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Decline of Red-Eared Sliders (*Trachemys scripta elegans*) and Texas Spiny Softshells (*Apalone spinifera emoryi*) in the Lower Rio Grande Valley of Texas

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Abstract. – In 2009, we repeated a freshwater turtle survey first conducted in 1976 in the Lower Rio Grande Valley (LRGV) of Texas to determine whether the abundance of freshwater turtles in the LRGV has changed over the past three decades. We captured significantly fewer red-eared sliders (*Trachemys scripta elegans*) and Texas spiny softshells (*Apalone spinifera*

***emoryi*) in 2 recently urbanized counties (Cameron and Hidalgo), and more red-eared sliders and Texas spiny softshells in a nonurbanized county (Willacy). Land-use changes, increased urbanization, and commercial turtle harvest are likely responsible for the decline of freshwater turtles in the LRGV.**

Typical consequences of urbanization include increase in human population density and substantial landscape modification (Kline et al. 2001; Henderson 2003; Siren 2007). Consequently, urbanization often negatively impacts wildlife populations (Czech 2000; Dietz and Adger 2003; Morgan and Cushman 2005). The influence of humans on the health and persistence of wildlife populations depends on how human-induced habitat changes affect the natural history of the species and whether the species is directly useful to humans (e.g., harvest for consumption). Habitat changes attributable to urbanization typically negatively affect biodiversity (Hamer and McDonnell 2009; Dolan et al. 2011) but can benefit individual species (Hansen et al. 2005; Gagné and Fahrig 2011).

Many freshwater turtles are declining in human-dominated landscapes (Garber and Burger 1995; Gibbons et al. 2000; Kiester and Olson 2011). They require water to survive (Ernst and Lovich 2009), and water is often highly regulated and manipulated (Levine 2007), sometimes with lethal consequences to turtles (Hall and Cuthbert 2000; Clark et al. 2009). However, introduced water bodies (e.g., golf course and sewage treatment ponds) can provide valuable habitat for turtles in urbanized environments (Germano 2010; Rose 2011). Freshwater turtles are arguably the most vulnerable vertebrate taxa to road mortality (Gibbs and Shriver 2002; Aresco 2005) and are negatively impacted by the increase in mesopredators (e.g., raccoons, *Procyon lotor*, and crows, *Corvus* spp.) that accompanies urbanization (Prange et al. 2003; Marchand and Litvaitis 2004; Marzluff and Neatherlin 2006). In addition, wild freshwater turtles are collected for human consumption and the pet trade, both of which have global markets (Warwick et al. 1990; Ceballos and Fitzgerald 2004; Brown et al. 2011a).

Historically, economic health in the Lower Rio Grande Valley (LRGV) of Texas was driven by agricultural production (Lopez 2006). Over the past three decades, intense human population growth and associated urbanization have occurred in Cameron and Hidalgo counties. The human population in Cameron County increased from 189,400 (57 people/km^2) in 1976 to 387,717 (117 people/km^2) in 2006 (United States Census Bureau 1982, 2007). The human population in Hidalgo County increased from 249,000 (61 people/km^2) in 1976 to 700,634 (171 people/km^2) in 2006. Huang and Fipps (2006) determined that urban land-use in Hidalgo County increased by 59.7% between 1993 and 2003, resulting in a 19.3% reduction in surface water. Further, based on population density, land transformation, accessibility, and electrical power infrastructure as a combined measure of human impacts to nature (the human footprint), the city of Brownsville in Cameron County now has the largest human footprint on earth, with similar footprint scores given to large populous cities like New York and Beijing (Sanderson et al. 2002). In contrast, Willacy County, which borders both Cameron and Hidalgo counties, remains a low density, agriculture-dominated county.

Despite the substantial land use changes in Cameron and Hidalgo counties, these counties are also rich in public and private parks, preserves, and refuges. The Lower Rio Grande Valley (LRGV) is one of the premier spots for bird watching in the world (Mathis and Matisoff 2004) and houses the only verified endangered ocelot (*Leopardus pardalis*) population in the United States (Jackson et al. 2005). If the habitat needs of freshwater turtles are met through management activities, these wildlife sanctuaries could serve to maintain robust freshwater turtle populations within what has become a heavily modified urban landscape.

In this study, we sought to determine whether the abundance of freshwater turtles in the LRGV has changed over the past three decades. To our knowledge, only one previous study, conducted in 1976, exists as a reference for past freshwater turtle abundances in the LRGV (Grosmaire 1977). Therefore, this study was by necessity a comparison between two snapshots in time, and our sampling design was inherently limited to sites surveyed in 1976. However, in addition to surveying the 2 recently urbanized counties (Cameron and Hidalgo), Grosmaire (1977) also surveyed Willacy County, providing a useful internal control for the study.

Methods. — Grosmaire (1977) trapped 3, 3, and 18 sites in Cameron, Hidalgo, and Willacy counties, respectively. We trapped all of the Cameron County and Hidalgo County sites and 10 of the Willacy County sites (Fig. 1). The remaining 8 sites in Willacy County were not available in 2009, being either dry or nonexistent (i.e., ponds had been filled). The sites consisted of federal and state protected areas ($n = 3$), public and private ponds ($n = 5$), and public flowing waters (i.e., rivers and canals; $n = 8$). Grosmaire (1977) trapped turtles using 183-cm long by 76-cm wide double-throated steel hoop nets with 2.54-cm mesh and 4 hoops per nets. Grosmaire (1977) baited traps with canned fish, fresh fish, or beef scraps. We trapped turtles using 183-cm long by 76-cm wide single-throated fiberglass hoop nets with 2.54-cm mesh and 4 hoops per net. We baited traps with canned fish (sardines in soybean oil), fresh fish (common carp, *Cyprinus carpio*), or shrimp (*Penaeus* sp.) placed in nonconsumable containers with holes for scent dispersal. We used approximately 55 g of bait per trap and changed bait every 2 d or when traps were moved to new water bodies.

Because one of the authors (JRD) supervised the 1976 trapping, we were able to repeat the original trap placement method. We placed traps along pond, canal, and river borders, securing traps to reeds or other vegetation. We placed traps equidistant to one another when possible, with distances between traps ranging from 2–6 m. Traps were

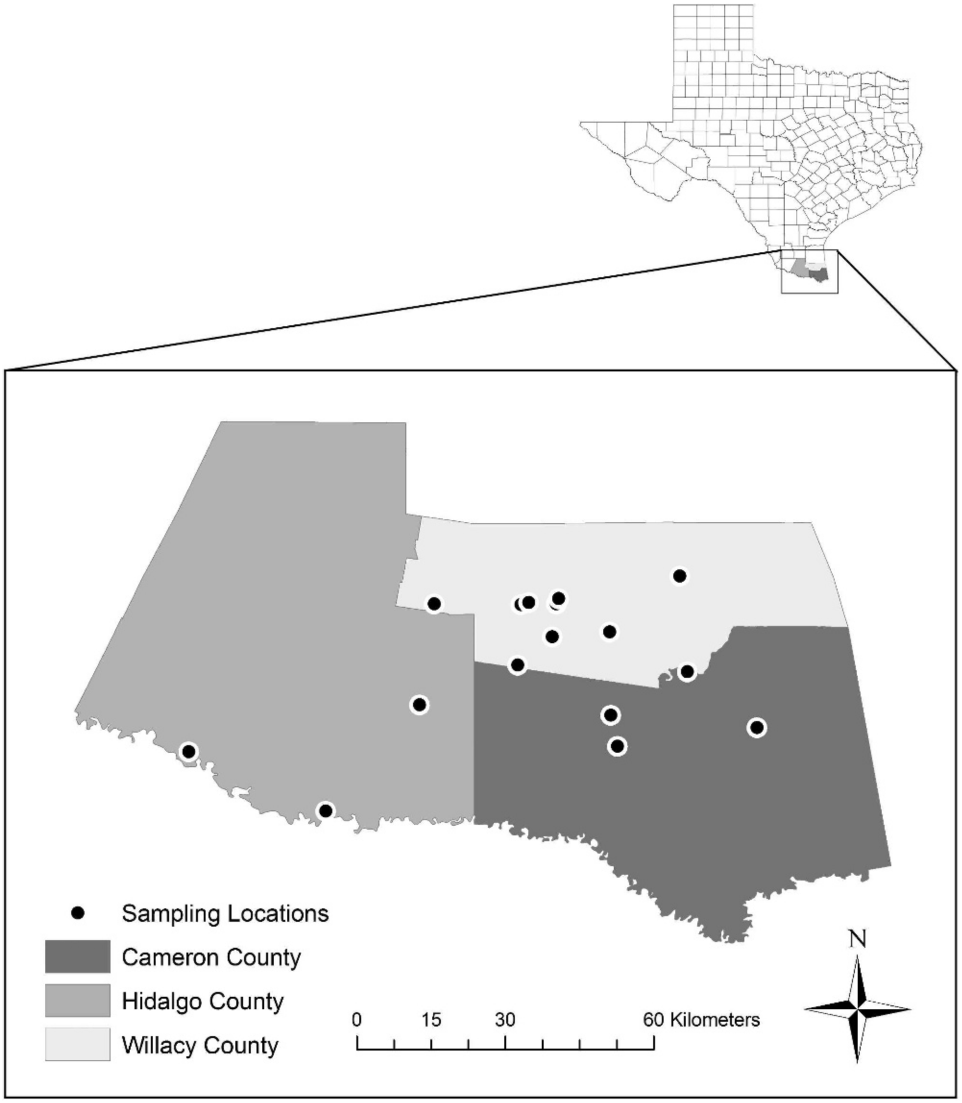

Figure 1. Locations of 16 freshwater turtle sampling sites in 3 counties in the Lower Rio Grande Valley of Texas in summer and fall of 1976 and 2009. Turtles were trapped using baited hoop nets, with trapping effort consistent between years.

checked daily in both studies, with traps checked at approximately 24-hr intervals. At sites with $\leq$ 20 trap days, both studies completed the total trapping effort in one day. At sites with $>$ 20 trap days, Grosmaire (1977) completed 20 trap days per day, whereas we completed between 40 and 50 trap days per day. Brown et al. (2011b) found that distribution differences in turtle trapping effort using hoop nets resulted in equivalent captures for equivalent total trapping effort.

The total trapping effort in 1976 for the 16 retrapped sites was 1065 trap days, with trapping conducted between 21 May and 15 November (primarily in June and July). The total trapping effort for this study in 2009 was also 1065 trap days, with trapping effort among the sites matching the 1976 trapping. In 2009, we trapped between 18 May and 28 September (primarily in May and June). Hard-shelled turtles were individually marked in both studies using carapace notches (Cagle 1939). Softshells were individually marked using metal fish tags in 1976. We used a portable rotary tool to etch a unique number in the carapace of softshells in 2009.

We used paired randomization tests with 10,000 iterations to determine whether number of red-eared slider (*Trachemys scripta elegans*) and Texas spiny softshell (*Apalone spinifera emoryi*) captures differed between 1976 and 2009 in Cameron and Hidalgo counties (urbanized) and in Willacy County (nonurbanized ''control''). For each iteration, the number of captures at sites was randomized by sample year, and the difference in captures between years was computed. The *p*-values obtained were the proportion of trials resulting in a difference between years greater than or equal to the one obtained in this study (Sokal and Rohlf 1995). We used total number of unique captures at each site as the sampling unit. Seven of the sites contained only 5 trap days; thus, captures at those sites may not be representative of relative abundance differences. To address this issue, we analyzed the data both with and without the inclusion of those 7 sites. We performed statistical analyses using R

Table 1. Number of red-eared sliders (*Trachemys scripta elegans*) and Texas spiny softshells (*Apalone spinifera emoryi*) captured at 16 sites in the Lower Rio Grande Valley (LRGV) of Texas in the summer and fall of 1976 and 2009. Substantial urbanization and land use changes have occurred in Cameron and Hidalgo counties since 1976, whereas Willacy County remains a low density, agriculture-dominated county.

			Red-eared sliders		Texas spiny softshells	
Sampling Location	County	Trap days	1976	2009	1976	2009
McCloud Hood Reservoir	Cameron	5	0	1	0	0
Laguna Atascosa NWR[a]	Cameron	280	16	0	5	0
Arroyo Colorado River	Cameron	5	0	1	0	5
Irrigation canal	Hidalgo	5	0	0	0	0
Bentsen–Rio Grande SP[b]	Hidalgo	120	19	0	6	0
Santa Ana NWR	Hidalgo	480	257	3	15	0
Irrigation canal	Willacy	20	9	1	0	0
Cattle pond	Willacy	10	0	11	1	0
Cattle pond	Willacy	20	8	17	0	0
Irrigation canal	Willacy	5	0	10	0	0
Retention pond	Willacy	10	1	16	0	2
Irrigation canal	Willacy	5	0	0	0	0
Irrigation canal	Willacy	70	0	7	10	12
Irrigation canal	Willacy	5	0	0	0	11
Cattle pond	Willacy	20	1	0	0	0
Arroyo Colorado River	Willacy	5	0	0	0	2

[a] NWR = National Wildlife Refuge.
[b] SP = State Park.

version 2.10.1 (The R Foundation for Statistical Computing, Vienna, Austria) and inferred significance at $\alpha = 0.05$.

Results. — Grosmaire (1977) captured 292 red-eared sliders and 26 Texas spiny softshells in Cameron and Hidalgo counties in 1976 (Table 1). We captured 5 red-eared sliders and 5 Texas spiny softshells in Cameron and Hidalgo counties in 2009. For the 10 sites, we trapped in Willacy County, Grosmaire (1977) captured 19 red-eared sliders and 11 Texas spiny softshells in 1976, whereas we captured 62 red-eared sliders and 27 Texas spiny softshells in 2009. In the following statistical results, ''All'' refers to analyses with all sites included and ''Reduced'' refers to analyses without the inclusion of the 7 sites with only 5 trap days. Relative to Grosmaire, we captured significantly fewer red-eared sliders (All: $p = 0.009$; Reduced: $p = 0.002$) and Texas spiny softshells (All: $p = 0.034$; Reduced: $p = 0.003$) in Cameron and Hidalgo counties and significantly more red-eared sliders (All: $p = 0.008$; Reduced: $p = 0.019$) in Willacy County. We did not detect a difference in number of Texas spiny softshells captured in Willacy County (All: $p = 0.094$; Reduced: $p = 0.349$).

Discussion. — We captured fewer red-eared sliders and Texas spiny softshells in Cameron and Hidalgo counties in 2009 compared to 1976, potentially indicating negative effects of increased urbanization on these species. In contrast, we captured more red-eared sliders and similar numbers of Texas spiny softshells in Willacy County in 2009 compared to 1976, indicating that these species have not declined in an adjacent nonurbanized county. However, 3 of the sites in Cameron and Hidalgo counties were federal and state protected areas, and turtle captures were substantially lower in all of them. It is possible that the decline in freshwater turtles at these protected sites was primarily attributable to land-use changes, with a shift in focus toward enhancing waterfowl and shorebird foraging habitat (United States Fish and Wildlife Service 1997). This draw-down management approach includes periodic draining of wetlands and extended periods with low water levels, which results in low annual habitat suitability for these freshwater turtle species (Ernst and Lovich 2009).

The United States Fish and Wildlife Service, Texas Parks and Wildlife Department, and communities in the LRGV recently partnered to create the World Birding Center, which includes 9 official sites and dozens of unofficial sites in the LRGV promoted as being exceptional for bird watching (Mathis and Matisoff 2004). Despite the physical protection of these sites from development and the presence of open water at the majority of the sites, these sanctuaries are not managed for freshwater turtles, and most do not appear to have sizeable populations. As part of a larger study investigating freshwater turtle harvest effects in the LRGV, we sampled many of these sanctuaries (Brown et al. 2011a). Only 3 of 13 sampled sanctuaries appeared to have large freshwater turtle populations (i.e., Southmost Preserve, Edinburg Scenic Wetlands, and a fish hatchery operated by Texas Parks and Wildlife Department). The water at these 3 sites was deeper than at most of the other sanctuaries (1–1.5 m) and, thus, was likely more suitable for freshwater turtles.

Urbanization will continue to increase in the LRGV, with the human populations in Cameron and Hidalgo counties projected to grow by 36.9% and 44.2%, respectively, over the next 30 yrs (Rio Grande Regional Water Planning Group 2001). The current trend of surface water loss will certainly continue as water is redirected for urban use (Huang and Fipps 2006). Thus, to prevent further declines of freshwater turtles from much of Cameron and Hidalgo counties in the near future, it is imperative that the public and private parks, preserves, and refuges seek a habitat management strategy that balances the needs of freshwater turtles with those of waterfowl and shorebirds. Draw-down management is problematic because it forces entire populations of turtles to temporarily disperse from water bodies. This undoubtedly increases the probability that a population will be negatively impacted by prominent urbanization effects such as road mortality (Aresco 2005), mesopredators (Boarman 1997), and human collecting (Ceballos and Fitzgerald 2004). Thus, the optimum solution would probably be persistent spatial segregation of aquatic habitats for birds and turtles or alternately to modify existing water bodies such that pockets of deep water remain during draw-downs.

In recent years, significant commercial freshwater turtle harvest has occurred in the LRGV (Ceballos and Fitzgerald 2004), and we detected probable harvest impacts in this region (Brown et al. 2011a). Therefore, we cannot discount the potential impact of commercial turtle harvest on the unprotected sites (i.e., direct take) or protected sites (i.e., potential source-sink interactions with harvested sites) in this study. In addition, 2007 and 2008 were intense drought years in the LRGV, which also may have influenced turtle movement patterns and, thus, our survey results in 2009. However, we maintain that the contrast between the results from Cameron and Hidalgo counties drawn from protected sites and those from Willacy County drawn from unprotected sites (in terms of legal harvest regulations; Texas Parks and Wildlife Department 2007) are likely better explained by effects of habitat management changes since 1976, coupled with urbanization effects.

We are currently facing worldwide declines of reptiles and amphibians (Gibbons et al. 2000; Stuart et al. 2004; Reading et al. 2010). Although long-term monitoring programs are optimal for detecting and responding to species declines (Congdon et al. 1993; Sherman and Morton 1993; Daszak et al. 2005; Burgmeier et al. 2011), in the absence of these data, periodic snapshot surveys can be a valuable species conservation tool (Dodd et al. 2007; Foster et al. 2009). However, historic surveys often lack crucial information necessary for repetition, particularly in the case of agency reports and theses. For instance, Grosmaire (1977) reported turtle captures but did not report trapping effort. We were able to replicate the study only because one of the authors (JRD) retained the original data files. Thus, we emphasize the importance of reporting effort in survey-based studies, regardless of whether the results are intended for publication.

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