Conservation Biology of Freshwater Turtles and Tortoises:
A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group
A.G.J. Rhodin, P.C.H. Pritchard, P.P. van Dijk, R.A. Saumure, K.A. Buhlmann, J.B. Iverson, and R.A. Mittermeier, Eds.
Chelonian Research Monographs (ISSN 1088-7105) No. 5, doi:10.3854/crm.5.093.versa.v1.2016

Graptemys versa Stejneger 1925 – Texas Map Turtle

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Summary. – The Texas Map Turtle, *Graptemys versa* (Family Emydidae), is a small freshwater turtle (carapace length to 204 mm in females, 116 mm in males) that is endemic to the Colorado River basin of Texas. The species exhibits pronounced sexual dimorphism in body size and large females are adapted to a highly molluscivorous diet. The species occurs mainly in lotic habitats but also inhabits reservoirs. Commercial and incidental collection of this turtle is possibly the most significant threat in some locations, although fragmentation and modification of its riverine habitat by dams are also of concern. It receives some protection under CITES and state regulations for commercial collection. The systematics, reproductive biology, diet, and morphology of the species have been investigated, although a rangewide study of its conservation status is needed.

Distribution. – USA. Restricted to the Colorado River drainage system in Texas.

Synonymy. – *Graptemys pseudogeographica versa* Stejneger 1925, *Graptemys versa*, *Malaclemys versa*.

Subspecies. – None recognized.

Status. – IUCN 2015 Red List: Least Concern (LC, assessed 2013); CITES: Appendix III (USA, as *Graptemys* spp.); US ESA: Not Listed; Texas: Not Listed.

Taxonomy. — The earliest recorded specimen of this species appears to have been collected by G. Stolley in 1883 but is now lost (USNM 13339; Lindeman 2013). The type series was collected in July 1900 by H.H. Brimley and C.S. Brimley at "Austin, [Travis Co.,] Texas" (Cochran 1961). Strecker (1909, 1930) collected additional specimens of this turtle and referred them to *Graptemys geographica* and *G. oculifera*. Stejneger (1925) recognized the map turtle in the Colorado River as a distinct form, describing the specimens collected by the Brimleys as *G. pseudogeographica versa* based on the new species' distinctive postorbital marking. The holotype (USNM 27473) is an adult male, as are the

Figure 1. A male *Graptemys versa* in Live Oak Creek, a tributary of the Pedernales River, in Ladybird Johnson Municipal Park, Gillespie County, Texas. Photo by Peter V. Lindeman.

Figure 2. A female *Graptemys versa* in the South Llano River, Kimble County, Texas. Photo by Peter V. Lindeman.

seven paratypes (USNM 27474–79 and MCZ 42346). Pope (1939) and Carr (1952) followed Stejneger's (1925) taxonomic arrangement. Smith (1946) elevated this form to full species without supporting data, but Smith and Sanders (1952) provided justification for this decision based on morphological distinctiveness and provided the first comprehensive description of the species. *Graptemys versa* is allopatric in relation to other map turtles and does not intergrade with any other form (*contra* Carr 1949, 1952). Its recognition as a distinct monotypic species is therefore not controversial and has been followed by subsequent workers (e.g., Cagle 1954; Vogt 1981, 1993) and in various chelonian checklists (e.g., Collins and Taggart 2009; Iverson et al. 2008; Fritz and Havaš 2007; TTWG 2014).

The phylogenetic relationship of *G. versa* to other map turtles has been extensively studied. McCoy and Vogt (1994) considered it a member of the *G. pseudogeographica* group of species. McKown (1972) was unable to distinguish *G. versa* from *G. caglei* based on karyotypes. Haynes and McKown (1974) suggested that the species is most closely related to *G. caglei* and *G. pseudogeographica kohnii* based on skull morphology and head pattern, although Vogt (1981) disputed the close affinity of these three species. Bertl and Killbrew (1983) distinguished *G. versa* from *G. caglei* based on color pattern, morphology of the vertebral spines, and eight osteological characters and suggested a biogeographical and phylogenetic affiliation among these two species, *G. ouachitensis*, and *G. sabinensis*. Vogt (1993), in a study of the *G. pseudogeographica* complex, noted that *G. versa* is more distant from this species complex than is *G. geographica* based on skeletal anatomy. Lamb et al. (1994) considered *G. versa* to be sister to the lineage containing *G. ouachitensis*, *G. sabinensis*, *G. flavimaculata*, and *G. oculifera* based on genetic data. Using genetic and morphological data, Stephens and Wiens (2003, 2009a) considered *G. versa* and *G. sabinensis* to be sister species in a clade that was

Figure 3. *Graptemys versa* from the South Llano River and its tributary, East Johnson Fork, Texas; five adult females (larger) and five adult males (smaller). Photo by Peter V. Lindeman.

Figure 4. *Graptemys versa* from the Colorado River, Concho County, Texas. Photo by Terry Hibbitts.

Figure 5. The USNM specimens of *Graptemys versa* in the type series, described as *Graptemys pseudogeographica versa* by Stejneger (1925). The holotype (USNM 27473) is in the foreground, while the remaining specimens (USNM 27474–79) are six of the species' seven paratypes (not pictured: MCZ 42346). Photo by Peter V. Lindeman.

sister to a clade containing *G. flavimaculata*, *G. oculifera*, *G. nigrinoda*, *G. ouachitensis*, and *G. pseudogeographica*; although, molecular data alone suggested a closer affiliation with *G. caglei* (Stephens and Wiens 2009b).

The proposed inclusion of *G. versa* and other map turtles in the diamondback terrapin genus *Malaclemys* (McDowell 1964) has received little support (McKown 1972; Wood 1977; Killebrew 1979; Dobie 1981; McCoy and Vogt 1994; Lamb and Osentoski 1997; Stephens and Wiens 2003).

Description. — *Graptemys versa* is a relatively small aquatic emydid and one of the smallest *Graptemys* (Lindeman 2005). The species exhibits pronounced sexual dimorphism in body size (Lindeman 2000, 2003, 2008; Stephens and Wiens 2009a) and the reduced size of males is possibly paedomorphic (Ward 1980). Adult females are 128–204 mm in straight-line carapace length (SCL) and 115–180 mm in midline plastron length (PL), while adult males are 62–116 mm in SCL and 54–95 mm in PL (Lindeman 2005, 2008). Lindeman (2005) found that *G. versa* from his study site on the South Llano River were smaller than populations elsewhere in the Colorado River basin (e.g., the San Saba River), although geographic variability in body size has not been well studied.

The species is a member of the "mesocephalic" group of *Graptemys*. The relative widths of the head and alveolar surface of the jaw in females are intermediate in size as compared to congeners and are perhaps most similar in development to *G. caglei*, reflecting a diet in females that is partially molluscivorous (Lindeman 2000, 2001, 2003, 2006, 2008; Lindeman and Sharkey 2001).

The carapace has a middorsal vertebral keel with indistinct knobs that are often dark-tipped and have a yellowish or "horn-colored" area anterior to each knob. The anterior scutes of the carapace are convex, elevated and rounded, with deeply grooved suture lines, providing a "quilted" appearance to the shell. The posterior marginals of the carapace are strongly serrated. The carapacial pattern is olive colored and each scute has 1–20 spots, each consisting of 3–4 concentric yellow circles with a yellow center. This carapacial pattern fades with maturity. The ventral surfaces of the marginals are marked with dark lines surrounding areas of irregular yellow blotches and the bridges are marked

Figure 6. A hatchling *Graptemys versa* in the South Llano River at Junction, Kimble County, Texas. Photo by Peter V. Lindeman.

Figure 7. A hatchling *Graptemys versa* from the Llano River, Kimble County, Texas. Photo by Terry Hibbitts.

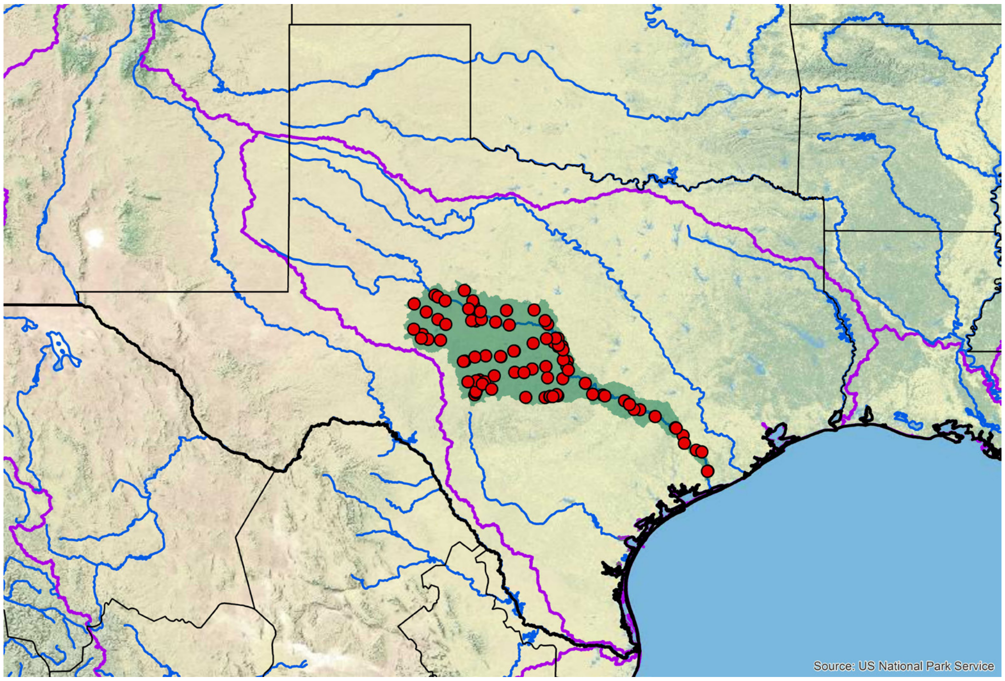

Figure 8. Distribution of *Graptemys versa* in the Colorado River watershed basin, Texas, USA. Purple lines = boundaries delimiting major watersheds (level 3 hydrologic unit compartments – HUCs); red dots = museum and literature occurrence records based on Iverson (1992) and Lindeman (2013, 2014) plus more recent data and the authors' personal data; green shading = projected native distribution based on GIS-defined level 10 HUCs constructed around verified localities and then adding HUCs that connect known point localities in the same watershed or physiographic region, and similar habitats and elevations as verified HUCs (Buhlmann et al. 2009; TTWG 2014), and adjusted based on authors' subsequent data.

with dark, fine longitudinal lines. In adults, the plastron is mostly yellow with dark lines along the inter-scute seams; whereas, hatchlings and juveniles possess a more distinct and elaborate plastral pattern.

The head pattern of *G. versa* is distinct and consists of a bold yellow or orange postorbital line on each side of the head that is often J-shaped, with the hook of the J extending posteriorly from lower edge of the postorbital mark behind the eye, and generally a slight anterior projection of the top of the line over the eye. In addition, there are 3–16 temporal yellow stripes that extend anteriorly to the orbit. The chin has three pale orange or yellow spots, one anteriorly and one under each angle of the jaw, with dark borders and yellow flecks on lower part of chin and neck (Smith and Sanders 1952; Vogt 1993).

In addition to a much smaller body size and relatively small head size, adult males are distinguished from females by possessing a longer, thicker tail with the anal opening posterior to the carapacial margin (Ernst and Barbour 1989). Unlike males in some other *Graptemys* species, male *G. versa* lack elongated foreclaws (*contra* Carr 1952). Hatchling and juvenile specimens differ from adult males in having a nearly circular carapace and a distinct plastral pattern.

McKown (1972, *in* Ernst and Lovich 2009) described the karyotype which consists of 50 chromosomes (11 pairs of metacentric or submetacentric and 2 pairs of acrocentric macrochromosomes; 12 pairs of microchromosomes). Other references with descriptions or photographs of the species include Ward (1980), Bonin et al. (1996, 2006), Vetter (2004), Ernst and Lovich (2009), and Lindeman (2013).

Distribution. — As is typical of the many drainage endemic species in *Graptemys*, *G. versa* has among the smaller geographic ranges of turtles in North America (Iverson 1992; Buhlmann et al. 2009; TTWG 2014). The species is endemic to the Colorado River basin of central Texas where it occurs in the Colorado and its tributaries, the Concho, Llano, San Saba, and Pedernales rivers, Pecan Bayou, and at least 15 smaller tributary creeks (Vogt 1981; Dixon 2000; Lindeman 2013). The species does not occur in the Brazos River (*contra* Carr 1952) and specimens from the Guadalupe-San Antonio drainage basin referenced by Webb (1962) are actually the earliest known specimens of *G. caglei* (Lindeman 2013).

Lindeman (2013, 2014) and Price and Dimler (2015) reported *G. versa* from 25 counties in Texas, ranging from Coke, Brown, Sterling, Irion, Schleicher, Edwards, and Gillespie counties in the higher reaches of the basin, downstream to coastal Matagorda County. Locality data are in Strecker (1909, 1930), Strecker and Williams (1927), Daugherty (1942), Marr (1944), Brown (1950), Smith and Sanders (1952), Semken (1961), Tinkle and Knopf (1964), Olson (1967), Raun and Gehlbach (1972), Rakowitz et al. (1983), Killebrew et al. (1984), Kizirian et al. (1990), Vogt (1993), Dixon (2013), Lindeman (2013, 2014), and Price and Dimler (2015).

Habitat and Ecology. — *Graptemys versa* is a river turtle (Moll and Moll 2004) and is most frequently found in

Figure 9. Habitat of *Graptemys versa* in Texas: (top left) lower Colorado River, Wharton County; (top right) San Saba River, Menard County; (bottom left) Pecan Bayou, Mills County; (bottom right) North Llano River, Kimble County. Photos by Peter V. Lindeman.

perennial lotic habitats. Marr (1944) described his collecting site on the Concho River as "relatively cold and rapid." Prior to the construction of major dams in the Colorado River basin, the habitat of this species likely consisted of rocky or gravelly streams consisting of riffles and lower-velocity deep sections that were periodically scoured by flood events. Optimal habitat includes emergent rocks or woody debris, which provide basking sites. Although reaches still exist within the basin that contain relatively unaltered habitat, these are now often separated by impoundments or areas of reduced flow with extensive sedimentation. The aquatic substrate in occupied areas can vary from cobbles and boulders to fine gravel and mud. Water depth can be highly variable and water clarity ranges from clear to turbid. The species has also been taken in broad, slow sections of river, near the mouths of reservoirs, and even within reservoirs (Killebrew, pers. obs; Stuart, pers. obs.); although, it is unknown if lentic habitats support populations. The species also occurs in a disjunct oxbow lake of the South Llano River (Lindeman, pers. obs.).

Figure 10. Seven male and juvenile *Graptemys versa* in the Colorado River in La Grange, Fayette County, Texas. Photo by Peter V. Lindeman.

Lindeman (2003) described sexual differences in aquatic habitat preference in the South Llano River, where *G. versa* occupies both deep, slow pools and shallow, fast-flowing riffle areas. In their use of habitat, small females were more similar to large females than they were to males of comparable body size; this pattern of habitat use was reflected in the similar diets of small and large females (both highly molluscivorous) compared to the diet of males (mostly insectivorous). The hatchlings of this species sometimes occur in quiet backwaters (Lindeman 1993).

Activity and Behavior. — The species is well adapted for a primarily aquatic lifestyle (Stephens and Wiens 2008); although, individuals will regularly bask on fallen logs, submerged stumps, rocks, boat docks, and other objects in or near water. Basking individuals are wary and quickly enter the water if disturbed. Lindeman (2008) suggested that the reduced body size of males may reflect the fact that they rarely travel overland, where a greater body size would provide protection against predation and desiccation. In addition, small body size might also provide an energetic advantage in lotic environments.

Diet. — In an unpublished study, Lehmann (1979, *in* Bertl and Killebrew 1983) reported mainly aquatic insect larvae in the diet, based on a small sample size. Hatchlings appear to be mostly insectivorous. Kizirian et al. (1990) noted gastropod shells in the feces of a large female from the San Saba River that exhibited "megacephaly."

The most detailed study of diet is from the South Llano River. Adult females collected in 1998–1999 fed almost exclusively on the Asian clam (*Corbicula* sp.), a non-native mussel introduced to this river system in the 1970s; other invertebrates (snails, crayfish, and aquatic insect larvae) were also consumed in small quantities (Lindeman 2006). Small females were mainly molluscivorous but consumed greater quantities of snails and insect larvae than large females, whereas males primarily consumed insect larvae (especially Trichoptera and Ephemeroptera). Vascular plants and filamentous algae were also consumed but were of relatively low importance in the diet of both sexes. A comparison of dietary samples from females taken in 1949 with those from the 1998–1999 collections indicated that prey had shifted from a diverse diet of native mussels, sponges, bryozoans, and algae to almost exclusively *Corbicula* by the late 1990s. However, the diet of males over the same 50-year period exhibited little change (Lindeman 2006). Female *G. versa* with greater body size, head widths, and alveolar surface widths consumed larger molluscan prey (Collins and Lindeman 2006). Ward (1980) studied the jaw closure force generated by female *Graptemys* and found that *G. versa* exhibited the second-strongest bite force measured; he suggested *G. versa* is likely omnivorous and not strictly molluscivorous.

Mating Behavior. — Male courtship behavior has not been studied, although Ernst and Lovich (2009) reported that a captive male exhibited head-bobbing (ca. 5 bobs per second) directed at a male *G. barbouri* housed in the same tank. In White Oak Creek of the Pedernales subdrainage, courtship has been observed in April, July, October, and November (Lindeman 2013). The lack of elongated foreclaws in males suggests that foreclaw titillation might not be a component of male courtship (*contra* Garrett and Barker 1987). Seidel and Fritz (1997) suggested that male courtship behavior in map turtles differs among species, with some exhibiting a "regressed" form without foreclaw stimulation, similar to the interspecies variability observed in sliders (*Trachemys*). Kirkpatrick (2006) illustrated copulation of *G. versa* in captivity.

Eggs and Nesting. — Females may lay as many as 4 clutches during an active season, based on dissected specimens from the South Llano River (Lindeman 2005). No decline in clutch size was observed over a season, although partial follicular atresia might occur in late-season reproductive efforts. Oviposited eggs averaged 35.09 mm (30.7–38.4 mm) in length and 20.73 mm (18.4–22.2 mm) in width (Lindeman 2005). Egg width (but not length) is correlated with female body size, presumably due to morphological constraints (Congdon and Gibbons 1987). Goode (1997) discussed reproduction in captive *G. versa* from the Columbus Zoo based on 19 clutches produced over five seasons. Individual clutch frequency ranged from 1 to 5 and clutch size ranged from 1 to 6 eggs (mean 4.63). The individual egg mass was 8.0–14.0 (mean 10.68) g. The nesting season in captive turtles was 19 February to 28 June (Goode 1997).

Graptemys versa, like other map turtles, has temperature-dependent sex determination that conforms with pattern Ia, in which mostly males are produced at lower incubation temperatures and mostly females at higher temperatures (Ewert and Nelson 1991; Ewert et al. 1994). Eggs of *G. versa* incubated at 25°C yield only males, whereas those incubated at 32°C yield only females. The pivotal incubation temperature (at which a 1:1 sex ratio for hatchlings would be expected) is ca. 30.4°C, consistent with an increase in pivotal temperature in more western populations of *Graptemys* species (Ewert et al. 1994). The relatively high pivotal temperature might be due to the scarcity of cool nesting sites in the more arid environment of the Colorado River basin (Ewert et al. 1994). No data are available on nesting in the wild. Lindeman (2003) noted the absence of flat sandy beach sites (typical nesting sites for other *Graptemys* spp.) in his study site on the South Llano River. As in most map turtles, hatchlings probably do not overwinter in the nest (Lindeman 2008, 2013).

Growth and Maturation. — *Graptemys versa* is an early-maturing species compared to its congeners, but also exhibits distinct sexual bimaturism, as do other species of map turtles (Lindeman 2003). In the South Llano River, females mature in about the seventh season of growth and at a size of 115 mm PL or greater, whereas males mature much earlier, in the second or third year of growth at 55–60 mm PL (Lindeman 2005). Hatchling size was estimated to be 21 mm PL based on growth curve analysis (Lindeman 2005). Shell annuli (growth lines) were not distinct enough in many larger specimens to provide information on growth rates (Lindeman 2005).

Parasites and Predators. — Lindeman and Barger (2005) studied parasitism by the acanthocephalan, *Neoechinorhynchus emydis*, in *G. versa* specimens collected in 1949 and 1998–1999. Infection was higher in females than in males. The incidental ingestion of ostracods, an intermediate host for *N. emydis*, may be the route for infection of *G. versa*. Other internal parasites found by Lindeman and Barger (2005) included trematode flukes (the digenean *Telorchis corti* and an unidentified aspidogastrean) and unidentified nematodes. McAllister et al. (1991, 1994) reported the coccidians *Eimeria graptemydos* and *E. mitraria* in fecal samples from *G. versa*. Ectoparasitism by leeches (species unknown) has been observed in this turtle (Killebrew, pers. obs.).

Predation on *G. versa* has not been studied in detail. Hatchlings and juveniles are preyed upon by herons, gar, bass, and raccoons (Killebrew, pers. obs.). Humans are likely the main predator of adults.

Aberrant Morphology. — In a study of repetitive variants in turtle shells, Zangerl (1969) described relatively low frequencies (<14%) of scute modifications and supernumerary scutes in a sample of 42 *G. versa*.

Associated Turtle Species. — Native species of aquatic turtles that are sympatric with *G. versa* include two other emydids, *Pseudemys texana* and *Trachemys scripta*; the chelydrid *Chelydra serpentina*; the kinosternids *Kinosternon flavescens*, *K. subrubrum*, and *Sternotherus odoratus*; and the trionychids *Apalone mutica* and *A. spinifera* (Dixon 2000).

Population Status. — Population studies of *G. versa* have been limited to the South Llano River (McKinney 1987; Lindeman 2005). While a formal rangewide status survey has not been conducted, comparative data on numbers and relative abundance in the turtle fauna in basking surveys were recently published for several sites (Lindeman 2014). The species was long regarded as primarily found on or even endemic to the Edwards Plateau upstream of the Balcones Escarpment (beginning with Smith and Buechner 1947; additional statements to this effect are reviewed in Lindeman 2014). However, recent evidence shows that in terms of both absolute and relative abundance, the densest and most dominant populations inhabit more than 400 river km of the lower mainstem Colorado River below the Balcones Escarpment.

Turtle researchers who have worked in the Colorado River basin have suggested that populations remain healthy, even in large reservoirs (Killebrew, pers. obs.). Dixon (2000) considered *G. versa* to be "relatively common in the riffle systems of the Concho and middle Colorado River basins." Lindeman (2004) suggested that local declines might occur where public access to rivers is available. Despite major changes in the diet of females due to changes in the mollusk prey base (Lindeman 2006), body sizes and reproductive potential apparently remained unchanged during the latter half of the 20th century (Lindeman 2005).

Threats to Survival. — Baillie and Groombridge (1996), based on an assessment by the IUCN Tortoise and Freshwater Turtle Specialist Group, listed *G. versa* as Lower Risk/Near Threatened. Map turtles are desirable species in the commercial pet trade. The available data for commercial trade in *Graptemys* spp. do not reflect the actual numbers of *G. versa* that are collected or bred for the pet market. Many or most map turtles in the U.S. Fish and Wildlife Service's LEMIS database are not identified to species; thus, available statistics for commercial trade in *G. versa* might be greatly underestimated (Telecky 2001; Reed and Gibbons 2002; Schlaepfer et al. 2005). The species is present in the foreign pet trade (e.g., Shiau et al. 2006) even if the source (wild-caught or captive bred) is often unclear. However, a survey of the turtle trade in Texas suggests that *G. versa* is not an important commercial species and most aquatic turtle collecting is not done in the Colorado River basin (Ceballos and Fitzgerald 2004). Incidental collection of *G. versa* is even more difficult to quantify than commercial collecting and its actual impact is unknown. Lindeman (2004) suggested that *G. versa* populations might be diminished by incidental collection in areas accessible to the public, such as at highway crossings or in river reaches used by boaters and other recreationists. Other river reaches bordered by private lands and lacking public access might be important conservation areas for the species (Lindeman 2004).

The Colorado River basin has been extensively modified. Major dams and reservoirs located within the range of *G. versa* include E.V. Spence, O.H. Ivie, Buchanan, L.B. Johnson, Travis, Inks, O.C. Fisher, and Twin Buttes. Although *G. versa* is taken in reservoirs, little information is available on how extensively it uses such sites, or to what extent impoundments have made upstream areas unsuitable due to changes in hydrology. Major dams, and perhaps even some low-head dams, are effective barriers to dispersal and gene flow in aquatic turtles and can result in population fragmentation. Some reaches of the Colorado River basin have been impacted by reduced flows, siltation, decline in water quality, and displacement of native riparian vegetation by invasive saltcedar (*Tamarix* sp.). Removal of woody debris (snagging and clearing) for floodway maintenance, channelization, and removal of gravel and sediment in channels can degrade riverine habitat for other *Graptemys* species (Lindeman 1998, 1999), although it is not known if *G. versa* is impacted by such activities.

Reduced river flows (due to diversions and drought) and increased siltation can affect water quality and substrates important to aquatic invertebrates (e.g., mussels and insects) that *G. versa* relies upon for food. A number of native mollusks in the Colorado River basin have been impacted by hydrological changes in the river system and the establishment of non-native species (Howells et al. 1996; Texas Parks and Wildlife Department 2010). Although female *G. versa* are known to rely heavily on non-native *Corbicula* sp. (Lindeman 2006), the long-term consequences to this turtle of reduced molluscan prey diversity are unknown.

Some *G. versa* are known to be killed or injured by recreational shooting ("plinking") and by impacts with motor boats (Killebrew, pers. obs.; Stuart, pers. obs.). Drowning in submerged fish traps set by local people is an additional hazard in some areas (Stuart, pers. obs.).

Conservation Measures Taken. — All *Graptemys* species are listed by the USA as Appendix III under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which provides for monitoring of international trade in these turtles as pets or food (U.S. Fish and Wildlife Service 2005). Information provided by monitoring can determine if exports are occurring legally and if additional conservation measures might be warranted. Since 2007, the state of Texas prohibits the commercial collection of all wild turtles on public land and in public waters, or the use of traps to take aquatic turtles in public waters.

Six state parks and a national historical site managed by the National Park Service protect riparian habitat along short stretches of river habitats inhabited by *G. versa* (Lindeman 2013): Colorado Bend, Fort McKavett Historic, Lyndon B. Johnson, Pedernales Falls, San Angelo, and South Llano River state parks and the Lyndon B. Johnson National Historical Site. The species likely benefits from various environmental improvement measures implemented in the Colorado River basin for other species. These include steps to improve aquatic habitat, maintain instream flows, and control saltcedar, efforts that serve in part to address the federal recovery goals for the Concho water snake (*Nerodia paucimaculata*; U.S. Fish and Wildlife Service 2008). This snake is broadly sympatric with *G. versa* and has similar habitat requirements. Water quality monitoring and watershed protection plans in the basin are conducted in part under the Texas Clean Rivers Program and are important measures that may help to maintain the aquatic invertebrate prey base used by this turtle.

Conservation Measures Proposed. — A comprehensive survey of the Colorado River basin, particularly the lower reaches below the Balcones Escarpment and small tributary creeks which in many cases seem to provide habitat for relatively dense populations, is needed to more precisely determine the current distribution and conservation status of *G. versa*. This survey should also include an emphasis on reservoirs and other modified reaches of rivers to determine to what extent the species is able to use such areas. Life-history studies of populations that persist in heavily modified river reaches would be valuable. Additional information is needed on reproduction, nesting sites, and the natural history of hatchlings. Although woody debris might not be a limiting factor for *G. versa*, Lindeman (1999) proposed anchoring deadwood in channels downstream of bridge supports to enhance basking and cover habitat for other map turtle species. *Graptemys versa* should be considered in comprehensive planning efforts that focus on aquatic habitat conservation and restoration in the Colorado River basin.

Captive Husbandry. — *Graptemys versa* requires a captive environment similar to that of other aquatic emydids. A source of natural or artificial full-spectrum light, a basking platform, and an aquatic habitat equipped with water filtration are required. Like other map turtles, captives tend to remain wary and prone to quickly fleeing into water from a basking spot if disturbed (Kirkpatrick 2006). Captives maintained in areas where they are frequently disturbed may become stressed and prone to impact injuries from diving off of basking sites. Map turtles are generally less tolerant of poor water quality than many other aquatic turtles and are prone to skin and shell infections if their captive environment is not properly maintained (Kirkpatrick 2006). Captive *G. versa* will eat a variety of foods such as fresh and canned fish, chicken, beef, dog food, insects, and occasionally lettuce (Ernst and Lovich 2009). The species has been successfully bred in captivity at the Columbus Zoo (Goode 1997) and by Tortoise Reserve, Inc.

Current Research. — We are unaware of any current life history or ecological studies.

Acknowledgments. — We thank Mike Dloogatch, Terry Hibbitts, Troy Hibbitts, Marsha May, Charles Painter, and Joe Ward for assistance in preparing this account, and Terry Hibbitts for two of his photos.

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Citation Format for this Account:

Lindeman, P.V., Stuart, J.N., and Killebrew, F.C. 2016. *Graptemys versa* Stejneger 1925 – Texas Map Turtle. In: Rhodin, A.G.J., Pritchard, P.C.H., van Dijk, P.P., Saumure, R.A., Buhlmann, K.A., Iverson, J.B., and Mittermeier, R.A. (Eds.). Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Monographs 5(9):093.1–10, doi:10.3854/crm.5.093.versa.v1.2016, http://www.iucn-tftsg.org/cbftt/.