FINAL REPORT

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THE ENDANGERED SPECIES ACT

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ENDANGERED RESOURCES BRANCH

Project 52: Population Analysis and Nesting Study of Cagle's Map Turtle

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FINAL REPORT

State: Texas **Grant Number:** E-3-1

Grant Title: Endangered and Threatened Species Conservation

Project Title: Population Analysis and Nesting Study of Cagle's Map Turtle

Contract Period: September 1, 1995 through August 31, 1996

Project Number: 52

Objective: To determine the size of the Guadalupe River population of Cagle's map Turtle (Graptemys caglei) from a data base of capture/recapture data. To establish the nesting period and to determine nest site characteristics of Cagle's map turtle from data collected on nesting activities.

PREFACE

The attached draft manuscript entitled "Population Analysis and Nesting Study of Cagle's Map Turtle" by Flavius C. Killebrew and Joel B. Babitzke resulted directly from this objective and is submitted in fulfillment of the Final Report requirement..

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Conservation Scientist

Approved by: ______________ **Date:** December 31, 1996
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Population Analysis and Nesting Study of Cagle's Map Turtle

Flavius C. Killebrew & Joel B. Babitzke

U.S. Fish & Wildlife Service Report

West Texas A&M University
Canyon, Texas
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ABSTRACT

Individuals of *Graptemys caglei* were captured by a variety of methods in a 36-kilometer stretch of the Guadalupe River near Cuero, (De Witt County) Texas, between May, 1985 and August, 1996 and marked for individual recognition. Considerable variation exists in population parameters. An estimate of 1769±211 (1 S.E.) animals was made for the study area using the Jolly-Seber open population model. Based on palpation and/or x-raying of females, the nesting season extends from late March through the end of August. Individual females reproduce annually and may lay multiple clutches during a given year. The average clutch size was 3.8 eggs, with a range of 1-8. Eggs incubated in artificial media hatched in 58-71 days, with an average incubation period of 62 days. Only four natural nests were found. These ranged from 4.5-11 cm deep in sandy to clay-loam soil 2-15 m from the water's edge and 30 cm to 2.5 m above the surface of the river. The egg chamber is 3 cm deep and 8 cm in diameter.

INTRODUCTION

Graptemys caglei Haynes and McKown (Cagle's Map Turtle; family Emydide) is a recently described species of map turtle that is confined to riverine habitat in the Guadalupe-San Antonio River System of Texas (Haynes and McKown, 1974). Studies on Cagle's map turtle include a chromosome study (Killebrew, 1977); an osteological comparison with *Graptemys versa* (Bertl and Killebrew, 1983); food habits (Porter, 1990); sex determination (Wibbels, Killebrew and Crews, 1991); coccidian parasites of *Graptemys caglei* and *Graptemys versa* (McAllister, Upton and Killebrew, 1991); and a radiotelemetry study (Craig, 1992). Literature on the estimation of population size and nesting of *Graptemys caglei* is lacking.

Cagle's map turtle is currently found only in segments of the Guadalupe and San Marcos Rivers in Kerr, Kendall, Comal, Guadalupe, Gonzales, DeWitt, Hays, and Victoria Counties (Dixon, 1987; Killebrew, 1992, Killebrew and Porter, 1991, Porter, 1992). Surveys using time-constrained basking turtle frequency indices and mark-recapture studies indicate that *Graptemys caglei* is distributed in three river segments: (a) The upper Guadalupe River from Kerrville to Seguin, (b) the middle Guadalupe River from Seguin to Cuero (including the San Marcos River from Ottine to its confluence with the Guadalupe River), and (c) the lower Guadalupe River from Cuero to Victoria.

The populations in the upper segment of the Guadalupe River from Kerrville to Seguin are unevenly distributed and minimal. Cagle's map turtle is absent from Canyon Lake proper and virtually absent from Canyon Dam downstream to New Braunfels. Five impoundments on the Guadalupe River (Dunalp, Placid, Starke Park, McQueeny, and Meadow Lakes) occur between New Braunfels and Seguin and lack populations of G.caglei, except in a 7.5 km (4.6 mi.) section above Lake Mcqueeny where riverine conditions exist (Killebrew, 1991a).

The middle Guadalupe is a 233 river km (144 river mi) stretch of river between Seguin and Cuero which supports the primary population of this species. The population in the San Marcos River is reportedly small and early estimates indicate that 60 to 70% of the G. caglei occur in the middle section of the Guadalupe River(Porter, 1992).

The Guadalupe River from Cuero to Victoria marks the southern extent of the distribution of this species and the number of Cagle's map turtles decreases as you go downstream from Cuero. The species disappears from the river in the vicinity of Victoria (Killebrew, 1991a; Killebrew 1992a).

Habitat requirements for Cagle's map turtle include a river bed consisting mostly of silt and gravel and gravel bars connecting long pool areas with a shallow average depth and a muddy, moderate flow. Basking habitat is provided by fallen logs, shrubs, rocks, and cypress knees (Haynes and

McKown, 1974; Killebrew, 1992). Cagle's map turtle is highly aquatic, and optimal habitat appears to include both riffles and pools (Haynes and McKown, 1974; Killebrew, 1991a; Killebrew, 1992a). Gravel bar riffles and transition areas between riffles and pools are considered important for Cagle's map turtles since they are highly productive of insect prey items (Killebrew, 1991a; Killebrew, 1991b). Recent radiotelemetry studies indicate that males may spend most of their time in these areas (Craig, 1992).

Haynes and McKown (1974) examined food items in several juvenile and adult males and two subadult females collected in July. They reported a diet of insects for both sexes (mostly caddisflies). Juveniles had also eaten large numbers of small gnat-like dipterans. The females had eaten caddisflies and snails. Lehmann(1979) reported both sexes as insectivorous, primarily consuming caddisflies and odonates (dragonflies and damselflies). The studies of Haynes and McKown (1974) and Lehmann(1979) involved small sample sizes and collections during a one or two month period.

Killebrew (1991b) described Cagle's map turtle feeding ecology, including seasonal, size-specific, and sex-specific diet differences. This study took place near Cuero in the southern part of the range. Adult males fed primarily on insects (81% of gastrointestinal contents by weight were insects) while adult females fed primarily on mollusks (88% of gastrointestinal contents by weight were Asiatic clam, _Corbicula fluminea_)(Killebrew, 1991b). Male Cagle's map turtles feed extensively on trichoperan (caddisfly) larvae of the genus Nectopsyche (45% gastrointestinal contents by weight). Other insect prey taken by both sexes included mayfly nymphs, damselfly nymphs and adults, dragonfly nymphs and adults, stonefly nymphs, and spongillafly larvae. Male juveniles fed on nearly equal quantities of snails and insects while female juveniles ate nearly equal quantities of Asiatic clams and insects (Killebrew 1991b).

Cagle's map turtle exhibits distinct sexual dimorphism. The adult male carapace length averages 7 to 12 cm, while those of females are generally larger and may reach sizes up to 20 cm (Conant and Collins, 1991; Haynes, 1976; Haynes and McKown, 1974; Killebrew and Porter, 1989; Killebrew and Porter, 1990).

Little is known regarding reproduction in this species. Haynes and McKown (1974) collected hatchling turtles from September through November and hypothesized that the Cagle's map turtle nesting period occurs in late spring and early summer. Nesting habits in this species are not well known. Haynes and McKown (1974) reported that sand bars are virtually nonexistent in many reaches of the Guadalupe River and concluded that nesting habits in Cagle's map turtle may differ from other species of Graptemys that often nest on sandbars.

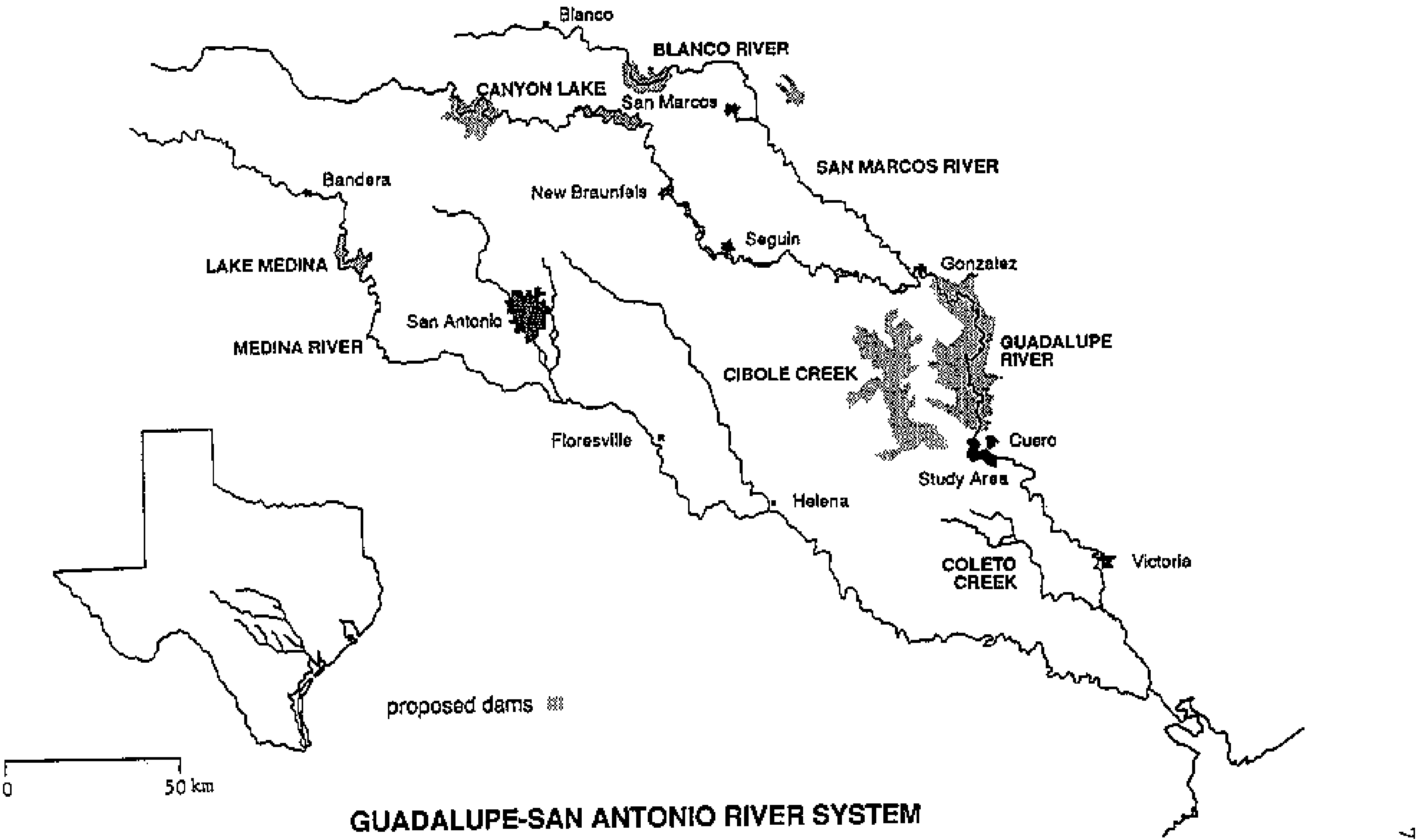
Graptemys caglei has a heritage rank of G3,S3. The U.S. Fish & Wildlife Service has determined that listing is warranted but precluded due to other listing priorities, and thus Graptemys caglei is currently designated as a category 1 species on the federal candiate notice of review. This action is based on the following reasons: (1) Cagle's map turtle has an extremely limited distribution; (2) within its current range, suitable habitat for Cagle's map turtle is fragmented and becoming more scarce. Further losses of suitable habitat will result if proposed impoundments and water diversions are constructed; (3) Cagle's map turtles diet of aquatic invertebrates (particularly insects) may be adversely affected by altered instream flow, pollution and increased sedimentation; and (4) human depredation is occurring from intentional shootings and over-collection for the pet trade, zoos, museums, and scientific studies (Killebrew, 1991a; Killebrew, 1992).

Data resulting from the current project is sought to fulfill the following objectives. First, to assess the population status by attempting to estimate population size in the various reaches of the Guadalupe River. Second, to gather data on the reproductive biology, especially the nesting ecology of Cagle's map turtle. Third, utilize this and other data to develop a recovery plan for this threatened species.

MATERIALS AND METHODS

The primary study area for a capture-mark-recapture population study and nesting surveys was established on a 36 km stretch of the Guadalupe River west of Cuero, DeWitt Co., Texas (Fig. 1). Turtles were collected by dip nets, traps and hand. Dip netting was done from a 15' jon boat powered by a 15 hp Mercury outboard motor. One person was required to maneuver the boat while the other person would net the specimen with a long-handled (6') dip net as it jumped from its basking site. Hoop-net traps were not used in the Guadalupe River since these traps could not be securely anchored in the rapidly flowing river and because of frequent changes in water level. However, hoop-net traps were used in small creeks flowing into the Guadalupe River. Basking traps were constructed as catch boxes from 1/2 inch mesh chicken wire and suspended under frequently used basking sites, leaving 2-3 inches above the waterline. Specimens were also caught by hand in the shallow water along the edge of gravel bars.

Sampling periods included all seasons and daily collections occurred at all hours during the day. Field observation and collection was interrupted only during hazardous weather conditions. Sampling dates are too numerous to list; however, a simplified account of dates are as follows. In 1985, surveys were conducted during the months of May and August, while in 1986 surveys were conducted during July and August. From 1987 to 1996, monthly (3-7 day) surveys were conducted during the period between September and May and daily during the months of June, July and August.



GUADALUPE-SAN ANTONIO RIVER SYSTEM

Captured animals were double-marked by means of numbered monel metal tags and a system of notching marginal carapacial scutes. The notching system represents a modification of the technique described for Graptemys pluchra (Shealy, 1976). A notch about one-half the depth of the marginal scute produced a semi-permanent mark on the specimen without injuring it or impairing its normal activity. Beginning in May 1993, captured animals were also implanted with passive integrated transponders (PIT Tags). A hand-held pit reader was used to ascertain whether recaptured animals contained pits.

Calculation of population size for the capture-mark-recapture study was performed using the computer program, "Jolly" (Pollock et al., 1990), which runs the Jolly-Seber open population model. An open population model was selected because the survey was conducted over a twelve year period, and deaths and births must be accounted for during this time. Additionally, the study area is only a section of the Guadalupe River and it cannot be isolated from the rest of the river; therefore, the resultant immigration and emigration will also be accounted for by this model.

Surveys of nesting areas were conducted from a boat from the late afternoon through the early morning hours to prevent disturbing females nesting on the beaches along the river. Beaches bordering pool areas, having numerous basking females, or where nests were found on the beach were selected to be monitored. During mid-day hours, beaches along the river were excavated for nests. Excavated eggs were weighed, measured, counted and placed in vermiculite trays until they hatched, which allowed identification of the nesting species. In the late evening, night and early morning hours, a filtered spot light was used to survey the beach from a boat or the beach was checked by a walking survey with a flashlight. If a nest was found, the following data was recorded: height from the water surface, soil type, amount and type of vegetation surrounding the nest, and nest depth.

Drift fences were constructed along probable nesting beaches to determine if it was a nesting area used by turtles. The drift fence was constructed of 1/2 inch mesh chicken wire, 40 cm high and placed at an angle to the waters edge. Holes (30 cm x 60 cm) were dug every 1.5 m along the fence. A turtle utilizing the beach to lay eggs would then fall into a hole as it followed the fence up the beach in search for a nest site. The fence was placed close enough to the waters edge where the sand was moist enough to keep from caving off and filling the holes.

Captured female turtles were also palpated for eggs. Turtles containing eggs were x-rayed to determine the number and size of the eggs in the clutch. Additional data on egg characteristics, clutch size, etc. is available from a previous study on sex determination in <u>Graptemys caglei</u> (Wibbels, Killebrew, and Crews, 1991). Eggs for this study were collected from seventy-four females which were induced to lay their eggs by administering 1 cc of oxytocin. The females were then placed in an 80 cm x 1.5 m partitioned box with an inclined, false bottom. This arrangement allowed the eggs to fall into a container of water, which protected them from being crushed and from drying out. The eggs were weighed, measured and placed in vermiculite trays. All of the eggs except 25 were taken to the University of Texas at Austin where they were used in a temperature dependent sex determination study (Wibbels, Killebrew and Crews, 1991). Seventeen (of the 25) hatchlings were tagged and released in the study area. Since only a small percentage of the animals hatched in the lab were released, no significant impact on the natural population was predicted and this balanced the impact of removal of eggs from the females. The remaining hatchlings were kept in our research lab to provide data on captive care and growth of this species.

RESULTS AND DISCUSSION

The capture-mark-recapture program at Cuero was conducted from May 1985 to August 1996 and encompassed 10,398 man/hours. Each year was considered as a capture period and the seventh capture period (1991) was used to represent the population estimate. Capture periods toward the middle yield a more precise estimate, because the population estimate is based on future recovery rates of marked animals (Pollock 1990), as well as the number of marked and unmarked animals captured in the sample. The population estimate for each year, capture probability, recruitment, and survival probability are listed in Tables 1-4. Parameters for males and females within the study area were calculated and are listed in Tables 6-13.

The Jolly-Seber model could not be used to calculate the number of hatchlings and juveniles because of insuficent data. The Jolly-Seber model uses both past and future recaptures and by the time a juvenile or hatchling is recaptured its sex may be distinguishable. Additionally, experience of the researcher in determining sex resulted in fewer specimens being placed in these categories. The Lincoln-Petersen model could not be used to determine the population of juveniles and hatchlings for each capture period due to the lack of recaptures.

There has not been enough work completed on the growth of <u>Graptemys caglei</u> to allow determination of individual age groups. Thus, parameters for individual age groups could not be calculated. The Jolly-Seber open population model also computes covariance for the population estimates. The covariances for the total population and male population of the study area are listed in Tables 1 and 6; however, there was not enough data on recaptures for the program to compute the covariances of the female population.

Table 1. Total population estimate for the 36 km study area at Cureo.

Capture Peroid	Year	Population estimate	Standard Error	95 % Conf. Limits	Covarance
1	1985	#	#	#	#
2	1986	1361	744	-97 - 2820	337
3	1987	1022	116	794 -1250	123
4	1988	1385	88	1212 -1559	167
5	1989	1289	67	1158 - 1421	291
6	1990	1767	123	1525 - 2009	305
7	1991	1769	211	1354 - 2184	194
8	1992	1017	167	690 - 1344	228
9	1993	958	145	672 - 1243	217
10	1994	954	165	631 - 1277	299
11	1995	1527	397	748 - 2306	#
12	1996	#	#	#	#

not enough data
Population Mean = 1305

Table 2. Capture Probability for the 36 km study area at Cuero.

Capture Peroid	Year	Capture Probability	Standard Error	95% Conf. Limits
1	1985	#	#	#
2	1986	0.03	0.02	-0.004 - 0.06
3	1987	0.31	0.04	0.23 - 0.38
4	1988	0.39	0.03	0.34 - 0.45
5	1989	0.39	0.02	0.35 - 0.44
6	1990	0.31	0.02	0.26 - 0.35
7	1991	0.19	0.02	0.14 - 0.24
8	1992	0.17	0.03	0.11 - 0.23
9	1993	0.23	0.04	0.16 - 0.31
10	1994	0.24	0.04	0.16 - 0.33
11	1995	0.14	0.04	0 .06 - 0.21
12	1996	#	#	#

not enough data

Table 3. Recruitment estimate for the 36 km study area at Cuero.

Capture Peroid	Year	Recruitment	Standard Error	95% Conf. Limits
1	1985	#	#	#
2	1986	-561	870	-2266 -1144
3	1987	450	124	206 - 694
4	1988	80	79	-75 -234
5	1989	516	80	358 - 673
6	1990	78	90	-100 - 255
7	1991	75	64	-51 - 201
8	1992	531	107	322 -741
9	1993	348	115	122 - 574
10	1994	736	254	237 - 1235
11	1995	#	#	#
12	1996	#	#	#

not enough data

Table 4. Survival Probability for the 36 km study area at Cuero.

Capture Peroid	Year	Survival Probability	Standard Error	95% Conf. Limits
1	1985	0.69	0.05	0.59 -0.79
2	1986	1.16	0.56	1.05 - 1.27
3	1987	0.92	0.04	0.84 - 0.99
4	1988	0.87	0.04	0.79 - 0.95
5	1989	0.97	0.06	0.84 - 1.09
6	1990	0.96	0.12	0.73 - 1.19
7	1991	0.53	0.09	0.34 - 0.73
8	1992	0.42	0.08	0.26 - 0.58
9	1993	0.63	0.11	0.42 - 0.85
10	1994	0.83	0.21	0.42 - 1.24
11	1995	#	#	#
12	1996	#	#	#

not enough data

Table 5. Number of marked and unmarked turtles for the Study Area.

Capture Period	Year	Specimens Captured Per Year			% of Marked/Unmarked	
		Marked	Unmarked	Total	Marked	UnMarked
1	1985	0	143	143	#	#
2	1986	3	51	54	6%	94%
3	1987	54	267	321	17%	83%
4	1988	161	393	554	29%	71%
5	1989	275	235	510	54%	46%
6	1990	277	265	542	51%	49%
7	1991	214	124	338	63%	37%
8	1992	115	60	175	66%	34%
9	1993	73	153	226	32%	67%
10	1994	72	162	234	31%	69%
11	1995	52	158	210	25%	75%
12	1996	53	152	205	26%	74%

not enough data

Table 6. Male population estimate for the 36 km study area at Cureo.

Capture Peroid	Year	Population Estimate	Standard Error	95 % Conf. Limits	Covariance
1	1985	#	#	#	#
2	1986	1244	678	-84 - 2572	235
3	1987	819	90	642 - 996	83
4	1988	1019	60	902 - 1136	125
5	1989	887	42	804 - 969	216
6	1990	1236	84	1071 - 1401	198
7	1991	1168	136	901 - 1437	131
8	1992	754	132	495 - 1012	115
9	1993	368	50	271 - 465	174
10	1994	590	103	389 - 792	155
11	1995	671	166	345 - 792	#
12	1996	#	#	#	#

not enough data
Population Mean = 876

Table 7. Male Capture Probability for the 36 km study area at Cuero.

Capture Peroid	Year	Capture Probability	Standard Error	95% Conf. Limits
1	1985	#	#	#
2	1986	0.03	0.02	-.003 - 0.07
3	1987	0.33	0.04	0.25 -0.40
4	1988	0.45	0.03	0.39 - 0.51
5	1989	0.43	0.03	0.39 - 0.49
6	1990	0.33	0.03	0.28 - 0.34
7	1991	0.22	0.03	0.17 - 0.28
8	1992	0.18	0.03	0.11 - 0.24
9	1993	0.32	0.05	0.22 - 0.41
10	1994	0.25	0.05	0.16 - 0.34
11	1995	0.19	0.05	0.09 - 0.28
12	1996	#	#	#

not enough data

Table 8. Male Rrecruitment Estimate for the 36 km study area at Cuero.

Capture Peroid	Year	Recruitment	Standard Error	95% Conf. Limits
1	1985	#	#	#
2	1986	-579	764	-2077 - 919
3	1987	271	93	90 - 452
4	1988	-19	53	-1122 - 84
5	1989	331	53	228 - 434
6	1990	-44	56	-153 - 65
7	1991	44	41	-36 - 124
8	1992	126	31	65 - 188
9	1993	271	72	130 - 411
10	1994	197	94	13 - 382
11	1995	#	#	#
12	1996	#	#	#

not enough data

Table 9. Male Survival Probability for the 36 km study area at Cuero.

Capture Peroid	Year	Survival Probability	Standard Error	95% Conf. Limits
1	1985	0.79	0.05	0.59 -0.79
2	1986	1.12	0.05	1.05 - 1.27
3	1987	0.91	0.04	0.84 - 0.99
4	1988	0.89	0.04	0.79 - 0.95
5	1989	1.02	0.07	0.84 - 1.09
6	1990	0.98	0.12	0.73 - 1.19
7	1991	0.61	0.12	0.34 - 0.73
8	1992	0.32	0.06	0.26 - 0.58
9	1993	0.87	0.15	0.42 - 0.85
10	1994	0.8	0.2	0.42 - 1.24
11	1995	#	#	#
12	1996	#	#	#

not enough data

Table 10. Female Population Estimate for the 36 km study area at Cureo.

Capture Peroid	Year	Population Estimate	Standard Error	95 % Conf. Limits	Covariance
1	1985	#	#	#	#
2	1986	4	#	#	#
3	1987	132	#	#	#
4	1988	472	#	#	#
5	1989	386	#	#	#
6	1990	480	#	#	#
7	1991	792	#	#	#
8	1992	134	#	#	#
9	1993	102	#	#	#
10	1994	46	#	#	#
11	1995	90	#	#	#
12	1996	#	#	#	#

not enough data

Table 11. Female Capture Probability for the 36 km study area at Cuero.

Capture Peroid	Year	Capture Probability	Standard Error	95% Conf. Limits
1	1985	#	#	#
2	1986	#	#	#
3	1987	0.18	0.19	-0.18 - 0.54
4	1988	0.08	0.04	-0.003 - 0.17
5	1989	0.23	0.06	0.11 - 0.36
6	1990	0.24	0.07	0.12 - 0.37
7	1991	0.08	0.04	0.0007 - 0.16
8	1992	0.2	0.09	0.01 - 0.38
9	1993	0.35	0.14	0.08 - 0.63
10	1994	1	#	#
11	1995	0.23	0.19	-0.14 - 0.61
12	1996	#	#	#

not enough data

Table 12. Female Survival Probability for the 36 km study area at Cuero.

Capture Peroid	Year	Survival Probability	Standard Error	95% Conf. Limits
1	1985	#	#	#
2	1986	1.36	0.51	0.35 - 2.38
3	1987	0.9	0.21	0.49 - 1.30
4	1988	0.87	0.19	0.50 - 1.24
5	1989	0.93	0.24	0.45 - 1.41
6	1990	0.9	0.44	0.044 - 1.75
7	1991	0.2	0.12	-0.02 - 0.43
8	1992	0.34	0.16	0.024 -0 .65
9	1993	0.26	0.07	0.12 -0 .39
10	1994	0.47	0.39	-0.29 - 1.24
11	1995	#	#	#
12	1996	#	#	#

not enough data

Table 13. Female Recruitment Estimate for the 36 km study area at Cuero.

Capture Peroid	Year	Recruitment	Standard Error	95% Conf. Limits
1	1985	#	#	#
2	1986	128	#	#
3	1987	352	259	-156 - 859
4	1988	-25	202	-421 - 371
5	1989	121	98	-71 - 313
6	1990	362	236	-101 - 825
7	1991	-27.51	46	-118 - 63
8	1992	57	30	-2 - 116
9	1993	20	9	2 - 38
10	1994	69	63	-56 - 193
11	1995	#	#	#
12	1996	#	#	#

not enough data

The total *Graptemys caglei* population in the 36 km study area at Cuero was estimated using the seventh capture period to be 1769 (Table 1). Ninety-five percent confidence limits places the population estimate between 1354 and 2184. A specimen captured during the seventh capture period has a 19% probability (Table 2) of being recaptured during the next capture period and a 53% (Table 4) probability of surviving until the next capture period. An estimated 75 animals (Table 3) was added to the population through immigration or hatchlings.

Fluctuations in the population estimate are partly due to the model used and the increasing success of recapturing marked animals. The population estimate for the early capture periods is biased by having too few marked animals in the population to be recaptured. The last capture periods lack enough marked animals to yield accurate future recovery rates; therefore, a population estimate for the 12th period could not be computed. Thus, the middle capture periods yield a more precise population estimate (Pollock et al., 1990). The population estimates for the sixth and seventh periods only fluctuate by 2 animals. The factor that contributes to the lower estimates in the 9th, 10th, and 11th capture periods was the expansion of the study area from 27 km to 36 km in 1993 and the drought during the summer of 1996 (12th capture period). The addition of unmarked turtles in the newly added section of river affects the population estimates because it changes the future recovery rate of marked animals for that period and increases the number of unmarked animals. The drought affected the population estimate by forcing collecting efforts to be concentrated to the newly added section of the study area.

The 36 km study area at Cuero is divided into two parts by a power plant dam. Low water levels below the dam precluded use of the motorboat as a means of capturing turtles. The area below the dam is the older portion of the study area and has the largest number of marked animals and yeilds a larger number of recaptures. The area above the dam is the section of river added to the study area in 1993. This area has fewer marked animals so recaptures will be lower. During the summer of 1996 (12th period) data was collected mainly from the newly added section of the study area because the dam impounded enough water to allow access by the motorboat. The effects of the added section and inability to collect equally from the entire study area is seen in the ratio of marked to unmarked animals captured in the 9th, 10th 11th and 12th capture periods (Table 5). From the beginning of the study (1985) the number of marked animals captured, steadily increases until it surpasses the number of unmarked animals captured in 1989 and remains larger until the addition of the new section of river in 1993. The percent then changes as the number of unmarked animals captured increases with the addition of the new section of river. However, the frequency at which marked animals are captured is still high. The number of marked animals captured in the 5th through the 8th capture periods was greater than the capture of unmarked animals, with the eighth period having the largest number of recaptures of all the periods (66%).

Data collection on nesting habits began in 1991. The drift fences failed to catch any turtles coming on to the beach to nest. The beaches in the study area were periodically surveyed for tracks during May and June of 1991 in order to gain a better idea of the area utilized by Graptemys caglei for nesting. Surveying for tracks was the only method used to locate nests during 1991. Man/hours and distance surveyed were not recorded for this time period. In April, May and June of 1992, 1993 and 1994 surveys failed to yield a nest or nesting female. In 1995, two nests were found, and in July of 1996 a female was observed nesting. A total of 351 man/hours were spent searching for nests. The proportion of available nesting habitat surveyed cannot accurately be approximated because of the size of the study area. However, a total of 19.8 km of beach area was surveyed along the Guadalupe River.

Preliminary data indicates that nesting may begin as early as late March and extends through the end of August, since females captured during this period were determined to contain eggs by palpation or examination of x-rays. Three confirmed Graptemys caglei nests have been discovered and one female was observed building a nest. The first nest was found in May 1991 by surveying the beach for tracks and following the tracks to the possible nest site. The nest was located 11 meters away from the waters edge, but the amount and type of vegetation surrounding the nest was not recorded. In July of 1995, two additional nests were discovered during beach surveys, when eroded portions of the beach gave way and exposed the nest. The first of the two nests (Table 14) was found 15 meters from the waters edge on a beach that was devoid of vegetation except for large willow trees whose canopies shaded the beach. The second nest (Table 14) was located 7 meters away from the waters edge on a dirt boat ramp. The nest was dug at the edge of the boat ramp which was bordered for its entire length by a thick growth (7-8') ragweed (Ambrosia trifida).

The female observed bulding a nest was found on the beach in the process of digging the nest, so the length of time it takes to build the nest is unknown. However, the female took aproximately 13 minutes to lay two eggs. A single egg chamber was dug using the hind leggs, and the ground was moist around the opening of the nest chamber while the surrounding soil was dry. The female had apparently moistened the ground with a discharge of water from her body to aid in digging the nest. The nest was flask shapped with a small opening approximately the size of a single egg. The beach was composed of a sandy loam and was devoid of vegetation except for large willow trees whose canopies converged to shade the entire beach.

Table 14. Nests measurements for the Cagles Map Turtle.

Nest	Year	Substrate	Above River Surface	From Edge of Water	Depth	Chamber Shape	Size of Chamber Opening	Chamber Size	Slope of Bank	Clutch Size
1	1991	Sandy	1.6 m	11 m	6 cm	UNKNOWN	UNKNOWN	3 cm x 8 cm	Gentle	3
2	1995	Sandy	30 cm	15 m	10 cm	UNKNOWN	UNKNOWN	5 cm x 8 cm	Gentle	3
3	1995	Clay Loam	2.5 m	7 m	4.5 cm	UNKNOWN	UNKNOWN	5 cm x 5 cm	Steep	4
4	1996	Sandy Loam	65 cm	2 m	11 cm	FLASK	3 cm x 4 cm	5 cm x 5 cm	Steep	2

Nest placement varies in proximity to the river, substrate, depth, chamber size, clutch size and slope of bank. These variances are listed in Table 14.

A total of 94 females were x-rayed or induced to lay their eggs and were determined to contain a total of 359 eggs. Clutch size varied significantly (r=1-8), while average clutch size was 3.8. Average egg length (38.3 mm) and average egg width (22.8 mm) were determined by direct measurement and by measuring x-rays. Average egg weight (12.5 g) was determined from eggs collected for the temperature dependent sex determination study (Wibbels, Killebrew and Crews, 1991). It took an average of 62 days (r=58-71 days) for the eggs to hatch. The difference in time may be due to the stage of development of the embryo when oviposition was induced by the injection of oxytocin since other conditions were kept similar. The length of time that females carry their eggs before laying is unknown. Females which contained eggs in May were recaptured in August and still contained eggs.

Congdon and Gibbons (1985) studied the relationship of body size and egg components. They observed for most of the 12 species of Emydine turtles they studied, that clutch size (wet mass) increased with body size (wet mass); however, <u>Terrapene carolina</u> and <u>Deirochelys reticularia</u> did not show this relationship. It is important to note that Congdon and Gibbons did not use the number of eggs in the clutch, but the wet mass of the clutch in their study. Additional data will be required before we attempt to determine the relationship between clutch size and body size in Graptemys caglei.

Threats to the survival of Graptemys caglei include commercial and scientific purposes, pesticides, intentional killings and loss of habitat. Pet traders capture the turtles to sell at pet stores. The male Graptemys caglei remains small even as an adult (180 mm) so they are easy to maintain and adjust to captivity quickly. Researchers collect numerous specimens and perserve them for future studies and for museum collections.

Fishermen kill the turtles believing they feed on game fish and their eggs. Many turtles are victims of vandals who shoot them for target practice. Pesticides are carried by runoff from croplands and orchards located along the river. These pesticides kill the turtles' aquatic insect food. One area of the river especially vulnerable to these pesticides are the shallow gravel bars along the river. Because the water is shallow in these areas it allows the pesticide to be more concentrated as runoff carries it over these areas and into the river. Insect larvae, niads, and nymphs use the cobble and gravel rock of these areas as habitat and have to filter water through gills to obtain oxygen, further exposing them to pesticides.

The proposed construction of five new impoundments on the Guadalupe-San Antonio River System and its tributaries (Fig. 1) threatens the habitat of Cagle's map turtle. Porter (1990) reported that the male Graptemys caglei diet is composed primarily of insect larvae (80.5%) of the order Trichoptera. These insects are found in great abundance on gravel bars within the study area at Cuero. The remainder of the male's diet is composed of gastropods (16%) and isopods (1.9%) (Porter 1990). Female Graptemys caglei eat insects (2.8%), plant material (7.8%), and pelecypods (88.5%) primarily the asiatic clam Corbicula fluminea (Porter 1990). Craig (1992) performed a radiotelemetry study on Graptemys caglei and found that males spend over 50% of their time on areas between gravel bars and pool areas (transition areas), while female Graptemys caglei spend 86.6% of their time in pool areas. This difference in habitat utilization by male and female Graptemys caglei is probably due to prey item preference. Impoundments flood vast areas of riverine habitat and diminish the flow rate of the river. The loss of lotic water and increased depth of water over the gravel and cobble bars may reduce the suitability of habitat for the prey items.

Impoundments are planned for the Guadalupe River and a tributary near Cuero, Texas. The proposed site on the Guadalupe River will impound water upstream to Gonzales, Texas. The other site on Sandies Creek, a tributary of the Guadalupe River will extend upstream and lie parallel to the shoreline of the impoundment on the Guadalupe River.

A master plan of proposed dams obtained from the Guadalupe-Blanco River Authority, was used to determine the placement and lengths of river covered by impoundments near

Cuero, Texas. If these proposed dams are constructed, at least 52% of the optimum habitat for this species will be eliminated, which may threaten the survival of the species. Conclusions regarding loss of preferred habitat are based on field observations. Thus, additional data must be gathered to support accurate population estimations and nesting studies as a prerequisite to the development of future recovery plans for Graptemys caglei.

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