	(1)	(1)	(1)	(1)	(1)	(1)	

Table 3. Basking densities and relative abundance of turtles in portions of the Tennessee River drainage, Kentucky. Kentucky Lake sites are divided based on whether they are north or south of State Highway 68. *Go = Graptemys ouachitensis, Gp = G. pseudogeographica, Gg = G. geographica, Pc = Pseudemys concinna, Ts = Trachemys scripta, Cp = Chrysemys picta, Gsp.* = unidentified *Graptemys, Esp.* = unidentified Emydidae, *Am = Apalone mutica, As = A. spinifera, Asp.* = unidentified *Apalone, Ko = Kinosternon odoratum, Ks = K. subrubrum, Cs = Chelydra serpentina.* Sites = total number of sites surveyed, km = total km surveyed.

Drainage	Sites	km	Basking density, turtles per 100 m (% of all turtles) *Go*	*Gp*	*Gg*	*Pc*	*Ts*	*Cp*	*Gsp.*	*Esp.*	*Am*	*As*	*Asp.*	*Ko*	*Ks*	*Cs*	Total
Tennessee River	5	5.58	1.07	1.24	0.00	0.00	0.57	0.00	0.25	0.07	0.22	0.00	0.00	0.00	0.00	0.00	3.43
			(31)	(36)	(0)	(0)	(17)	(0)	(7)	(2)	(6)	(0)	(0)	(0)	(0)	(0)	
Kentucky Lake N	8	7.90	3.29	2.65	0.01	0.32	4.84	0.00	0.53	0.27	0.30	0.08	0.00	0.01	0.01	0.01	12.27
			(27)	(22)	(<1)	(3)	(39)	(0)	(4)	(2)	(2)	(1)	(0)	(<1)	(<1)	(<1)	
Kentucky Lake S	7	6.70	2.76	0.16	0.00	0.30	6.40	0.04	0.24	0.30	0.00	0.01	0.04	0.00	0.04	0.00	10.31
			(27)	(2)	(0)	(3)	(62)	(<1)	(2)	(3)	(0)	(<1)	(<1)	(0)	(<1)	(0)	
Total	20	20.18	2.50	1.43	0.01	0.22	4.17	0.01	0.35	0.23	0.17	0.01	0.01	0.01	0.02	0.01	9.17
			(27)	(16)	(<1)	(2)	(45)	(<1)	(4)	(3)	(2)	(<1)	(<1)	(<1)	(<1)	(<1)	

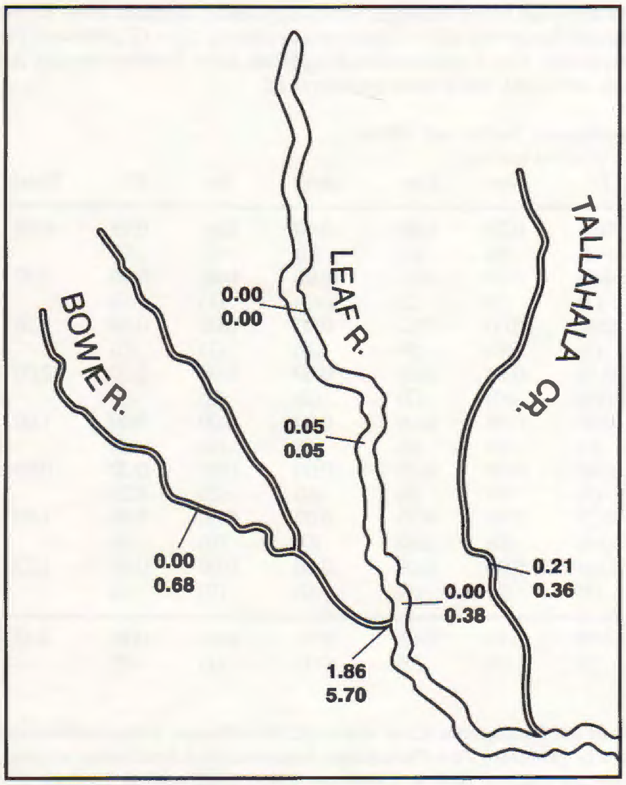

Figure 3. Map of survey sites on the upper Leaf River drainage of the Pascagoula drainage. The upper number at each site is the number of *G. flavimaculata* observed per 100 m of riverbank in eight surveys, the lower number is the total number of turtles of all species observed per 100 m.

The contrast in basking densities between the two reservoirs surveyed probably relates to their habitat characteristics and degree of shoreline development. The Ross Barnett Reservoir of the Pearl River is a wide, lacustrine reservoir with a high degree of residential shoreline development. Little deadwood was observed at the three sites surveyed, and turtle densities were very low compared to river sites (Table 1). In contrast, Kentucky Lake on the Tennessee River is a narrow, riverine reservoir with numerous side embayments representing old creek beds, and the east shoreline I surveyed is part of the Land Between the Lakes National Recreation Area, with minimal shoreline development. Deadwood and basking densities were both higher at 15 reservoir sites than at 5 sites below the dam on the Tennessee River (Table 3). Shoreline development and current within a reservoir are both probably important determinants of reservoir deadwood abundance.

Data collected on the abundance of *G. oculifera* will supplement trapping and visual census data obtained more intensively at five sites on the Pearl River (Jones and Hartfield, 1995) in serving as baseline data for future comparisons. A recovery plan objective for this species is to achieve stable or increasing populations over 10 years (U.S. Fish and Wildlife Service, 1988). Basking density should serve as a useful indicator of population stability or increase, especially if counts are replicated to dampen variation and if methodology is consistently applied, particularly with regard to time of year and climatic conditions.

The recovery of *G. flavimaculata* is conditioned upon observations of basking densities of 4.4 turtles/100 m in the Pascagoula River, and 2.2 turtles/100 m in the Leaf and Chickasawhay rivers (U.S. Fish and Wildlife Service, 1993). My surveys indicate that the species meets or exceeds these thresholds at only two of three sites on the Pascagoula River and one of eight sites on the Chickasawhay River. Population declines, of turtles in general and *G. flavimaculata* in particular, may be associated with water-quality degradation in the Leaf drainage, as evidenced by a comparison of basking densities at three sites in the upper Leaf River with two sites in its smaller tributary, the Bowie River (Fig. 3). Cliburn (1971) collected *G. flavimaculata* at the site furthest upstream on the Leaf River, but I found no turtles of any species in eight visits to the site in 1994–95, making this the only site in any drainage at which no turtles were observed. At the next site downstream I observed only one turtle basking, a *G. flavimaculata* (one *G. gibbonsi* was seen swimming, however). At the third site, the Leaf River channel adjacent to the mouth of the Bowie River, only seven turtles were observed basking in eight surveys (0.38 turtles/100 m). At the two sites on the Bowie River, basking densities were considerably higher (0.68 turtles/100 m at the upstream site, all *P. concinna*; 5.70 turtles/100 m at the mouth of the river, including high densities of *P. concinna*, *G. flavimaculata*, and *G. gibbonsi*). If water-quality degradation is responsible for the very low basking densities in the Leaf River, then the Bowie River may be the most important upstream refuge for *G. flavimaculata* and other aquatic turtles of the Pascagoula drainage.

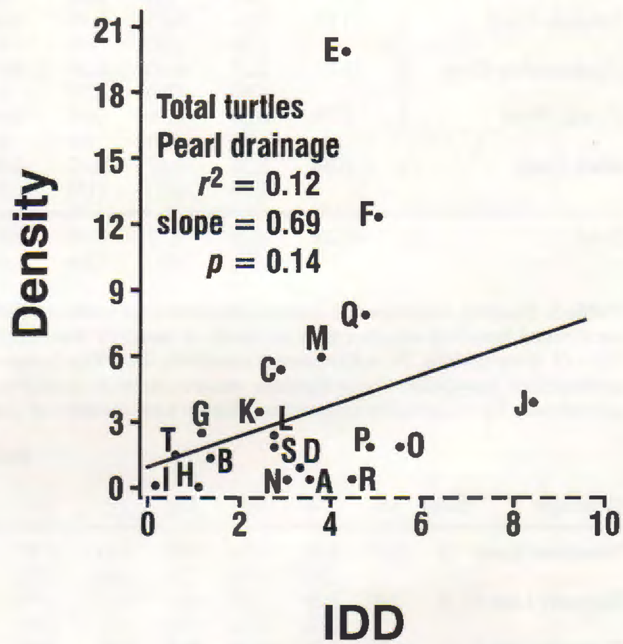

Figure 4. Correlation of the index of deadwood density (IDD) with weighted-average density of basking turtles (all species) at 20 sites on the Pearl River drainage, Mississippi. Letters denote labels of sites (see map in Lindeman, 1996).

An unexpected finding of the present study was the low basking abundance of *G. gibbonsi* relative to its two sympatric congeners. Combining data from the Pearl and Pascagoula drainages, *G. oculifera* and *G. flavimaculata* outnumbered *G. gibbonsi* by greater than 5:1. Trapping records have indicated more equitable ratios of these species in past decades (Cagle, 1953; Tinkle, 1958; Cliburn, 1971; Vogt, 1980). Current population strongholds for *G. gibbonsi* appear to occur in southern portions of the Pearl River and in the Pascagoula and Chickasawhay rivers (Tables 1 and 2). The species should be studied more intensively for consideration for listing as Threatened under the ESA and as Endangered by the IUCN (which currently lists the species as Lower Risk/near threatened). I suggest that *G. gibbonsi* be so listed unless 1) larger populations are found to exist upstream in tributaries beyond the ranges of congeners, as is true in Louisiana, where the upstream extent of *G. ouachitensis*, a narrow-headed species, coincides with an increase in abundance of *G. pseudogeographica*, a broad-headed species (Shively and Jackson, 1985), or 2) the species basks at much lower frequencies than its two sympatric congeners, and was observed less frequently in the present study for that reason.

A total of 60 analyses (20 per drainage) were conducted on the correlation of basking densities of *Graptemys* species, total *Graptemys*, total emydids, or total turtles (as averages over all surveys, or from dates of maximum basking density only) with basking-site abundance (total potential substrates or the index of deadwood abundance). All but three correlation coefficients were positive, and significant positive correlation was noted in 33 of the 60 analyses. The predominant pattern observed in data scatterplots (see Fig. 4 for one example), regardless of whether correlation was significant or not, was of a triangle skewed to the right: as deadwood density increased, turtle density at some sites, but not all, also increased. High basking densities were not observed at low deadwood densities, in spite of the fact that most potential basking substrates were not occupied, and few seemed occupied to capacity. This consistent pattern suggests that deadwood density is an important (though not sole) limiting factor in the ecology of *Graptemys* and of aquatic turtles in general, and that anthropogenic removal of deadwood is detrimental to *Graptemys* and other aquatic turtles.

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